BY PHILIP A. KRAMER AND
PATRICIA RICHARDS KRAMER
EDITED BY MELANIE McFIELD

ECOREGIONAL CONSERVATION PLANNING

for the Mesoamerican Caribbean Reef

ECOREGIONAL CONSERVATION PLANNING *for the* Mesoamerican Caribbean Reef (MACR)

BY PHILIP A. KRAMER AND PATRICIA RICHARDS KRAMER
EDITED BY MELANIE MCFIELD

Philip Kramer, Ph.D. and Patricia Richards Kramer
MGG, Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Cswy.
Miami, FL 33149
Phone 305-361-4664 Tel/Fax 305-361-4632
pkramer@rsmas.miami.edu

Melanie McField, Ph.D.
MACR Reef Scientist/Senior Program Officer for Belize
P.O. Box 512
Belize City, Belize, Central America
Phone 501-2-37680
Tel/Fax 501-2-37681
mcfield@btl.net

Sylvia Marín
MACR Ecoregional Coordinator
P.O. Box 629-2350
San Francisco de Dos Ríos
San Jose, Costa Rica
Phone 506-253-1529 Tel/Fax 506-234-7976
smarin@wwfca.org

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The purpose of this report is to present the findings of the MACR Ecoregional Planning Workshop and an overview of the breadth of information synthesized for the MACR Biodiversity Database. The authors hope this report proves a valuable resource to all those

involved in preserving and managing the biodiversity of the MACR ecoregion. The information in this report is based on the best information available at the time and, while every attempt had been made to ensure its accuracy, errors and omissions are bound to occur; therefore it is our hope that readers will "use this information," add to it, and verify and update its accuracy. While we have tried to acknowledge the many individuals and organizations that contributed to this report, there may be some we have missed and we deeply apologize in advance for any oversight of their hard work.

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The publication of the MACR Ecoregional Biodiversity Vision is dedicated to Mario Lara Pérez Soto, colleague and friend who has made important contributions to our understanding on the reefs of Quintana Roo, Mexico and the importance of their conservation.

Mario completed a master's degree in biology with emphasis on aquatic resources and worked with the Mexican Secretariat for the Environment, Natural Resources and Fisheries (SEMARNAP) as reef researcher and also as the former Director of the Isla Contoy National Park. As lecturer and researcher with the Mexican National Autonomous University (UNAM), Mario also promoted greater understanding on coral reefs, contributing to environmental education and outreach efforts throughout Quintana Roo.

Mario participated actively during the MACR Ecoregional Workshop, sharing information providing insights, and guiding fascinating discussions on ecoregional reef conservation priorities. We are extremely grateful for his valuable professional and personal contributions to this process.

¡Gracias Mario!

Philip A. Kramer and Patricia Richards Kramer
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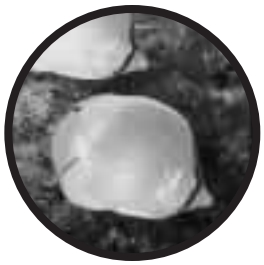

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Executive Summary

The Mesoamerican Caribbean Ecoregion (MACR) extends over 1,000 km along the coastlines of Yucatán Mexico, Belize, Guatemala, and Honduras, and supports the second longest barrier reef in the world, a diverse array of fauna and flora, and numerous rich nursery/feeding grounds. To help guide conservation efforts toward preserving the integrity of this unique ecoregion, WWF initiated Ecoregional Conservation Planning (EC) by supporting the development of a MACR Biodiversity Database and sponsoring an Ecoregional Conservation Planning Workshop in Cancun in April 2000. A preliminary goal of the EC process is to identify a network of conservation priority sites that will represent the region's biodiversity, while contributing to the maintenance and resilience of ecological processes. This report aims to provide a greater understanding of the region's biodiversity and present the results and recommendations of the EC workshop.

Evaluating MACR Biodiversity

To understand the MACR's biodiversity, distinctive indicators such as key species, representative habitats, and key ecological processes were targeted for further examination. Using a Geographic Information System (GIS) as a platform, a MACR Biodiversity Database containing such information as land cover, marine benthic habitats, currents watersheds, and the distribution and status of coral reefs, focal species (manatees, sea turtles, birds) and commercially significant species like lobster, grouper, and conch was created. To promote the evaluation of large-scale features (100-1,000 kms), the ecoregion was delineated into distinctive subregions according to similar biodiversity features such as oceanographic patterns (e.g., currents, upwelling), characteristic habitat types (e.g., coral reefs, seagrass, mangroves), bathymetry, watersheds and terrestrial influences. Recognizing the vital role humans play in the maintenance of biodiversity, socioeconomic data such as human uses, threats to biodiversity, and management efforts was integrated. This information was compiled into a series of thematic 3' x 3' maps and used as visual conservation planning tools at the EC workshop in Cancun, Mexico (see Appendix A).

Ecoregional Conservation Planning Workshop

Using a priority-setting framework, the EC workshop provided more than 60 local and international experts the opportunity to evaluate biodiversity properties of the MACR ecoregion, select those areas of highest conservation priority, and recommend actions to ensure their long-term preservation. The key in adapting this process was recognizing the open and transboundary nature of this large and interconnected tropical marine ecosystem by focusing on the importance of connectivity, larval distribution, currents, habitat linkages, and upwelling.

Identifying Priority Areas for Taxa/Guilds

The first priority-setting analysis focused on selecting priority areas important for the conservation of significant taxa or guilds, including corals, fishes, focal species, and plants. Conserving areas important to these groups may contribute to the protection and maintenance of ecosystem processes and functions throughout the ecoregion. Taxa/Guild Priority Areas were ranked based on criteria such as uniqueness, endemism, trophic importance, representation, ecological phenomena (e.g., spawning aggregations), economic importance, vulnerability, and need for inventories in their ranking analysis. Given their predominance and importance in the MACR, ranking criteria specific to coral reefs, including habitat diversity, size, condition, proximity to similar habitats, nursery areas or larval transport, environmental gradients, well-developed coral framework, regenerative capacity, representation, "swath" potential, uniqueness, and dominance of "old growth" corals, were developed and evaluated. From these analyses, 137 areas were selected including 26 Coral

Priority Areas, 53 Fish Priority Areas, 37 Focal Species Priority Areas, and 21 Plant Priority Areas. Taxa/Guild Priority Areas included important coral reefs such as the longest barrier reef in the western Atlantic (Belize) and four of the best-developed coral atolls (Banco Chinchorro, Lighthouse, Turneffe Islands, and Glovers Reef Atoll) in the Caribbean; largest snapper-grouper spawning/aggregation (2,000-4,000 individuals) (Gladden Spit); sandy beaches with some of the highest densities of sea turtle nests (e.g., Cozumel, Punta de Manabique); large manatee populations (e.g., Belize River, Northern and Southern Lagoons) and important manatee calving areas (e.g., Chetumal and Corozal Bays); and numerous large nursery grounds for key fishery species like lobster (e.g., Bahía de la Ascención, and Espíritu Santo), conch (e.g., Banco Chinchorro), and shrimp (e.g., Graciosa Bay-Amatique Bay). An overview of the Taxa/Guild Priority Areas is provided in Appendix B.

Selecting Biodiversity Priority Areas for the MACR

The Taxa/Guild Priority Areas were then integrated and served as the basis for identifying Ecoregional Biodiversity Priority Areas. Experts conducted an ecoregional Biodiversity Analysis to select and rank priority areas into four categories—Highest Priority, High Priority, Priority, and Areas Requiring Additional Assessments (or Unknown)—using several criteria such as species richness, trophic linkages, habitat connectivity, habitat complexity, habitat representation, and ecological and evolutionary phenomena. Twenty-six Biodiversity Priority areas were selected: 9 Highest, 7 High, 6 Priority, and 4 Unknown (see table below). Detailed descriptions are found in Appendix C.

Threats to MACR Biodiversity

To evaluate threats to MACR biodiversity, a socioeconomic working group identified and ranked the primary threats to the ecoregion's biodiversity as high, medium, or low based on four of the greatest threats: coastal habitat degradation or conversion, declining water quality, declining or depleted fisheries, and increased stresses due to oceanographic and climato-meteorological phenomena. Areas at greatest risk included Cancun (development), Chetumal Bay (pollution), Belize City (shipping, development), La Ceiba and Trujillo (agriculture, oil-port activities), and Bay Islands (development, overfishing).

Identifying Persistence Likelihood and Future Threats

A Persistence Analysis of the Biodiversity Areas was then conducted based on the degree to which an area would likely retain its present status should the current level of human pressure remain unchanged. Several landscape and integrity criteria were ranked, including intactness of trophic structures, linkages to adjacent ecosystems, habitat quality, structure and complexity, status of key species and susceptibility to large-scale disturbances. Of the 26 Biodiversity Priority areas, 11 were considered to have a high persistence value, 11 were ranked moderate, 2 were ranked low, and 2 were ranked as unknown. No Priority areas were ranked as

Highest Priority	High Priority	Priority	Unknown
NE Yucatán (QR2)	Cozumel (QR1)	Ría Lagartos (QR3)	Arrowsmith Bank (QR4)
Banco Chinchorro (SK1)	Central Yucatán (SK2)	Cancun Corridor (QR5)	English Channel (BB5)
Sian Ka'an (SK3)	Chetumal/Corozal (SK5)	Tulum Corridor (QR6)	Swan Islands (HG1)
S. Yucatán (SK4)	Belize City Complex (BB4)	Central Barrier Reef (BB7)	Rosa/Misteriosa Banks (HG6)
Turneffe Islands (BB1)	Sapodilla Cayes (BB8)	Río Platano (HG2)	
Lighthouse Reef (BB2)	Port Honduras (BB9)	Tela – Manabique Coast (HG4)	
Glovers Reef Atoll (BB3)	Gulf of Honduras (HG5)		
Gladden Spit (BB6)			
Bay Islands (HG3)			

having the highest likelihood of persistence. The Biodiversity Priority Areas with the greatest likelihood of persistence included NE Yucatán (QR2), Sian Ka'an (SK3), Banco Chinchorro (SK1), Lighthouse Reef (BB2), Turneffe Islands (BB1), Gladden Spit (BB6), Belize City Complex (BB4), Ría Lagartos (QR3), Central Barrier Reef (BB7), and Río Platano (HG2).

The final analysis was a Future Threats Analysis where experts evaluated the likelihood that threats would result in significant changes in the next 15 years, based on three broad categories of threats: 1) land-based (e.g., pollution associated with runoff); 2) marine-aquatic (e.g., loss or disruption of nursery or spawning grounds); and 3) marine biota (e.g., shifts in community structure, unsustainable fishing). Fourteen of the Biodiversity Priority Areas were ranked as having high levels of threats, nine as moderate, only one as low, and two as unknown. Those at highest risk include: NE Yucatán (QR2), S. Yucatán (SK4), Glovers Reef Atoll (BB3), Gladden Spit (BB6), Bay Islands (HG3), Cozumel (QR1), Central Yucatán (SK2), Chetumal/Corozal (SK5), Belize City Complex (BB4), Sapodilla Cayes (BB8), Port Honduras (BB9), Gulf of Honduras (HG5), Cancun Corridor (QR5), Tulum Corridor (QR6), and Tela-Manabique Coast (HG4).

Seascape Considerations

The experts discussed important seascape features to consider for developing a long-term conservation plan for the MACR. They identified specific conservation strategies and actions needed to achieve and measure conservation success over the next one to two years, five to ten years and 25-50 years. Workshop experts also identified important data needs such as status and condition of key habitats, organisms, and fisheries; water quality and sources of contamination; sustainable development, and effects of global climate change. Subsequent to the workshop, an area analysis was conducted to evaluate the range of representative habitat types within the system of Biodiversity Priority Areas.

The results of the workshop are seen as an initial step to help focus conservation efforts by identifying those areas of highest priority as well as those at greatest risk. With better insight into the important areas and ecological processes of the MACR, WWF will continue to work with partners toward our common goal of preserving the region's unique biodiversity and ensuring its continued contribution to the ecological health of the region and the livelihood of present and future generations. The relatively low state of development and overall good environmental quality of most of the ecoregion provide a unique conservation opportunity to prevent the kinds of ecological damages that have occurred in similar habitats in other parts of the world.

Contributors

C. Alduvín (DIBIO SERNA)
I. Amirthanayagam (Embajada de EU en Mexico)
A. Anderson (World Wildlife Fund — USA, People and Conservation)
R. Appeldoorn (Universidad de Puerto Rico)
E. Arias-González (CINVESTAV-Universidad de Mérida)
A. Arrivillaga (U.S. Geological Survey)
B. Aspra (DIGEPESCA/Unidad Ambiental)
N. Auil (UNDP, Coastal Zone Management Project)
J. Barborak (Wildlife Conservation Society)
M. Basurto (Centro Regional de Investigaciones Pesqueras Puerto Morelos)
J. Bezaury (The Nature Conservancy)
R. K. Bonde (Florida Caribbean Science Center, Geological Survey)
M. Butler (Department of Biological Sciences, Old Dominion University)
S. Christiansen (World Wildlife Fund — USA, ERBC Program)
M. Cifuentes (World Wildlife Fund — Centroamérica)
J. Cortés (Universidad de Costa Rica, CIMAR)
R. Cowen (RSMAS-MBF, Universidad de Miami)
A. Cubas (Honduras Coral Reef Fund)
T. Done (Australian Institute of Marine Sciences)
M. Gallegos (Universidad Autónoma Metropolitana)
M. del C. García (Parque Nacional Isla Contoy)
C. García Saez (Honduras Coral Reef Fund)
V. Gillet (Coastal Zone Management Authority)
E. González (ICSED)
J. González Cano (World Wildlife Fund — Mexico, CRIP Puerto Morelos)
D. Guevara (Unidad Coordinadora de Areas Protegidas, INE)
*D. Gutiérrez (*Unidad Coordinadora de Areas Protegidas, INE)
C. Hasbun (Molecular Ecology, University of Hull)
G. Horta Pugo (UNAM, Mexico)
A. Izurieta (World Wildlife Fund — Centroamérica)
N. Jacobs (CCAD/BM Proyecto SAM)
M. Jorge (World Wildlife Fund — USA)
P. Kramer (University of Miami MGG/RSMAS, World Wildlife Fund Consultant)
T. Kramer (World Wildlife Fund Consultant, MGG/RSMAS)
Mi. Lara (Wildlife Conservation Society)
Ma. Lara (Instituto Nacional Ecologista/SEMARNAP)
M. A. Lazcano (Amigos de Sian Ka'an)
K. Lindeman (Environmental Defense Miami Field Office)
G. Llewellyn (World Wildlife Fund — Indonesia)
R. M. Loreto (Amigos de Sian Ka´an)
B. Lupreck (Ocean Research and Education)
B. Mackinnon (Amigos de Sian Ka´an)
K. Marchant (World Wildlife Fund — USA, Conservation Science)
S. Marín (World Wildlife Fund — Centroamérica)
M. McField (University of South Florida/Consultant)
L. Morales (DIGEPESCA)
M. Moreno (CECARENA, ITESM Campus Guaymas)
J. Morrison (World Wildlife Fund — USA, Conservation Science)
J. Ogden (Florida Institute of Oceanography)
L. D. Olivera Gómez (Laboratorio de Fauna Silvestre, Departamento de Ecología, CICESE)
D. Olson (World Wildlife Fund — USA, Conservation Science)
C. Padilla Souza (CRIP)
T. Padovano (World Wildlife Fund — USA)
S. Palminteri (World Wildlife Fund — USA)
D. Parra (Instituto de Ecología Aplicada, Universidad San Francisco de Quito)
I. Parra (World Wildlife Fund — Mexico, Programa Golfo de California)
*H. Payn*e (World Wildlife Fund — Mexico)
E. Polanco (CECARENA, ITESM, Campus Guaymas)
S. Ramclam (Fisheries Department — Belize)
M. Reaka-Kudla (World Wildlife Fund Council Member, University of Maryland)
S. Rojas (World Wildlife Fund — Mexico)
T. Román (WWF-US consultant)
P. Rubinoff (University of Rhode Island, Coastal Resources Center)
J. Ruíz (CONAP)
C. Saavedra (Summit Foundation)
A. Salaverría (CEMA/Universidad de San Carlos de Guatemala)
P. Sale (UNU-INWEH, Biology Dept; University of Windsor)
M. Sánchez (World Wildlife Fund — Mexico)
P. Santos (World Wildlife Fund — Mexico)
F. Secaira (World Wildlife Fund — Centroamérica)
C. Shaw (Centro Ecológico Akumal)
S. Snedaker (MBF RSMAS)
R. Steneck (School Marine Sciences, University of Maine)
H. Strand (World Wildlife Fund — USA)
M. Valle (RSMAS Universidad de Miami)
J.M. Vargas Hernández (Universidad Veracruzana, Museo de Zoología, Facultad de Biología)
B. Wade (Belize Fisheries Department)
W. Wettengel (World Wildlife Fund — USA)
P. White (USAID/ Mexico)

Acronyms and Abbreviations

ASK	Amigos de Sian Ka'an, Mexico
BFD	Belize Fisheries Department
BPA	Biodiversity Priority Area
CCAD/SICA	Central American Commission on Environment and Development/Central American Integration System
CITES	Convention on the International Trade in Endangered Species
CIAT	The Inter-American Center of Tax Administrations
CIQR	Centro de Investigaciones de Quintana Roo (EcoSur/Colegio de la Frontera Sur)
CPA	Coral Priority Area
CPUE	Catch Per Unit of Effort
CZMA/I	Coastal Zone Management Authority/Institute of Belize
DHW	Degree Heating Weeks
EC	Ecoregion Conservation
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
FPA	Fish Priority Area
GEF	Global Environment Facility
GIS	Geographic Information Systems
IDB	Inter-American Development Bank
IUCN	International Union for the Conservation of Nature
LIC	Land Information Center, Belize
MACR	Mesoamerican Caribbean Reef Ecoregion
MARPOL	International Convention for the Prevention of Marine Pollution
MBRI	Mesoamerican Barrier Reef Initiative
MBRS	Mesoamerican Barrier Reef System
MPA	Marine Protected Area
NAFTA	North American Free Trade Agreement
NGO	Non-governmental Organization
ORE	Ocean Research and Education Foundation
PA	Priority Area
PMAIB	The Bay Island Environmental Management Project
PPA	Plant Priority Area
PROARCA/Costas	Programa Ambiental Regional para Centro América (The Coastal Zone Management Component)
RSMAS	University of Miami's Rosenstiel School of Marine and Atmospheric Sciences
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEMARNAP	Secretaría del Medio Ambiente, Recursos Naturales y Pesca de Mexico
SPA	Species Priority Area
TIDE	Toledo Institute for Development and Environment
TNC	The Nature Conservancy
TRIGOH	Trinational Alliance for the Gulf of Honduras
UNAM	Universidad Nacional Autónoma de Mexico
UNAH	Universidad Nacional Autónoma de Honduras
USF	University of South Florida
USGS	United States Geological Survey
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund/World Wide Fund for Nature

Section 1

Introduction

The Mesoamerican Caribbean Reef (MACR), which extends from the Bay Islands of Honduras north through Guatemala and Belize to the tip of Mexico's Yucatán peninsula, is part of an interconnected system of coastal habitats and currents that stretch throughout the Caribbean basin and beyond (Figure 1). The MACR is recognized as one of World Wildlife Fund's (WWF) Global 200 priority ecoregions, which are areas of outstanding biodiversity whose protection are vital for the conservation of the world's biodiversity. The MACR contains the largest barrier coral reef system in the Western Atlantic and is considered a distinct ecoregion because it conforms to the following general criteria: "a characteristic set of communities that share a large majority of their species, dynamics, and environmental conditions, and interact ecologically in ways that are critical for their long-term persistence" (Dinerstein *et al.*, 1995).

In an effort to safeguard the biodiversity found in important ecoregions like the MACR and others throughout the globe, WWF uses the broad approach known as Ecoregion Conservation (EC). EC shifts the goals of conservation from a primary focus on preserving species diversity to including larger landscape-level attributes in an ecoregion; these attributes might include spatial and temporal scale patterns of biodiversity, habitat diversity, and ecological processes, as well as natural disturbances and anthropogenic threats (Olson *et al.*, 1998; Dinerstein *et al.*, 2000).

WWF began EC planning for this Global 200 ecoregion by hosting a preliminary workshop in Belize City, April 12-14, 1999, supporting the creation of a regional database, and leading its first Ecoregional Conservation Planning Workshop in Cancun in 2000. The focus of the preliminary workshop was to seek expertise in identifying specific types of biodiversity data needs, sources of biodiversity data, and effective ways of using the data for conservation planning (see Jorge, 1999). Many of the suggestions from this workshop were used in the creation of the MACR Biodiversity Database and the design of the Ecoregional Planning Workshop. These efforts build upon ongoing local and regional conservation work and integrate with the larger Mesoamerican Barrier Reef System Initiative (MBRI).

This report provides an overview of the MACR database and presents the results of the Ecoregional Conservation Planning Workshop. Section 2 provides background information on the MACR; Section 3 describes the workshop findings; Section 4 provides a further look at areas of high conservation priority; Section 5 describes the main data gaps and needs; and Section 6 presents conservation opportunities. It is our hope that this information will be beneficial to managers, scientists, and others who are trying to further understand and conserve the MACR's biodiversity. As the process of Ecoregional Conservation continues, the information compiled in this document will serve as a valuable reference, as well as a guide to further discussion, collaboration, and data collection.

1.1 MACR Biodiversity Database

A principal goal of conservation planning in the MACR ecoregion was to improve our understanding of biodiversity by synthesizing available information and improving access to it. To further these efforts, a group from the Ocean Research and Education Foundation (ORE) and the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences (RSMAS) created the *MACR Biodiversity Database*. This new database is a comprehensive regional synthesis of key ecological, biophysical, and socioeconomic data. A Geographic Information System (GIS) was used as a platform for synthesizing information on biological resources, physical environment, human uses, threats to biodiversity, and management efforts (Table 1).

Data was often lacking for specific subjects and locations, so new GIS data was created to fill in many of these gaps. This information was then combined to produce several large (3'x3') thematic maps that were used as reference tools at WWF's Ecoregional Conservation Planning and Priority Setting Workshop.

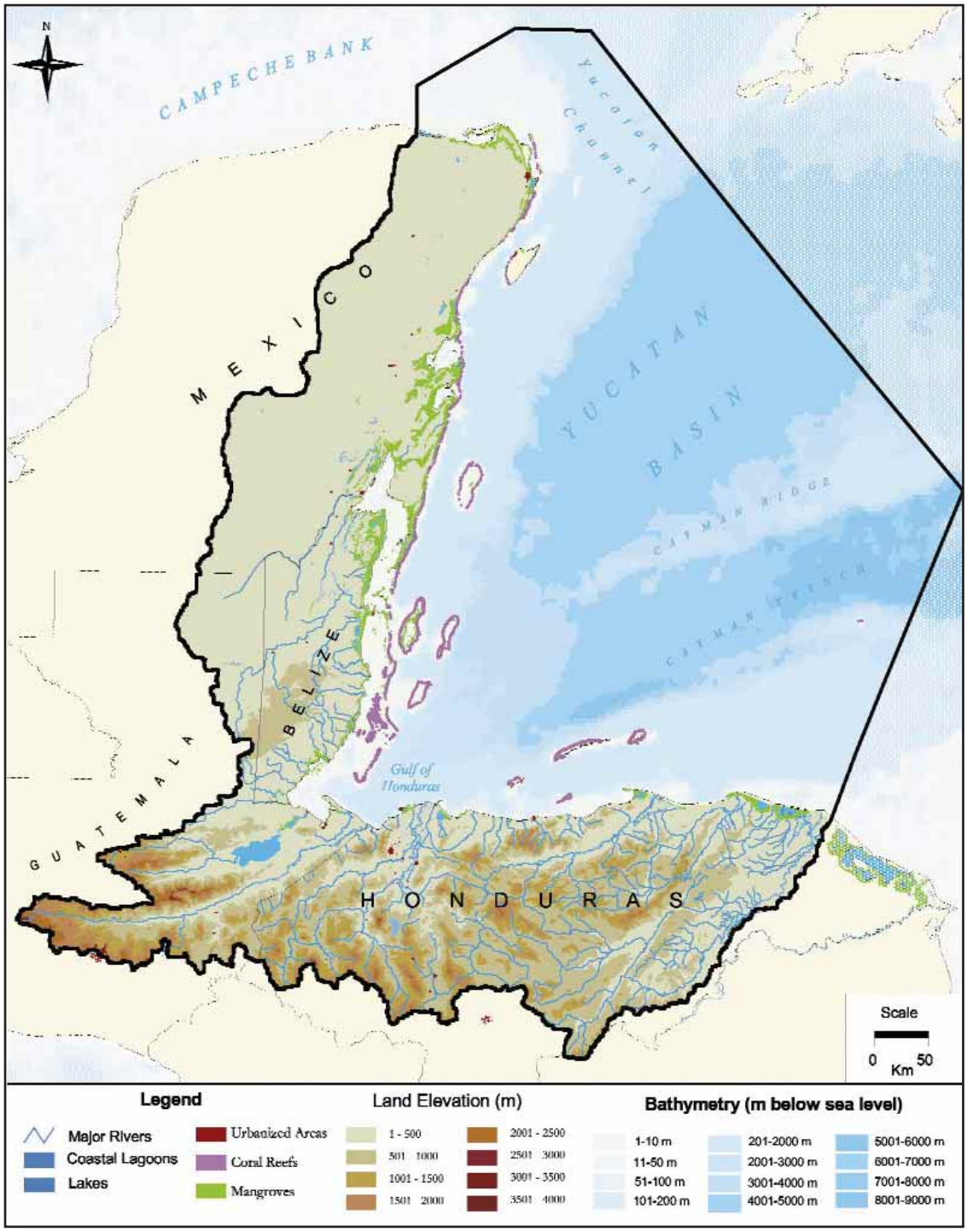


Figure 1. Mesoamerican Caribbean Reef Ecoregion
Base map of the region includes major rivers, lagoons, lakes, urbanized areas, coral reefs, mangroves, land elevation, bathymetry, and ecoregional boundary.

The thematic maps presented data in an easy-to-use format and provided workshop experts with the information necessary to confidently discuss the region's biodiversity features and recommend conservation priorities. Appendix A contains select examples of the maps created for the workshop and explains the methods used to create the database. The maps in Appendix A include:

- Watersheds
- Currents
- Benthic habitats (sample area)
- Fish spawning areas
- Disturbance to coral reefs
- Threats to MACR biodiversity
- Manatee distribution
- Sea turtle distribution
- Protected areas
- Sea surface temperature
- SeaWiFS data

1.2 Ecoregional Conservation Planning Workshop

The Ecoregional Conservation Planning Workshop for the MACR was held April 26-28, 2000 in Cancun, Mexico. This EC workshop provided an opportunity for biodiversity experts to use the best information available to identify areas of the highest conservation priority and to recommend actions to ensure their long-term preservation. Participants used their own expertise as well as the regional scale data presented in the thematic information maps created from the MACR database. The objectives of the workshop were to:

1. Review and compile the available biophysical/socioeconomic information and establish the main gaps and research needs.
2. Analyze the relationship between the main threats and the viability of maintaining the long-term ecological functions of the ecoregion.
3. Select areas of the highest conservation priority and recommend possible response strategies.
4. Develop a long-term ecological vision for the ecoregion.

Almost 80 local, regional, and international experts from conservation organizations, government agencies, and research institutions attended the workshop to develop an ecological vision and establish conservation priorities for the MACR ecoregion. Specialists had a wide variety of areas of expertise, including coral reefs, mangroves, seagrasses, and other marine vegetation; fishes and fisheries management; focal species; marine protected areas; and socioeconomics. Of particular value were the in-country specialists, who were able to provide information often unavailable through conventional data-gathering means. International experts made significant contributions in their areas of specialization and lent a broader, more global, perspective to workshop discussions. The workshop process and findings are presented in Section 3; descriptions and maps of Taxa Priority Areas are found in Appendix B; and Biodiversity Priority Areas for the ecoregion are found in Appendix C.

Table 1. Data Synthesized for MACR Biodiversity Database

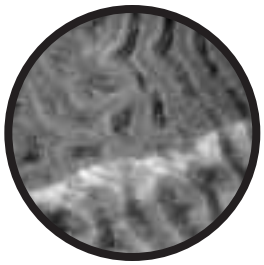
Base Data
Shoreline
Shallow bathymetry (10 m, 30 m)
Deep bathymetry (>100 m)
Land elevation
Major rivers
Major watersheds
Lakes
Coastal lagoons
Mangroves
Reef crests
Major urban areas
Land forest cover

Marine Benthic Habitats
Deep water
Turbid water
Shallow lagoon floor
Backreef pavement
Diffuse/dense patch reef
Forereef
Reef crest
Spur and groove
Back reef

Status of Marine Resources
Coral reef condition (mortality, bleaching, disease)
Fish spawning/aggregation sites
Manatees (sightings, manatee habitat, deaths)
Sea turtles (nest locations/density)
Whale shark sightings
Bird nesting areas (by species)

Socioeconomic
Land cover (e.g., crop land, forest, irrigated, urban)
Demographics (population density)
Transportation (shipping lines, highways, roads, railroads)
Agriculture (conversion, shrimp farms)
Fishing grounds for commercial species (lobster, conch, grouper, shrimp)
Fisheries catch information (conch, lobster, finfish, shrimp)
Industrial development (oil pipelines, petroleum, power plants)

MBRS Threats (FAO, 2000)
Infrastructure construction
Port construction/operations
Urbanization
Industrial development
Petroleum exploitation
Cruise ship operation
Unplanned tourism development



Section 2

The Mesoamerican Caribbean Reef Ecoregion

Extending over 1,000 km, the Mesoamerican Caribbean Reef Ecoregion is composed of extensive coral reefs, including luxuriant patch, fringing, and barrier reefs and unique offshore atolls. A diverse array of fish, invertebrates, birds, plants, sea turtles, and mammals utilize the area. In addition to the productive reef resources, the region also has important coastal habitats such as beaches, coastal rivers and lagoons, mangroves, seagrasses, and coastal wetlands that provide important breeding, nesting, and foraging habitat for numerous species.

The MACR sustains nearly 2 million people from four neighboring countries, Mexico, Belize, Guatemala, and Honduras, a large proportion of whom live along the coasts and islands (FAO, 2000). Indigenous Garifuna, Miskito, and Pesch communities depend heavily on the reefs for subsistence. These four countries also share several important transboundary drainage systems, including the Bay of Chetumal (Mexico and Belize) and the Gulf of Honduras (shared by Belize, Guatemala, and Honduras). The rich resources in the region have important ecological, aesthetic, and cultural value to its inhabitants. Productive fishing grounds support valuable commercial and artisanal fisheries. Millions of tourists, attracted to the sandy beaches and teeming reefs, provide important economic revenue to the people and their governments.

2.1 Ecoregion and Subregion Boundaries

The MACR ecoregion is defined by several natural physiographic boundaries that separate it from other areas of the Caribbean. Bordering the western and southern ecoregion boundaries are watersheds of the North American continent, consisting mainly of dry and wet tropical broadleaf forest. Strong ocean currents between the Yucatán peninsula and the southwest coast of Cuba create a natural boundary that is believed to inhibit larval exchange along the northeastern edge. Shallow waters of the Campeche bank off the northern tip of the Yucatán peninsula and the Nicaraguan rise off eastern Honduras complete the northern and southeastern boundaries of the ecoregion. Within the coastal areas of the MACR lies an array of distinctive community types, organisms, currents, and ecological processes that interact as a single functional unit. While some marine environmental factors (such as temperature and, to a lesser degree, salinity) are similar within the ecoregion, differences in terrestrial factors such as rainfall, elevation, and geology create several distinct subregions within the ecoregion.

To initiate the priority-setting process for the MACR, the ecoregion was divided into subregions that contained similar biodiversity features (Figure 2a). The ecoregion limits and subregional boundaries were initially determined by the group of experts at the WWF meeting in Belize City in 1999. Specialists at this workshop conducted a preliminary habitat representation analysis by reviewing significant features that affect biodiversity patterns, including oceanographic patterns (e.g., currents, upwelling), reef structure and distribution (e.g., patch, barrier, fringing), and watersheds and terrestrial influences. Eight subregions were selected and included: 1) Northern Quintana Roo – Cozumel; 2) Sian Ka'an – Ambergris; 3) Chetumal Bay; 4) Belize Barrier Reef System (barrier reef, atolls, shallow coastal habitats); 5) Gulf of Honduras; 6) Coast of Honduras; 7) Bay Islands; and 8) Deep Ocean (Yucatán Current, Gulf of Honduras Gyre).

Ecoregional and subregional boundaries were subsequently modified based on biophysical analysis of available information (Figure 2b). First, the ecoregion and subregion boundaries were adjusted to coincide with boundaries of the major watersheds on land. The southern ecoregion boundary in Honduras was moved from its original position at Cabo Camarón to coincide with the Patuca River watershed boundary. The northern ecoregion boundary was moved from its original position at Cabo Catoche to coincide with the Ría Lagartos depression.

An analysis of current patterns suggested a strong connection between the offshore banks of Rosario and

Figure 2a. Preliminary MACR ecoregional and subregional boundaries (dark line) selected at the WWF experts Workshop in Belize City, April 1999.

Figure 2b. Adjusted MACR ecoregional and subregional boundaries (dark line) designed for WWF's Ecoregional Planning Workshop, Cancun 2000. Modifications were based on updated biophysical information.

Misteriosa and the MACR region via strong westerly currents that are prevalent much of the time. Therefore, the eastern limits of the ecoregion boundaries established at the workshop were extended to the banks of Rosario and Misteriosa around the Swan Islands and up to include portions of the upwelling zone off the Yucatán Peninsula. Subregional divisions within the ecoregion were also moved to coincide with watershed boundaries and adjusted to follow the 1,000-m contour between coastal and oceanic areas. This standardization allowed for a more rigorous analysis of the representation of habitat types within each of the subregions, as can be seen in Tables 16-18. In some cases, boundaries of the original subregions were merged together to better conform to geo- and hydromorphic boundaries. The Chetumal Bay subregion was merged together with the Sian Ka'an-Ambergris subregion and designated a subunit of this larger area. Similarly, the Bay Islands were incorporated as a subunit with the Northern Coast of Honduras subregion. The final subregional boundaries, described in Table 1, were presented and discussed at the Cancun Workshop.

Final Subregional Boundaries for MACR

1. Northern Quintana Roo – Cozumel
2. Sian Ka'an – Ambergris (including Chetumal Bay)
3. Belize Barrier Reef System (barrier reef, atolls, shallow coastal habitats)
4. Gulf of Honduras
5. Northern Honduras Coast (including the Bay Islands)
6. Open Ocean (e.g., Yucatán Current, Gulf of Honduras Gyre, Offshore banks).

Table 2. Subregion Descriptions

Subregion I: Northern Quintana Roo

This area includes the northeastern portion of the Yucatán Peninsula from Ría Lagartos south to the Tulum coast, including the offshore islands of Cozumel, Isla Mujeres, Contoy, and Arrowsmith Bank Atoll. The northeastern tip of the Yucatán Peninsula is an important transitional area between the Caribbean Sea and the Gulf of Mexico, and upwelling produced by the Yucatán Upwelling Zone has a dominant influence in the area. Sea birds are prolific and coastal mangrove lagoons (Yalahau and Chacmochuc) provide ample foraging and nursery areas. Coral reefs are only locally developed and interesting hard-bottom communities and deep-water ahermatypic communities exist. The resort city of Cancun, including Holbox to the north, continues to grow at a phenomenal pace, putting many coastal areas at risk.

Subregion II: Sian Ka'an to Ambergris

This area extends along the eastern Yucatán coast from Tulum south to the southern tip of Ambergris Cay in Belize and includes the large bays of Bahías de la Ascención, Espíritu Santo, and Chetumal. The flat, dry, paleokarst Yucatán coast features magnificent white sandy beaches interspersed with coastal lagoons and an almost continuous fringing reef. Impressive shallow reefs dominated with *Acropora palmata* and *Millepora complanata* are found on the narrow shelf and on the offshore atoll of Chinchorro. The Sian Ka'an Bays support some of the largest spiny lobster (*Panulirus argus*) populations remaining in the region. The area supports critical habitat for the endangered West Indian Manatee, which thrive in shallow waters around Chetumal Bay. Historically low human usage has preserved many of the coastal habitats and fishing grounds; however, the current fast pace of development threatens wetlands, beach areas, and coral reef habitats.

Subregion III: Belize Barrier Reef

This area spans nearly the entire Belize shelf from the southern end of Ambergris Cay to the terminus of the barrier reef at the Sapodilla Cays, including the mainland coast and offshore atolls. The wide Belize shelf contains an impressive assemblage of inshore, mid-shelf, shelf-edge, and offshore coral reef, seagrass, and mangrove habitats, all of which contribute to the region's high biodiversity. The most unique feature is the barrier reef, the second longest in the world and the best-developed example of this reef type in the western Atlantic. Also exceptional are the offshore atolls of Lighthouse, Turneffe, and Glovers, which contain pristine shallow lagoons encircled by a halo of reef. Numerous patch reefs are found throughout the coastal lagoon, as well as rhomboidal-shaped reefs (faroes) and drowned reefs in the deeper southern lagoon where the influence of coastal mountains and rivers becomes more evident.

Subregion IV: Gulf of Honduras

This area extends from Río Grande, Belize across the southern end of the Barrier Reef to the Ulúa River in Northern Honduras and includes most of the Gulf of Honduras. The influences of a Caribbean and North American plate boundary are evident through this area, with mountainous terrain and a steeply dipping shelf margin that drops off quickly into the abyssal Cayman Trench. Several large rivers supply significant seasonal pulses of fresh water and support numerous estuarine fishes and invertebrates. Excellent seagrass habitats are found around the Bay of Amatique and luxuriant old growth mangroves line the lower reaches of the Dulce, Temash, and Sarstoon rivers. Deforestation and large-scale farming in the rich alluvial Montagua and Ulúa basins threaten the region by contaminating waterways with sediment, pesticides, and fertilizers.

Subregion V: Northern Honduras Coast

This area spans much of the northern coast of Honduras from the Ulúa River to the Patuca River and includes the offshore Bay Islands. Located at the "headwaters" of the MACR region, the mountainous northern Honduran coast is characterized by long expanses of sandy beaches interspersed with large rivers, bays, and coastal lagoons. The turbid water near the coast, particularly sediment-laden water from the Aguán River, prevents substantial coral reef development. Significant reef development is only found on the Bay Islands, an archipelago of approximately 200 minor islands and several larger islands (Utila, Roatán, Barbareta, Guanaja, and Cayos Cochinos) that are fringed by well-developed reefs.

Subregion VI: Open Ocean

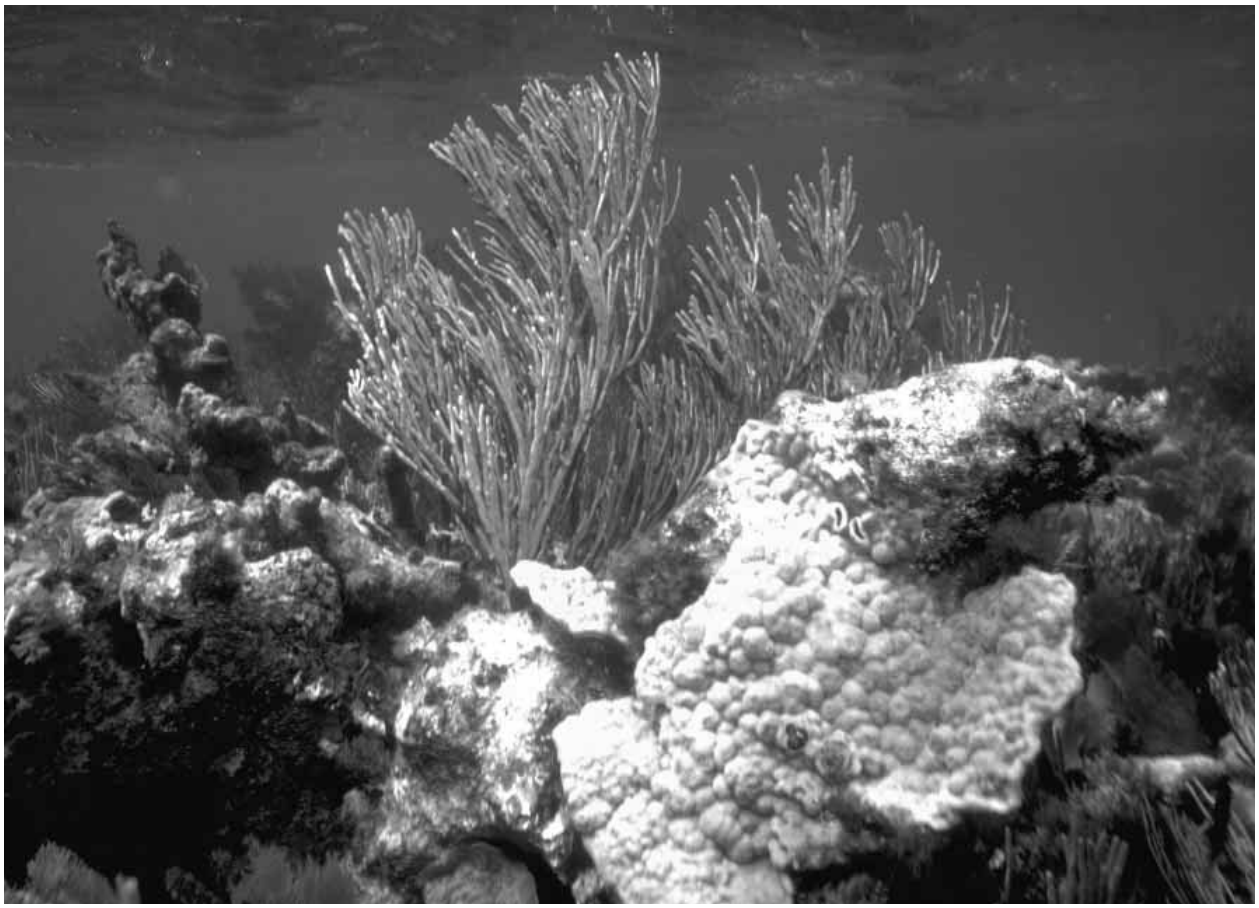
This large region includes the pelagic waters from the 1000 m contour out to the submerged banks of Rosaria and Misteriosa, and the Swan Islands. Strong westerly currents associated with the Caribbean Current dominate the oceanic areas. This large conveyor belt brings larvae into the region from upstream sources in the central and southern Caribbean and eventually carries larvae out to the downstream Gulf of Mexico and Florida Keys. The current is mainly west near the Swan islands to coastal areas off central Belize and southern Yucatán, at which point it veers north, reaching a maximum velocity near Cozumel. South of Glovers Reef Atoll, much weaker and more variable currents prevail, leading to much higher residence times and less exchange in the Gulf of Honduras. The submerged platforms of Rosario and Misteriosa Banks as well as the Swan Islands are the only shallow water features in this large area and their resources are largely unknown.

2.2 Biological Significance

The Mesoamerican Reef System comprises the longest barrier reef system in the Western Hemisphere and the second longest in the world. With more than 66 stony coral species and over 500 fish species, this Global 200 ecoregion is one of the most diverse coral reefs in the western Atlantic. Shallow reefs are often distinguished by majestic forests of interlocking elkhorn coral (*Acropora palmata*), while large mountainous corals (*Montastraea annularis*) carpet the deeper reefs. The elegant and commercially-sought-after black coral is found on many deep coral reefs. Four outstanding coral reef atolls exist here, including Banco Chinchorro, Turneffe Islands, Lighthouse, and Glovers Reef Atoll. Seagrasses flourish in coastal bays and behind reefs, while mangroves fringe the numerous rivers, lagoons, and islands. The seagrasses and mangroves serve as rich nursery and feeding grounds for many commercially significant species, such as conch, lobster, and grouper, as well as for species of recreational significance like tarpon and bonefish. The extraordinary Blue Hole Natural Monument, a World Heritage Site, and its elaborate stalactites may host a unique community of cryptic marine organisms.

A variety of colorful and odd-shaped fish swim in these waters, including the queen parrotfish (*Scarus vetula*), queen angelfish (*Holocanthus ciliaris*), and trumpetfish (*Taulostomus maculatus*). The richness of reef fish species is high in the MACR region, with at least 245 reef species found along the Yucatán, 317 in Belize, and 294 in Honduras. The MACR ecoregion supports numerous active snapper and grouper spawning aggregations, with an estimated five in southern Mexico, two in Banco Chinchorro, ten in Belize, and at least two in Honduras. Gladden Spit is the site of the largest aggregation in the ecoregion supporting more than 22 species including yellowtail, dog, cubera, and mutton snapper; Nassau and black grouper; red hind, ocean jack, rockfish, and schoolmaster. Gigantic yet gentle whale sharks (*Rhincodon typus*) frequent the reefs at Gladden Spit to feed on the plentiful spawn produced during snapper and grouper aggregations. Yet some of the highest diversity on the reefs exists in the rarely observed cryptofauna that inhabit its myriad of crevices and holes. The splendid toadfish (*Sanopus splendidus*), one of many rare and possibly endemic species, lives under reef ledges and recesses. The sandy cays and islands are home to several endemic species like the snail *Leptophis mexicana hoeversi* and Belize Atoll Gecko *Phyllodactylus insularis.*

The lagoons, rivers, and seagrass meadows are home to the largest population of endangered manatees (*Trichechus manatus*) in Central America, with an estimated 900 cows and calves in Belize alone. Endangered hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) and vulnerable loggerhead (*Caretta caretta*) sea turtles nest along the shoreline and offshore cays and forage on nearshore seagrasses and reefs. Inhabiting the numerous riverbanks, lagoons, and islands is the endangered American crocodile (*Crocodylus acutus*). Several dolphin species, including the bottlenosed dolphin (*Tursiops truncates*), the spotted dolphin (*Stenella plagiodon*), and the rough-toothed dolphin (*Steno bredanensis*) roam the coastal waters. The ecoregion is a principal stopover on the major North American-South American flyway for migratory birds as well as the first stopover after passing over the Gulf of Mexico. Bird species include the magnificent frigate bird (*Fregata magnificens*), red-footed booby (*Sula sula*), roseate spoonbill (*Ajaja ajaja*), greater



flamingo (*Phoenicopterus ruber*), sooty tern (*Sterna fuscata*), and brown noddy (*Anous stolidus*). Endangered least terns (*Sterna antillarum*) nest on the sandy cays. The protected bays of Sian Ka'an host the largest nesting population of wood storks (*Mycteria americana*) in the Yucatán. Regional endemic species include Yucatán jay (*Cissilopha yucatánica*) and the melodious catbird (*Melanoptila glabrirostris*). Several local endemics also are present, including two subspecies endemic to the island of Cozumel, the Cozumel wren—*Troglodytes beani* and the golden warbler-*Dendroica petechia.*

2.3 Changes in the MACR

The MACR also offers numerous benefits for coastal inhabitants and visitors including subsistence, recreational, and commercial fishing; and tourism, snorkeling and diving, and maritime activities; it also provides structural protection against storms and erosion. Yet years of unsustainable use, including unregulated coastal development and overexploitation of fishery resources, and significant natural disturbances such as hurricanes and coral bleaching now threaten the delicate balance of this ecoregion. Anthropogenic pressures are the greatest threats to the MACR ecoregion's biodiversity and ecological integrity, with the potential to alter or reduce species richness and diversity; species abundance; quality and quantity of natural habitats; critical nursery, breeding, and foraging areas; productivity; and important ecosystem processes such as larval transport. Tourism is currently the fastest-growing industry in the MACR. As population growth increases, especially along the coastlines, the threats to the ecoregion will continue unless effective conservation measures are adopted and implemented.

Biodiversity has changed significantly over the past several decades. Manatee populations have drastically declined along the Guatemalan coastal waters due to a long history of commercial and subsistence hunting. Established nesting sites for rare birds like roseate and least terns have disappeared off many of the offshore cays due to human encroachment. The MACR reefs have a long history as a traditional source of food for subsistence fishing and productive commercial and sport fishing. The intensity and frequency of fishing have increased at an astonishing rate, resulting in the overexploitation of numerous species including spiny lobster, queen conch, shrimp, grouper, and snapper. Over the last several years, marine fish captures have steadily increased in Guatemala, while there is an overall decline in landings in Mexico, Belize, and Honduras. Declining fisheries are attributed to lowered fish populations, overfishing, changing economic circumstances, illegal fishing, destructive fishing methods like gill nets, and lack of enforcement. Historically abundant grouper aggregations (e.g., Caye Glory, South Long Cay and Middle Long Cay) have been reduced or eliminated by overfishing. Overexploitation of conch has resulted in its being listed in Appendix II of the Convention on the International Trade of Endangered Species (CITES).

The frequency and intensity of disturbances to the MACR's reefs have increased in recent years, with several reefs affected by repeated and/or coinciding events. Prior to 1998, the principal natural disturbances were hurricanes, coral diseases, and recent coral bleaching (notably in the years 1995 and 1997). In 1998 a sequence of catastrophic events impacted the ecoregion's coral reefs. From mid-1997 to late 1998, unprecedented coral bleaching as well as elevated incidences of coral diseases occurred throughout the region. In late October 1998, Hurricane Mitch, a category-5 storm, impacted much of the coast from Guanaja northward to Yucatán. Bleaching caused catastrophic coral loss in southern Belize, while shallow reefs in Belize were heavily impacted by the hurricane (Kramer and Kramer, 2000). Even deeper fore reefs throughout Belize suffered a reduction of almost 50% in live coral cover between 1997 and 1999 (McField, 2001a). Global climate change will play a critical role in influencing the frequency and magnitude of *El Niño-La Niña* bleaching-related events and hurricanes, as well as in potential modifications to current and wind patterns. With sea surface temperatures predicted to continue to warm over the next 100 years, future bleaching events are perhaps the greatest future threat to the ecoregion's coral reefs.

In light of these recent changes and future global threats to the MACR, sound local and regional management is urgently required.

Section 3

Identifying Priority Areas

The planning workshop provided a framework for the evaluation of large-scale (defined as covering areas of 100-1,000 kms) biodiversity information with the goal of setting conservation priorities for the MACR ecoregion. The format for the workshop was adapted from WWF's methods for conducting biological assessments and developing biodiversity visions (Dinerstein *et al*., 2000). The process was modified for the MACR ecoregion to account for the importance of connectivity in conserving marine ecosystems. Therefore, the workshop focused on population-level, community-level, and ecological processes, such as larval distribution, currents, and upwelling that are specific to tropical marine ecosystems. An "expert opinion" method was used whereby the opinions of an interdisciplinary group of experts were synthesized to evaluate the biodiversity properties of the MACR ecoregion and select those areas of highest conservation priority. Working groups (separated first by taxa, then by subregion) were formed to promote an interactive and hands-on setting, while large 3'x3' maps provided visual tools and promoted product-oriented analyses. The workshop process involved the following five important steps:

Step 1: Identifying Priority Areas for Focal Taxa/Guilds
Step 2: Selecting Biodiversity Priority Areas
Step 3: Identifying Threats to MACR Biodiversity
Step 4: Identifying Persistence and Future Threats
Step 5: Seascape Considerations.

The process and incremental products are illustrated in Figure 3. For Steps 1-4, experts conducted a series of analyses to evaluate and rank criteria for selecting priority areas. Experts were asked to draw the boundaries (polygons) of important areas on the large 3'x3' base maps. The results were then digitized using GIS to produce a series of map products (shown in Appendices B and C). Step 5 was discussion-oriented, with the goal of producing written recommendations for strategies and actions for conservation planning. Methods and results for each step are provided in the following sections. Definitions used in this section are presented below.

Thematic Maps — Series of maps created as conservation planning tools that contain data from the MACR Biodiversity Database (see Appendix A for examples).

Taxon Priority Areas — Priority areas selected as important for the conservation of the MACR's corals, fishes, focal species, and plants (Appendix B); these served as the basis for identifying biodiversity priority areas.

Biodiversity Priority Areas (BPA) — Areas considered of highest priority for conserving the MACR's biodiversity (Appendix C).

Persistence — The degree to which a BPA (including habitats, communities, and populations) will tend to retain its present status should the current level of human pressure on the system remain unchanged.

Future Threat — The likelihood of a degradation of the status of a BPA (including habitats, communities, and populations) should there be a change in human pressure to the system.

Seascape Considerations — Features considered important on the seascape level (synonymous to landscape-level) in planning conservation strategies and goals for the MACR (e.g., biodiversity features, ecological processes, natural and anthropogenic disturbances, and management opportunities).

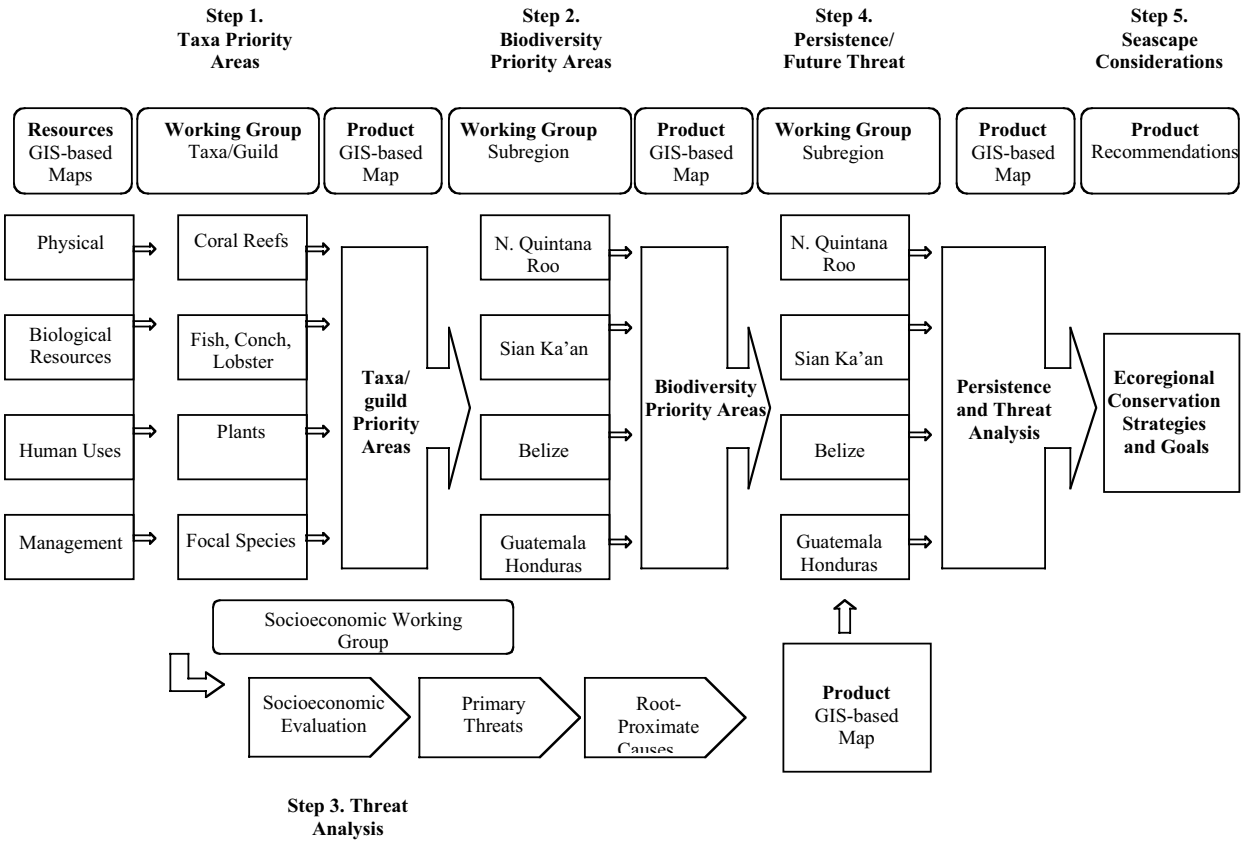


Figure 3. Key Steps in the MACR Priority-setting Process

3.1 Identifying Priority Areas for Taxa/Guilds

3.1a Taxa Priority Areas Approach

To conduct the analysis of areas important for Focal Taxa/Guilds, the experts divided into four taxa breakout groups: corals (sessile invertebrates), fish (including commercially-important mobile invertebrates), focal species (manatees, reptiles, sea birds) and plants (seagrasses and mangroves). Each taxon breakout group reviewed the available biological information prepared for the workshop, assessed data quality, suggested other possible sources of data, and identified information gaps. The approach each group used for the biodiversity analysis and the identification of priorities varied depending on the quality and quantity of available information and the number of experts present.

Both the *Coral* and the *Marine Plants* groups adopted a habitat-based approach as a surrogate measure of biodiversity since species-level inventories were missing or incomplete for many areas. The *Coral* group stratified reefs into similar types based on geomorphology and position within a cross-shelf framework. The cross-shelf framework was broken into four strata (inner-shelf, mid-shelf, outer-shelf, and offshore) based primarily on bathymetry and the presence of emergent reef and sediment structures (Lindeman *et al.*, 1998). Priority coral areas were identified for each reef type by applying a ranking based on criteria the group developed (Table 3).

The diversity and spatial distributions for most marine plants are poorly known for the MACR, so the *Marine Plants* group used habitat assemblages as surrogates for evaluating biodiversity. They used benthic habitat maps and expert knowledge to stratify coastal areas of the MACR into three dominant habitat complexes: 1) coastal wetlands (mangroves and seagrasses); 2) seagrasses and coral; and 3) mangroves, seagrasses, and coral. This approach was complementary to the one used by the coral group, which did not take into consideration associated plant habitats. Ranking was based on the quality, size, and representation of each type of complex within the ecoregion.

The *Fish* and *Focal Species* groups selected a taxon-based approach to assess biodiversity, believing that the use of a wide variety of umbrella or flagship species would be the most effective predictors of biodiversity since regional, comprehensive data was often lacking. The *Fish* group chose conch (*Strombus gigas*), lobster (*Panulirus argus*), reef fishes, estuarine fishes, snapper/grouper complex, pelagic fishes, and cryptofauna. The *Focal Species* group selected representative taxa including the West Indian manatee, American crocodile, sea turtle, and "island-terrestrial" endemic vertebrate species and subspecies. For several focal species, significant amounts of information already existed and were synthesized into maps prepared in advance of the workshop (e.g., Appendix A). Priority areas were identified on the basis of expert knowledge and ranked using criteria such as uniqueness, endemism, trophic importance, representation, ecological phenomenon (e.g., spawning aggregations), economic importance, vulnerability, and the need for inventories (Table 4). The importance of these criteria was also considered at various spatial scales (when known), with each criterion evaluated as biologically distinct at the level of Caribbean, MACR Ecoregion, or Subregion.

Each working group submitted its final nominations for Priority Areas, which were then digitized and geographically referenced to produce individual Taxa Priority Maps (Appendix B). These four maps were superimposed to create an Overlapping Priority Map for all Taxa (Appendix B). This new map was presented to the entire group for discussion and comparison, then used as a reference for the Biodiversity Priority Area Analysis.

3.1b Results: Taxa Priority Areas

From these analyses, 26 Coral Priority Areas, 53 Fish Priority Areas, 37 Focal Species Priority Areas, and 21 Plant Priority Areas were identified (see Appendix B). All 137 Focal Taxa/Guilds Priority Areas were then overlapped onto one ecoregional map and presented to the entire expert group for discussion (Appendix B). The following are brief summaries synthesizing each working group's selected taxa or guilds and their nominated Priority Areas (PA). These summaries are based on data from the GIS database and information provided at the workshop by the experts. See Appendix B for the maps.

Coral Reef Priority Areas

The MACR contains perhaps the most complex and extensive coral reef system in the western Atlantic. Reef development along the MACR is highly variable on both small and large spatial scales, creating several distinctive reef areas including patch, rhomboid-shoal, fringing, bank/barrier, and atolls. Unlike most island nations in the Caribbean, the MACR reef system is

Table 3. Coral Reef Criteria Ranking Results

Criteria for Ranking High-priority Coral Reefs

1. High Diversity of Habitats Per Unit Area
2. Large Area
3. Good Condition
4. Close to Similar Habitats
5. Close to Nursery Areas — Migration
6. Larval Transport
7. Crosses Environmental Gradients
8. Well-developed Coral Framework
9. Regenerative Capacity
10. Representative
11. Swath Potential
12. Uniqueness
13. "Old Growth" Coral Reefs
14. Need for Inventories

Swath potential was defined as: *"The extent to which an area contains or is linked to a variety of interconnected habitats and environmental regimes including upland watersheds. The swath is envisioned as a full "ridge to reef" gradient fostering the areas' potential for holistic conservation integrating terrestrial, coastal, and marine ecosystems."*

Old Growth reefs were characterized as: *"Ecologically mature, dominated by large corals, complex topographic structure, great age of some corals, presence of standing dead corals, multi-storied coral formations, and negligible evidence of structural disturbances."*

Table 3. (continued)

BPA Land+ Aquatic+ Biota=Future Threat Source of Future Threats

Priority Area	Map ID•	Shelf position+	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cabo Catoche	1	I,M					*		*				*			
Isla Contoy	2	M			*		*									
Arrowsmith Bank	3	OF						*						*		*
Punta Petempica to P. Nizuc	4	I,O			*	*				*		*				
Punta Moroma	5	I,O			*	*	*			*		*				
Cozumel	6	OF				*					*			*		
Punta Piedra to Punta Xpujil	7	I,O			*	*					*					
South Cozumel	8	OF	*	*	*	*		*		*					*	
Punta Tupa to Boca Paila	9	I,O	*	*	*	*	*			*	*	*				
Tampalen to Lag. Mosquitero	10	I,O			*	*				*	*	*				
Punta Gruesa to P. Changuay	11	I,O			*	*				*						
Banco Chinchorro	12	OF	*	*	*	*	*	*		*				*		
Basil Jones to P. Herradura	13	I,O	*	*	*	*				*	*				*	
Mexico Rocks	14	I				*				*		*		*	*	
NE Cay Caulker to Hol Chan	15	I,O				*				*		*				
Gallows to Bluefield	16	O				*	*			*		*				
Turneffe Islands	17	OF	*	*	*	*	*	*		*			*	*	*	
Lighthouse	18	OF	*	*	*			*		*				*	*	
Glovers Reef Atoll	19	OF	*	*				*	*	*				*	*	
Gladden Spit South	20	I,M,O	*	*		*	*		*	*	*		*	*		
Snake Key to Sapodilla Swath	21	I,M,O	*	*		*	*		*	*			*	*		
Tela Bay	22	I,M												*		*
Utila	23	OF				*		*		*		*			*	
Cayos to Roatán Swath	24	I,M,O, OF	*	*		*		*	*	*			*			
Guanaja	25	OF				*		*		*		*		*		
Swan Islands	26	OF						*						*		*

• Coral Priority Areas Map, Appendix B, p.2
+ I=Inner-shelf, M=Mid-shelf, O=Outer-shelf, and OF=Offshore

adjacent to a continental landmass and is very much prone to its terrestrial influences. Hermatypic or reef-building corals are the foundation for the MACR coral reefs. At least 66 species of corals and 44 species of octocorals are known in this region. Important shallow reef-building corals include *Acropora palmata, Millepora complanata, Agaricia tenuifolia, Montastraea annularis, Diploria strigosa,* and *Porites*

Table 4. Fish and Focal Species Criteria Ranking Results

(Biological distinctiveness levels are Caribbean (C), Ecoregion (E), Subregion (S), Not Outstanding (N) or Unknown (U); H=High, M=Medium, L=Low, *=Importance for Tourism)

Criteria for Ranking Fish and Focal Species Priority Areas

- Uniqueness
- Endemism
- Trophic Importance
- Representation
- Vulnerability
- Economic Importance
- Level of Understanding
- Need for Inventories

Species	Uniqueness	Endemism	Trophic Importance	Representation	Economic Importance	Vulnerability	Level of understanding	Need for inventories
Conch	N	N	H	H	C	H	H	H
Lobster	N	N	H	M	C	H	H	H
Snapper-Grouper	C	N	H	H	C	H	L-M	H
Reef Fish	N	S	H	H	E	M-H	M	M
Pelagics	E	N	H	U	C	H	L	H
Estuary Fish	N	N	H	M	S	M	M	M
Cryptofauna	C	C	H	H	N	U	L	H
Manatee	C	C	H	H	C*	H	L-M	H
Sea Turtles	S	N	H	H	S	H	L-M	L-M
Birds	S	S	H	H	E*	M	M	M
Dolphin	S	N	H	L	S*	M	M	M
Crocodile	C	N	H	M	C	H	M	M
Island/ Endemic	E	E	L	U	U*	M-H	L	H

astreoides. Deep reefs are often dominated by *Montastraea annularis, M. franksi, M. faveolata, Agaricia agaricites,* and *Diploria* sp. The complex three-dimensional space created by coral reefs supports critical habitat for reef fishes, lobsters, conch, and other reef fauna. Descriptions of reefs from north to south are provided below with significant Coral Priority Areas (CPA) identified.

At the MACR's northernmost point in Mexico, a discontinuous fringing reef extends nearly 350 km along the eastern Yucatán peninsula from Isla Contoy south through Xcalak to Ambergris Caye (Subregions I and II). Well-developed reef crests break the surface in many locations and contain impressive stands of the reef-building coral, *Acropora palmata*. Reefs near Punta Herradura to Basil Jones (BZ) (CPA 13) have a unique double reef crest geomorphology. Mexico Rocks patch reef (CPA 14) is one of the only well-developed patch reefs in Subregion II, with extensive coverage of "old growth" corals; unfortunately it has suffered very high mortality in recent years.

The most diverse and complex coral reef development occurs in the Belize Lagoon (Subregion III). A nearly continuous barrier reef extending from Bluefield (CPA 16) south to Gladden Spit (CPA 20) contains textbook examples of backreef, reef flat, reef crest, and fore reef morphologies. Numerous patch reefs are found throughout the lagoon, as well as unique rhomboidal-shaped reefs (faroes) and drowned reefs in the southern lagoon. The Belize Barrier Reef terminates with an interesting hook-shape feature at the Sapodilla Cays (CPA 21). The Snake Keys (CPA 21) near Port Honduras contain a network of islands fringed with coral that are unique in the ecoregion because of their

close proximity to the mainland; they have also suffered high mortality recently.

The Bay Islands of Honduras (CPA 23-25, Subregion V) is an archipelago of more than 60 offshore minor islands and several larger islands (such as Roatán, Utila, Guanaja, and Cayos Cochinos), many of which are encircled by well-developed fringing reefs. Cayos Cochinos is the only one of the Bay Islands representative of coral reefs in the mid-shelf location.

The MACR is home to several unique and distinctive coral features. The Belize barrier reef stands out as the second-longest barrier reef in the world and the best-developed barrier reef in the Western Atlantic (CPA 20). Although there may be as many as 15 atolls or atoll-like structures in the Caribbean, the MACR contains four of the best developed, including Banco Chinchorro (CPA 12), Lighthouse (CPA18), Turneffe (CPA 17), and Glovers (CPA19). Of these, Glovers Reef Atoll is perhaps the most authentic atoll in the Caribbean with its large number of patch reefs (over 700) and its deep interior lagoon. At the northernmost part of the MACR system, ahermatypic reefs are found on Arrowsmith Bank. The coralline algal ridges along Cozumel's northeastern coast are the only ones of this type in the Western Caribbean. The reefs of the Swan Islands (CPA 26) are uniquely located far from the continental landmasses of the MACR and are situated in direct contact with the highly productive Caribbean Current.

Several swaths or corridors encompassing a suite of productive habitats (including mangrove, seagrass, hardbottom, and coral reef) across the coastal shelf from inshore to mid-shelf to offshore settings occur in the MACR. These swaths provide shelter, productive foraging grounds, and nurseries for the many different developmental stages of numerous species. Examples include the Tampalem to Laguna Mosquitero Swath near the Sian Ka'an Reserve in Mexico (CPA 10), the Snake Cayes to Sapodilla Cayes Swath (CPA 21), and the Cayos Cochinos to Roatán Swath (CPA 24).

Fish Priority Areas

Perhaps no other taxon group is as economically and culturally intertwined with the people of the region as fish resources (including lobster, conch, and shrimp). In the Southern Belize region around the town of Punta Gorda, for example, the majority of men fish as part of their livelihood. The fish working group distinguished five subdivision "complexes" with significant importance to the MACR, including reef fish, snapper/grouper, estuarine fish, pelagics, conch/lobster, and cryptofauna. Overviews of each complex are given below, followed by examples of selected Fish Priority Areas (FPA).

The ***reef fish complex*** encompasses many of the region's more than 400 species of fish that are commonly associated with the highly complex coral reef ecosystems. These include the herbivorous Scaridae (parrotfish), Pomacentridae (damselfish), Labridae (wrasse), and Acanthuridae (surgeonfish), all of which have great trophic importance as principal primary consumers in the reef ecosystem. Secondary consumers such as Lutjanidae (snappers), Haemulidae (grunts), and Serranidae (groupers) also form the basis of commercial and artisanal fishing in the region. Planktivores such as blue chromis (*Chromis cyanea*) and corallivores like butterfly fish (*Chaetodon* spp.) also play a critical role in maintaining the fragile energy balance on reefs. Many of these reef fish frequently use nearby non-reef habitats (e.g., seagrass, mangrove) either intermittently or throughout their juvenile and adult life. Reef fish are found throughout the MACR's extensive reef system, although limited information is available on their abundance and distribution. Outstanding priority areas for reef fish include the Belize Barrier Reef (FPA 11), S. Yucatán Coast (FPA 9), Sian Ka'an Reserve (FPA 8), Gladden Spit (FPA 26), the four atolls (FPA 17, 19, 24), and the Bay Islands (e.g., FPA 34).

The ***snapper-grouper complex*** has formed the basis for commercial and recreational fisheries in the region for decades. Traditionally exploited during the months they aggregate off reef promontories to spawn, their populations have declined dramatically from historic levels. Particularly important species in the MACR include Nassau grouper (*Epinephelus striatus*), jewfish (*E. itajara*), mutton snapper (*Lutjanus analis*), black grouper (*Mycteroperca bonaci*), red hind (*Epinephelus guttatus*), Cubera snapper (*Lutjanus cyanopterus*), and yellowtail (*Ocyurus chrysurus*). Some species associate with reefs throughout their entire life cycle, while others utilize nearshore mangrove or seagrass vegetation as juveniles. Several spawning aggregations occur in the MACR, with at least ten located in Belize. Gladden Spit (FPA 26) is home to the largest grouper/snapper spawning aggregation (2,000-4,000 individuals) in the ecoregion and includes fish species such as Nassau grouper, black grouper, red hind (*Epinephelus guttatus*), ocean jack (*Caranx* sp.), schoolmaster (*Lutjanus apodus*), Cubera snapper, yellowtail snapper, dog snapper (*Lutjanus jocu*),

and mutton snapper. Other spawning aggregations occur at Mahahual, Rocky Point and Mexico Rocks (FPA 9), Banco Chinchorro (FPA 10), S. Columbus Reef (FPA 23), S. Long Rock (FPA 22), St. George's Cay (FPA 12), Turneffe (FPA 17, 18), Lighthouse (FPA 20), Glovers (FPA 24, 25), and Guanaja (FP 46). Caribbean red snappers (*Lutjanus purpureus*) have been found along the continental shelves of the Yucatán Peninsula and Honduras and are abundant in depths between 30 and 160 m. The offshore banks, Rosario and Misteriosa (FPA 52-53), and the Swan Islands (FPA 51) may also be important spawning aggregations.

The ***estuarine fish complex*** represents those species that inhabit the inshore brackish waters for at least a portion of their life. This includes many economically important species such as snook (*Centropomus undecimalis*), tarpon (*Megalops atlanticus*), bonefish (*Albula vulpes*), mullet (*Mugil* spp.), permit (*Trachinotus falcatus*), and drum (*Sciaenops* sp.). They form the principal artisanal fishery in many areas of the MACR, but also provide substantial economic value as sport fish for the growing recreational/sport fishing industry. These coastal species have many evolutionary and ecological features that distinguish them from other tropical coastal fishes. Estuarine fish are trophically important; mullet are common detritivores in inshore waters, and snook and tarpon are key carnivores. Significant large estuarine lagoons in the ecoregion include: Sian Ka'an Reserve (FPA 8), Chetumal Bay, Port Honduras (FPA 27), Amatique Bay (FPA 30), and the Río Platano (FPA 48-50).

The ***pelagic fish complex*** includes small coastal pelagic fishes such as jacks (e.g., *Caranx* spp.) and mackerels (*Scomber* spp.), flying fish (*Cypselurus* sp.), to larger, more migratory species including dolphinfish (*Coryphaena hippurus*), billfish (e.g., *Tetrapturus* spp., *Xiphias* sp.), tuna (e.g., *Thunnus* sp.), and large sharks. Some species typically occur in waters at the interface between coastal and oceanic habitats and include several distinctive "giant" species (e.g., billfishes, whale sharks) that are outstanding at the ecoregional scale. Many pelagics are highly migratory, with large ranges and broad distributions in the ecoregion. These fish are important trophically; small pelagics (e.g., herring, silversides) are the forage base for many fish species, while larger pelagics (dolphins, jacks, billfish, sharks) are key piscivores. Larger pelagics represent a principal economic resource as both commercial and sport fisheries. Oceanic regions around areas like Arrowsmith Bank (FPA 6), Isla Contoy (FPA 2), Turneffe (FPA 16), Misteriosa Bank (FPA 53), and Rosario Reef (FPA 52) provide important habitat for pelagic and migratory species like marlin, sailfish, wahoo (*Acanthocybium solandri*), kingfish, tuna (bonito, yellowfin), mackerel, jack (amber, horse-eye, crevalle), and shark. Gladden Spit (FPA 26) has the largest whale shark (*Rhincodon typus*) concentration in the ecoregion (36 were observed in one day) and perhaps globally. Other whale shark sightings have been reported at S. Long Cay (FPA 22), Middle Long Cay (FPA 15), Crawl Cay, Turneffe (FPA 18), Sapodilla Cays (FPA 11), and North Utila (FPA 37).

Throughout the ecoregion, the ***queen conch*** and ***spiny lobster*** have important economic, social, and cultural value. Conch are important herbivores in seagrass and algal plain habitats and are one of the most important commercial species in the Caribbean. Due to its overexploitation and declining populations over the last 30 years in the Caribbean and Western Atlantic, it has been placed in Appendix II of the Convention on the International Trade of Endangered Species (CITES); this permits only certain countries to export it as long as the fishery is sustainable. One of the largest and last commercially viable conch fisheries in Mexico is found at Banco Chinchorro (FPA 10), although conch are also exported from Belize and Honduras. Although three spiny lobster species occur in the ecoregion, along with several species of slipper lobster (e.g., *Scyllarides nodifer*), the emphasis on the spiny lobster as a priority species reflects its overwhelming economic importance in the region, as well as its great abundance and widespread distribution. For example, it is the most economically significant fishery on the Yucatán Peninsula. Some of the largest spiny lobster populations remaining in the ecoregion occur in the Sian Ka'an Reserve's two bays, Ascención and Espíritu Santo (FPA 8). The Graciosa Bay-Amatique Bay (FPA 30) area has highly productive grounds for shrimp, another important fishery.

Cryptofauna represent numerous small-bodied organisms (e.g., crustaceans, mollusks, fish, echinoderms) that live within holes and crevices inside the reef, often with highly specialized habitat requirements. These small organisms have the highest species diversity on the reef but are almost entirely unknown. They have restricted dispersal and very small geographic ranges, making them more vulnerable to extinction than

larger species that have long-lived larvae and wide geographic ranges. They are ecologically and economically important because they are the base of the food chain and support numerous reef fisheries. Endemism and uniqueness in this group was ranked outstanding in the Caribbean. For example, one species of mantis shrimp is restricted to inhabiting only one foot of upper intertidal reef/rubble area. An endemic group of snapping shrimp living only in one sponge species is evolutionarily unique in that it is the only example of marine invertebrates that exhibits true social behavior. Members live in extended family groups where some forego reproduction in order to work for the colony. Since so little is known about the distribution of these species, priority areas were often selected based on the presence of habitat suitable for cryptic species. For example, the unique habitat of the Great Blue Hole on Lighthouse Atoll (FPA 19) is likely the home to numerous species of cryptofauna. Complex, well-developed reef areas, found along much of the Belize Barrier Reef (FPA 11) provide excellent habitat for cryptofauna. Cryptic and possibly endemic or rare fish include the splendid toadfish (*Sanopus splendidus*) found in Cozumel (FPA 7) and Sian Ka'an (FPA 8) and the whitelined toadfish (*Sanopus greenfieldorum*) observed at Lighthouse (FPA 19) and Turneffe atolls (FPA 17).

Focal Species Priority Areas

The ***Focal Species group*** selected several key indicator species/guilds including the ***West Indian manatee, American saltwater crocodile, sea turtles, birds,*** and ***"island-terrestrial" endemic vertebrate species and subspecies.*** As keystone species, their status is often indicative of the condition of many other flora and fauna that rely on similar habitats. For example, seagrass beds and mangroves are critical manatee habitat, but they also provide resources for other aquatic species such as wading birds, crocodiles, turtles, fishes, and invertebrates. Descriptions of each species/group are provided below, along with specific examples of Species Priority Areas (SPA) identified.

The MACR is home to the largest population of endangered ***West Indian manatees*** (*Trichechus manatus*) in Central America. Experts at the workshop estimated that Belize has 400-900 manatees; the Yucatán coast has 6-12; Chetumal Bay has 250; Honduras has 120-140; and Guatemala has 22-106. They also estimated the number of deaths per year, with Port Honduras, Belize City, and Chetumal Bay having the most deaths. Illegal killing of manatees still occurs near Port Honduras, Río Sarstun, and the Río Dulce. Manatees have recently become an economically valuable tourist attraction, particularly near the lower Belize River, Ambergris Cay, and Placencia. Manatees inhabit the region's fresh, brackish, and marine waters and depend on quiet areas for feeding, resting, cavorting, mating, and calving. Critical manatee habitat is found in several of the rivers, lagoons, seagrass meadows, and cays. The Belize River mouth and adjacent cayes support the largest populations of manatees in the ecoregion. Pristine foraging grounds and freshwater sources in the Southern and Northern Lagoons (SPA 11) are important habitat for large numbers of manatees. Cows and claves migrate from the lagoons to the complex river and cay system around Belize City. Manatees also forage on the vast seagrass meadows and calve in the quiet waters of Placencia Lagoon (SPA 18). Chetumal Bay (SPA 9) is also an important calving area in the ecoregion. Small but important populations of manatees live and travel along the Yucatán coast (SPA 6-7) and frequent the protective bays in Sian Ka'an (SPA 8). Historically, the vast interconnected freshwater and estuarine system of the Río Dulce (SPA 23) supported numerous manatees, but a long and continuing history of commercial and subsistence hunting has drastically reduced populations. In Honduras, a large population of cows and calves finds refuge in the pristine bays and rivers of the Río Platano Biosphere Reserve (SPA 37).

The ***American Saltwater Crocodile*** (*Crocodylus acutus*) is the single marine-adapted crocodilian on the American continent and the only one of the two species of crocodiles found in the Mesoamerican Caribbean that is ecologically integrated into the MACR. It is the only amphibious reptilian top predator in the ecoregion, feeding on fish, crustaceans, and birds. Crocodiles are protected from international commerce with their designation as a CITES Appendix I species; however, crocodile hides are luxury items for the leather trade and several commercial crocodile farms and harvesting programs exist in the region. Critical nesting habitat has been lost or degraded due to agriculture, shrimp farming, and construction activities (particularly tourism-related construction). Crocodiles are found along the region's rivers, coastal lagoons, islands, and cays. Turneffe atoll (SPA 12) is home to some of the largest

crocodile populations and best remaining habitat in Belize. Other ecologically significant habitat for crocodiles is found in the Sian Ka'an Biosphere Reserve (SPA 8), Río Platano (SPA 37), Cozumel (SPA 5), Chetumal Bay (SPA 9), and Río Aguán (SPA 36). West Roatán (SPA 32) is the only remaining habitat for crocodiles in the Bay Islands.

Endangered green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and leatherback (*Dermochelys coriacea*) sea turtles and the vulnerable loggerhead turtle (*Caretta caretta*) roam the region's marine waters. ***Sea turtles*** are important indicator species because they use a wide variety of habitats for their different life cycle stages. For example, green turtles forage in pastures of seagrasses, hawksbills search for sponges on coral reefs, juvenile hawksbills roam the pelagic zone, and all species nest along coastal beaches and cays. Punta de Manabique (SPA 25) is one of the most important hawksbill nesting beaches in the region, supporting more than 380 hawksbill sea turtle nests along 50 km of beach. Cozumel's (SPA 5) east coast often supports more than 1,900 green turtle nests. Loggerhead and green turtles rely on the availability of extensive habitat along the Yucatán coast, especially near Puerto Morelos (SPA 4), Playa de Carmen to Akumal (SPA 6), Tulum (SPA 7), and Sian Ka'an (SPA 8). The most critical nesting habitats for sea turtles in Belize are found on Ambergris Cay (SPA 9), along the mainland near Manatee Bar (SPA 11), and in the sandy cays from Silk Cay to Sapodilla Cay (SPA 16, 21). Greens, loggerheads, and hawksbills nest along the coastal beaches near Río Leon (SPA 28), Río Cuero y Salado (SPA 29), and Río Platano (SPA 37). Green turtles occasionally nest on the Bay Islands (SPA 30-34), particularly at Cayos Cochinos (SPA 31).

The MACR is home to exceptionally rich and diverse ***bird*** life. The Sian Ka'an Biosphere Reserve is one of the most important nesting and roosting estuaries in the entire ecoregion. At least 339 (120 migratory, 219 resident) bird species find refuge here, six of which are endangered, 14 threatened, six regionally endemic, and two of limited range. One of only two wood stork nesting sites on Yucatán is located in Ascención Bay. Flocks of colorful roseate spoonbills (*Ajaia ajaja*) and greater flamingos (*Phoenicopterus ruber*), along with countless other wading birds, forage for small fish and crustaceans in the Reserve's shallow grass flats. Further north on the Yucatán Peninsula, Yalahau (SPA 2) is home to more than 10,000 magnificent frigate birds and at least 250 other bird species. The offshore cays and atolls are important land stopover sites for migratory land and seabirds. Adjacent to Yalahau, the Island of Contoy (SPA 2) supports the largest colony of brown pelicans on the Mexican east coast and more than 177 bird species (more than 50% of them are migratory), of which eight are endemic and two have restricted distribution. Further south in Belize, numerous birds roost on the intricate network of mangroves in Turneffe's interior lagoon (SPA 12). More than 3,000 red-footed boobies nest on the small sandy Half Moon Cay (SPA 13) on Lighthouse Atoll, one of only two unique white-phase nesting colonies in the Caribbean. Expanses of pristine mangrove forests and seagrass meadows along the Guatemalan-Honduran coasts are critical bird habitat. More than 600 species of resident and migratory birds forage and nest along the rich coastal floodplain of Jeanette Kawas National Park (SPA 27) in Honduras. The extensive mangrove and lagoonal systems of the Río Platano Biosphere Reserve (SPA 37) are one of the largest and most pristine bird refuges in the southern portion of the ecoregion.

Some of ecoregion's larger islands and cays support a unique guild of ***island-terrestrial endemic vertebrate species and subspecies,*** although very little is known about them. These species are often more susceptible to extinction because of their highly specialized habitat requirements and limited distribution. Unique, endemic reptiles are found on the Honduran Bay Islands, including *Ctenosaura bakeri* on Utila (SPA 30), *C. oerdriona* on Roatán (SPA 32), and the pink boa on Cayos Cochinos (SPA 31). Offshore of the Yucatán coast, Cozumel (SPA 5) and Banco Chinchorro (SPA 10) have endemic *Anolis* and other lizards. The Belize Atoll gecko has only been observed on Half Moon Cay, Lighthouse (SPA 13) and Middle Cay, Glovers (SPA 17). The Pelican Cays and Turneffe (SPA 12) also have several endemics. Endemic birds are found on the islands and cays: an endemic dove inhabits Cozumel (SPA 5); a limited range cat bird lives on Cay Caulker and Bacalar Chico (SPA 9); three possible subspecies of birds reside on Banco Chinchorro (SPA 10); and a possible endemic

parrot resides on the Bay Islands (SPA 32). The Swan Islands may also have a number of endemics.

Plant Priority Areas

Coral reef ecosystems depend on adjacent seagrass and mangrove habitat to provide essential foraging and nursery areas for many of their inhabitants. These ecosystems contain a mosaic of different microhabitats utilized by many reef fishes and invertebrates during different developmental stages of their lives. Complex root structures offer shelter and nursery areas for many species that are commercially and recreationally important in the MACR (e.g., lobster, fish). Dense mangrove canopy layers also provide roosting and nesting habitat for resident and migratory birds, including several endangered species. Mangroves are most commonly found as a thin fringe along lagoons, rivers, and cays, but extensive forests can extend many kilometers inland in low-lying areas such as the southern Yucatán Peninsula and Chetumal Bay. Many forested areas along the Honduras and Belize coasts (e.g., Jeannette Kawas National Park (PPA 14)) are classified as mangroves, but also contain other coastal wetland species such as broad leaf flooded forest (e.g., *Pachira acuática)*. Some mangrove islands (e.g., Port Honduras) contain salt ponds, a rare natural community often having unique species. Coastal development and dredging have destroyed much of the historic mangrove and seagrass habitat. It is estimated that the MACR Ecoregion now contains more than 2,500 km^2 of mangroves and 4,000 km^2 of seagrasses distributed primarily in Belize and southern Yucatán.

The presence of seagrass, mangrove, and coral reef habitats in close association to one another is considered especially valuable since they provide a natural energy flow between systems and serve as corridors for transient and developing species. Prioritization of Plant Areas was therefore based on the diversity of habitats and how well these habitats were linked together. Three habitat associations were identified: mangrove-seagrass-coral reef; mangrove-seagrass; and seagrass-coral reef.

The best example of the ***mangrove-seagrass-coral reef*** association in the ecoregion occurs on the Belize Barrier Reef from the mainland out to the shelf margin (PPA 5). Here, coastal, riverine, and lagoonal mangrove forests, extensive seagrass meadows, lagoonal patch, and barrier reefs occur in close proximity across a wide and complex shelf. The highly productive ecosystem of Sian Ka'an Reserve has nearly 900 km^2 mangrove forests fringing the Bahías de la Ascención and Espíritu Santo (PPA 4), adjacent seagrass meadows, and more than 90 km of well-developed coral reefs. The two bays support some of the largest spiny lobster populations remaining in the region as well as one of the largest endangered wood stork nesting sites on the Yucatán Peninsula. The Deep-River-Punta Ycacos watersheds support extensive old growth mangrove forests, dwarf mangrove flats and lagoons that are adjacent to seagrass beds and the unique nearshore reefs of the Snake Cays (PPA 5). Of all the atolls, Turneffe (PPA 7), with its intricate network of mangroves and seagrasses in its interior lagoon and fringing reefs along its outer margin, has the most developed *mangrove-seagrass-coral reef* habitat. La Ceiba to Cayos Cochinos swath (PPA 17) encompasses terrestrial and marine habitats such as tropical broadleaf forest, coastal wetlands, seagrass beds, coral reefs, and open oceanic habitat. It is an example of the mangrove-seagrass-coral habitat occurring on the near-shore and mid-shelf locations.

The ***mangrove-seagrass*** habitats predominate in many of the MACR's coastal lagoons, bays, and watersheds. The coastal lagoons of Yalahau and Chacmochuc contain remarkable seagrass and mangrove habitat that serves as nurseries for many species of fishes and invertebrates (PPA 1). The Bay of Chetumal (PPA 5), the Northern and Southern Lagoons (PPA 5), and the Río Platano Biosphere Reserve's Brus and Ibans Lagoons (PPA 21) have extensive seagrass beds and fringing mangrove forests that were considered important as Priority Areas because they support some of the largest manatee populations in the ecoregion. Graciosa Bay and Amatique Bay (PPA 11) are exceptional habitat, particularly for shrimp, with their pristine turtle grass beds and mangrove forest.

Striking examples of productive ***seagrass-coral*** associations occur in areas like the Belize Barrier Reef (PPA 5) and Glovers Reef (PPA 9). Both are important foraging grounds for sea turtles such as the endangered hawksbill turtle that feeds on sponges and the endangered green turtle that feeds primarily on turtle grass (*Thalassia testudinum*). The extensive seagrass-coral systems of Banco Chinchorro (PPA 6) support one of the largest populations of conch remaining in the ecoregion.

3.2 Selecting Biodiversity Priority Areas in the MACR

3.2a Biodiversity Priority Areas Approach

For the Biodiversity Priority analysis, participants were divided into four working groups based on their expertise or interest in one of the six subregions: 1) N. *Quintana Roo* (Subregion 1); 2) *Sian Ka'an – Ambergris* (Subregion 2); 3) *Belize Barrier Reef System* (Subregion 3); and 4) *Gulf of Honduras/N. Coast of Honduras/Deep Ocean* (this fourth group combined Subregions 4-6). Each group reviewed the Overlapping Priority Map for all Taxa (Appendix B) and identified candidate Biodiversity Priority Areas for their particular subregion. The biological importance of each candidate area was analyzed by ranking the criteria below. The candidate areas were then categorized into final Biodiversity Priority Areas (BPA) according to Highest Priority, High Priority, Priority, or Unknown Priority. Detailed descriptions of each final Biodiversity Priority Area are found in Appendix B. These priority areas were then evaluated and assessed for their likelihood of persistence and the level of future threat in a Persistence and Future Threat analysis.

The following criteria were evaluated:

- species richness/endemism
- species of special concern
- trophic linkages
- habitat connectivity
- habitat complexity
- habitat representation
- ecological and evolutionary phenomena
- biological surveys needed
- complementarity importance

3.2b Biodiversity Priority Areas Results

Twenty-six Biodiversity Priority Areas (BPA) were selected: 9 Highest, 7 High, 6 Priority, and 4 Unknown (Table 5). Detailed summaries of each Priority Area are found in Appendix C and include information on location, approximate size, biological importance, description of the area, outstanding biological features, current conservation status, resource use, threats, and data gaps.

The ranking results for the top nine priority areas are given in Table 6. Several of the Biodiversity Priority Areas were chosen based on outstanding distinct habitat criteria such as habitat uniqueness, connectivity, complexity, and representation. The MACR region supports unique coral reef habitats considered to be outstanding for the Caribbean, including the only true barrier reef in the Caribbean; distinctive reef structures like Gladden Spit (promontory reef) and Sapodilla Cayes (BB8) (terminal end of Belize Barrier); and four of the best-developed coral atolls (Banco Chinchorro-SK1, Lighthouse-BB2, Turneffe-BB1, and Glovers-BB3) in the Caribbean. Other unique reef habitats include the offshore carbonate banks (Swan Islands-HG1, Arrowsmith-QR4, Rosa Linda/Misteriosa-HG6); ahermatypic reefs (Arrowsmith-QR4); microalgal ridges (Cozumel-QR1); mid-shelf reefs (Cayos Cochinos-HG3); and the Blue Hole-BB2). Three priority areas were selected based on their importance as "swath" habitat: Central Yucatán Coast-Sian Ka'an seascape (SK3), Gladden Spit seascape (BB6), and Bay Islands seascape (HG3). These seascapes encompass highly diverse complex habitat with high connectivity, and support important ontogenetic and migration corridors, adult habitat and foraging areas, juvenile nursery grounds, larval dispersal, high species diversity, and

Table 5. Biodiversity Priority Areas

Highest Priority	High Priority	Priority	Unknown
NE Yucatán (QR2)	Cozumel (QR1)	Ría Lagartos (QR3)	Arrowsmith Bank (QR4)
Banco Chinchorro (SK1)	Central Yucatán (SK2)	Cancun Corridor (QR5)	English Channel (BB5)
Sian Ka'an (SK3)	Chetumal/Corozal (SK5)	Tulum Corridor (QR6)	Swan Islands (HG1)
S. Yucatán (SK4)	Belize City Complex (BB4)	Central Barrier Reef (BB7)	Rosa/Misteriosa Banks (HG6)
Turneffe Islands (BB1)	Sapodilla Cayes (BB8)	Río Platano (HG2)	
Lighthouse Reef (BB2)	Port Honduras (BB9)	Tela-Manabique Coast (HG4)	
Glovers Reef Atoll (BB3)	Gulf of Honduras (HG5)		
Gladden Spit (BB6)			
Bay Islands (HG3)			

high biological productivity. Biodiversity Priority Areas with some of the most exceptional ecological and evolutionary phenomena include Gladden Spit seascape (BB6), which has unique current flows, supports the largest snapper/grouper spawning in the ecoregion, and has the largest concentration of whale sharks in the Caribbean, and possibly in the world. The Northeast Yucatán Peninsula (QR2) is a unique priority area with its proximity to a highly productive upwelling area.

Additional Biodiversity Priority Areas were selected based on other outstanding habitats than coral reefs. The rich and highly productive estuaries of Rio Platano Biosphere Reserve (HG2) and Sian Ka´an Biosphere Reserve (SK3) have some of the highest habitat and biological diversity in the ecoregion, including well-developed coastal lagoons, flood forests, mangroves, and seagrasses.

Many of the Biodiversity Priority Areas in the region support habitat essential for species of special concern, including beaches with some of the highest densities of sea turtle nests in the Caribbean (e.g., Cozumel, Punta de Manabique); largest manatee population in the Caribbean (Belize City Complex-BB4); important manatee calving areas (e.g., Chetumal and Corozal Bays-SK5); and numerous large nursery grounds for key fishery species like lobster (e.g., Bahía de la Ascención and Espíritu Santo-SK3), conch (e.g., Banco Chinchorro-SK1), and shrimp (e.g., Graciosa Bay-Amatique Bay-HG5).

Biodiversity Priority Areas that did not have enough information to receive a ranking but warrant additional attention because of their likely importance included Arrowsmith Bank (QR4), Swan Islands (HG1), and Rosa and Misteriosa Banks (HG6). All of these are remote offshore systems that are believed to have significant biological importance because of their roles in currents, connectivity, and biological productivity.

3.3 Identifying Threats to MACR Biodiversity

3.3a Threats Analysis

A separate working group of experts conducted an analysis to identify and rank the primary threats to the ecoregion's biodiversity. The experts first reviewed and discussed socioeconomic data made available to them in a series of large-scale maps; the maps were based on an ecoregional synthesis of socioeconomic data created specifically for the MACR Biodiversity GIS-Database (Table 1), including data from the Threat and Root Cause Analysis (FAO, 2000) (Table 7). Because the countries in this region share many of the same resources, the experts reviewed issues regarding the use and management of transboundary resources. The socioeconomic group also referred to the findings of WWF's preliminary experts meeting held in Belize in 1999, where the principal biodiversity threats and their root causes were identified by country (Table 8) (Jorge, 1999). The socioeconomic group identified the most important threats by subregion (Table 9), then ranked the total level of threat to a particular area as high, medium, or low (Appendix C). In addition, they identified and discussed existing institutional entities/infrastructure responsible for minimizing these threats, and existing and potential opportunities for reducing the impact these threats have on biodiversity.

3.3b Threats Results

Based on their analysis, they identified four primary threats that were likely to have significant impact on biodiversity in the ecoregion:

1. **Coastal Habitat Degradation or Conversion**

- Changes in coastal morphological processes, beach erosion, sedimentation of natural and navigational channels and reefs, and fragmentation and stress of terrestrial, riparian, coastal, estuarine, and reef ecosystems;
- Changes in the composition of species and the introduction of exotics;
- Changes in the hydro-geomorphological functioning of watersheds;
- Increased consumption of ground water leading to changes in ecosystem functions and water supplies.

2. **Declining Water Quality**

- Loss of productivity due to nutrification and/or chemical contamination of estuaries, bays, wetlands, reefs, and seagrass beds, potentially causing massive kills and/or threats to aquatic organisms;
- Declining water quality as a chronic stress on reefs, seagrasses, fish, spawning sites, etc.;
- Impacts of oil spills on reefs, aquatic organisms, and related trophic structures;
- High levels of localized coral bleaching associated with suspended sediments and contaminants in close

Table 6. Ranking Results of Nine Highest Biodiversity Priority Areas

Biodiversity Priority Area (BPA) codes are given in Table 5.

* Species of special concern include birds (B), American crocodile (CR), conch (CO), grouper (G), lobster (L), sea turtles (ST), West Indian manatee (WIM).

** Habitat Representation is broadly grouped as coral reef (C), island/cay (I), lagoon/bay (L), mangrove (M), river (R) and seagrass (S).

Remaining column ranks are H=High, M=Medium, L=Low.

BPA	Species richness/ endemism	Species* of special concern	Intact habitat	Habitat connectivity	Habitat complexity	Habitat** represent	Unique habitat	Ecological and evolutionary phenomena	Biological surveys needed
QR2	H	ST, B	H	H	H	I,L,M,S		upwelling transition zone	H
SK3	H	WIM, ST, CR,B,L,G	H	H	H	C,I,L, M,R,S	Bays	nursery, swath	H
SK1	M-H	ST, CR, B,CO,L,G	H	M	M	C,I,L,M,S	Atoll	Spawning, nursery, oceanic	M
SK4	M-H	ST,WIM, B,G,L,C,O	M	H	H	C,I,L,M,S		Spawning	M
BB2	M-H	ST,B,L	H	H	M	C,I,L,M,S	Atoll	Blue Hole, oceanic	H
BB1	M-H	WIM, ST,CR, CO,L,G,B	H	H	H	C,I,L,M,S	Atoll	Habitat	M
BB3	M-H	ST,G,L,CO,B	M	H	M-H	C,I,L,M,S	Atoll	Habitat variety (atoll, patch reefs), oceanic, spawning	M
BB6	H	G	M	H	H	C,I,L, M,R,S	Reef	swath, largest spawning	H
HG3	H	ST,CR, WIM,B,CO, L,G	M	H	H	C,I,L, M,R,S	Reef	swath, location	H

proximity to land drainage in the Gulf of Honduras, Belizean nearshore reefs, and Bay Islands.
- Subsurface and surface salt intrusion and changes in ecosystem function and sustainability of local and regional water supply due to increased consumption of ground water.

3. Declining or Depleted Fisheries

- Overfishing for shrimp, lobster, conch, and certain species of finfish, resulting in reduced CPUE (catch per unit of effort) and overall industrial harvest by 60-70%;
- Losses of by-catch species (estimated at 60-70% of industrial catches) usually not consumed or commercialized;
- Reduction of coral grazers, resulting in algal invasion and reduction in coral productivity and their recovery from diseases;
- Destruction of seagrass beds and corals from shrimp trawlers.

4. Increased Stress Due to Oceanographic and Climato-meteorological Phenomena

- Storm surges and associated wave damage;
- Regional and local flooding exacerbated by loss of coastal defenses to storm events;
- Destruction and/or degradation of mangroves, wetlands, and particularly coral reefs due to increased water temperatures and coral bleaching;
- Concentration of suspended sediments and contaminants in gyre within the Gulf of Honduras, negatively affecting estuaries, bays, reefs, seagrass beds, and associated organisms;
- Alternating drought and torrential rains and flooding in region in association with increased dieback of reefs, due to *El Niño-La Niña* events.

Table 7. Threats to MACR's Biodiversity

Threats to the MACR's Biodiversity

Principal Threats

Inappropriate coastal/island development and unsustainable development
Inappropriate inland resource and land use and industrial development
Overfishing and inappropriate aquaculture development
Inappropriate port management, shipping, and navigation practices
Natural oceanographic and climato-meteorological phenomena

Transboundary Threats

Agricultural/industrial runoff (e.g., Dulce River)
Territorial dispute of country boundary (e.g., Belize and Guatemala)
Land-based pollution, contamination (Chetumal Bay, Sarstun River)
Maritime transport/port pollution (e.g., Gulf of Honduras)
Loss of migratory/endangered species (e.g., sea turtles, manatees)
Sedimentation, contamination (e.g., Gulf of Honduras)
Tourism (regional)
Unsustainable fishing (regional)
Illegal fishing (e.g., Guatemalan fishermen in Belize)

Source: FAO, 2000

Table 8. Causes of Biodiversity Loss (Jorge, 1999)

Country	Proximate Cause	Root Cause
Mexico	• Overfishing • Eutrophication (coastal urbanization, tourism)	• Political support for tourism development • Migration to Quintana Roo from other areas • Lack of effective fisheries management
Belize	• Habitat loss due to agriculture urbanization • Pollution due to inappropriate waste disposal and sewage treatment • Overfishing	• Population growth/poverty • Lack of education • Lack of enforcement of regulations • Incentives for exports and foreign exchange • Lack of incentives for conservation
Guatemala	• Tourism development on the coast • Pollution and inappropriate land use • Destruction of habitat • Degradation of water quality	• Speculative demand for land • (Manabique, Bahía La Graciosa, and Río Dulce) • Promotion of petroleum and mining development (Izabal, Golfete, Santo Tomás) • Lack of clarity in the institutional roles of government agencies (fisheries, shipping, environmental protection)
Honduras	• Sedimentation (Bay Islands development) • Land-use patterns (agricultural, deforestation) in northern Honduran watersheds • Eutrophication (Bay Islands sewage) • Overfishing	• Lack of institutional capacity to develop and monitor land-use policies (e.g., tourism, agriculture on Bay Islands, and mainland) • Lack of sustainable tourism policy (Bay Islands and N. Honduras) • Rapid migration to the Bay Islands • Growing demand for fisheries products in the tourism sector of the Bay Islands

3.4 Identifying Persistence and Future Threats

3.4a Persistence Analysis

A Persistence Value Assessment was conducted for each of the Biodiversity Priority Areas to better predict which areas were most likely to be resilient (i.e., able to recover their ecological functions following a disturbance). Before the analysis could be conducted, a clear definition for persistence as applied to the MACR ecoregion was developed; it reads: "The degree to which a particular habitat, community, or population will tend to retain its present status should the current level of human pressure on the system remain unchanged." Persistence was determined to be dependent on the system's resilience (ability to recover) under various natural disturbance trajectories. By this definition, a priority area would be considered highly persistent if it was likely to retain its ability to recover following future major disturbance events assuming that current anthropogenic pressures remained stable. A low-persistence area would be unable to recover following a disturbance unless substantial management actions were taken to alleviate current anthropogenic pressures.

To evaluate persistence at the species, population, community, and ecosystem levels, specific criteria were selected to describe the seascape-level processes occurring in the Biodiversity Priority Areas. The workshop experts analyzed the likelihood of persistence for each Biodiversity Priority Area by evaluating and ranking the following seascape and integrity features that contribute to the stability or recovery of an area after a disturbance:

Table 9. Biodiversity Threats by Subregion (adapted from Jorge, 1999 and FAO, 2000)

Threat	Subregion (as in Table 2) I	II	III	IV	V	VI
Agricultural runoff			*	*	*	
Aquaculture development	*		*	*		
Coral bleaching	*	*	*	?	*	?
Coral extraction (curio trade)	*	*	*		*	
Deforestation				*	*	
Destructive fishing	*	*	*	*	*	?
Diving activities	*		*		*	
Dredging	*		*			
Habitat loss	*	*	*	*	*	?
Heavy extraction of fish	*	*	*	*	*	?
Heavy metal pollution				*		
Hurricanes, storms	*	*	*	*	*	?
Industrial activities		*		*	*	
Oil transport				*	*	
Ports/piers	*		*	*	*	
Ranching				*	*	
Sedimentation/siltation			*	*	*	
Sewage pollution	*	*	*		*	
Ship-generated discharges	*		*	*		?
Tourism activities	*		*	*	*	
Urban development	*		*	*	*	

Seascape and Integrity Features to Evaluate Persistence Value

- Size and intactness of area
- Habitat structure and complexity
- Linkages/proximity/connectivity to adjacent intact ecosystems
- Quality of habitat or assemblage
- Abundance of larval supply/settlement areas/nurseries
- Intactness of trophic structures (e.g., presence/absence of key herbivores, top predators)
- Status of species, populations
- Abundance/density of key species (e.g., *Diadema*, grouper, manatee)
- Presence/absence of top predators
- Susceptibility to large-scale disturbances (e.g., bleaching, hurricanes)

The level of persistence was then ranked as:

- Highest: Would tend to maintain high quality and resilience under current pressures and management regimes.
- High: Would maintain quality and resilience with minimal reduction of human pressures.
- Moderate: Would require a reduction of human pressures and/or minor restoration effort to restore desired resilience and quality.
- Low: Would require major intervention to remove anthropogenic pressures and/or major site restoration and restocking efforts to restore desirable resilience and quality.
- Unknown: Not enough information available to assess likelihood of persistence.

3.4b Persistence Analysis Results

The results of the Persistence Analysis are presented in Appendix C. The inherently dynamic nature of the MACR marine ecosystem contributes to its ability to recover from disturbance events, yet not one of the 26 Biodiversity Priority Areas was ranked as having the highest likelihood of persistence. This suggests that none of these areas would be able to maintain their ecological functions and high quality under current pressures and management regimes; thus, some form of human involvement to improve their resiliency potential would be required. Eleven priority areas were considered to have a high persistence value and 11 were ranked as moderate. Only two priority areas were ranked as having a low persistence value, suggesting that these areas need significant intervention to reduce human impacts and proactive habitat restoration efforts would be necessary to reestablish desirable resilience and quality. Insufficient information was available to rank two priority areas (Banco Arrowsmith (QR4), English Channel (BB5)). Examples of each category of persistence likelihood are presented below.

High Persistence

Most of the Biodiversity Priority Areas with a high persistence rating were intact areas that would require only a slight reduction of current human pressures to preserve their quality of habitat, biota, and ecosystem functioning. Some of the best examples were those priority areas with high swath potential such as Sian Ka'an (SK3) and Gladden Spit (BB6). In addition to their large size, the intactness of key ecological processes contributes to their resiliency. Although some habitat degradation was present in these areas, it was limited in its extent. Their high vulnerability to future global impacts, such as coral bleaching, is likely to be the greatest factor affecting their persistence likelihood. For example, the Gladden Spit Swath Priority Area (BB6) encompasses a diverse mosaic of habitats from shore to reef and has retained intact ecosystem functions such as healthy trophic structures, larval supply, and important cross-shelf habitat linkages. Habitat along the offshore barrier reef shelf is largely intact; nearshore habitats are slightly degraded due to nutrients and pollution from coastal development; and coral bleaching has impacted mid-shelf coral reefs. Fishing activities (e.g., lobster, conch, grouper) have removed some of the largest individuals, but the area has not been overexploited. Despite these disturbances, this priority area has a high potential for preserving the natural character of the offshore reef system; this is less the case for the coastal lagoon. Management actions targeting coastal development and fishing will help restore habitat quality and contribute to this area's ability to recover from future disturbances. Other priority areas, such as the highly diverse biota and rich nursery grounds in Ría Lagartos (QR3) and Río Platano (HG2), have a history of low human pressures and minimal habitat degradation, which contributes to their high likelihood of persistence.

Moderate Persistence

These priority areas have a moderate capacity to adjust and recover from future disturbances and some intervention would be needed to maintain ecosystem integrity and functioning. For example, Chetumal and Corozal Bays Priority Area (SK 5) has moderately degraded habitat quality due to low fish populations, lack of vegetation, and poor water quality, although the area remains a stronghold for manatee populations. This priority area would require a reduction in pollution from these sources to prevent further habitat degradation. Several other priority areas have suffered from human impacts associated with coastal development (e.g., increased fishing, untreated sewage, habitat loss), although many species and habitats have remained in good condition. These impacts would need to be reduced and/or minor restoration actions applied to improve resiliency. The small size and isolated nature of some (e.g., QR6, SK2) of these areas may decrease their resiliency potential, while the larger size and prox-

imity of others (e.g., SK4, BB8) to nearby habitats will contribute to their ability to adapt to change. The only atoll with a moderate persistence capacity was Glovers Reef Atoll, which has experienced a decrease in species abundance, a shift in community structure, and loss of habitat complexity due to disturbances such as coral bleaching, hurricanes, and competition from macroalgae. Glovers is highly vulnerable to future natural disturbance events; thus, the reduction of human pressures (proximate and distant) is of great importance here.

Low Persistence

Only two priority areas were considered to have a low persistence capacity. These priority areas differ in total size, but both have small- to medium-sized patches of intact habitat remaining due to pronounced habitat degradation and fragmentation. The Northern coast of Guatemala and Honduras from Tela to Manabique (HG 5), the second-largest priority area (4,376 km^2) in the ecoregion, has been impacted by the synergistic effects of human activities and natural disturbances (e.g., Hurricane Mitch). Untreated sewage and pollution from port activities at Puerto Barrios/Puerto Santo Tomás de Castilla (Guatemala) and Puerto Cortés (Honduras), and pollution and sedimentation from agricultural and industrial runoff from numerous watersheds (Río Dulce, Río Motagua, Río Ulúa) have degraded coastal habitats and water quality. Continuation of these activities places this priority area at high risk and decreases its resiliency potential. Cancun (QR 5), one of the smallest priority areas in the ecoregion (299 km^2), has experienced considerable disturbance from extensive urban development for tourism, resulting in loss of coastal habitat, eutrophication of coastal waters, excessive sedimentation, and pollution from terrestrial run-off. Elevated fishing pressure due to increased population has affected local fish populations. The small size, pronounced degraded habitat, and possible loss of fish species lowers its ability to withstand or recover from additional disturbances. Both priority areas would require major intervention to remove these anthropogenic pressures as well as proactive measures to restore ecosystem functioning and desirable habitat quality. Contributing to their possible stabilization are their proximity and connectivity to adjacent natural habitats.

Integration of persistence and biological distinctiveness

Future conservation planning strategies often need to consider how to best prioritize actions that will conserve the ecoregion's biodiversity. Subsequent to the workshop, the Biodiversity Priority Areas were categorized into a simple integration matrix (as illustrated in *Dinerstein et al.,* 1995) to account for the integration of biological importance (y-axis) and persistence likelihood (x-axis) (Table 10). Many priority areas with outstanding biological importance had high resiliency capacity and may only need a minimal reduction of human pressures to help maintain their integrity. Priority areas requiring significant management intervention to restore resilience and quality often had lower biological distinctiveness. The integration of both biological importance and persistence potential may help focus conservation planning efforts. The persistence ranking of two areas with a biological importance of "unknown" are not included in Table 10. Swan Islands (HG1) was considered to have a high persistence due to its distance from the mainland, while Rosa/Misteriosa Banks was considered to have a moderate persistence due to continued fishing pressures (HG6).

3.4c Future Threats Analysis

The workshop participants conducted a Future Threats Analysis for each Biodiversity Priority Area. "Future threat", as it pertains to the MACR ecoregion, was defined at the workshop as "The likelihood of a degradation of the status of a particular habitat, community, or population should there be a change in human pressure to the system." The future threat analysis entailed evaluating three broad categories of threats: 1) land-based, 2) marine-aquatic, 3) marine biota, and ranking their severity as high, medium, or low. Criteria specific to the marine environment were developed for each threat category. Future threats were evaluated based on their likelihood of resulting in changes in the next 15 years. In addition, experts discussed the impacts of these threats to biodiversity and ecological functioning, their severity and spatial extent, and the likelihood of recovery or resilience. The final step of the Future Threat Analysis was to determine an overall future threat level. The following is a synopsis of each threat category and the criteria used for the ranking process.

1. Land-based threats: The likelihood that threats originating from land-based activities would result in a loss, degradation, or alteration of terrestrial or marine habitats or processes was ranked as high (potential change of >50%), medium (25-50% change), low (up to 25% change), or no threat (0% change), including:

Table 10. Integration Matrix of Biological Importance and Persistence Value for Each Biodiversity Priority Area

Biological Importance	Persistence Value: High	Persistence Value: Moderate	Persistence Value: Low
Highest	NE Yucatán (QR2) Sian Ka'an (SK3) Banco Chinchorro (SK1) Lighthouse Reef (BB2) Turneffe Islands (BB1) Gladden Spit (BB6)	S. Yucatán (SK4) Glovers Reef Atoll (BB3) Bay Islands (HG3)	
High	Belize City Complex (BB4)	Cozumel (QR1) Central Yucatán (SK2) Chetumal/Corozal (SK5) Sapodilla Cayes (BB8) Port Honduras (BB9) Gulf of Honduras (HG5)	
Priority	Ría Lagartos (QR3) Central Barrier Reef (BB7) Río Platano (HG2)	Tulum Corridor (QR6)	Cancun Corridor (QR5) Tela — Manabique Coast (HG4)

- Loss of coastal habitats (e.g., mangroves)
- Urbanization and associated changes in runoff
- Changes in coastal processes
- Pollution from urbanization, agriculture, shrimp farming
- Increased contamination/consumption of groundwater

2. Marine habitat threats: Threats that would alter or degrade marine habitats and associated processes were ranked high, medium, or low by evaluating expected changes in marine habitats such as:

- Habitat fragmentation, or other barriers to dispersal and general movement
- Loss or disruption of nursery or spawning grounds
- Loss of transition zones or environmental gradients
- Degraded water quality (e.g., point or nonpoint source pollution; changes in temperature, pH, DO, other physical parameters; sedimentation and/or siltation)
- Altered hydrographic integrity (flow regimes, water levels), resulting from surface or groundwater withdrawals, canalization, etc.
- Loss/conversion of riparian/floodplain vegetation
- Excessive recreational impacts

3. Marine biota threats: Threats affecting marine biota were ranked based on the intensity (high, medium, low) of exploitation or disturbance anticipated. The following criteria were evaluated:

- High species mortality and population decreases
- Loss of species richness or diversity
- Poor recruitment or alteration of reproductive patterns
- Shifts in trophic and/or community structures
- Decrease in resilience potential
- Loss of coral reef complexity or structure
- Increased disease outbreaks
- Impacts associated with increased frequency/intensity of *El Niño-La Niña*, hurricanes, etc.
- Competition, predation, or infestations of exotic species
- Unsustainable or illegal fishing or hunting

3.4d Future Threats Results

Results from the future threats analysis for each Biodiversity Priority Area are given in Table 11. The ecoregion is at high risk especially to reduction or loss of key fisheries, coastal habitat degradation or conversion, water quality degradation, and increased stress due to oceanographic and climato-meteorological phenomena. The majority (14) of the Biodiversity Priority Areas were ranked as having high levels of future threats, suggesting they are at high risk to significant alteration or degradation. Nine Biodiversity Priority Areas were ranked as being at moderate risk to future threats. Only one area (Central Barrier Reef) was considered at low risk to future threats. Not enough information was known about two priority areas (Banco Arrowsmith, English Channel) to rank future threats. An integration matrix (Table 12) was created to compare each priority area's biodiversity rank with its future threat.

Table 11. Results of Future Threats Ranking

H=High, M=Medium, L=Low, N=Not Significant, U=Unknown. Biodiversity Priority Area (BPA) codes are as given in Table 5.

BPA	Land+	Aquatic+	Biota=	Future Threat	Source of Future Threats
QR1	M	L	M	M	Tourism, urban development and associated pollutants
QR2	M	M	H	H	Isla Blanca development
QR3	M	M	L	M	Tourism
QR4	U	U	U	U	Unknown, possible overfishing?
QR5	H			H	Tourism, fishery, urban development
QR6	H	H	H	H	Tourism
SK1	N	L	M	M	Tourism, lack of enforcement, coral bleaching
SK2	H	H	H	H	Tourism, population growth, cruise ship activity (including groundings, sewage)
SK3	L	L	M	M	Agricultural pollution, unsustainable fishing if not regulated and enforced, loss of coastal habitat
SK4	M	M	H	H	Tourism, land conversion, overfishing
SK5	H	M	M	H	Pollution from sugar plantation runoff, heavy metals from sugar cane factories' untreated sewage, creation of canal for cruise ships, tourism, illegal hunting of manatees
BB1	L	L	M	M	Maritime activities in English Channel, loss of crocodile habitat to development, overfishing of spawning sites, global impacts on reefs (bleaching, hurricanes), recreational damage
BB2	N	L	M	M	Recreational impacts, increased fishing pressure, some coastal development, global impacts on reefs (bleaching, hurricanes)
BB3	H	M	H	H	Agricultural contaminants (e.g., pesticides) from Gulf of Honduras degrading water quality, global impacts on reefs
BB4	H	H	H	H	Loss of mangrove habitat to development, urban pollution (e.g., sewage) from Belize City, risk of oil spills from ships, agriculture runoff, global impacts on reefs (bleaching, hurricanes)
BB5	U	U	U	U	Unknown, possible shipping? Global reef impacts? Fishing?

chart continues on following page

Table 11. (continued)

BPA	Land+	Aquatic+	Biota=	Future Threat	Source of Future Threats
BB6	M	H	H	H	Increased fishing, tourism, coastal development, aquaculture, agriculture, shipping, population growth, global impacts on reefs (bleaching, hurricanes)
BB7	L	L	M	L	Fishing, global impacts on reefs (bleaching, hurricanes)
BB8	H	H	H	H	Land-based pollutants transported by Gulf of Honduras Gyre, runoff from Guatemala watersheds, fishing (illegal also), recreational activities on cayes, global impacts on reefs (bleaching, hurricanes)
BB9	H	H	H	H	The few remaining reefs are at high risk to global impacts (bleaching, hurricanes), land-based pollution (logging, agriculture), illegal manatee killings, poor water quality from land-based activities transported by Gulf of Honduras Gyre
HG1	N	L	H	M	Fishing
HG2	L	L	H	M	Fishing
HG3	H	M	H	H	Bay Island development (sedimentation, sewage, habitat loss, recreational impacts), global impacts on reefs (bleaching, hurricanes), land based-pollution (e.g., agriculture, shipping), commercial/artisanal fishing on coast and islands
HG4	H	M	M	H	Water quality degradation due to land-based activities (agriculture) and shipping (major ports), coastal fishing
HG5	H	M	H	H	Population growth/urban development near Livingston, overfishing, cattle farms
HG6	N	L	H	M	Fishing

3.5 Seascape Considerations

Having identified Biodiversity Priority Areas and assessed their likelihood of persistence and susceptibility to future threats (Table 13), the experts discussed strategies for developing a long-term conservation plan for the MACR. Historically, conservation efforts have focused on preserving areas important for single rare or endangered species or conserving areas with high species richness or diversity. To assure the long-term persistence of the MACR as an ecoregion, experts were asked to take a broader seascape (equivalent to landscape) perspective with the goal of moving beyond looking at local or subregional features toward considering regional and global forces that shape the integrity of the region's biodiversity. Given the open nature of large tropical marine systems like the MACR and the important role larval dispersal plays, experts needed to consider the linkages between local-scale patterns and processes of biodiversity and regional larger-scale oceanographic and meteorological phenomena. First the experts suggested key seascape features to consider for developing a long-term conservation strategy (Section 3.5a). Then they were asked to identify the specific conservation strategies and actions needed to achieve and measure conservation success over the next one to two years, five to ten years, and 25-50 years (Section 3.5b).

Table 12. Integration Matrix of Biological Importance and Future Threat Value for Each Biodiversity Priority Area

Biological Importance	Future Threat Value: High	Future Threat Value: Medium	Future Threat Value: Low
Highest	NE Yucatán (QR2) S. Yucatán (SK4) Glovers Reef Atoll (BB3) Gladden Spit (BB6) Bay Islands (HG3)	Sian Ka'an (SK3) Banco Chinchorro (SK1) Lighthouse Reef (BB2) Turneffe Islands (BB1)	
High	Cozumel (QR1) Central Yucatán (SK2) Chetumal/Corozal (SK5) Belize City Complex (BB4) Sapodilla Cayes (BB8) Port Honduras (BB9) Gulf of Honduras (HG5)		
Priority	Cancun Corridor (QR5) Tulum Corridor (QR6) Tela — Manabique Coast (HG4)	Ría Lagartos (QR3) Río Platano (HG2)	Central Barrier Reef (BB7)

Table 13. Biodiversity Priority Areas: Biological Importance, Persistence Value, and Future Threat Value

Biodiversity Priority Areas		Biological Importance				Persistence Value				Future Threat Value			
Subregion	# of Priority Areas	Highest	High	Priority	Unknown	High	Moderate	Low	Unknown	High	Medium	Low	Unknown
I	6	1	1	3	1	2	2	1	1	3	2		1
II	5	3	2			2	3			3	2		
III	9	4	3	1	1	5	3		1	5	2		
IV, V, VI	6	1	1	2	2	2	2	1	1	3	3	1	1
Total	26	9	7	6	4	11	10	2	3	14	9	1	2

3.5a Seascape Questions/Answers

Experts developed a series of questions regarding features and issues that need to be considered in order to conserve the MACR seascape. Their suggested questions are as follows:

1. What are the important biodiversity features to consider?

- Diversity of coral reef habitats (e.g., fringing, patch, atolls, bank-barrier, windward vs. leeward, etc.)
- Diversity of inter-related habitats (e.g., seagrasses, mangroves, estuaries, oceanic, etc.)
- Populations of threatened or endangered species

2. What are the important ecological processes?

- Currents, including coastal/nearshore currents, oceanic currents, and gyres
- Connectivity, larval source-sinks
- Role of offshore atolls with shelf reefs
- Impacts of hurricanes and other major disturbances
- Atmospheric and oceanographic conditions and their effect on or role in marine systems
- Herbivory and trophic dynamics
- Competition for space and nutrients

3. What are the main disturbances?

- Overfishing, which can result in:
  - Changes in trophic dynamics (loss of predators and/or herbivores)
  - Changes in benthic community structure (phase shifts/algal domination)
- Disease outbreaks, which can result in:
  - Loss of keystone species (like *Diadema*)
  - Reduced abundance of affected species (acroporid corals)
- Meteorologic or climatic events (like coral bleaching and hurricanes), which can result in:
  - Demise of corals
  - Coral disease outbreaks
  - Increased terrestrial run-off

4. What are the main considerations regarding MPA design?

- Connectivity
- Representativeness of all habitat/community types (ecoregional scale)
- Size of protected areas – suggest several large areas
- Groundwater influx (e.g., Sian Ka'an, Ambergris Caye, etc)
- Role of Swan Islands/offshore banks and atolls
- What reefs are sources or sinks for the ecoregion?
- What reefs support critical fish spawning aggregations and/or threatened species?
- Protected area system to include reefs at various depths and under different environmental conditions (turbidity, water flow, etc.) to serve as a potential buffer for the impacts of future bleaching events

5. What further considerations are needed to promote adaptive management of MPAs?

- Advance alternate hypothesis testing (sound scientific methods)
- Include testing on a range of reef systems and species (e.g., closed vs. open reefs; species with brooding vs. broadcasting (long distance dispersal) reproductive strategies, etc.)
- In addition to priority areas, have alternate areas identified to act as potential "re-seeding" areas in case of severe catastrophe (e.g., NQR experts selected Punta Maroma as an alternate to PA QR 5-Isla Mujeres to Puerto Morelos)
- Cross-shelf integration of terrestrial (especially existing protected areas) and marine systems, incorporating "ridge-to-reef" perspective
- Alternative uses for protected areas/multiple-use zoning
- Provide training in adaptive fishing methods and economic alternatives to fishing
- Study the impacts of tourism within MPAs

3.5b Conservation Success in MACR: Responses, Strategies, and Benchmarks

As a way of achieving and measuring conservation success in the MACR, the experts identified options for threats, including responses, strategies, and benchmarks. Responses included short-term actions (one to two years) and were considered urgent and necessary for future actions. Strategies were actions that could be completed in five to ten years and pointed toward meeting the ecoregional vision. Benchmarks of success included long-term indicators that fulfilled the ecoregional vision and could be completed within 25-50 years. The socioeconomic group took a broader ecoregional perspective (Table 14). The four subregion groups (NQR, ASK, BBR, and GH) focused on specific recommendations for their respective subregions, although there was some variation in the interpretation of this process. The results of these discussions follow:

Table 14. Socioeconomic Group's Recommendations for Achieving Conservation Success (Regional Perspective)

Threat	Response (1-2 years)	Strategy (5-10 years)	Benchmark of Success (25-50 years)
Destruction of coastal habitats (mangroves, lagoons, wetlands) critical for reproduction of marine fauna and maintenance of marine ecosystems.	Stop degradation of key habitats (e.g., mangrove stands in S. Belize).	Implement coastal management plan to conserve critical coastal habitats and restore those habitats that have become severely degraded.	Conserve or restore at least X percent of critical coastal habitats (target values to be determined for each coastal subregion).
Reduced water quality.	Map and target all sources of water-borne pollutants (e.g., untreated sewage and contaminants carried by runoff) in MACR.	Implement integrated system for monitoring all water-borne pollutants in MACR.	Reduce current inflows of water-borne pollutants in MACR by X percent (target values to be determined for each subregion).
Loss of fish populations and other marine species.	Identify critical areas to be designated as no-take zones in MACR.	Enforce the implementation of no-take zones and designate additional artisanal fishery zones for sustained management by local communities.	Restore fish productivity in MACR to targets defined subregionally.
Stress due to oceanographic and climatological phenomena.	Establishment of integrated coastal zone monitoring program with uniform parameters, data collection, and analytical methods, networked throughout MACR and with other major reef ecoregions worldwide.	Recuperate shorelines and critical coastal environments in MACR (mangrove, beaches, etc.) for enhanced defense from storm events.	Lower emissions of greenhouse gases from major industrialized countries, develop target value for each country.

Subregion I. North Quintana Roo

Threats

- Urban development
- Tourism development
- Fisheries

Responses (up to 2001)

- Initiate studies to characterize the region's hydrology
- Implement a system of sewage water treatment plants, including primary and tertiary treatment
- Investigate the implementation and effectiveness of urban and tourism development planning and regulations on the environment (e.g., habitat modification, groundwater, illegal fishing)
- Analyze the feasibility of implementing a National Biosphere Reserve (Chamochuc, Yalahau, humedales)
- Implement fishing regulations
- Characterize the habitat and diversity of Banco Arrowsmith

Strategies (up to 2010)

- Implement the National Protected Area Systems

Subregion II. Sian Ka'an

1. Gather key information while engaging in planning process

Immediate

- Create regional interactive database of research/information
- Develop prioritized list of research needs
  - Oceanography
  - Water/groundwater flows
  - Smaller biota (as indicators of deterioration)
  - Continue data-gathering on corals, birds, mammals, reptiles, fish, lobster, conch, etc.

2. Reduce pollutants at their source

Immediate

- Initiate monitoring system to measure (and understand) pollutant flow/dynamics across water systems
- Develop scientific biomonitoring methods to understand flows, intensity, etc. and identify places at risk
- Implement monitoring system
- Identify target areas for mitigation of sewage impacts

Use the Chetumal Bay area as an area that needs immediate attention.

Immediate

- Analyze core sediments and vegetation in Chetumal Bay and other bays, present and historic
- Begin citizens' monitoring in 2010
- Establish region-wide monitoring program
- Change policy from deep-well dumping to wetland system with sewage treatment system

3. Strengthen marine protected areas network

Immediate

- Provide support for strengthened capacity for enforcement of existing parks and regulations (e.g., more personnel, equipment)
- Consolidate existing advisory committees to parks that have representatives from users/interests (e.g., increase staff; increase/improve mechanisms between researchers and managers) — link these to a regional agenda

2010

- NAFTA — link with MPA effort

2050

- Mainstream MPA into ICM

4. Encourage appropriate development

Develop strategies for planning and implementation that is regionally integrated (i.e., has both conservation and economic development interests at the table). Ensure that mechanisms are in place to anticipate the wave of tourism development.

Immediate

- Schedule a workshop on setting management priorities for southern Quintana Roo
- In preparation for the workshop, complete assessment of development trends overlaid on biological priorities
- Work with existing strategies: for example, the development plan for the Mayan Coast is opening up for more involvement from other sectors.

5. Strengthen policy framework

Immediate

- Undertake assessment to identify existing regulations; level of enforcement and capacity to enforce; recommendations for new and adapted policies
- Work toward new and adapted policies such as restricting the use of toxic agricultural pesticides

2010

- Develop capacity to transfer knowledge on sustainable agriculture practices

6. Increase communication and collaboration

Immediate

- Improve links among existing programs (MBRS, etc.)
- Establish link with other regional and international initiatives (e.g., NAFTA)

Subregion III. Belize Barrier Reef Complex

Develop an overall Coastal Zone Management Strategy, focusing on and incorporating three primary areas:

- Integrated coastal management (management unit should include the whole EEZ)
- Establishment of a representative MPA network (use full range of options)
- Improved fisheries management

The following criteria could help guide the development of the MPA network:

- Use of standard conservation biology principles
- Selection of high quality habitats
- Connectivity (capture fisheries) – life histories of key species
- Inclusion of prime areas (spawning aggregations, etc.) along with alternate areas, to be used for security purposes in case of major disturbances

- Incorporation of traditional ecological study areas, such as high quality, high diversity, long-term datasets
- Paying special attention to species of concern (e.g., conch, lobster, sea turtles, manatee)
- Incorporation of "hot spots" or critical nursery areas, habitat for adults
- Conducting a representation analysis for the MPA system

Adaptive management needs

A well-designed, fully functional monitoring system to provide clear feedback for adaptive management of the designed network is needed. We have made a good start on the network but need to implement the monitoring in a systematic program, including monitoring of benchmarks and milestones of management and potential revision of the network.

Specific critical recommendations

- All spawning aggregations must be strictly protected
- A significant percentage (20 - 50%) of priority areas must be strictly protected
- 100% of highest priority areas must be strictly protected.

Data gaps

- Manatees: questions about most viable populations
- Saltwater crocodiles: questions about most viable populations
- Other coastal migratory species: questions about most viable populations
- Coral reef health and ecosystem function/responses

Assumption

Stakeholders involved

Subregions IV, V, and VI: Gulf of Honduras, Northern Honduras Coast, and Open Ocean

Threats

- Lack of information
- Loss of habitat
- Water quality deterioration
- Over usage of resources

Responses (up to 2001)

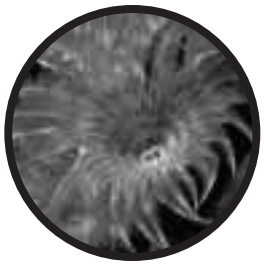
- Gain the approval of the legal decrees for the protected areas: Punta Izopo, Laguna de Guaymoreto, Jeanette Kawas National Park, wetlands between Puerto Cortés and Tela, Cayos Cochinos and West End in Honduras; Temash-Río Dulce and Punta de Manabique in Guatemala
- Systematic monitoring of the resources and their management (design) primarily on the Islas del Cisne, Misterioso y Rosario Banks and drains of larva benchmarks bodies in the islands
- Profile the current situation of the subregion in the biological, ecological, technological, economic, legal, social, and institutional fields, giving priority to the areas already identified as most important

Strategies (up to 2010)

- Design, implementation, and monitoring of the management plans recommending the integrated ordering of the coastal and marine zones in the priority areas
- Political lobbying of strategies
- Development of research projects to document the ecological and economical importance of the identified zones, especially those having little information

Benchmarks of Success (up to 2050)

- Optimum water quality
- At least 50% of the hydrographical watersheds are under efficient management (i.e., they are sustainable)
- At least 75% of the fishing extraction area has a mechanism with rules and incentives to help the activity and resources mainly in the use of economic instruments
- A protected areas system is in operation



Section 4

Representativeness of Priority Areas

A principal strategy in conserving the MACR ecoregion is to preserve and maintain biodiversity and ecological processes by ensuring a full range of representative habitat types within a system of protected areas. To support this strategy a simplified area analysis was conducted to estimate the size and distribution of principal habitat categories in the Biodiversity Priority Areas. Data layers used in this analysis included bathymetry, elevation, bottom type (based on Landsat-TM), and cross-shelf strata. All calculations were made using scripts within Arcview 3.2. The accuracy of the calculations depended on the availability and quality of the original data (see Appendix A). Many areas did not have benthic habitat information available, so in some cases potential habitat area was calculated partly from a habitat map and partly from estimates based on bathymetry and cross-shelf location. Calculating potential area (especially for coral reefs and seagrasses) presents a uniform platform for comparison between the areas, as well a baseline to use for verifying accuracy. The raw data is provided in the tables below. It is hoped that this information will be useful in future efforts to examine the distribution and diversity of habitats and reveal gaps in representation, as well as in efforts to verify the accuracy of available data.

4.1 Size of Biodiversity Priority Areas

Broad area calculations were estimated for each Biological Priority Area then, compared to the Biological Importance, Persistence, and Future Threat ranking results (Table 15). The total area selected for conservation as priority areas was 39,599 km^2 and varied by subregion: Subregion I (2,812 km^2), Subregion II (9,020 km^2), Subregion III (5,878 km^2), and Subregions IV, V, and VI (21,888 km^2). Most (30%) priority areas in the ecoregion were small, between 100-500 km^2 in size. The two largest priority areas were Bay Islands (HG3) and Tela–Manabique Coast (HG4). The Highest Priority areas ranged in size from 300

Table 15. Size and Number of Priority Areas by Biological Importance, Persistence, and Future Threat

Biodiversity Priority Areas		Biological Importance				Persistence Likelihood				Future Threat			
Size of area	No. of Priority Areas	Highest	High	Priority	Unknown	High	Moderate	Low	Unknown	High	Medium	Low	Unknown
0-100 km^2	1		1				1				1		
101-500 km^2	8	2	2	4		3	4	1		5	2	1	
501-1000 km^2	4	2	1		1	2	2			2	2		
1001-2000 km^2	4	2	2			3	1			3	1		
2001-3000 km^2	2	1		1		2				1	1		
3001-4000 km^2	3	1	1		1	1	2			1	2		
4001-5000 km^2	1			1				1		1			
>5001 km^2	1	1					1			1			
Unknown area	2				2				2				2
Total	26	9	7	6	4	11	11	2	2	14	9	1	2

to almost 10,000 km^2. High Priority areas ranged from 90 to <3000 km^2. Priority areas ranged from 100 to >4000 km^2. The size of only two "Unknown" priority areas was calculated: Swan Islands (781 km^2) and Rosa/Misteriosa Banks (3,126 km^2). The likelihood that a priority area would persist did not necessarily correlate to its size. For example, areas with high persistence likelihood ranged from small (101-500km^2) to fairly large (3,001-4,000 km^2). Similarly, the ranking of future threats did not clearly coincide with the size of the BPA, although the majority of areas were considered at high risk to future threats. Further analyses of these data are needed.

4.2 Habitat Estimates

The total area (km^2) of broad habitats, including land/watershed (over 5m elevation), deepwater, mangrove, lagoon, lake, coastal zone, and coastal shelf, was calculated for the MACR Ecoregion (Table 16). The coastal zone was defined as land area that is 5 m or less in elevation and the adjacent marine area to a depth of 30 m. The coastal shelf was divided by elevation/depth into: a) +5 to 0 m area (intertidal/land); b) 0 to –10 m area; and c) -10 to –30 m area. Some overlap occurs between categories, but the total area does not include overlap (i.e., no areas were counted twice). Based on the MACR Ecoregion boundaries (Figure 2b), the total size of the ecoregion is approximately 464,263 km^2, with 192,282 km^2 (~ 50%) of land >5 m elevation and 241,317 km^2 (~ 40%) of deep (>30 m) water. The remaining 46,223 km^2 (~ 10%) are coastal shelf areas, which support most of the region's known marine biodiversity. There are approximately 3,655 km^2 of mangroves along the ecoregion's coastline. Estimates of habitat were calculated by subregion (Table 17). The most extensive mangrove area (2,181 km^2) is found in Subregion II (Sian Ka'an-Ambergris), while the largest inland lagoon area (782 km^2) is found in the Gulf of Honduras (Subregion IV). Subregion V (Northern Honduras Coast/Bay Islands) and Subregion II (Sian Ka'an-Ambergris) have the largest reef crest areas, although calculations are difficult to verify due to the lack of available data for Mexico, and because the Bay Island/Honduras coast classification has not been verified through groundtruthing. Habitat estimates are also provided for each Biodiversity Priority Area (Table 18).

Table 16. Habitat Estimates for the MACR Ecoregion

Habitat Category	Total Area (km^2)
Land	192,282
Deep water	241,317
Mangrove	3,655
Lagoon	1,707
Lakes	671
0 – -10 m area	15,845
-10 – -30 m area	12,373
+5 – 0 m area	18,005
Area of coastal zone	46,223
Total area in MBRS	464,263

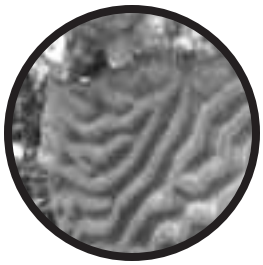
Table 17. Habitat Estimates by Subregion

Subregions	Inland Lagoon Area (km^2)	Mangrove Area (km^2)	Reef Crest Area (km^2)	Total $0 - {}^{-}10$ m Area (km^2)	Total $^{-}10 - {}^{-}30$ m Area (km^2)	Total $^{+}5 - 0$ m Area (km^2)
1. Northern Quintana Roo	127	396	12	3680	4288	4313
2. Sian Ka'an – Ambergris	343	2181	30	4604	1304	6622
3. Belize Barrier Reef	175	458	19	4529	2532	1606
4. Gulf of Honduras	782	212	0	856	1269	3863
5. N. Honduras Coast	277	401	35	1369	2969	1609

Table 18. Habitat Estimates by Biodiversity Priority Area

Area codes are as given in Table 5.

Bio-diversity Priority Area	Total Area (km^2)	Coastal Zone Area (km^2)	Terrestrial Area (km^2)	Deep Water Area (km^2)	Island Lagoon Area (km^2)	Estimated Number of Lagoons	Mangrove Area (km^2)	Total 0-$^{-}$10m Area (km^2)	Total $^{-}$10–30m Area (km^2)	Total $^{+}$5–0m Area (km^2)
QR1	90	88	0	2	3	5	0	32	14	42
QR2	2189	1838	351	0	49	2	242	1150	64	623
QR3	122	122	0	0	44	3	0	19	0	103
QR5	299	299	0	0	41	2	46	119	45	135
QR6	113	51	0	62	0	0	0	22	15	15
SK1	1065	903	0	162	0	0	6	641	225	37
SK2	221	138	0	83	7	13	44	41	31	65
SK3	3623	3126	258	239	137	105	967	1261	320	1545
SK4	903	641	0	262	53	31	142	263	81	297
SK5	3209	3100	109	0	127	65	408	1865	0	1236
BB1	678	667	0	11	0	0	112	478	71	117
BB2	398	355	0	43	0	0	5	285	57	12
BB3	299	299	0	0	0	0	0	265	30	4
BB4	1403	1246	133	24	80	4	135	860	50	336
BB6	1808	1720	47	39	35	10	32	667	668	385
BB7	418	371	0	48	0	0	12	298	41	32
BB8	505	338	0	167	0	0	0	188	150	0
BB9	370	300	70	0	14	2	53	162	57	81
HG1	3126	43	0	3083	0	0	0	0	43	0
HG2	2075	1647	68	360	205	16	281	317	674	656
HG3	9979	2338	335	7306	40	4	111	419	1891	27
HG4	4376	2321	739	1316	58	13	171	881	887	553
HG5	1552	267	1285	0	50	2	34	49	0	217
HG6	781	50	0	731	0	0	0	11	12	27



Section 5

Data Availability and Information Gaps

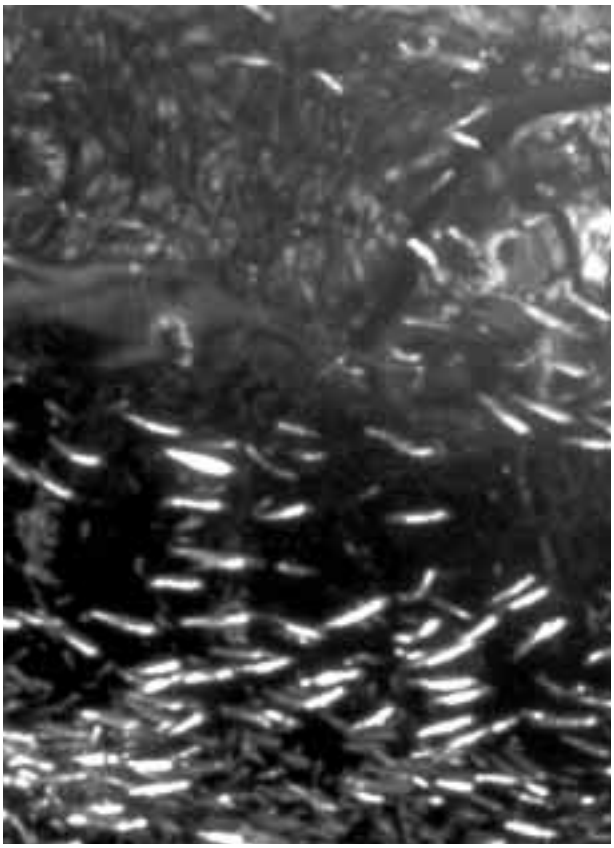
Our ability to conserve MACR biodiversity depends largely on our understanding of key issues and our assimilation of critical data. Considerable information was synthesized for this workshop, but the challenge remains to fill in the data gaps and verify or update existing information. Workshop experts identified the principal data gaps, focusing on those of the highest priority. Several-cross cutting themes of critical data needs emerged, including status and condition of key habitats and organisms, status of key fisheries, water quality and sources of contamination, land conversion and sustainable development, and effects of and vulnerability to global climate change. Creation of an effective adaptive management strategy for conserving the region's biodiversity will require a regional approach to long-term monitoring and experimental research.

Status of Coral Reefs

A regional comparable monitoring program needs to be implemented to identify, characterize, and monitor the extent and condition of coral reef habitat and associated organisms. Significant information gaps remain for Swan Islands, Arrowsmith Bank, and mainland Guatemala and Honduras. Studies on coral reef recovery, reef vulnerability, and resiliency, especially in response to climate change, are urgent priorities, particularly given the recent impacts of the 1998 coral bleaching event and Hurricane Mitch. Understanding the ecological processes (such as larval transport and trophic structure) that contribute to reef health is imperative. Physical oceanographic and climatological data is urgently needed for coastal and oceanic currents, circulation patterns and water temperature trends and patterns. Also of high priority is the identification of areas that warrant immediate protection, in particular those with high biological productivity; sources/sinks of larval corals, fishes, and other important reef organisms; biodiversity hot spots; nursery and breeding areas; and areas at high risk of human impacts. Ecological connections between reefs and adjacent coastal ecosystems also warrant further investigation.

Major habitats

Coral reef, mangrove, and some seagrass distributions of the ecoregion have been mapped using remote sensing techniques, although verification of accuracy is needed. Coral reef distribution is well-documented for Belize and localized areas in Mexico, while groundtruthing and verification of Bay Island coral reef maps created for this workshop remain to be done. Much of Mexico's coral reefs and nearshore areas of Guatemala and Honduras still need to be mapped. The accuracy of mangrove distribution needs to be verified and corrected for the entire ecoregion. For example, many forested areas along the coast of Honduras and Belize are classified as mangroves, but are often mixed



with or dominated by contiguous broad leaf flooded forest (*Pachira acuatica*). We still lack sufficient information on the status of mangroves, lagoons, bays, and wetlands. The distribution and condition of seagrasses is poorly known throughout the entire ecoregion, primarily because of the limitations of remote sensing techniques. The group of seagrass specialists attending the workshop suggested the use of a plastochrome index as a simple, inexpensive technique for monitoring seagrass bed health and offered to collaborate on implementing a standardized ecoregional seagrass monitoring program. Information is needed on the relationships of organisms that spend sequential parts of their life cycle in different habitat types (e.g., ontogenetic migrations) for all the major habitats.

Fishes/Priority Guilds

Our scientific understanding of key fish species (snapper/grouper complex, estuarine, reef, and pelagic fishes) varies in the ecoregion. Basic information on growth and reproductive parameters is often lacking. Of highest priority are studies that identify and investigate juvenile nursery areas, spawning sites, larval transport pathways, and migration corridors, particularly in areas like Gladden Spit (spawning), Isla Contoy (upwelling/pelagics), Río Platano (estuarine), Sian Ka'an (nursery), and offshore banks (e.g., Arrowsmith, Misteriosa). Substantial information is available for many Caribbean reef fish species, but little exists on species abundance and distribution, utilization of cross-shelf habitats, and interconnections between reefs within this ecoregion. Because of its economic importance, the conch and lobster fishing industry is better documented than the status and distribution of remaining conch and lobster populations; thus ecoregional inventories are urgently warranted. Important nursery grounds need to be identified and monitored and areas with known large populations (e.g., conch in Banco Chinchorro, lobster in Sian Ka'an) need immediate surveys, as do less known areas like Swan Islands and Misteriosa/Rosa Linda Banks. Fishery statistics are available for the ecoregion, although they differ considerably by country and species. Uniform reporting standards and yearly updates for fishery statistics would be beneficial. Specific data on fishing activity (e.g., number of fishing boats, effort, catch volume); exploitation of nursery and spawning areas; artisanal, sport, and destructive or illegal fishing practices; and economic alternatives to fishing (e.g., catch and release) is needed. Due to their small size and cryptic nature, very little is known about reefal cryptofauna in the ecoregion. A review of distributions from the literature and museum collections would provide an excellent and inexpensive overview of these species to help identify priority areas for immediate surveys.

Focal Species

Monitoring of endangered and vulnerable species varies in the subregions and a regional monitoring program is warranted. Well-established West Indian manatee monitoring efforts exist in Belize and Mexico and need to be continued, while baseline and monitoring efforts need to be implemented in Guatemala and Honduras. A pressing issue is the extent of illegal killings of manatees (Belize/Guatemala). Minimum viable population (MVP) analyses are essential for endangered species like the West Indian manatee and American crocodile. Data gaps exist on crocodile nesting ecology, dispersal and survivorship of hatchlings, population density, interaction in human populated areas, and population genetics. Availability of sea turtle information varies in the ecoregion; surveys are needed on the number of nests per kilometer, quality of foraging and nesting habitat, habitat requirements, illegal fishing, and impacts of coastal development. Two priority areas include important nesting beaches at Punta de Manabique, Guatemala and Cozumel, Mexico. Information about island-terrestrial endemics is very limited, and is based primarily on anecdotal reports. Rapid assessments are needed throughout the ecoregion, especially for poorly known areas like Swan Islands and Barbareta, Honduras.

Socioeconomic/management concerns

Impacts of anthropogenic activities on the region, particularly those involving land use, water quality, and fishery impacts, are poorly understood. A better understanding of the status of coastal development, including current and projected land use, land cover (e.g., forest wetlands, croplands, shrimp aquaculture (Belize)), land tenure (e.g., Quintana Roo, Honduras), land carrying capacity (e.g., Bay Islands, numerous cays), tourism (e.g., Bay Islands, Ambergris, Cozumel), and industrial and agricultural activities (especially transboundary activities) is

needed. Improving our understanding of water quality is of utmost importance and a regional monitoring plan focusing on status of water quality, point and non-point sources of contamination, discharge and flow rates (e.g., Aguán River, Honduras, Chetumal Bay, Mexico), and transboundary pollution needs to be implemented. Data availability and quality on current human population density (e.g., coastal communities, proximity to urban centers, and roads) could be improved. Information on tourism is lacking and surveys need to focus on the number of tourist rooms, location of diving sites, fleet data, and cruise operators in the area. Improved documentation on the impacts of the oil industry and pipelines (e.g., Puerto Cortés, petroleum derivatives, smaller pipelines) and of maritime activities, especially major ports (e.g., Belize City, Big Creek, La Ceiba, Trujillo) is needed. As mentioned earlier, collection of fisheries data needs to be improved, especially as it pertains to catch data, status/distribution data, and effects of fishing regulations. Other data gaps include how human impacts interact with natural disturbances like hurricanes (e.g., revenue loss to fisheries and tourism industries) and their subsequent effect on biodiversity. Potential and future threats, such as tourist growth, population growth, and roads with electric lines, need to be identified and monitored. An evaluation of management effectiveness, potentially based on the WWF/CATIE methodology that has been applied to MPAs in Belize (McField, 2001b), is needed for MPAs throughout the ecoregion. In designing marine protected areas, human "exclusion" or "no use" experiments should also be incorporated. Opportunities to incorporate local communities in examining sustainable resource use also exist.

Section 6

Conservation Opportunities

6.1 WWF and the MACR

Recognizing the ecological, aesthetic, cultural, and economic value of the region's coral reefs, the leaders of Mexico, Belize, Guatemala, and Honduras signed the Tulum Declaration in June 1997, launching the Mesoamerican Barrier Reef Initiative (MBRI). The primary objective of the MBRI is to promote the conservation and sustainable use of the Mesoamerican Barrier Reef System (MBRS) and to ensure its continued contribution to the ecological health of the region and the livelihood of present and future generations.

World Wildlife Fund (WWF) played a key role in developing an Action Plan for the MBRI at the first meeting of the Mesoamerican Barrier Reef Congress (November 1997). In response to and in line with the specific conservation targets developed for the MBRI, WWF is involved with projects that focus on the development of a regional system of protected areas, improving regional fisheries management, providing science for management decision-making, building institutional capacities, and conserving key species and habitats. The creation of the MACR Biodiversity Database and the MACR Conservation Planning Workshop described in this report are part of this effort.

The MBRI is supported by several different projects and programs involving local and international NGOs and governmental agencies. The World Bank/Global Environmental Facility's "Conservation and Sustainable Use of the Mesoamerican Barrier Reef System (MBRS)" project provides $11 million in funding over five years in three main areas: (1) facilitating the harmonization of relevant policies and regulations related to sustainable management of shared/transboundary resources; (2) strengthening the system of MPAs in the MBRS; and (3) building capacity through training, environmental education, and improved information systems. Government departments, marine protected areas staff, local NGOs, and international institutions will implement most MBRS project activities. The entire MBRS initiative, including funding from the national governments, the GEF project, World Wildlife Fund, the Oak Foundation, the Summit Foundation, and the University of Miami, totals more than $24 million, illustrating the global interest and significance of this ecoregion.

WWF's MACR initiative seeks to complement other efforts by filling gaps and meeting additional conservation needs as identified through this process of ecoregional conservation planning. WWF's successful track record of conservation management can assist in leveraging additional funding sources for the ecoregion. While the WWF program is focused on established conservation priorities, it is also dynamic and responsive to changes in the environmental or socio-political context within the ecoregion. The geographic boundaries of WWF's Mesoamerican Reef Ecoregion and the GEF MBRS Project are similar, although WWF's area also includes the offshore Swan Islands and Misteriosa/Rosa Linda Banks in the south and the productive upwelling area off the northern Yucatán Peninsula.

WWF continues to collaborate with other organizations involved with the MBRI such as the International Union for the Conservation of Nature (IUCN), Ocean Research and Education Foundation (ORE), the University of Miami (RSMAS), the Oak Foundation, The Nature Conservancy (TNC), and the Wildlife Conservation Society (WCS). WWF's MACR team includes representatives in each country, with expertise in coral reef ecology, fisheries management and protected area management. The team provides technical expertise to local conservation partners, governments, and other regional programs, and oversees implementation of projects with partner organizations.

The relatively low state of development and overall good environmental quality of most of the ecoregion provides a unique conservation opportunity to prevent the kinds of ecological damage that have occurred in similar habitats in other parts of the world. The region's value as an ecotourism destination can provide long-term economic benefits to local populations, including several traditional cultures, if ecosystem integrity is maintained. However, numerous large-scale, unsustainable coastal developments are currently being initiated.

The region has reached a socio-economic and environmental precipice regarding the form of development that will be pursued. WWF is addressing these issues within a sustainable tourism development research project (see below), which will identify socio-economic and environmental trends associated with this growing industry and make informed policy recommendations.

Building on its global experience, WWF works to foster sustainable development and provide the technical and financial resources needed to continue and expand conservation efforts. Given WWF's tradition of supporting Marine Protected Areas (MPAs) and Conservation Science, it is envisioned that WWF will work with local partners, governments, and research institutions to obtain the necessary information to design and implement a truly representative regional network of MPAs. Support for the management of existing and proposed MPAs is being provided in several locations throughout the MACR, and one preliminary reef survey is being conducted to compare reef structure, health, and recovery in the wake of hurricane and coral bleaching disturbances. Other studies to address the resiliency of different reefs to the effects of global climate change, and their inclusion in the network of MPAs, are also envisioned.

Finally, WWF is fostering the development of a regional environmental trust fund, which will assist in the provision of long-term financial sustainability for these conservation initiatives. More immediate financial solutions and mechanisms will be discussed at a regional training workshop on sustainable financial mechanisms for MPAs.

A shortlist of WWF'S program in the MACR for 2002-2003 includes:

- Strengthening management effectiveness of Amigos de Sian Ka'an (MX), Banco Chinchorro (MX), Xcalak (MX), Gladden Spit (BZ) Reserves, and Cayos Cochinos (HO)
- Studies on "limits of acceptable change" in relation to tourist visitation at Xcalak and Hol Chan (BZ)
- Establishment of a marine protected area at Cayos Cochinos
- Development of an ecoregional sea turtle conservation plan
- Development of transboundary management strategies among the four governments to strengthen cooperation and coordination for sustainable lobster and conch fisheries
- Lobster fishery certification process in Banco Chinchorro
- Promotion of sustainable tourism through research into the relationship between tourism and demographic change, including socio-economic, cultural, and environmental factors
- Assessment of socioeconomic, political, and institutional capacity in the region
- Ecoregional comparative study of coral reefs involving regional scientists
- Studies on coral reef recovery, reef vulnerability, and resiliency assessment for climate change
- Developing a long-term interdisciplinary marine and coastal research and training agenda for the ecoregion
- Cross-visits and exchanges of artisanal fishermen and protected areas managers
- Development of ecoregional finance mechanism for a regional environmental trust fund
- Hosting a regional training workshop to discuss specific financial mechanisms for sustaining marine protected areas based on a Global WWF initiative.

6.2 Ecological Vision for MACR

The purpose of Ecoregional Conservation is to create a common ecological vision—an ambitious template to ensure the conservation of the full expression of biodiversity in the ecoregion. This vision is the reference point or the framework for determining how a conservation effort in a particular site contributes to the biological integrity of the entire ecoregion. The Ecological Vision of the MACR will be finalized during an Ecological Vision/Action Plan Workshop to be held in 2002, at which time the draft ecological vision and vision statement will be revised and finalized. The vision will guide conservation efforts toward accomplishment of four fundamental conservation goals:

1. Representation of all distinct natural communities;
2. Maintenance of ecological and evolutionary processes;
3. Maintenance of viable populations of species; and
4. Resiliency in the face of large-scale periodic disturbances and long-term change.

Some of the themes that were discussed in Cancun and will be further developed at the Ecological Vision/Action Plan Workshop include:

- The MACR must be viewed as one ecological system and managed holistically.

- Comparative studies of the entire ecoregion on reef status, critical ecological processes, population dynamics and abundance of focal species, environmental impacts, and pollutants are needed. Studies should also address alternate hypothesis testing, where applicable.
- Integrated studies of the current patterns in the region, including coastal/nearshore currents, oceanic, and gyres are needed in order to better understand connectivity and larval source-sinks of this ecoregion and its relation to the greater Caribbean Basin.
- The socioeconomic factors, which are the overarching root causes of environmental degradation, need to be addressed with targeted actions.
- The governments of Mexico, Belize, Guatemala, and Honduras need to work together to harmonize legislation and conservation management efforts. In addition, local and international NGOs need to strengthen ecoregional and transboundary cooperation and coordination on conservation and sustainable use of shared resources.
- Recognizing that there will be increased tourism and other development in the region, the aim is to balance the need for economic growth while maintaining ecological integrity, through sound coastal planning and sustainable development.
- Across the ecoregion, the fast pace of economic and social change threatens the region's remaining biodiversity. Specific "hot spots" of coastal development need to be identified and planning efforts supported. Furthermore, "biodiversity hot spots," especially those with high biological productivity, nursery and breeding areas, and those at high risk of human or natural impacts, need to be identified and immediate conservation efforts must be applied.
- Building on the existing marine protected areas in the ecoregion, identify gaps in the representativeness of ecosystems and ecological processes and assist in the development of a truly representative and holistic ecoregional network of MPAs. The network must also be integrated with the system of terrestrial protected areas through the linked coastal and upland watershed areas.
- Develop and achieve sustainable adaptive fishing techniques and economic alternatives to fishing, especially in and around marine protected areas.
- Acknowledging the role that global climate change (e.g., coral bleaching) has played in the degradation of the region's reefs, develop some actions to address this global concern.

6.3 Draft Vision Statement

The following draft ecological vision for the Mesoamerican Reef Ecoregion was developed through the ideas presented and discussed by the local and international experts during this workshop. The follow-up workshop in 2002 will finalize this vision statement, and consolidate the ecological vision and action plan.

Draft MACR Ecological Vision

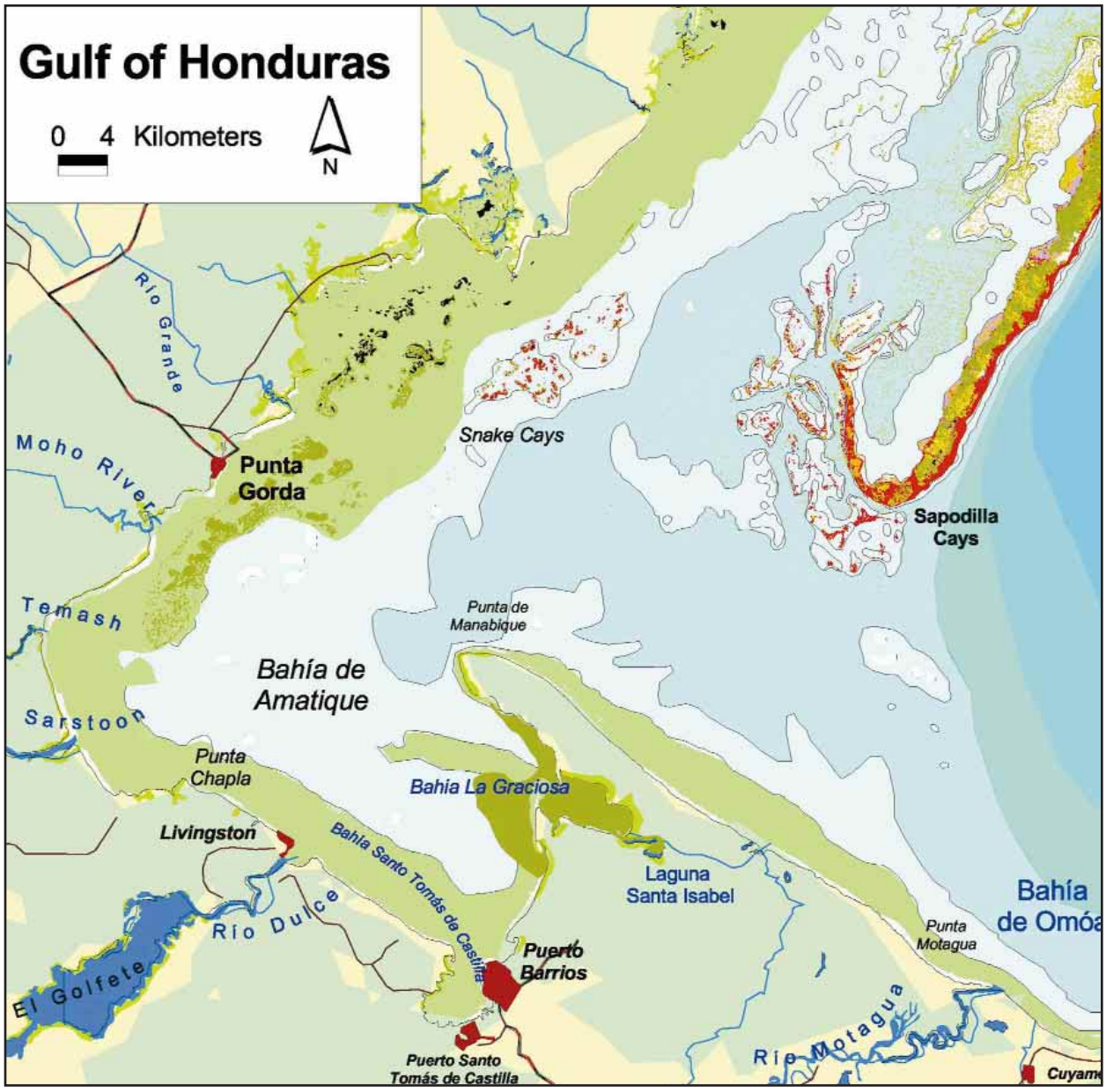
Our vision for the Mesoamerican Caribbean Reef is to ensure that the ecoregion's diverse marine resources and interdependent ecosystems are maintained, allowing local people to benefit from long-term sustainable development that coexists with natural ecosystems, promotes social welfare, and allows for the preservation of local cultures. The foundation of our conservation efforts lies in the creation of a truly representative and interconnected regional system of marine protected areas, capable of maintaining vital ecological functions and restoring depleted and threatened populations. Our efforts must also be incorporated into the broader context of integrated and adaptive coastal zone management, balancing the needs and actions of various stakeholders with those of the ecosystems. Given that threats to the ecoregion emanate from local, regional, and global sources, our conservation efforts must occur on all scales in order to minimize anthropogenic stress and maximize natural resiliency of the ecosystems and populations in order to ensure their long-term preservation.

MACR Biodiversity Database and Maps

A comprehensive regional synthesis of significant ecological, biophysical, and socioeconomic data was created in a Geographic Information System (GIS). This information was combined to produce several large (3'x3') thematic maps used as reference tools at WWF's Ecoregional Conservation Planning and Priority Setting Workshop held in Cancun in April 2000. Workshop maps were printed at two spatial scales: large-scale maps of the entire ecoregion were printed at 1:1 million and subregion maps were printed at 1:250,000. Simplified examples of these maps are provided in this appendix; however, because of the size reduction of maps for this report, much of the detail of the original maps has been removed. Background information explaining how the database was compiled and origin of data sources follows the example maps.

MAPS **PAGE #**

Map A1. Marine Benthic Habitats of Gulf of Honduras



Map A1. Marine Benthic Habitats of Gulf of Honduras

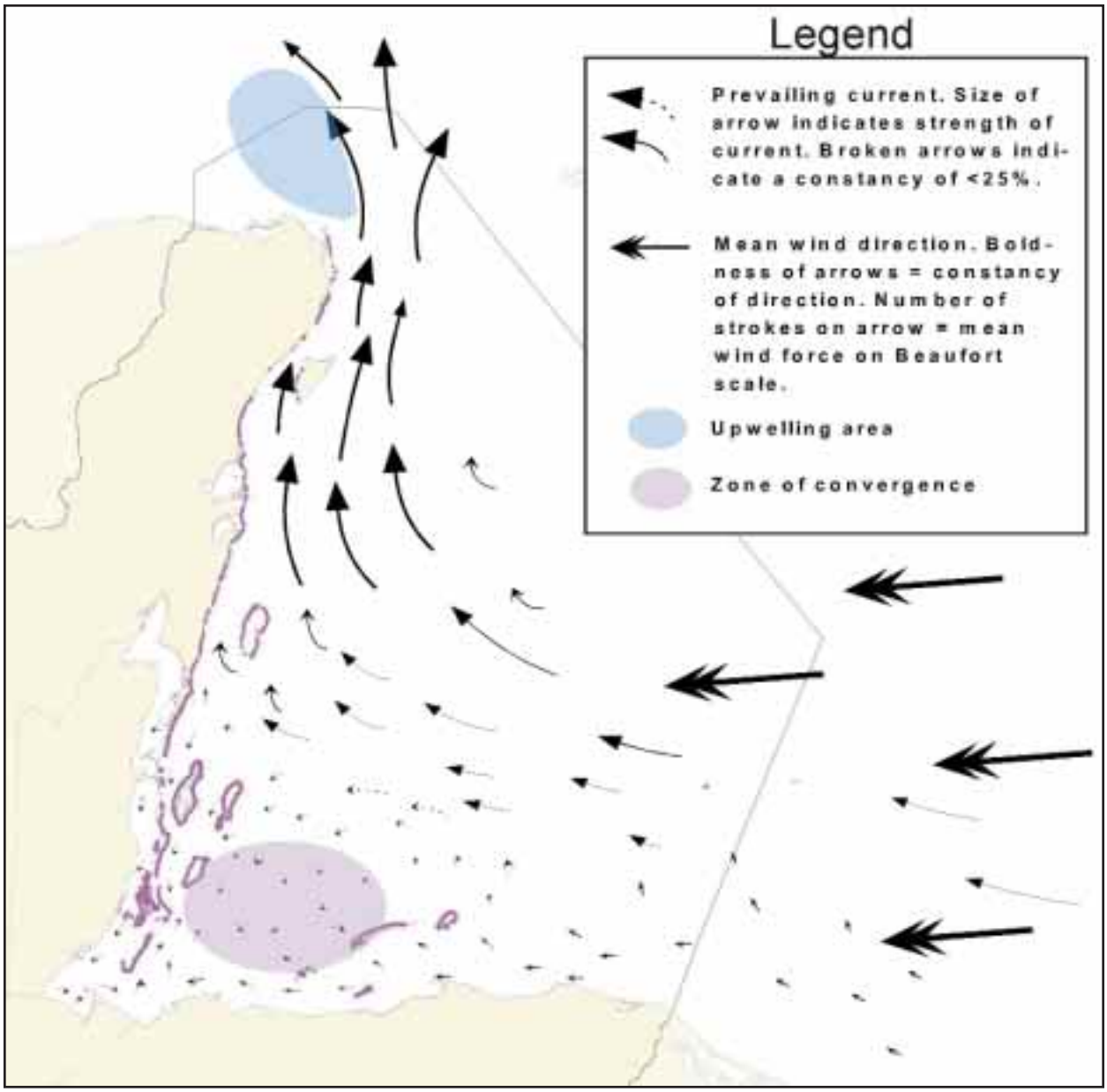
Maps showing the types and distribution of marine benthic habitats are an important source of information and critical to the prioritization planning process. Benthic habitat maps for shallow (<10 m) areas of the MACR region were constructed based on existing and new data sets. This example of the Gulf of Honduras shows the diversity of coral reef, seagrass, mangrove, and open water habitats.

Land
- Forest
- Mangroves
- Deforested Areas
- Principal Highways
- Other Roads
- Cities
- Coastal Lagoon
- Major Rivers

Bathymetry
- 0 - 10 m.
- 11 - 30 m.
- 31 - 200 m.
- 201 - 500 m.
- 501 - 1000 m.
- 1001 - 2000 m.
- 2001 - 3000 m.

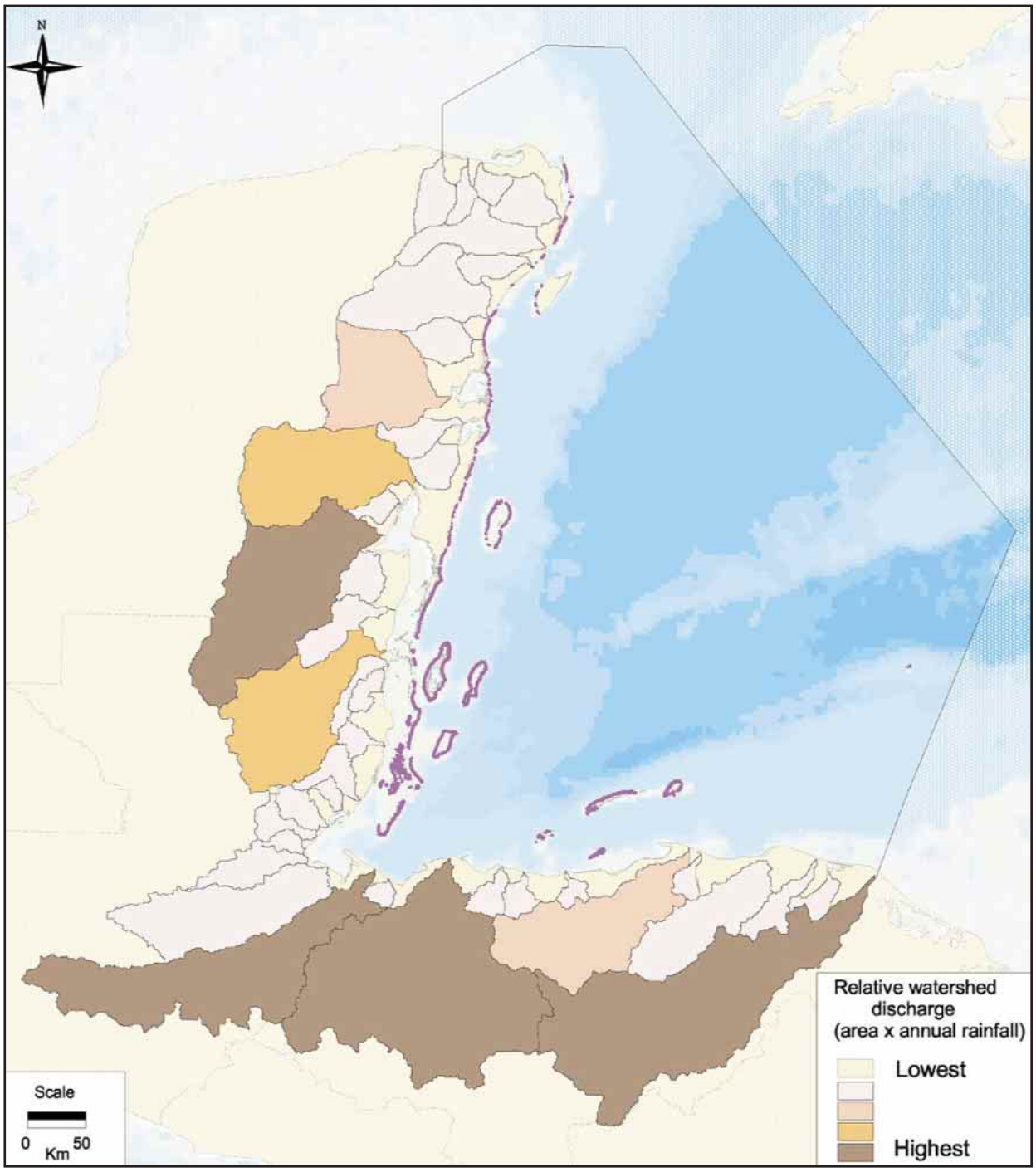
Shallow Benthic habitats (Geomorphological Categories)
- Turbid Water (sparse seagrass)
- Shallow Lagoon Floor (seagrass)
- Shallow Lagoon Floor (sediment)
- Coral-Rubble Zone
- Diffuse - Dense Patch Reef
- Forereef
- Reef Crest
- Sand

Map A2. Currents and Wind Patterns of MACR (schematic)



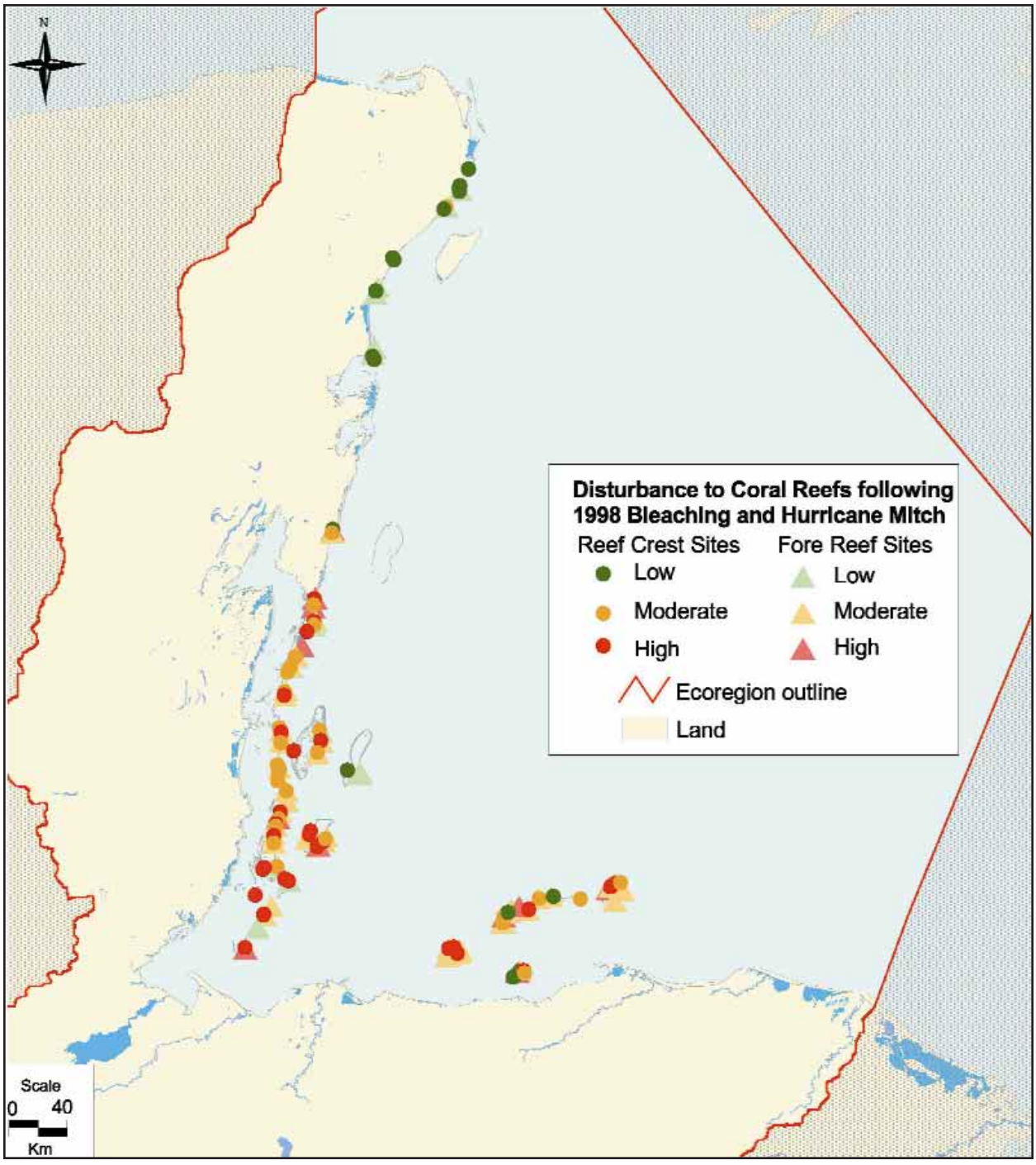
Map A2. Currents and Wind Patterns of MACR (schematic)
This schematic diagram shows a predominant west-northwest flow of the equatorial Atlantic gyre as it passes the Nicaraguan rise and moves into the MACR ecoregion. Currents veer sharply northward near Ambergris Cay in Belize as they encounter continental landmasses and offshore atolls. A distinct low-flow area exists between the Belize atolls and the northern Honduran mainland that is dominated by wind-driven circulation and the convergence of highly variable counter currents flowing along the Guatemala and Honduras coasts. North of Banco Chinchorro, current velocities increase to 2-5 knots as water is funneled through the narrow Yucatán Strait between Cuba and the Yucatán peninsula. A persistent area of upwelling occurs north of Cabo Catoche along the edge of the Yucatán Shelf (Cochrane, 1966; Merino, 1997). After leaving the MACR, currents continue to flow northward into the Gulf of Mexico as the Loop Current and later back into the Atlantic Ocean as the Gulf Stream.

Map A3. Watersheds of the MACR



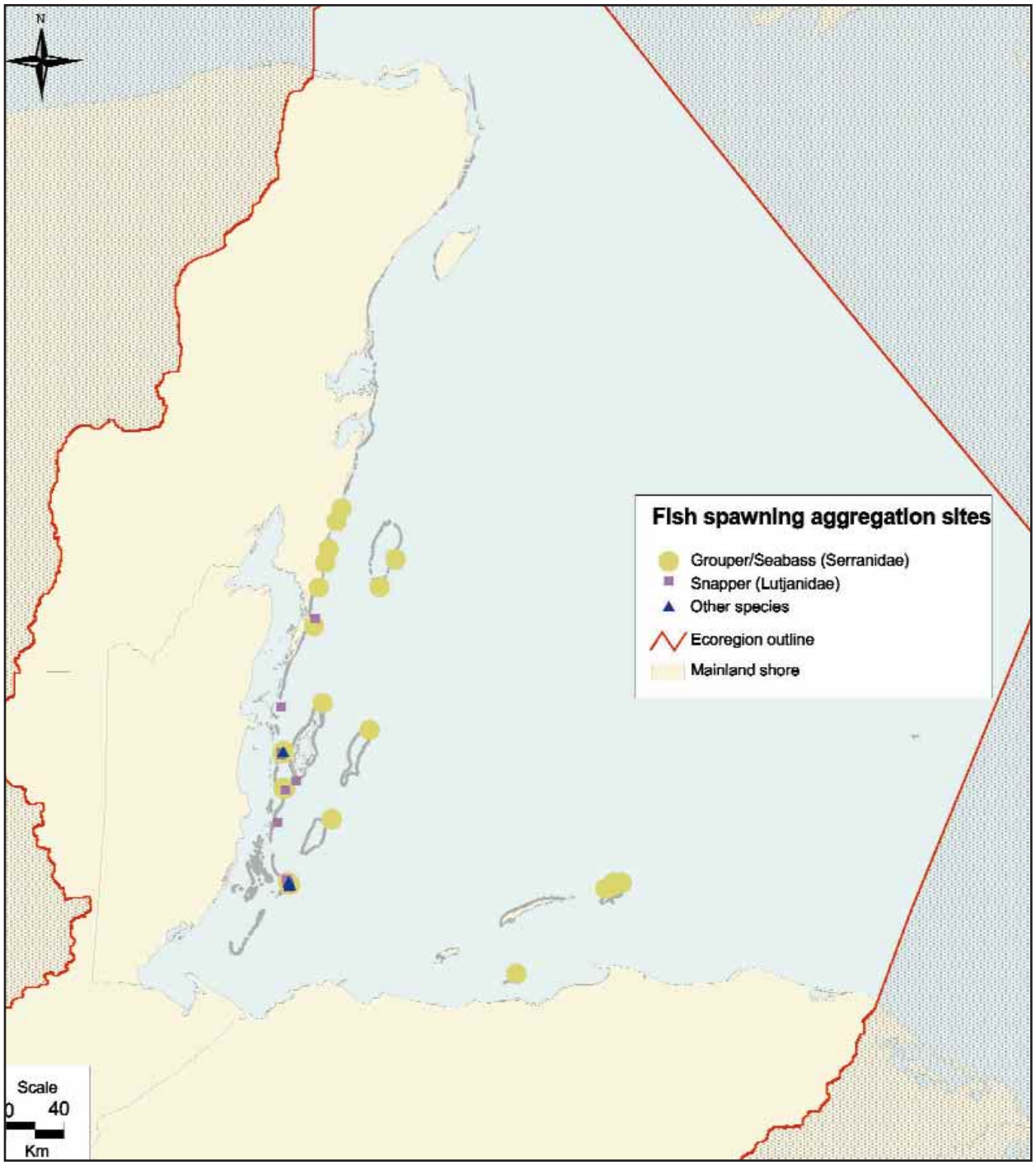
Map A3. Watersheds of the MACR
Coastal marine habitats and coral reefs of the MACR are linked to adjacent terrestrial areas by rivers and groundwater that carry nutrients, sediments, and pollutants. A watershed-based approach is essential to identify the spatial extent that inland threats may pose to coastal habitats, particularly those associated with human activities such as agriculture and urbanization. This map shows the major watersheds of the MACR region color-coded based on their relative discharge. The most significant watersheds occur from southern Belize to Honduras, including the Ríos Dulce, Aguán, Ulúa, Patuka, Motagua, and Hondo.

Map A4. Disturbance to MACR Coral Reefs Following 1998 Bleaching and Hurricane Mitch



Map A4. Disturbance to MACR Coral Reefs Following 1998 Bleaching and Hurricane Mitch
Map shows a qualitative index of coral disturbance (high, medium, low coral mortality) based on the synergistic impacts of coral bleaching and a large category V hurricane (Mitch), which impacted the region during 1998 (Kramer and Kramer 2000). Bleaching was widespread throughout the MACR region, although shallow reefs in southern Belize experienced some of the greatest coral mortality. Impacts from Hurricane Mitch ranged from minor to severe and extended from Honduras to as far north as the northern Yucatán.

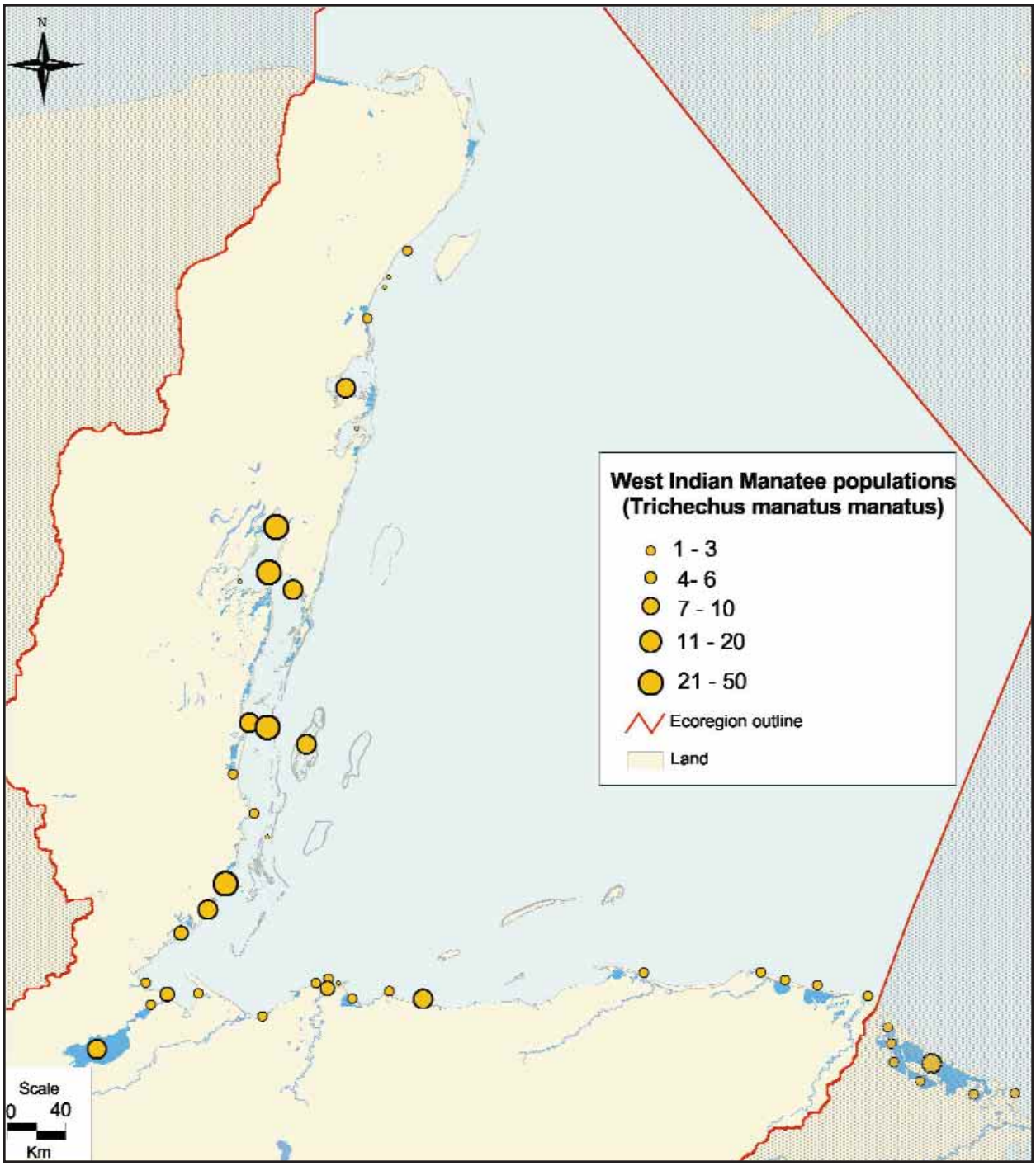
Map A5. Fish Spawning/Aggregation Sites of MACR



Map A5. Fish Spawning/Aggregation Sites of MACR

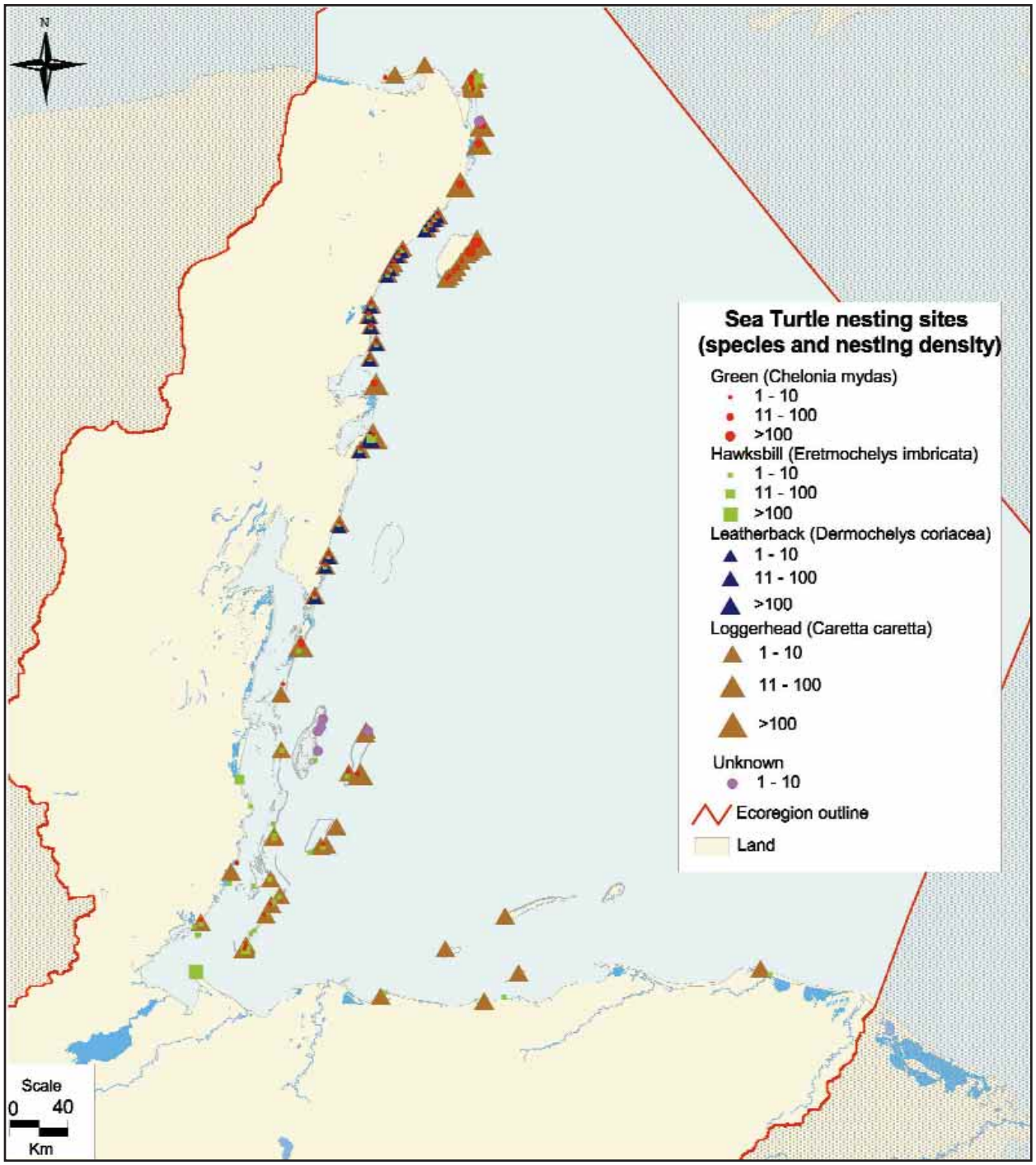
Several fish spawning aggregations occur in the MACR, including an estimated five in southern Mexico, two in Banco Chinchorro, ten in Belize, and at least two in Honduras. Gladden Spit, Belize supports the largest grouper/snapper spawning (2,000-4,000 individuals) aggregation in the ecoregion and includes fish species such as Nassau and black grouper; Cubera, yellowtail, dog, and mutton snapper; red hind, ocean jack, and schoolmaster. Other spawning aggregations occur at Mahajual, Rocky Point, Mexico Rocks, Banco Chinchorro, S. Columbus Reef, S. Long Rock, St. George's Cay, Turneffe, Lighthouse, Glovers, and Bay Islands. Important spawning aggregations may also occur on the offshore banks (Rosario and Misteriosa) and Swan Islands, but more information is needed.

Map A6. Manatee Distribution of MACR



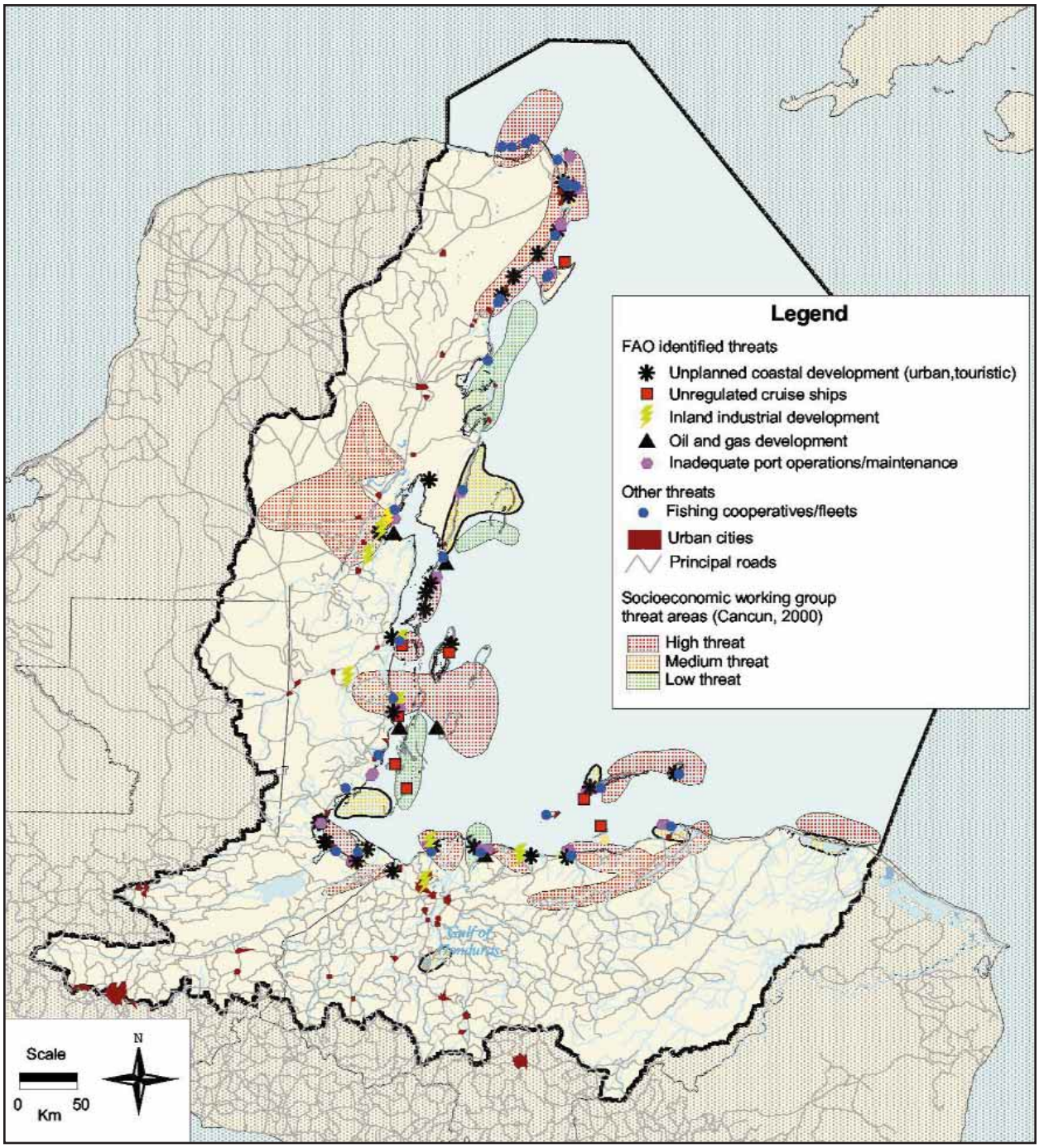
Map A6. Manatee Distribution of MACR
The MACR is home to the largest population of endangered West Indian manatees in the Caribbean. Experts at the Cancun workshop estimated that Belize has 400-900 manatees; the Yucatán coast has 6-12; Chetumal Bay has 250; Honduras has 120-140, and Guatemala has 22-106 (number of individual manatees is shown with yellow circles). Important manatee areas include Belize River and N. and S. Lagoons, Chetumal Bay, Río Dulce, Río Platano, and Sian Ka'an.

Map A7. Sea Turtle Distribution of MACR



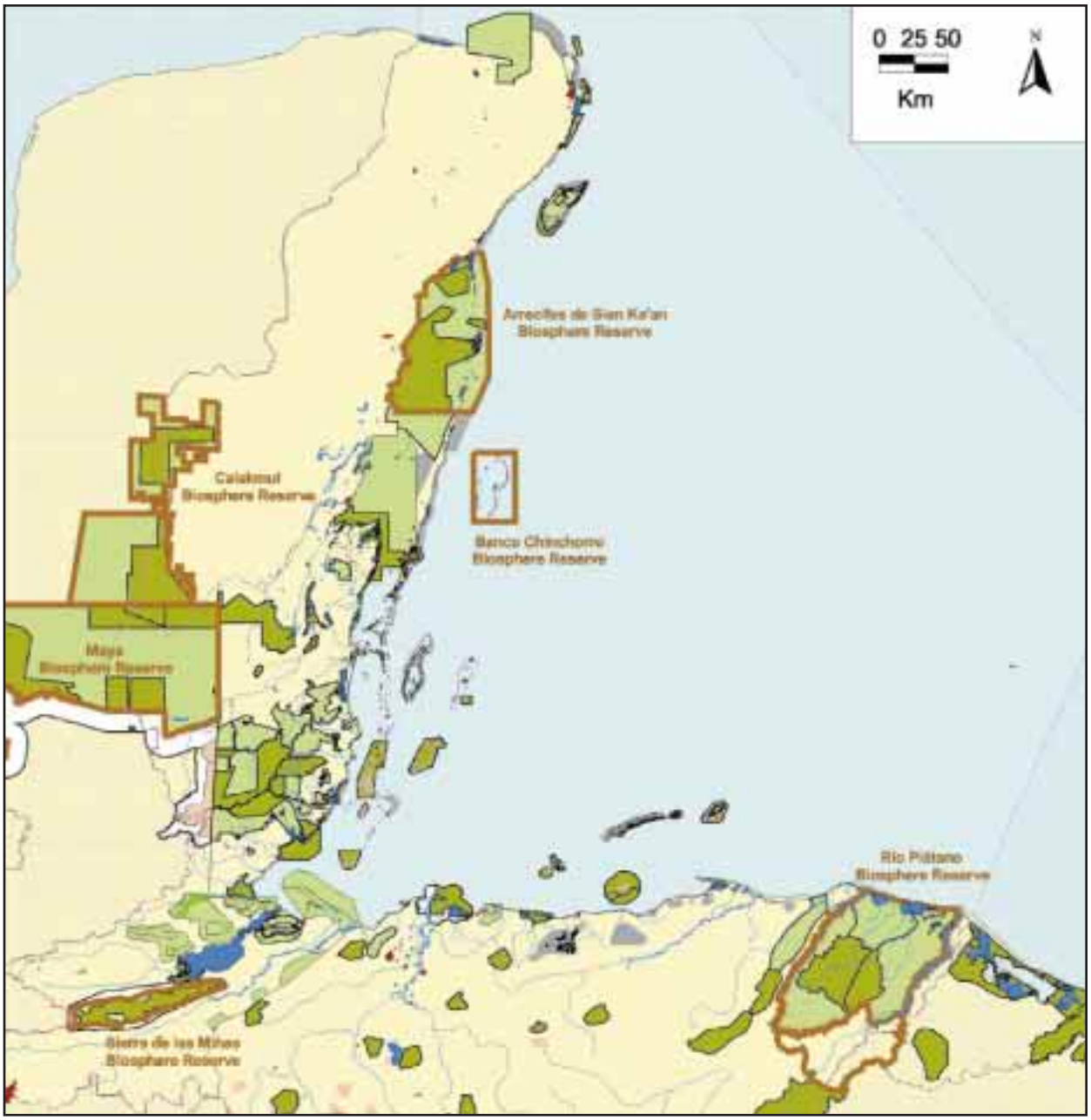
Map A7. Sea Turtle Distribution of MACR
Green, hawksbill, leatherback, and loggerhead sea turtles are found throughout the MACR coastal waters, cayes, and sandy beaches. Two of the most important nesting areas are Cozumel (>1,900 green turtle nests) and Punta de Manabique (~ 400+ hawksbills nests). Other important nesting areas include Isla Contoy and extensive habitat along the Yucatán coast (e.g., Puerto Morelos, Playa de Carmen to Akumal, Tulum, and Sian Ka'an); Ambergris, Manatee Bar and Silk to Sapodilla Cayes in Belize, northern Honduras coastline (e.g., Río Leon, Río Cuero y Salado and Río Platano) and occasionally on the Bay Islands.

Map A8. Threats to MACR Biodiversity



Map A8. Threats to MACR Biodiversity
Anthropogenic pressures are some of the greatest threats to the MACR ecoregion's biodiversity (e.g., FAO 2000). A Socioeconomic Working Group at the Cancun Workshop delineated levels of threat (high, medium or low) for the region based on four of the greatest threats, including coastal habitat degradation or conversion, declining water quality, declining or depleted fisheries, and increased stresses due to oceanographic and climato-meteorological phenomena. Areas at greatest risk include Chetumal Bay (pollution); Cancun (development); Belize City (shipping, development); La Ceiba and Trujillo (agriculture, oil-port activities) and Bay Islands (development, overfishing).

Map A9. Protected Areas of the MACR

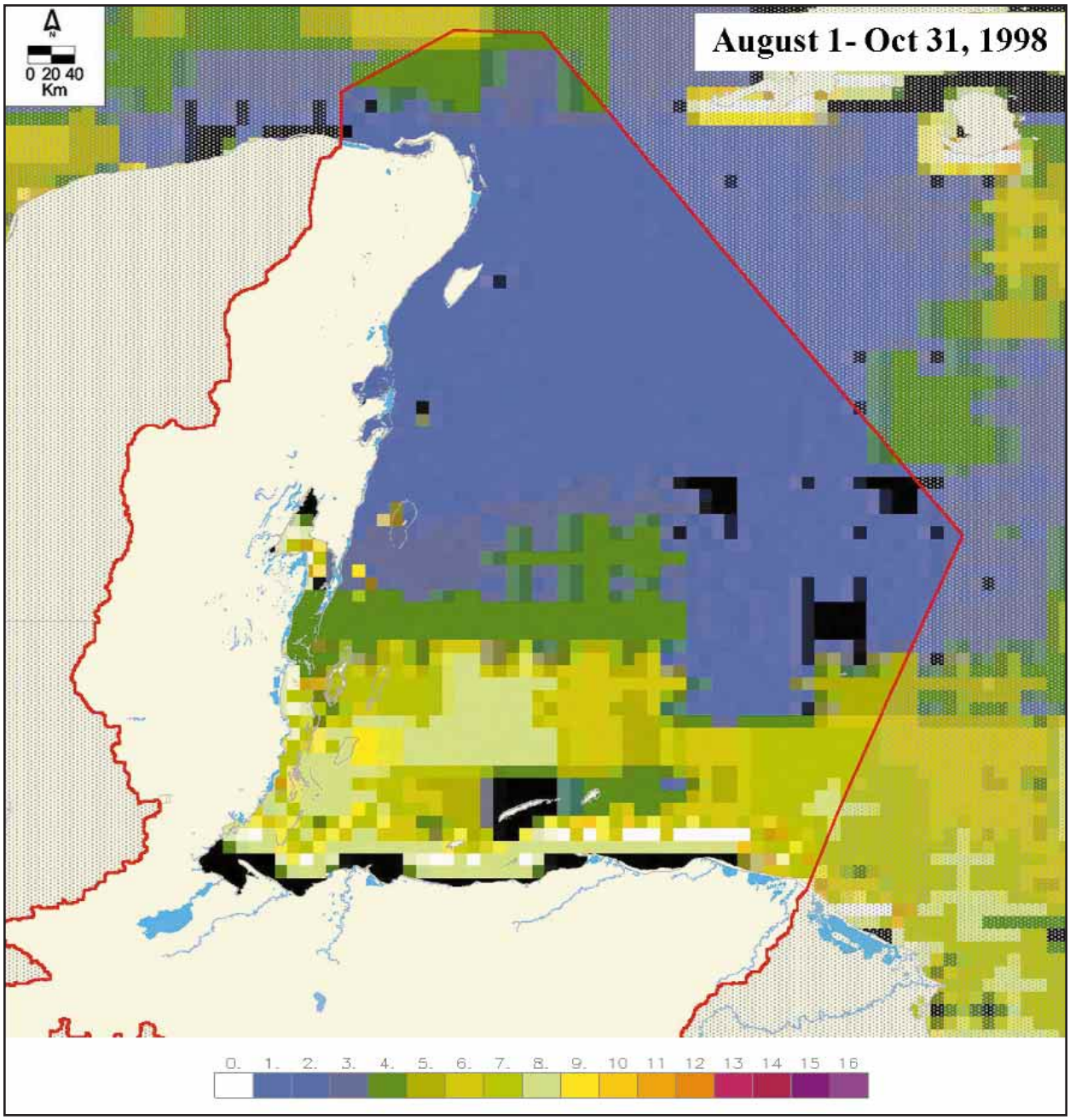


Map A9. Protected Areas of the MACR
At least 80 designated marine and coastal protected areas exist within the MACR, although the level of protection and enforcement varies considerably. This map indicates the status of protected areas (land, coastal, marine) in the region and is based on a recent inventory by the Wildlife Conservation Society (WCS). Most protected areas have been designed to address issues of over-exploitation of fishery and other natural resources, protection of critical habitat or species, and/or pollution and degradation of resources.

Protected Area Status- 2000

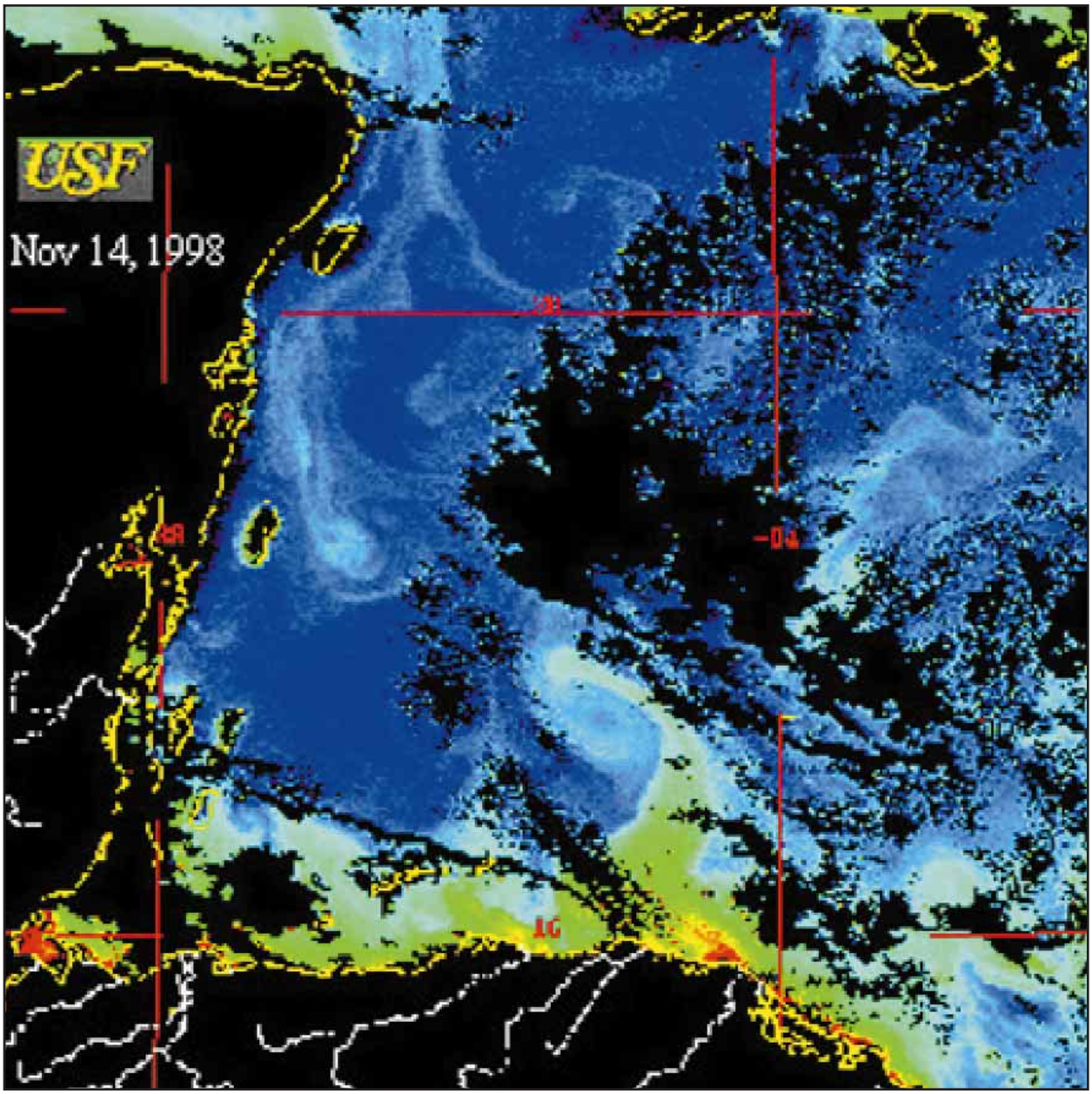
- Biosphere Reserves
- Strict Conservation (National Parks, Nature Reserves)
- Private Reserves
- Extractive or Multiple Use (Wildlife Refuges, Forest Reserves)
- Buffer Zones
- Proposed Protected Areas
- Unknown status

Map A10. 1998 Sea Surface Temperatures



Map A10. 1998 Sea Surface Temperatures
During 1998, a widespread coral bleaching event occurred throughout the MACR, particularly impacting reefs in southern Belize. This NOAA's "hotspot" sea surface temperature anomaly image (degree heating weeks (DHW) index), generated between August 1st and October 31st, 1998, shows anomalously high surface water temperature stress south of 18°N, where the DHW index varies between 4 to 11. (One DHW is equivalent to one week of sea surface temperature one degree Celsius warmer than the expected summer-time maximum. Two DHWs are equivalent to two weeks at one degree above the expected summertime maximum OR one week of two degrees above the expected summertime maximum).

Map A11. SeaWiFS Imagery: Effects of Hurricane Mitch



Map A11. SeaWiFS Imagery: Effects of Hurricane Mitch
Hurricane Mitch (1998) caused widespread damage to terrestrial and marine areas in the MACR. This SeaWiFS image (November 14, 1998), taken approximately 2 weeks after the passage of Hurricane Mitch, shows large plumes of sediment-laden water being transported north by prevailing currents. Warmer color tones indicate higher levels of chlorophyll in the water column. This plume affected inshore coral communities of Honduras and Guatemala, portions of the Bay Islands, and as far north as Glovers Atoll in Belize (Andréfouët et al., in press).

Methods for Developing MACR Biodiversity Database

Base Maps

The base map contained data on shoreline, detailed bathymetry, land elevation, major rivers, watersheds, lakes, coastal lagoons, mangroves, reef crests, urbanized areas, and land cover. The GIS data used to create this map was obtained from existing GIS datasets from the region and by creating new data layers for gaps in the coverages by digitizing data from a variety of sources. The principal collaborating agencies in providing existing GIS coverages for this effort were: Belize Coastal Zone Management Authority/Institute (CZMA/I); Amigos de Sian Ka'an (ASK); Wildlife Conservation Society (WCS); World Wildlife Fund (WWF); The Nature Conservancy (TNC), and the Inter-American Center of Tax Administrations (CIAT). Table A1 lists the data layers that were included in the base map.

Mapping of Marine Habitats

Marine habitat maps were constructed using a variety of techniques depending on the sources available for each region. Benthic habitat maps based on Landsat TM images were previously constructed in Belize by Mumby et al. (1998). To retain consistency between areas, the same marine habitat classification scheme was used throughout; it identifies 29 distinct classes which are organized into both geomorphological and benthic habitat categories. The original 29 categories were subsequently grouped by the Belize Coastal Zone Management Unit into 12 habitat categories. In order to produce a common classification scheme for the entire MACR, the Belize classification scheme was further simplified to include a total of nine habitat classes: deep water, turbid water, dense seagrass shallow lagoon floor,

Table A1: Data Layers Compiled/Generated for Base Map

Data Layer	Source	Scale
Shore line	Mexico - ASK; Belize - CZMA/I; Guatemala - digitized from nautical charts; Honduras - topographic maps	Mexico - approximately 1:100,000; Belize approximately 1:100,000; Guatemala and Honduras - 1:100,000
Shallow bathymetry (10 m, 30 m)	All - digitized from nautical charts (NOAA and British Admiralty)	1:150,000 - 1:350,000
Deep bathymetry (>100 m)	WWF	1:1,000,000
Land elevation	ALL - Digital Elevation Model (DEM)	1:1,000,000
Major rivers	Mexico - ASK; Belize - CZMA/I; Guatemala/Honduras - WCS/CIAT. *Note: lower portions of large rivers digitized from topographic maps*	1:100,000 - 1:250,000
Major watersheds	All - generated from DEM, using watershed analysis tool	1:1,000,000
Lakes	All - digitized from topographic maps	1:250,000 and 1:350,000
Coastal lagoons	All - digitized from nautical charts and topographic maps	1:150,000 -1:350,000
Mangroves	Mexico - ASK; Belize - CZMA/I; Guatemala - digitized from CEP technical report; Honduras - modified from CIAT	Mexico - unknown; Belize - Spot satellite imagery; Guatemala - 1:300,000; Honduras - unknown
Reef crests	Mexico - digitized from reef atlas; Belize - CZMA/I; Guatemala/Honduras - image analysis of Landsat TM	Mexico -1:100,000; Belize/Guatemala/Honduras - Landsat TM
Major urban areas	All - digitized from topographic maps	1:150,000 - 1:250,000
Land forest cover	Belize, Guatemala, Honduras - TNC; Mexico - ASK	Variable

Table 2. Benthic Habitat Classification Scheme

Belize Grid Code	Belize Geomorphological Category	Belize Benthic Category	MACR Class
1	Deep water	Unclassified	1
4	Turbid Water	Seagrass	2
26	Shallow Lagoon Floor (1)	Dense seagrass (standing crop > 80g.m^2; cover > 70%)	3
9	Shallow Lagoon Floor (2)	Medium dense seagrass (standing crop 11-80g.m^2; cover 30-70%)	4
2,14,15, 33,34, 35,36, 37,38, 39,40, 42,43	Shallow Lagoon Floor (3)	Mud; sparse seagrass (standing crop 1-10g.m^2 cover < 30%); fleshy brown algae with sparse gorgonians (> 3 gorgonians m^2); bedrock; sand & sparse seagrass; bedrock/rubble & dense gorgonians (> 3 gorgonians m^2); sand sparse algae & sparse corals; seagrass with distinct coral patches; sparse massive & encrusting corals; bedrock/rubble and dense gorgonians (> 5 gorgonians m^2); sparse massive & encrusting corals (1-5% coral cover); bedrock/rubble sparse gorgonians and algae (<3 gorgonians m^2)	4
7,10,32	Backreef Pavement	Sand; sparse coral & algae; fleshy brown algae with dead coral; rubble and sparse algae	5
12,13	Diffuse/Dense Patch Reef	Massive & encrusting corals	6
23,25,28	Forereef	Dense massive & encrusting corals (> 5% coral cover); sparse massive & encrusting corals (1-5% coral cover)	7
24	Reef Crest	Branching corals	8
30	Low Relief Spur & Groove	Leaf corals with green calcified algae; massive & encrusting corals	7
31	High Relief Spur & Groove	Massive & encrusting corals	7
41	Back Reef	Sparse massive & encrusting corals (1-5% coral cover)	9

medium/sparse seagrass-shallow lagoon floor, backreef pavement, diffuse/dense patch reef, reef crest, back reef, forereef /spur and groove (Table A2). This produced a scheme that could be applied with reasonable accuracy to the entire area, including those areas for which only limited groundtruth data was available. Each class in the new scheme corresponds to class or a combination of classes in the Belize scheme and is also linked in a hierarchical manner. Table A2 presents the MACR classification scheme and its correspondence to the Belize Barrier Reef classification scheme. Map A1 is an example of a Gulf of Honduras benthic habitat map.

Honduras and Guatemala

No existing benthic habitat maps could be located for this region apart from localized small-scale efforts. Therefore Landsat TM images were acquired and classified using the following methods. Three overlapping Landsat TM scenes covering the Honduras and Guatemala portions of the Mesoamerican Reef System were acquired. These were:

- May 18, 1995 scene of the Caribbean coast of Guatemala and the southern coast of Belize;
- March 15, 1986 scene of the coast of Honduras and the island of Utila; and
- 1997 scene covering Roatán, Guanaja, and the remaining portion of the coast.

As a first step toward mapping, color composite images were prepared separately for both land and water. The water composites were constructed using bands 1, 2 and 3, which allow for the best subsurface penetration, and thus visual interpretation of location of reefs and other benthic habitat types. Bands 3, 4 and 5 were used for the land, and provided an optimal combination for interpreting vegetation features. The land and water composites were prepared separately and then overlaid to produce one image for each of the TM scenes. Prior to the start of benthic habitat classification, all land areas were masked out with TM band 4.

Since limited groundtruth information was available, the scenes were classified using unsupervised techniques. Cluster analysis was initially applied using fine detailing and a maximum possible number of clusters for a combination of bands 1, 2 and 3. The histogram of the classified image was subsequently examined in order to identify the strongest clusters and natural breaks in the histogram. A maximum number of clusters was determined from the histogram. This procedure retained the clusters with the largest membership, while replacing those clusters with only a small number of pixels in them. In general, this procedure retained between 12 and 16 clusters.

Better results were obtained by performing the classifications separately over small sections of an image. Each of the Bay Islands was classified as a separate unit. Similarly, the mainland coast of each image and the southern portion of the Belize Barrier Reef were each classified separately. This ensured that the distinct zonation patterns of each area were retained. Once the optimal numbers of histogram-based clusters for each section of image were created, the clusters were assigned to the appropriate geomorphological class. The assigning of clusters continued until each cluster category was assigned to one of the nine classes. Scientists familiar with the area and consultation with the literature provided feedback to the assignment of clusters. Finally, contextual editing by hand was undertaken to complete the assignment of clusters and to improve accuracy. All maps were georeferenced by obtaining control points from the GIS coastline file and mosaicked together to produce one map. All files were converted into tiff format and imported into ArcView for integration with other benthic habitat data.

The Guatemala/Honduras benthic habitat map should be viewed only as a preliminary first stage in a longer process of producing a detailed and accurate marine habitat map for the area. There was little time or budget for collecting groundtruth points that would have enabled us to conduct an accuracy assessment of the map. Therefore, the accuracy of the present map is not known and this limitation must be taken into account when utilizing these maps.

Mexico

For the Mexican Yucatán coast, only localized benthic habitat maps existed for several of the protected areas (e.g., Punta Nizuc). Landsat TM images could not be obtained in time for the workshop, but we were able to obtain maps showing the distribution of shallow reef crests, which were based on aerial photographs (Jordan-Dahlgren, 1992). These maps were digitally scanned, georeferenced, mosaicked, and finally digitized to produce a shallow reef crest GIS layer. We were unable to fill in the other shelf area habitats (seagrasses, sand, etc.) and these areas were classified as unknown. For Banco Chinchorro, an unsupervised classification of a Landsat TM image was provided by ASK. The image was modified to match the MACR classification scheme, but no accuracy assessment could be done since no groundtruth points were provided.

Physical Data and Biological Resources

In addition to base GIS data layers, other relevant biophysical information was compiled including currents, watersheds, species of special concern, socioeconomic, and protected area data (Tables A3 and A4).

Currents

Understanding how circulation patterns influence coastal ecosystems is important, especially how they affect the dispersion and exchange of larvae as well as pollutants and runoff. While gross current patterns for the MACR are known from early studies and piloting atlases (e.g., Clarke 1997), detailed smaller-scale flow patterns and variability are poorly quantified. Recent results from the Ocean Drifter Program along with satellite measures of ocean color (SeaWiFS) and ocean height (TOPEX) do reveal some of the smaller scale patterns. A schematic representation of predominant current patterns was made based on a qualitative examination of all these data sets (e.g., Map A2).

Watersheds

This biophysical analysis included an examination of the principal watersheds within the MACR Ecoregion. A 1:1,000,000 digital elevation model (DEM) was used to determine the inland boundary of the ecoregion and to delineate the principal watersheds based on elevation gradients. Watersheds are well defined in the southern and central section of the MACR, but are poorly constrained for the northern Yucatán peninsula due to small elevation gradients. An estimate of relative discharge from each watershed was also made based on the mean annual precipitation values with no correction for evapotranspiration (Map A3). Results indicate that the principal inputs to the ecoregion are from the large Motagua, Ulúa, and Patuka Rivers along the northern Honduras coast as well as the Hondo River in Belize.

Status of coral reefs

Mapping spatial patterns of coral condition is essential for understanding the ecological integrity of the MACR as well as contributing to conservation planning. As part of the Mesoamerican Barrier Reef Initiative (MBRI), a large-scale survey was conducted to assess the impacts of the 1998 coral bleaching event and the physical reef damage caused by Hurricane Mitch to 151 reefs in the region (Kramer and Kramer, 2000). This study established a regional baseline of reef condition (coral mortality, bleaching, disease, hurricane damage). A map indicating the level of disturbance to the region's reefs was created (Map A4). Additional information available to help understand coral reef condition was also synthesized for the MACR database including NOAA Hot spot maps (Map A10) and SeaWiFS imagery (Map A11).

Species of special concern

Since data on biodiversity was often lacking, information on species of special concern was synthesized as an indicator of biodiversity, including flagship species like manatees, sea turtles, crocodiles, whale sharks, and birds and commercially significant species like finfish (e.g., grouper, yellowtail snapper), lobster, conch, and shrimp. Individual maps depicting this information were generated for the Cancun Workshop. Manatee maps (Map A6), including distribution of important habitat, estimated population sizes of cows and calves, and number of deaths, was based on reports from in-country agencies responsible for collecting data, biologists conducting science, and existing literature. Information for Belize and Mexico was based on ongoing manatee sighting programs; Honduras data came from a recent study conducted in Honduras in 1993, while information for Guatemala is based on literature.

Table A3: Focal Species GIS Data

Data Layer	Source	Type
Coral reef condition	Kramer and Kramer - 2000	Point
Fishing grounds for commercial species (lobster, conch, grouper, shrimp)	J. González - World Bank working group report	Polygon
Annual catch information (conch, lobster, finfish, shrimp) by cooperative fishing area	Mexico - SEMARNAP; Belize/Guatemala/ Honduras - Fisheries Dept.; All – FAO reports	Polygon
Fish spawning aggregation sites	Literature, Fishery Departments	Point
Shrimp farms	Belize - CZMA/I	Point
Whale shark sightings	Belize & Honduras - Fisheries Dept.	Point
Bird nesting areas (by species)	Literature	Point
Turtle nesting beaches, nest locations, density, foraging grounds, and harvest	Literature, CZMA/I, ASK, Cayos Cochinos Station	Point/ Polygon
Manatee sighting (cows/calves), manatee habitat, manatee deaths	Literature, CZMA/I, ASK, Honduras Fishery Dept.	Point and Polygon

Table A4: Socioeconomic GIS Data

Data Layer	Source	Type
Major and minor roads	WCS, CIAT, Landsat TM	Line
Shipping lanes	Literature, nautical charts	Line
Major ports, oil terminals	Nautical charts	Point
1995 population (municipalities)	Various	Polygon
Urban areas and developed coastal areas	Topographic maps, Landsat TM	Polygon
Protected areas	WCS	Polygon
Land use	CIAT, ASK, other	Polygon
Watershed discharge	Based on mean annual precipitation x watershed area	Polygon
Threats 1 (farming, overfishing, pollution)	FAO 2000 Report	Point
Threats 2	WRI Reefs at Risk data	Point
Threats 3	Results of Cancun workshop	Point

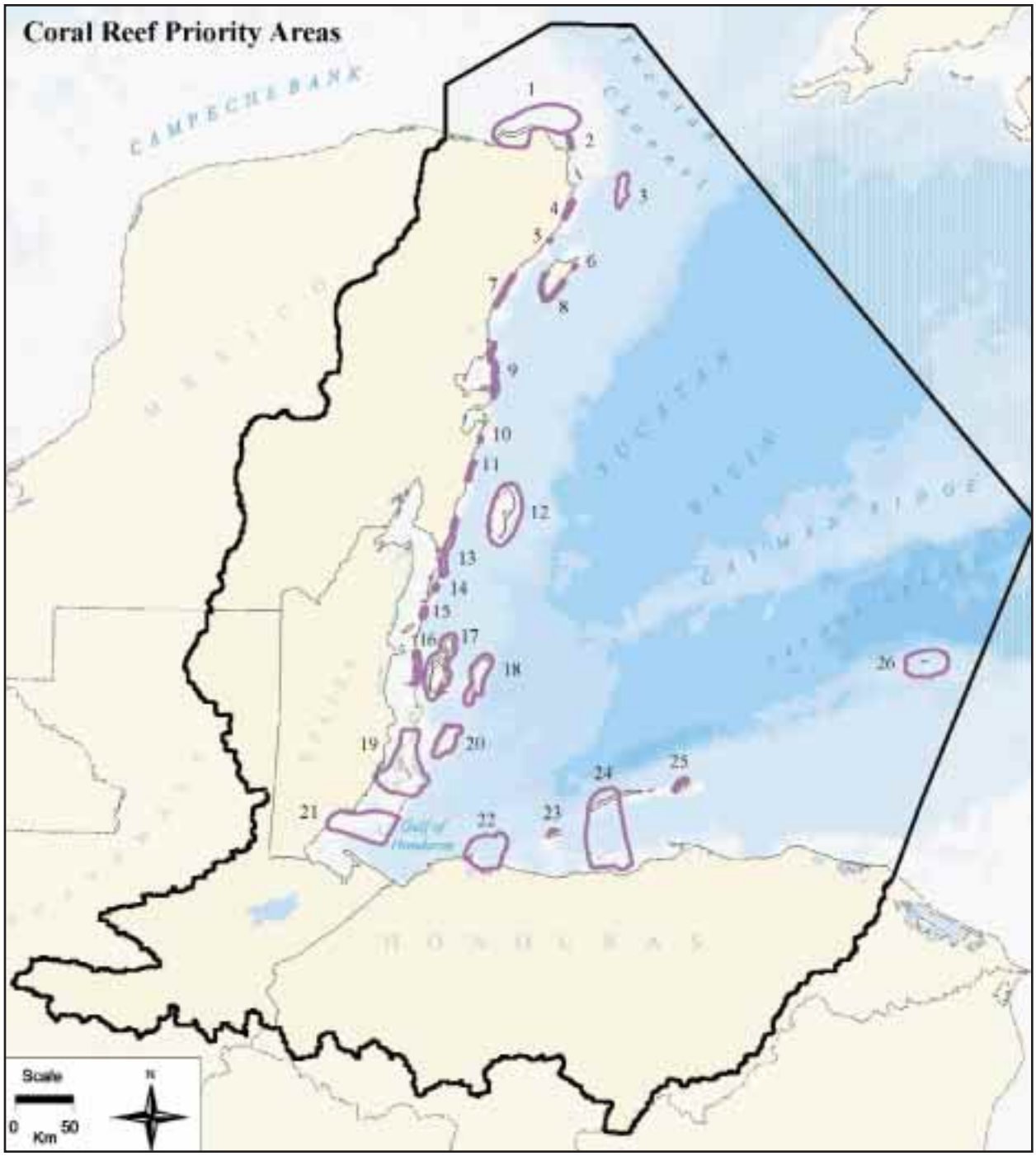
Sea turtle maps (Map A7) included data on turtle nesting beaches, nest locations, density of nests, foraging grounds, and harvest by species and originated primarily from literature, Amigos de Sian Ka'an, and experts. Important bird nesting data obtained from literature was generated into a regional map. Maps with fisheries catch information (conch, lobster, finfish, shrimp) were produced based on data from national fisheries departments and FAO literature, while fish spawning sites (Map A5) and whale shark sightings were obtained from literature and expert knowledge. Additional fish information was synthesized from the REEF database.

Socioeconomic

Socioeconomic maps (Map A8) included population data and major threats to the region's resources such as urbanization, population density, transportation (shipping lines, highways, roads, railroads), agriculture (conversion, shrimp farms), industrial development (oil pipelines, power plants), and port operations. Threat data was obtained from a comprehensive Threat and Root Cause Analysis (TRCA) conducted to identify existing and potential threats and their underlying root causes to the region's ecological integrity (FAO 2000) and "Reefs at Risk" data. The boundaries of existing and proposed protected areas were adopted from coverages developed by the Wildlife Conservation Society (WCS).

Taxa Priority Areas: Maps and Descriptions

Following are descriptions of the priority areas selected as important for the conservation of the MACR's corals, fishes, focal species, and plants. Short descriptions include the priority area's name, map identification number, ecological significance (ecoregional, subregional, local, unknown), and important biological features. These priority areas were then combined to produce an overlap map, which served as the basis for identifying priority areas of regional biodiversity (Appendix C).


Coral Reef Priority Areas
CAMPECHE BANK
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Map ID #: 1
Name: Cabo Catoche
Ecological Significance: Ecoregion
Biological Feature: Extensive sand and hardbottom communities at the end of the MACR system, moderately large area in good condition, high diversity of habitats, important part of connections downstream, connected to oceanic influences.

Map ID #: 2
Name: Isla Contoy
Ecological Significance: Local
Biological Feature: Coral covered beach ridge complex extending around portions of island. Hardbottom communities.

Map ID #: 3
Name: Arrowsmith Bank
Ecological Significance: Unknown
Biological Feature: Unique ahermatypic reefs, rare in ecoregion, high diversity, directly influenced by oceanic transition currents, unique oceanic hardbottom habitats.

Map ID #: 4
Name: Punta Petempica to Punta Nizuc
Ecological Significance: Local
Biological Feature: Small isolated reef with little connection to other areas, but reef crest in good condition, connected to nursery areas.

Map ID #: 5
Name: Punta Maroma
Ecological Significance: Local
Biological Feature: Small isolated reef with little connection to other areas, but reef crest in good condition, connected to nursery areas.

Map ID #: 6
Name: Cozumel – algal reefs
Ecological Significance: Ecoregion
Biological Feature: Unique microalgal reefs formed by coralline algae, only one in ecoregion.

Map ID #: 7
Name: Punta Gruesa to Punta Changuay
Ecological Significance: Subregion
Biological Feature: Bank barrier reef covering a large area in good condition, diversity is high; close to similar habitats and connected to nursery grounds, crosses several environmental gradients — part of greater system, high regenerative capacity, high swath potential, “old growth” corals.

Map ID #: 8
Name: South Cozumel
Ecological Significance: Ecoregion
Biological Feature: Large well-developed reef area in good condition, high diversity of habitats and species diversity, unique leeward location, old growth corals on windward side and leeward deep.

Map ID #: 9
Name: Punta Tupa to Boca Paila
Ecological Significance: Subregion
Biological Feature: Bank barrier reef covering a large area in good condition, diversity is high; close to similar habitats and connected to nursery grounds, crosses several environmental gradients — part of greater system, high regenerative capacity, high swath potential, “old growth” corals.

Map ID #: 10
Name: Tampalam to Laguna Mosquitero
Ecological Significance: Ecoregion
Biological Feature: Large reef area in good condition, diversity is high; close to similar habitats and connected to nursery grounds, crosses several environmental gradients — part of greater system, high regenerative capacity, high swath potential, “old growth” corals.

Map ID #: 11
Name: Punta Piedra to Punta Xpujil
Ecological Significance: Subregion
Biological Feature: Bank barrier reef covering a large area in good condition, diversity is high; close to similar habitats and connected to nursery grounds, crosses several environmental gradients — part of greater system, high regenerative capacity, high swath potential, “old growth” corals.

Map ID #: 12
Name: Banco Chinchorro
Ecological Significance: Ecoregion
Biological Feature: One of the best-developed coral atolls in the Caribbean. Large reef area with diverse habitats, close to nursery habitats (conch, lobster), fish spawning aggregation sites, possibly connected with oceanic currents.

Map ID #: 13
Name: Basil Jones to P. Herradura
Ecological Significance: Ecoregion
Biological Feature: Unique double reef crest geomorphology, bank barrier reef covering a large area in good condition, diversity is high; close to similar habitats and connected to nursery grounds, crosses several environmental gradients — part of greater system, high regenerative capacity, high swath potential, "old growth" corals.

Map ID #: 14
Name: Mexico Rocks
Ecological Significance: Local
Biological Feature: One of most developed reef structures in subregion with "old growth" corals, unique patch reefs.

Map ID #: 15
Name: S.E. Ambergris Caye to Caye Chapel
Ecological Significance: Subregion
Biological Feature: Hol Chan Marine Reserve hosts numerous large fish species and reefs are well-protected, area representative of reefs in the Belize subregion. Highly developed spur and groove formations throughout.

Map ID #: 16
Name: Gallows to Bluefield
Ecological Significance: Local
Biological Feature: Gallow's Reef is unique with its well-developed spur and groove framework. Goff's Banks is representative of local reefs, with higher coral diversity and healthier reef condition.

Map ID #: 17
Name: Turneffe Islands
Ecological Significance: Ecoregion
Biological Feature: Largest offshore coral atoll in ecoregion and one of best developed in Caribbean. Well-developed reefs at southern end, reefs in good condition, complex interior lagoon, with numerous mangroves and seagrass beds.

Map ID #: 18
Name: Lighthouse
Ecological Significance: Ecoregion
Biological Feature: One of the best-developed coral atolls in Caribbean with large blue hole, which is a unique geological feature with diverse biota and numerous stalagmites. Some of the best reefs in Belize — highest coral cover, oceanic influence — larval connectivity, variety of reef types.

Map ID #: 19
Name: Glovers Reef Atoll
Ecological Significance: Ecoregion
Biological Feature: Best-developed coral atoll in Caribbean, largest number of patch reefs (over 700) in interior lagoon, variety of reef types, oceanic influence — larval connectivity.

Map ID #: 20
Name: Gladden Spit south
Ecological Significance: Ecoregion
Biological Feature: High diversity of habitats, unique midshelf reefs, large area, high habitat complexity, close to nursery habitats, crosses environmental gradients, highest swath potential, high regeneration capacity, prominent point at Gladden Spit is a unique geological feature, largest aggregation site in ecoregion.

Map ID #: 21
Name: Snake Key to Sapodilla swath
Ecological Significance: Ecoregion
Biological Feature: Large unique cross-shelf swath encompassing nearshore mangrove nursery areas across shelf gradient, Belize Barrier Reef ends here in a unique hook shape, Snake Keys are nearshore reefs unique to ecoregion.

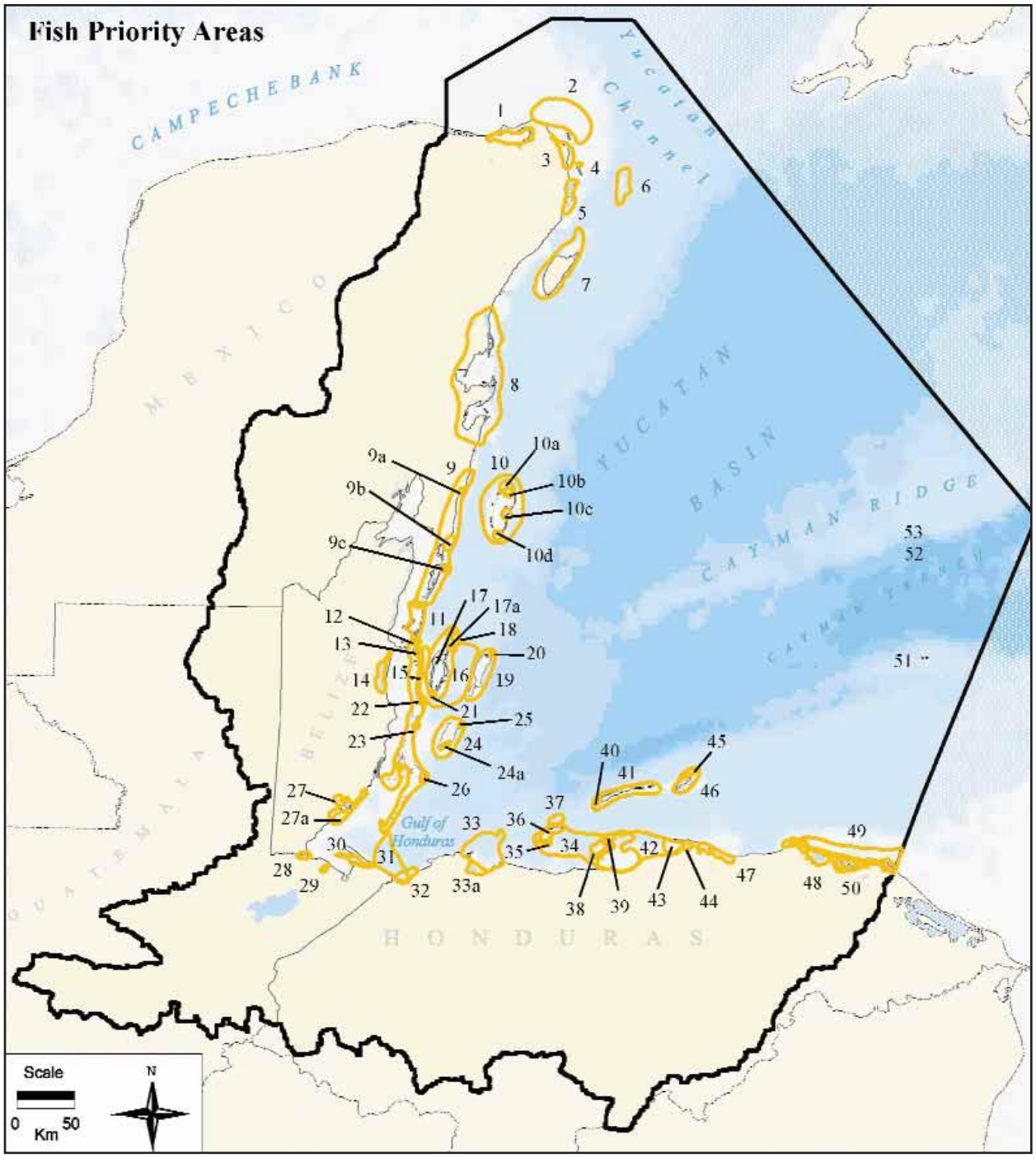
Map ID #: 22
Name: Tela Bay
Ecological Significance: Local
Biological Feature: Little information available, warrants further investigation, possible unique nearshore reefs.

Map ID #: 23
Name: Utila
Ecological Significance: Subregion
Biological Feature: Reef crest is most developed on northeast side. Complex reef structure provides habitat for numerous fish.

Map ID #: 24
Name: Cayos Cochinos to Roatán swath
Ecological Significance: Ecoregion
Biological Feature: A large unique cross-shelf area encompassing nearshore banks, diverse shallow and deep reef habitats of Cayos and NW end of Roatán, Cayos Cochinos is representative of midshore zone and different than NW Roatán and nearshore banks. High biodiversity for ecoregion. Possible important source of larvae for ecoregion.

Map ID #: 25
Name: Guanaja
Ecological Significance: Subregion
Biological Feature: Part of Bay Islands, unique coral structures.

Map ID #: 26
Name: Swan Islands
Ecological Significance: Unknown
Biological Feature: Unique location for ecoregion, far from continental land mass, "beginning" of MBRS ecoregion, in path of currents, important for larval transport, little known about area.


Fish Priority Areas
CAMPECHE BANK
Yucatan Channel
MEXICO
YUCATAN BASIN
CAYMAN RIDGE
CAYMAN TROUGH
BELIZE
GUATEMALA
HONDURAS
Gulf of Honduras
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9a
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9c
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Map ID #: 1
Name: Yalahau Lagoon
Ecological Significance: Subregion
Biological Feature: Entire coastal shallow lagoon, which separates the communities of Chiquila and Holbox, is an important nursery for lobsters, finfish, shrimp, and sharks.

Map ID #: 2
Name: Isla Contoy
Ecological Significance: Ecoregion
Biological Feature: Very important upwelling area near Isla Contoy influences the N, NE part of the Yucatán peninsula. The strong currents funnel baitfish and attract numerous pelagic species. Important spawning area.

Map ID #: 3
Name: Chacmochuc Lagoon
Ecological Significance: Subregion
Biological Feature: Located on northern coast of Isla Contoy, the Chacmochuc lagoon contains excellent seagrass and mangrove habitats that serve as nursery areas for many species of fishes and invertebrates, including lobsters, finfish, shrimp, and sharks. Many species migrate to this area or use it for spawning or various developmental stages.

Map ID #: 4
Name: N Isla Mujeres
Ecological Significance: Subregion
Biological Feature: Open sea NE of Isla Mujeres is important habitat for queen conch, spiny lobster, finfish (e.g., grouper, snapper), and shark. Habitat is a transition zone between a barrier reef and outer shelf edge. Important corridor for benthic and pelagic fishes migrating northward and southward along the coast.

Map ID #: 5
Name: Punta Nizuc to Punta Petempich
Ecological Significance: Ecoregion
Biological Feature: Lagoonal region with nearby well-developed emergent reefs provides various shallow water habitats to a rich assemblage of nearshore fish species and various life stages.

Map ID #: 6
Name: Arrowsmith Bank
Ecological Significance: Unknown
Biological Feature: Submerged bank offshore at mouth of the westerly Yucatán channel in an area of high speed and high volume currents. Reported extensive seagrass beds. Spiny lobster, snappers, and grouper species present. Important area for pelagic fish including marlin and swordfish. Unusual spatial positioning of this bank may be responsible for interesting small-scale ecological phenomena and unusual fish assemblages.

Map ID #: 7
Name: Cozumel
Ecological Significance: Ecoregion
Biological Feature: Wide variety of habitats for snapper-grouper complex, conch, lobster, and smaller reef fishes. At least 336 reef fish species are known. Availability of nursery areas and high species richness. The splendid toadfish, a rare and possibly endemic species, is locally abundant here.

Map ID #: 8
Name: Sian Ka'an Reserve
Ecological Significance: Ecoregion
Biological Feature: High habitat diversity, including well-developed reefs, coastal lagoons, wetlands, freshwater springs and creeks, flood forests, and bays. The two bays support some of the largest spiny lobster populations remaining in the ecoregion; they also provide important nursery habitat for other species. Fish are abundant. Reef habitats include shallow patch reefs, reef crest and deep fore reefs that broaden out to shelf edge. Reefs extend 90 km along coast providing important habitat for numerous reef fishes. Dense thickets of elkhorn coral (*Acropora palmata*) offer complex foraging areas and shelter. The splendid toadfish, a rare and possibly endemic species, has been observed in Ascención Bay. The Reserve has higher fish species diversity than adjacent reefs outside the Reserve as well as higher abundance of upper trophic level fish. Lagoons are nursery grounds for silky shark, spinner shark, and bull sharks.

Map ID #: 9
Name: S. Yucatán Coast S. Sian Ka'an
Ecological Significance: Ecoregion
Biological Feature: A high diversity of interconnected habitats (lagoons, mangroves, channels, beaches, seagrasses, reefs). Chetumal Bay, one of the largest bays in the entire ecoregion, provides habitat to a wide variety of estuarine and marine fishes, including historic bonnet head shark aggregations. Rocky Point, the only place where the barrier reef touches the coastline, is a historically important spawning aggregation site for several species of groupers, and snappers. Deep banks supporting conch reproduction are also found here. Mexico Rocks was historically a grouper spawning site. At least 217 reef fish species are present. Hol Chan Marine Reserve has been effective in protecting fish populations; there are more fish species and more abundance (>60% more), especially commercial species, than in non-protected areas, and commercial species are often greater in size. Conch and lobster abundances are also much higher. Bacalar Chico Marine reserve also includes no-take replenishment zones.

Map ID #: 10a-d
Name: Banco Chinchorro
Ecological Significance: Ecoregion
Biological Feature: Extensive and complex mangrove, seagrass, reef, and oceanic habitats. Over 180 species of marine fishes have been counted, and at least two viable grouper (*Epinephelus striatus*) spawning aggregation sites are known. One of the largest and last commercially viable conch fisheries in Mexico is here. Existing lobster fishery is stable. Important areas include 10a=N. Banco Chinchorro; 10b=Cayo Norte; 10c=Cayo Centro; 10d=Cayo Lobos.

Map ID #: 11
Name: Belize Barrier Reef
Ecological Significance: Ecoregion
Biological Feature: Large area of very complex assemblage of habitats including reefs, patch reefs, mangrove islands, shallow seagrass beds, and shallow hardbottoms. Important area for many species (e.g., reef fish, cryptofauna, lobster, and conch) to complete complex life histories. Several “hot spot” nursery habitats and adult populations are present. Whale sharks have been sighted at various places (e.g., Sapodilla).

Map ID #: 12
Name: St George's Caye
Ecological Significance: Subregion
Biological Feature: Prominent point on barrier reef east of St. George's Caye where snappers and groupers aggregate. Historically a very productive aggregation, but currently yield is very low and area is not fished commercially.

Map ID #: 13
Name: Gallows Point
Ecological Significance: Subregion
Biological Feature: Shallow seagrass flats with sparse massive corals located east of Swallow Caye. Important conch nursery with very high density of juvenile conch. Historic reported fish spawning site – unknown status.

Map ID #: 14
Name: Northern & Southern Lagoons
Ecological Significance: Subregion
Biological Feature: Large estuarine lagoons with extensive mangrove habitat important for life cycle of estuarine fishes, such as snook and tarpon.

Map ID #: 15
Name: Middle Long Caye
Ecological Significance: Subregion
Biological Feature: Reef east of Middle Long Key where several species of grouper and snapper spawn (e.g., *E. guttatus, E. striatus, L. juco, M. bonaci*). High fishing yield from this aggregation until 1998 when suddenly low numbers were found. Possible whale shark location.

Map ID #: 16
Name: Turneffe - Oceanic
Ecological Significance: Local
Biological Feature: Oceanic region around Turneffe where deep water passages between offshore atolls and barrier reef provide important habitat for pelagic species like marlin, sailfish, wahoo, kingfish, tuna (bonito, yellowfin), mackeral, jack (amber, horse-eye, crevalle), and shark. Many of these species are migratory with large ranges.

Map ID #: 17
Name: Turneffe Atoll
Ecological Significance: Ecoregion
Biological Feature: Unique reef development around the atoll margins and interior mangrove and seagrass habitats provide important habitat for diverse assemblage of reef fish, lobster, conch, and sportfish (bonefish, permit, etc.). Fish spawning sites are also known to exist off both the northern and southern tips of the atoll. At least 253 reef fish species are known. The whitelined toadfish (*Sanopus greenfieldorum*), a rare and cryptic fish, is reported here. Whale sharks have been sighted here.

Map ID #: 17a
Name: N. Turneffe
Ecological Significance: Local
Biological Feature: Shallow seagrass and hardbottom habitat is "hot spot" feeding site for key fish species (bonefish and permit) important to catch-and-release sport fisheries.

Map ID #: 18
Name: Crawl Caye, Turneffe
Ecological Significance: Subregion
Biological Feature: Crawl caye area located on the northern-most point on Turneffe Atoll. Active aggregation site where groupers (tiger and black) and snapper migrate to the area to spawn. Historically, whale sharks were reported to congregate here to feed during the spawning season.

Map ID #: 19
Name: Lighthouse Reef Atoll
Ecological Significance: Ecoregion
Biological Feature: Well-developed coral barrier and interior lagoon patch reefs provide habitat for a diverse assemblage of reef fish, lobster, conch, and sportfish (bonefish, permit). Open oceanic influences contribute to fish diversity and presence of pelagic species. Two fish spawning aggregations are present. Unique blue hole provides habitat for sharks and possible unique assemblage of endemic and cryptic species. The whitelined toadfish, a rare and cryptic fish, has been observed here. At least 289 reef fish species are present. Half Moon Caye and Blue Hole Natural Monuments provide no-take replenishment zones.

Map ID #: 20
Name: Caye Point, Lighthouse
Ecological Significance: Subregion
Biological Feature: Located northeast of Caye Point, Lighthouse Atoll where groupers actively congregate to spawn.

Map ID #: 21
Name: Big Caye Bokel
Ecological Significance: Subregion
Biological Feature: Well-developed fore reef with steep drop off, located at prominent southern tip of Turneffe, has high coral and benthic cover. Abundant and high diversity of fish species. Spawning aggregation site, especially for black and tiger groupers.

Map ID #: 22
Name: S. Long Caye
Ecological Significance: Subregion
Biological Feature: Important spawning aggregation located east of Southern Long Caye. Large numbers of fish and multiple species (*E. guttatus, E. striatus, L. juco, M. bonaci*) are present for short time periods. Historically, the aggregation was heavily fished, but currently yield is too low for active fishery and populations are still susceptible to fishing pressure. Possible whale shark location as well.

Map ID #: 23
Name: S. Columbus Reef
Ecological Significance: Subregion
Biological Feature: Southern-most end of Columbus reef, east of Man-O-War Caye and just north of Tobacco Caye channel. Reef morphology forms a noticeable point and attracts several snapper species to aggregate and spawn.

Map ID #: 24
Name: Glovers Reef Atoll
Ecological Significance: Ecoregion
Biological Feature: Best-developed coral reef atoll in Caribbean provides diverse habitat that serves as recruitment, nursery, and feeding and dwelling areas for lobster, conch, and finfish. Interior lagoon provides unique fish habitat with its assemblage of at least 700 patch reefs, numerous seagrass beds and extensive sandy hardbottom. Large grouper spawning aggregation site on NE end of atoll. Fish diversity and abundance affected by both open ocean and Gulf of Honduras currents. Over 250 reef fish species are present. Glovers Reef marine reserve – includes no-take replenishment area.

Map ID #: 24a
Name: S. Glovers
Ecological Significance: Local
Biological Feature: Southern areas on Glovers Reef Atoll including Long Caye and Middle Caye with high concentration of adult bonefish, snook, and permit. Known "hot spot" for sport fishing.

Map ID #: 25
Name: NE Glovers
Ecological Significance: Subregion
Biological Feature: Northeastern most tip of Glovers Atoll where several species of groupers and snappers still actively aggregate during spawning season.

Map ID #: 26
Name: Gladden Spit
Ecological Significance: Ecoregion
Biological Feature: One of the most exceptional areas in the ecoregion located east of Placencia. A change in directional axis forms a prominent point in the barrier reef causing unique current flows in the area. The largest spawning (grouper, snapper etc.) aggregation in the ecoregion as well as significant and predictable whale shark concentrations (36 observed in one day) that come to feed primarily on the spawn. Fish species that spawn here include cubera snapper, yellowtail snapper, dog snapper, mutton snapper, Nassau grouper, black grouper, red hind, ocean jack, rockfish, schoolmaster. Between 2,000-4,000 individuals, representing numerous snapper species, have been observed at one time at this aggregation site. Seagrass beds behind the reef serve as productive lobster fishing ground. Numerous reef fish inhabit the myriad of surrounding reefs. Gladden Spit and Silk Cayes Marine Reserve provide some protection to fish.

Map ID #: 27
Name: Port Honduras
Ecological Significance: Local
Biological Feature: Diverse coastal habitats include lagoons, mangroves, and estuaries. One of the few large estuarine lagoons in ecoregion that is important for life cycle of estuarine fish, such as snook, tarpon, bonefish, permit, and mullet. Several nursery areas for lobster and conch. Unique oceanic/coastal circulation patterns associated with Gulf of Honduras may be important for fish and invertebrate spawning, larval transport, and recruitment. Port Honduras Marine Reserve (declared 2000) has helped reduce illegal fishing.

Map ID #: 27a
Name: Snake Cayes
Ecological Significance: Local
Biological Feature: Unique in that it is one of only two areas in Belize where patch reef habitat occurs nearshore. Influenced by coastal, reef, and oceanic systems. Important area for adult lobster, adult conch, and snapper.

Map ID #: 28
Name: Sarstún River
Ecological Significance: Subregion
Biological Feature: Mangroves lining the Sarstún River banks are important fish habitat and potential nursery areas for estuarine and possible reef species. The anticyclonic current patterns near the river mouth suggest possible connection with the southern Belize barrier. Río Sarstún Game Reserve provides protection for mangroves and its associated fauna.

Map ID #: 29
Name: Río Dulce
Ecological Significance: Subregion
Biological Feature: A large complex and mainly freshwater ecosystem (El Golfete, Río Dulce-Chocón-Machacas, Lago de Izabal, Río Polochic and Río Oscuro) that empties into Bahia de Amatique. The Río Dulce National Park protects a 1 km wide by 39 km long fringe along the mangrove-lined river and gulf area. Important habitat for estuarine and coastal fish. Important shrimp nursery.

Map ID #: 30
Name: Graciosa Bay - Amatique Bay
Ecological Significance: Subregion
Biological Feature: Highly productive and pristine mangrove and seagrass habitat in Graciosa Bay, with extensive seagrass beds extending into the eastern part of Bahia de Amatique. Over 100 species of fish, mollusk, and crustacean. Important nursery for fishes and invertebrates, particularly 4 species of shrimp. Graciosa Bay is a transition area between warm-temperate and tropical seagrass associated species. Artificial reefs in Amatique Bay provide additional fish habitat.

Map ID #: 31
Name: Motagua Point
Ecological Significance: Subregion
The Motagua river and its tributary the San Francisco River is one of the largest and most important freshwater systems in the area emptying directly into the Caribbean Sea. Its well-developed mangroves provide extensive habitat for estuarine and saltwater fishes. Aggregation site for groupers and snappers. Coastal fish species are found along the extensive sand/beach shorelines. River and sediment discharge is carried to the west to form the dynamic sand barrier habitats of Punta de Manabique. Likely associated with the southern Belize barrier reef to the north

Map ID #: 32
Name: Bahía de Omoa
Ecological Significance: Subregion
Biological Feature: Coastal habitats including Alvarado Lagoon and significant stands of mangroves. Extent of seagrass and coral unknown. Important area for shrimp and fish (e.g., snapper, grouper). Proposed protected area.

Map ID #: 33
Name: Bahía de Tela
Ecological Significance: Subregion
Biological Feature: Large coastal area with marshes, mangroves, channels, flooded savannahs, coastal lagoons, rocky beaches, sandy beaches, and unique nearshore reef pinnacle-like structures. Coastline serves as large nursery area for 4 species of shrimp and important habitat for coastal fish species. Janet Kawas National Park protects 284 km^2 of marine habitat. Punta Izopo is a protected coastal system with beaches/dunes, mangroves, small patches of nearshore corals, and seagrass meadows.

Map ID #: 33a
Name: Micos Lagoon
Ecological Significance: Subregion
Biological Feature: Shallow estuarine ecosystem with mangrove shorelines and high diversity of coastal fish species. Important fish nursery area.

Map ID #: 34
Name: Cayos Cochinos-Utila Corridor
Ecological Significance: Ecoregion
Biological Feature: Large nearshore corridor extending from mainland near La Ceiba seaward to Cayos Cochinos and westward to Utila. A good representation of complex cross-shelf habitats including upland watersheds, nearshore communities, island habitats, reefs and open ocean habitat, and a variety of bathymetric gradients. Coastal area provides habitat for finfish and shrimp. Coral reefs around the islands have high topographic complexity for productive fish, lobster, and conch habitat. Cayos Cochinos is representative of midshore zone and different than Utila and nearshore banks. High biodiversity for ecoregion. Possible important larval source for ecoregion.

Map ID #: 35
Name: SW Utila
Ecological Significance: Local
Biological Feature: Unique shallow platform at southern end with sandy cayes, patch reefs, and seagrass beds that provide diverse and interconnected habitat for reef fish.

Map ID #: 36
Name: Utila
Ecological Significance: Subregion
Biological Feature: The westernmost of the Bay Islands is encircled by fringing reefs. At least 313 reef fish species present.

Map ID #: 37
Name: North Utila
Ecological Significance: Subregion
Biological Feature: Important area for whale shark aggregation. Reef crest is most developed on northeast side.

Map ID #: 38
Name: Cayos Cochinos
Ecological Significance: Subregion
Biological Feature: The Marine Natural Monument covers about 485 sq. km of reef, seagrass, and sand bottom habitats. At least 226 species of reef fish are known. Coral reefs with over 50 species of corals have high topographic complexity for fish, lobster and conch.

Map ID #: 39
Name: North Cayos Cochinos
Ecological Significance: Subregion
Biological Feature: Complex reef structure provides habitat for numerous fish.

Map ID #: 40
Name: West end Roatán
Ecological Significance: Local
Biological Feature: Complex reef topography provides habitat for high abundance of fish. Sandy Bay West End Marine Reserve protects a fringing coral reef of ~ 10,400 m^2. Numerous large groupers present.

Map ID #: 41
Name: Roatán
Ecological Significance: Ecoregion
Biological Feature: Largest of the Bay Islands encircled by several reef types (shallow fringing crest, patch reefs, and shelf-edge reefs), seagrass beds, and mangroves. Located at the "headwaters" of the MACR region and likely to play an important role in larval distribution and habitat connectivity with the rest of the ecoregion. Over 309 reef fish species present. Important habitat for fish, lobster, and conch.

Map ID #: 42
Name: Cochinos Guaimoreto
Ecological Significance: Local
Biological Feature: Nearshore caye located near Point Trujillo. Important area for fish. Little information available.

Map ID #: 43
Name: Bahía de Trujillo
Ecological Significance: Local
Biological Feature: Large semi-enclosed bay with mangrove, beach, and seagrass habitats and protected on the north by extended land spit. Adjacent to Laguna Guaimoreto.

Map ID #: 44
Name: Laguna Guaimoreto
Ecological Significance: Subregion
Biological Feature: Diverse habitats including mangroves, saline lagoon, dune/beach habitat (on north side of lagoon), freshwater wetlands (south side of lagoon).

Map ID #: 45
Name: North Guanaja
Ecological Significance: Subregion
Biological Feature: Important aggregation site of at least 4 grouper species (*E. striatus* and 3 species of *Myceroptera*).

Map ID #: 46
Name: Guanaja
Ecological Significance: Subregion
Biological Feature: Easternmost of the Bay Islands with well-developed fringing reefs on northern side. Located at the "headwaters" of the MACR region, they likely play an important role in larval distribution and habitat connectivity with the rest of the ecoregion. At least 161 reef fish species are known. Mangroves devastated by Hurricane Mitch.

Map ID #: 47
Name: Aguán River
Ecological Significance: Subregion
Biological Feature: Located east of La Ceiba, the Río Aguán and adjacent lagoons El Lirio and Guaimoreto have high productivity and species richness. Important fish species include snook, tarpon, shark, and kingfish. The Aguán carries large amounts of inland sediments to coastal areas.

Map ID #: 48
Name: Laguna de Ibans
Ecological Significance: Subregion
Biological Feature: Large lagoon (63 km^2) fringed with mangroves (mainly *Rhizophora mangle*). Important shrimp and fish nursery area. High biodiversity of fish species. Influenced by Caribbean currents. Part of the Río Plátano Biosphere Reserve.

Map ID #: 49
Name: Río Plátano Coast
Ecological Significance: Ecoregion
Biological Feature: The Río Plátano Biosphere Reserve (5,250 km^2), a large and relatively pristine area, includes important coastal habitat such as rocky and sandy beach, river, lagoonal, and broad coastal savanna. This World Heritage Site has high abundance and diversity of fish species. Large tracts of mangroves serve as important nursery areas, especially for fish and shrimp. Extensive sandy beaches occur along the mainland and on barrier spits around the river mouths. Important fish species include snook, tarpon, shark, and kingfish. Endemic subspecies probably exist. Used mainly by indigenous Mosquitia indians.

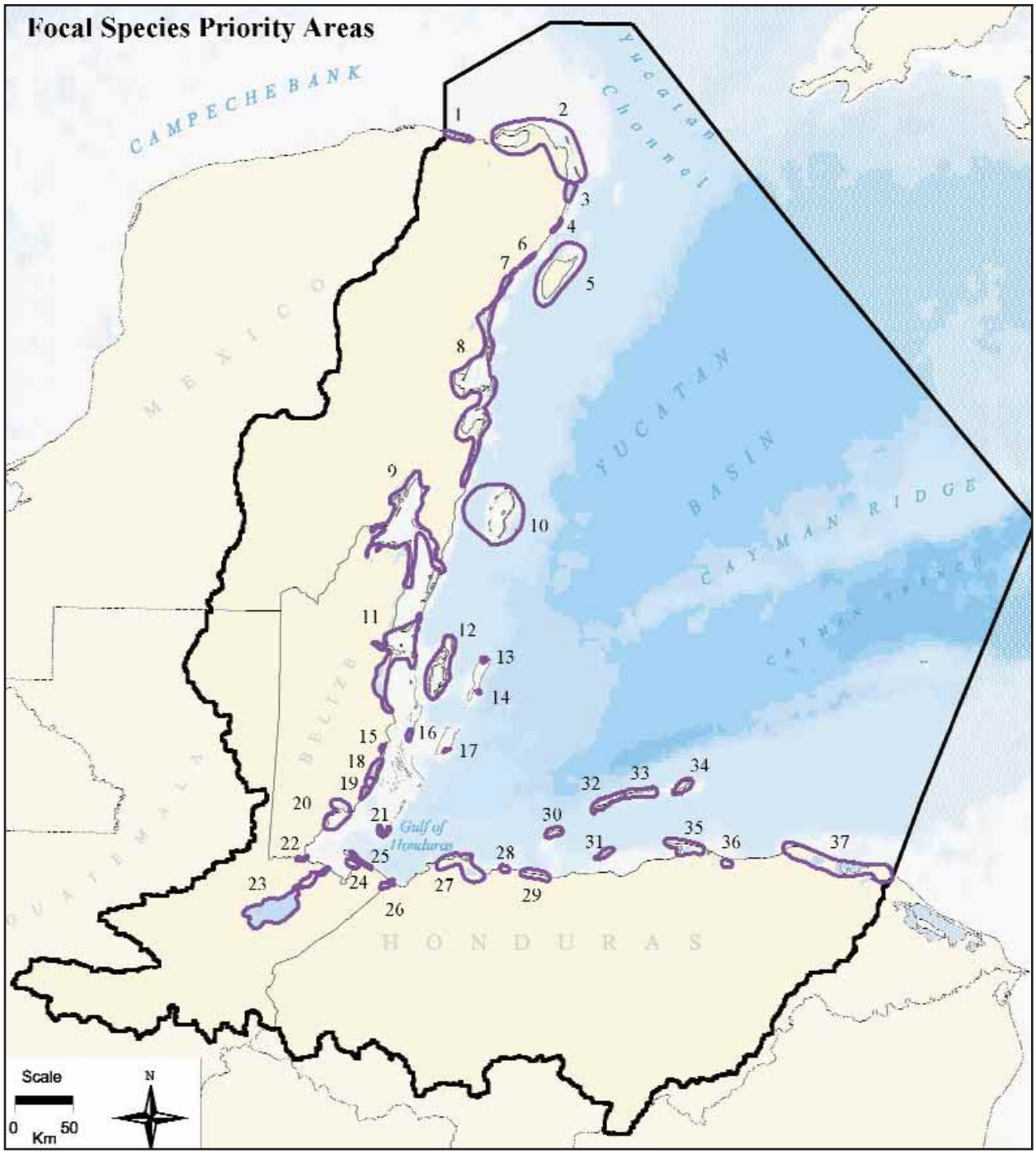
Map ID #: 50
Name: Laguna de Brus
Ecological Significance: Subregion
Biological Feature: Large lagoon (120 km^2) fringed with mangroves (mainly *Rhizophora mangle*). Important shrimp and fish nursery area. High biodiversity of fish species. Influenced by Caribbean currents. Protected under the Río Plátano Biosphere Reserve.

Map ID #: 51
Name: Swan Islands
Ecological Significance: Unknown
Biological Feature: Highly productive fishing grounds for conch and fish (e.g., snapper, dolphin, grouper), although very little is known about these habitats. May be an important spawning ground for fish. Currents flowing past the islands and banks toward the west are likely rich in planktonic life and probably play an important role in larval transport.

Map ID #: 52
Name: Rosario Reef
Ecological Significance: Unknown
Biological Feature: Highly productive fishing grounds for conch and fish (e.g., snapper, dolphin, grouper), although very little is known about these habitats. May be an important spawning ground for fish. Adjacent deep water may provide unique habitat for deepwater species. Currents flowing past the islands and banks toward the west are likely rich in planktonic life and probably play an important role in larval transport.

Map ID #: 53
Name: Misteriosa Bank
Ecological Significance: Unknown
Biological Feature: Highly productive fishing grounds for conch and fish (e.g., snapper, dolphin, grouper), although very little is known about these habitats. May be an important spawning ground for fish. Adjacent deep water may provide unique habitat for deepwater species. Currents flowing past the islands and banks toward the west are likely rich in planktonic life and probably play an important role in larval transport.

Focal Species Priorities Areas (manatees, sea turtles, birds) (SPA) Map



Map ID #: 1
Name: Ría Lagartos
Ecological Significance: Subregion
At least 315 bird species (in 179 different genera).

Map ID #: 2
Name: Contoy-Yalahau
Ecological Significance: Ecoregion
Biological Feature: Historic site for manatees. Two important seabird and wading bird nesting islands. Yalahau has 250-300 bird species, is important nesting site for pelicans (>300 birds); has over 10,000 magnificent frigate birds; has nesting sites of white crowned pigeon, and has 3,000-5,000 double-crested cormorants. Chacmochuc is important feeding area for brown pelican and numerous sea and wading birds. Isla Contoy is important stopover site for migratory birds; has 177 bird species (>50% are migratory), 8 of which are endemic and 2 with restricted distribution; largest colony of brown pelicans on Mexican east coast; important reddish egret colonies; at least 2 least tern nesting sites; sooty and bridled tern nests, and summer population of nesting white-crowned pigeons. Loggerhead and green sea turtles nest at Hol Box and Cabo Catoche. Isla Contoy has fairly large number of sea turtle nests; ~ 47 loggerhead nests/1.9 km, ~ 40 green nests/1.9 km, and 47 hawksbill nests/1.9 km.

Map ID #: 3
Name: Isla Mujeres
Ecological Significance: Subregion
Biological Feature: Small coral islet off of eastern point of Cancun. Isla Mujeres historically was an important feeding and resting stopover for Trans-Gulf migratory land birds. Possible presence of the Yucatán woodpecker. Over 350 sooty terns and 6 pairs of bridled terns use islet for nesting; 200 brown noddys use the area. 2 black noddys present - a record for Mexico. Loggerheads (13 nests/4 km beach) and green turtles (38 nests/ 4km) nest on Isla Mujeres.

Map ID #: 4
Name: Puerto Morelos
Ecological Significance: Subregion
Biological Feature: High density of loggerhead (120 nests/10 km) and green (100 nests/35 km) sea turtle nests.

Map ID #: 5
Name: Cozumel
Ecological Significance: Subregion
Biological Feature: One of the largest sea turtle nesting beaches in ecoregion. Extensive sea turtle nesting along east coast: (e.g., 323 loggerhead nests in the north/18km, 665 green turtle nests/18 km in north and 1,268/375 green turtle nests in south). Over 238 bird species. Important feeding and resting stopover for Trans-Gulf migratory land birds. Three Cozumel endemic bird species, 5 regional endemic species, 2 species of limited distribution, and 2 endemic subspecies to Cozumel (Cozumel wren, golden warbler). Endemic lizard species are present. Year-round population of resident white crowned pigeons. Crocodiles use the northern and southern part of the island.

Map ID #: 6
Name: Playa de Carmen — Akumal
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat provides important coastal corridor — ~ 3-5 manatees. Important nesting habitat for all four sea turtle species.

Map ID #: 7
Name: Tulum
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat and important manatee corridor — ~ 6-10 manatees. Important nesting habitat for all four sea turtle species.

Map ID #: 8
Name: Sian Ka'an
Ecological Significance: Ecoregion
Biological Feature: Most important above-ground watershed in Quintana Roo and 2nd largest community of water birds in Mexico. At least 17 species of colonial waterbirds breed here, 13 in Ascensión Bay, 11 in Espíritu Santo Bay. At least 339 (120 migratory, 219 resident) bird species are found here, 6 of which are endangered, 14 threatened, 6 regionally endemic, and 2 of limited range (catbird and Banaeraquil). Large number of migratory birds (e.g., 3,000 eastern kingbirds forage near Punta Allen). Ascención Bay has largest wood stork nesting site on Yucatán Peninsula (also one of only two wood stork nesting sites on Yucatán). Endangered tern nesting sites. Sixteen raptor species. Cayo Culebra has large nesting colonies of frigate birds and white-crowned pigeon. Large concentrations of wading and seabirds including cormorant, roseate spoonbill, greater flamingo, and jabiru. At least 3 wading bird and seabird nesting islands in Espíritu Santo Bay. Over 64 km of excellent nesting habitat for sea turtles, including the green, hawksbill, loggerhead, and leatherback. High density of sea turtles north and south of bays. The Morelet's crocodile and American crocodile nest and forage here. Chetumal Bay has critical manatee habitat and calving area – also ~ 12 manatees in Ascención Bay, 3-5 in Espíritu Santo Bay. Manatees also are found on east side of northern Ambergris.

Map ID #: 9
Name: Chetumal Bay
Ecological Significance: Subregion
Biological Feature: Large area including Chetumal Bay, Corozal, Bacalar Chico, and north Ambergris. Large manatee populations (~ 250 manatees) and one of most important calving areas in Caribbean. About 90% of Chetumal Bay population uses Guerro Lagoon and Río Honda. Habitat for crocodiles, dolphins, and sea turtles. Two small bird nesting islands with wood storks (one of only two wood stork nesting sites in Yucatán). Over 250 bird species are found in Bacalar Chico. Some of the highest densities of loggerhead nests in Belize and a few green turtle nests.

Map ID #: 10
Name: Banco Chinchorro
Ecological Significance: Ecoregion
Biological Feature: At least 105 bird species; 68 of these are migratory, and 55 of these are migratory landbirds. Important stopover for migratory, especially landbirds. Nesting sites for sooty and bridled terns, brown noddy, frigates, cormorants, and white crowned pigeon. Sea turtles use the area.

Map ID #: 11
Name: Belize City River- Lagoons
Ecological Significance: Ecoregion
Biological Feature: Coastal lagoon area surrounding Belize City, including Gales Point, two rivers (Belize and Sibun) and sandy caye system (Caye Caulker to Drowned Cayes). Largest manatee habitat in Belize and important calving area. Manatees are seen mainly in the Southern/Northern Lagoon area, including Quamina Creek, Cornhouse Creek, Wagoner Creek, and Tum Tum Creek. Some of the highest numbers of manatees have been reported in the Southern Lagoon (55 in a 1987 aerial survey). Lagoon area provides undisturbed habitat, access to the sea through the Manatee Bar River, productive foraging habitat and freshwater sources such as Tarpon Hole. This area is protected as a Manatee Special Development Area (MSDA). Also largest hawksbill nesting area (over 100 nests) on adjacent Manatee Bar. About 16-50 manatees seen in Belize River and 16-50 around Drowned Caye area. Bottlenose and rough-toothed dolphins utilize the area. Bird sanctuary in Northern Lagoon. Burdon Canal Nature Reserve. Loggerhead and green sea turtles nest on cayes.

Map ID #: 12
Name: Turneffe Islands
Ecological Significance: Ecoregion
Biological Feature: Some of the best remaining salt water crocodile habitat, with perhaps the largest population in Belize. Manatees (~ 10-35) and calves are found in interior mangroves. High density of hawksbill sea turtles on eastern sand cayes. At least three Belize-endemic species are present – a snail, yellow tail parrot, and the white-spotted toadfish. Potential habitat for the endemic Belize Atoll Gecko may occur here as well. Numerous birds roost on interior network of mangroves. Several breeding seabird colonies (e.g., brown booby, cormorant, sooty tern, frigate bird). White crowned pigeon nesting area.

Map ID #: 13
Name: Half Moon Caye
Ecological Significance: Ecoregion
Biological Feature: Over 120 bird species. One of two white-phase nesting colonies of red-footed booby in the Caribbean is found here with between 3,000-4,000 individuals. Loggerhead and hawksbill turtles nest on sandy caye.

Map ID #: 14
Name: Lighthouse Atoll
Ecological Significance: Ecoregion
Biological Feature: Loggerhead (~ 12 nests) and hawksbill (~ 8 nests) turtles nest on sandy caye. Important bird habitat. Brown pelicans nest on Saddle Caye.

Map ID #: 15
Name: Sitee River - Sapodilla Lagoon
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat; ~ 3-5 manatees.

Map ID #: 16
Name: Man-o-War Caye - Central Barrier
Ecological Significance: Subregion
Biological Feature: Manatees observed here. Loggerhead, green, and hawksbill turtle nesting habitat.

Map ID #: 17
Name: Middle Caye, Glovers
Ecological Significance: Ecoregion
Biological Feature: Loggerhead (~ 12 nests), green (~ 8) and hawksbill (~ 1) turtle nesting habitat. Several migrating bird species use area. The endemic Belize Atoll Gecko, previously only recorded on Half Moon Caye, has been observed here

Map ID #: 18
Name: Placencia Lagoon
Ecological Significance: Ecoregion
Biological Feature: Placencia Lagoon system including Silver, Jenkins, and Big Rivers and coastal areas. Critical manatee habitat and calving area; ~ 16-50 manatees. Loggerhead (~ 3 nests), green (~ 2) and hawksbill (~ 1) turtles nest along beaches.

Map ID #: 19
Name: Rocky Point
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat near Northern Shelf Lagoon; ~ 10-15 manatees.

Map ID #: 20
Name: Port Honduras
Ecological Significance: Subregion
Biological Feature: Port Honduras including Deep River to Río Grande, including Punta y Cacos Lagoon and Snake cayes. Critical manatee habitat. Green, loggerhead, and hawksbill sea turtles nest along coastline. Hawksbills nest on the Snake cayes.

Map ID #: 21
Name: Sapodilla Cayes
Ecological Significance: Subregion
Biological Feature: Important sea turtle nesting/foraging area. Historically, large numbers of hawksbill nests were common, although only “false nests” have been reported recently. Habitat for migratory birds.

Map ID #: 22
Name: Sarstún River
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat; ~ 3-5 manatees. Wading birds nesting site.

Map ID #: 23
Name: Río Dulce
Ecological Significance: Ecoregion
Biological Feature: Critical manatee habitat. Most manatees in Guatemala occur mostly in the freshwater Río Dulce ecosystem (El Golfete, Río Chocón-Machacas, Lago de Izabal, Río Polochic, and Río Oscuro). Manatees most frequently observed in Lago de Izabal, particularly in the southwestern area between Punta Chapín and Cayo Padre, where vegetation, shallow canals, and lagoons are abundant, and boat traffic is reduced. Calves frequently observed in Cayo Padre. First marine reserve in Central America (1979).

Map ID #: 24
Name: La Graciosa
Ecological Significance: Ecoregion
Biological Feature: Critical manatee habitat. 10-35 manatees found along the short Guatemalan coast (Bahia de Amatique, Bahia de la Graciosa, and Punta Manabique).

Map ID #: 25
Name: Punta de Manabique
Ecological Significance: Ecoregion
Biological Feature: Punta de Manabique has extensive sea turtle nesting habitat. At least 380 hawksbill sea turtle nests/50 km are reported.

Map ID #: 26
Name: Motagua River
Ecological Significance: Subregion
Biological Feature: Motagua River and associated watershed has stands of red mangroves, interior lagoons, and estuarine habitats that are important refuge for birds, manatees, and sea turtles. Critical manatee habitat; about 10-35 manatees use the area.

Map ID #: 27
Name: Punta Sal
Ecological Significance: Subregion
Biological Feature: Highly diverse array of coastal habitats along north Honduras, includes Jeannette Kawas National Park. Has some of the highest bird diversity along coast and has important wading bird nesting and foraging areas. A few sea turtles (loggerheads) nest on the coastal beaches. Critical manatee habitat in the Sula basin, especially at the mouth of the Ulúa and Chamelecón Rivers. About 3-5 manatees near Punta Sal, 10-15 near the Rivers.

Map ID #: 28
Name: Río Leon
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat — ~ 6-10 manatees frequent freshwater, estuarine, and coastal habitat near Río Leon and Punta Izopo. Loggerhead, green, and hawksbill turtle nesting habitat along coastal beaches. Important area for resident and migratory birds.

Map ID #: 29
Name: Río Cuero and Río Salado
Ecological Significance: Subregion
Biological Feature: Critical manatee habitat. About 10-36 manatees have been sighted in Cuero and Salado Rivers and Laguna de Boca Cerrada. Loggerhead, green, and hawksbill turtle nesting habitat along coastal beaches. It includes Cuero y Salado Wildlife Refuge.

Map ID #: 30
Name: Utila
Ecological Significance: Subregion
Biological Feature: Sea turtle nesting (loggerheads and greens). Possible unique island terrestrial species. Seabird nesting.

Map ID #: 31
Name: Cayos Cochinos Marine Natural Monument
Ecological Significance: Ecoregion
Biological Feature: Over 120 sea turtles nested here in 1998. At least 43 species of birds are present. Several resident landbirds (e.g., white crowned pigeon, Yucatán vireo), migrant seabirds and shorebirds (e.g., laughing gull), and numerous migratory landbirds utilize the area. Two small colonies of brown pelicans nest on the small island (Cayo Cochinos Pequeño) and royal terns breed on a nearby sandy caye (Cayo Gallina), accounting for the first breeding records for these species on the Honduran coast. The pink boa is an endemic snake only found here.

Map ID #: 32
Name: West Roatán
Ecological Significance: Subregion
Biological Feature: Greatest array of terrestrial, coastal, and marine habitats in such a limited space. Several endemic species and subspecies (e.g., opossum, agouti, parrot, and ctenosaura lizard). Nesting hawksbill and green sea turtles. Only habitat for crocodiles in Bay Islands.

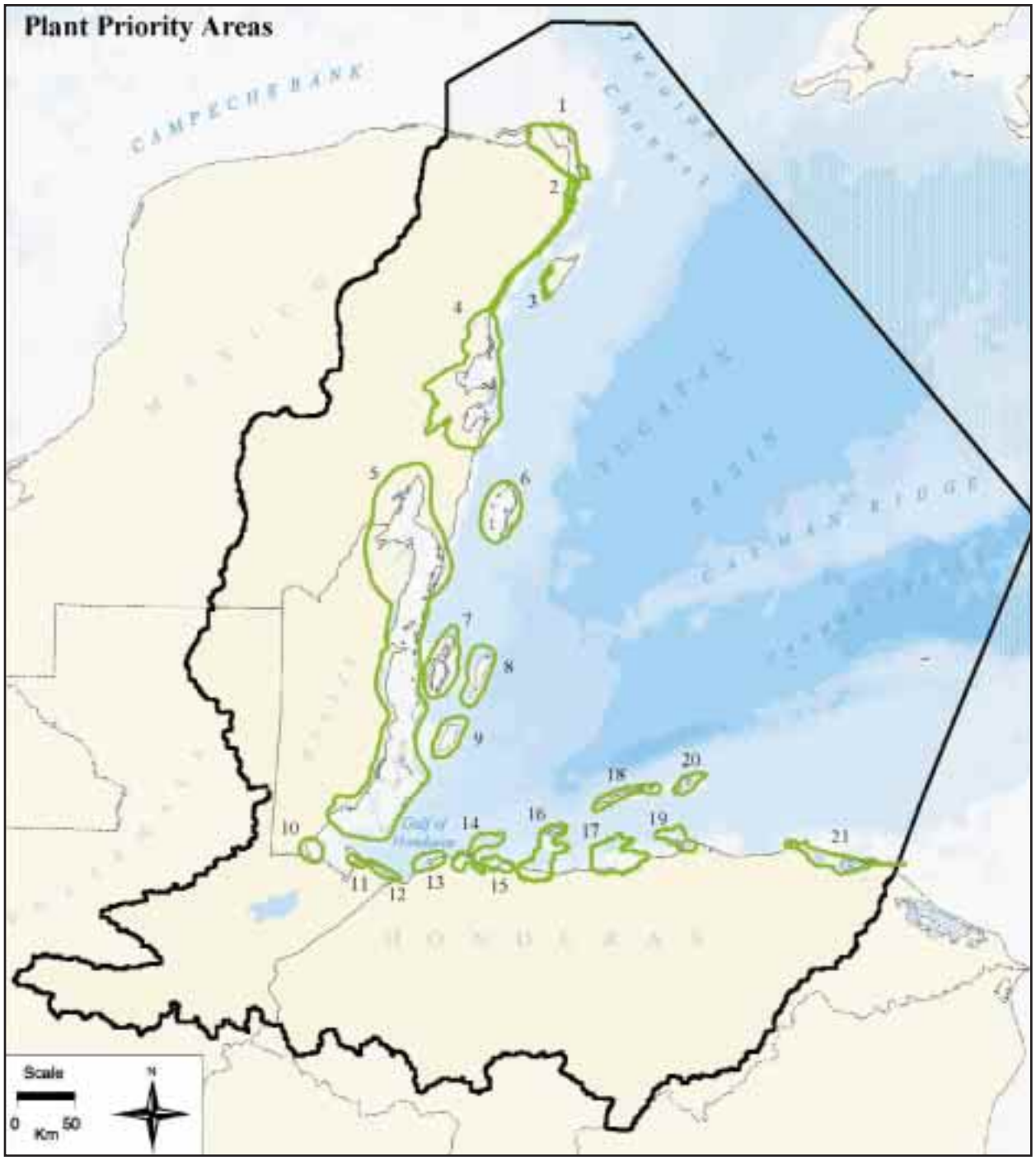
Map ID #: 33
Name: East Roatán - Barbareta
Ecological Significance: Ecoregion
Biological Feature: Greatest array of terrestrial, coastal, and marine habitats in such a limited space. Several endemic species and subspecies (e.g., opossum, agouti, parrot and ctenosaura lizard). Nesting hawksbill turtles. Only habitat for crocodiles in Bay Islands.

Map ID #: 34
Name: Guanaja
Ecological Significance: Subregion
Biological Feature: Sea turtle nesting. Possible unique island terrestrial species.

Map ID #: 35
Name: Bahía de Trujillo
Ecological Significance: Subregion
Biological Feature: Includes the Punta Coxinas peninsula, Guaimoreto Lagoon, and adjacent coastlines to the Chopaque River. Habitats include long continuous high energy beaches, dune vegetation, large mangrove-fringed lagoon, river and smaller lagoons. Critical manatee habitat.

Map ID #: 36
Name: Río Aguán
Ecological Significance: Subregion
Biological Feature: Important nesting area for sea turtles, migratory birds, crocodile and caimans, and wading birds. Critical manatee foraging and breeding grounds. Estimated 6-10 manatees use Río Aguán. Adjoins Capiro National Park – a 900 m high mountain rainforest behind Trujillo.

Map ID #: 37
Name: Río Plátano
Ecological Significance: Ecoregion
Biological Feature: World Heritage Site with high habitat complexity (lagoons, pine savannahs, swamp forest) and extensive coastal wetlands. Important habitat and nesting grounds for crocodiles, sea turtles, manatees, wading birds, and migratory birds. Largest potential manatee habitat in Honduras. Estimated 20-70 manatees in Ibans and Brus Lagoons. Loggerhead, green, and hawksbill turtle nesting habitat along coastal beaches. Least populated and developed area in the country.


Plant Priority Areas
CAMPECHE BANK
YUCATAN BASIN
CAYMAN RIDGE
HONDURAS
Gulf of Honduras
1
2
3
4
5
6
7
8
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10
11
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14
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16
17
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19
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21
Scale
0
Km
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Map ID #: 1
Name: Isla Contoy
Ecological Significance: Ecoregion
Biological Feature: Large area from barrier reef near Nichupté Lagoon north, including Isla Mujeres, Chakmuchuk Lagoon, Isla Contoy, and Cabo Cátoche. Includes a variety of marine plant habitats (e.g., seagrass, mangrove, etc). High biodiversity has been reported.

Map ID #: 2
Name: Nichupté Lagoon
Ecological Significance: Subregion
Biological Feature: Lagoon system near Cancun hotel zone. Has extensive mangrove and seagrass beds, although coastal development has led to increased eutrophication.

Map ID #: 3
Name: Cozumel
Ecological Significance: Subregion
Biological Feature: Island system comprised of diverse coral reef structures, seagrasses, and mangroves. Unique coralline algal ridges on east side. Important sea turtle nesting area.

Map ID #: 4
Name: Punta Nizuc to Sian Ka'an
Ecological Significance: Ecoregion
Biological Feature: Well-developed fringing reef from Punta Nizuc north to Tulum. Some of the most extensive mangroves and seagrasses near Sian Ka'an in ecoregion that provides important nursery habitat for marine organisms.

Map ID #: 5
Name: Belize Barrier Reef and Chetumal Bay
Ecological Significance: Ecoregion
Biological Feature: This area extends from the coastline out to the 200 m contour of the barrier reef. Contiguous coral reef, seagrass, and mangrove habitats across the Belize shelf. Outstanding species richness. Diverse habitats including barrier reef, lagoonal patch reefs, extensive seagrass meadows, and coastal mangrove forests. Pelican Keys represent unusual species assemblages and the Tobacco Range has unique seagrass turf habitat. Bay of Chetumal has extensive mangroves and seagrass beds.

Map ID #: 6
Name: Banco Chinchorro
Ecological Significance: Ecoregion
Biological Feature: Northernmost of the four ecoregional atolls and one of best-developed in Caribbean. Extensive coral reefs, seagrass meadows, mangroves, and sandy cayes. Area well-protected and in good condition.

Map ID #: 7
Name: Turneffe Islands
Ecological Significance: Ecoregion
Biological Feature: One of the best-developed coral atolls in Caribbean. Unique because of its extensive mangrove and interior lagoonal systems. The complex association between reefs, seagrasses, and mangroves provides a critical nursery for reef fishes, lobsters, conchs, and other reef fauna. Extensive vegetation is important habitat for bird roosting and foraging.

Map ID #: 8
Name: Lighthouse Reef Atoll
Ecological Significance: Ecoregion
Biological Feature: One of the best-developed coral atolls in Caribbean. Variety of reefs, mangroves, littoral forest, and lush seagrass beds. Patch reefs have diverse algae.

Map ID #: 9
Name: Glovers Reef Atoll
Ecological Significance: Subregion
Biological Feature: Best-developed coral atoll in Caribbean. Well-developed coral reefs, few mangroves, and various seagrass beds. Unique in the number of patch reefs (>700) that provide habitat for diverse marine biota. Unlike other atolls in that the major rivers of the Gulf of Honduras influence it.

Map ID #: 10
Name: Sarstún River
Ecological Significance: Subregion
Biological Feature: Important river system associated with a variety of coastal habitats including mudflats, mangroves, sea grasses, and corals. Important habitat for mammals, reptiles, birds, and manatees.

Map ID #: 11
Name: Bahia la Graciosa
Ecological Significance: Subregion
Biological Feature: 15 km north of Puerto Barrios. Shallow coastal lagoon with extensive mangrove and turtle grass beds (*Thalassia testudinum*) over muddy substrates in pristine condition. The mouth of the bay and surrounding areas also have turtle grass beds over sandy substrates. Mangrove forests cover the shoreline inside the bay and small creeks. Important nursery for fishes and invertebrates that supply local rural and urban populations through both fishery and recreational use of its natural resources. The area is relatively undisturbed but plans for tourism development exist. Important habitat for manatees.

Map ID #: 12
Name: Motagua River
Ecological Significance: Subregion
Biological Feature: Coastal area influenced by Motagua River, including the special protected area of Point Manabique. Dominated by stands of red mangroves, interior lagoons, and estuarine habitats.

Map ID #: 13
Name: Puerto Cortés and Omoa
Ecological Significance: Subregion
Biological Feature: Coastal habitats including Alvarado Lagoon and significant stands of mangroves. Extent of seagrass beds and coral unknown. Area experiences contamination from port activities.

Map ID #: 14
Name: Jeanette Kawas National Park
Ecological Significance: Ecoregion
Biological Feature: From the city of Tela west across the Sula valley floodplain to the mouth of the Chamelecón river. Over 600 species of resident and migratory birds. Coastal floodplain has large intact block of broadleaf forests with patches of mangroves. Nearshore habitats have some corals and seagrass meadows, although little is known. Refuge for over 100 threatened and endangered species, including manatee and jaguar.

Map ID #: 15
Name: Punta Izopo National Park
Ecological Significance: Subregion
Biological Feature: Coastal system with beaches/dunes, mangroves, small patches of nearshore corals, and seagrass meadows. High biodiversity of terrestrial habitats including modified upland deciduous and coniferous sub-tropical forests. Creeks and rivers originating from coastal mountains flow into the coastal plains. Diverse marine and terrestrial vegetation provide important habitat for resident and migratory birds.

Map ID #: 16
Name: Cuero and Salado Rivers to Utila Island swath
Ecological Significance: Subregion
Biological Feature: Coastal area 20 km west of La Ceiba including Cuero y Salado Refuge out to Utila. Boca Cerrada and Estero Gracia are coastal lagoons with extensive mangrove forests. Coastal area has flooded broadleaf forests, freshwater wetlands. The Salmedona Banks have patch reefs and seagrasses. Utila has diverse sand, seagrass, reef, and open ocean habitats. Diverse marine and terrestrial vegetation provide important habitat for migratory birds and manatees.

Map ID #: 17
Name: La Ceiba coast to Cayos Cochinos swath
Ecological Significance: Ecoregion
Biological Feature: From mainland coastal area 20 km east of La Ceiba to Cayos Cochinos Marine Natural Monument. Encompasses cross-shelf terrestrial and marine habitats from tropical broadleaf forest, coastal wetlands, seagrass beds, coral reefs, and open oceanic habitat. Connected to other insular Honduran systems.

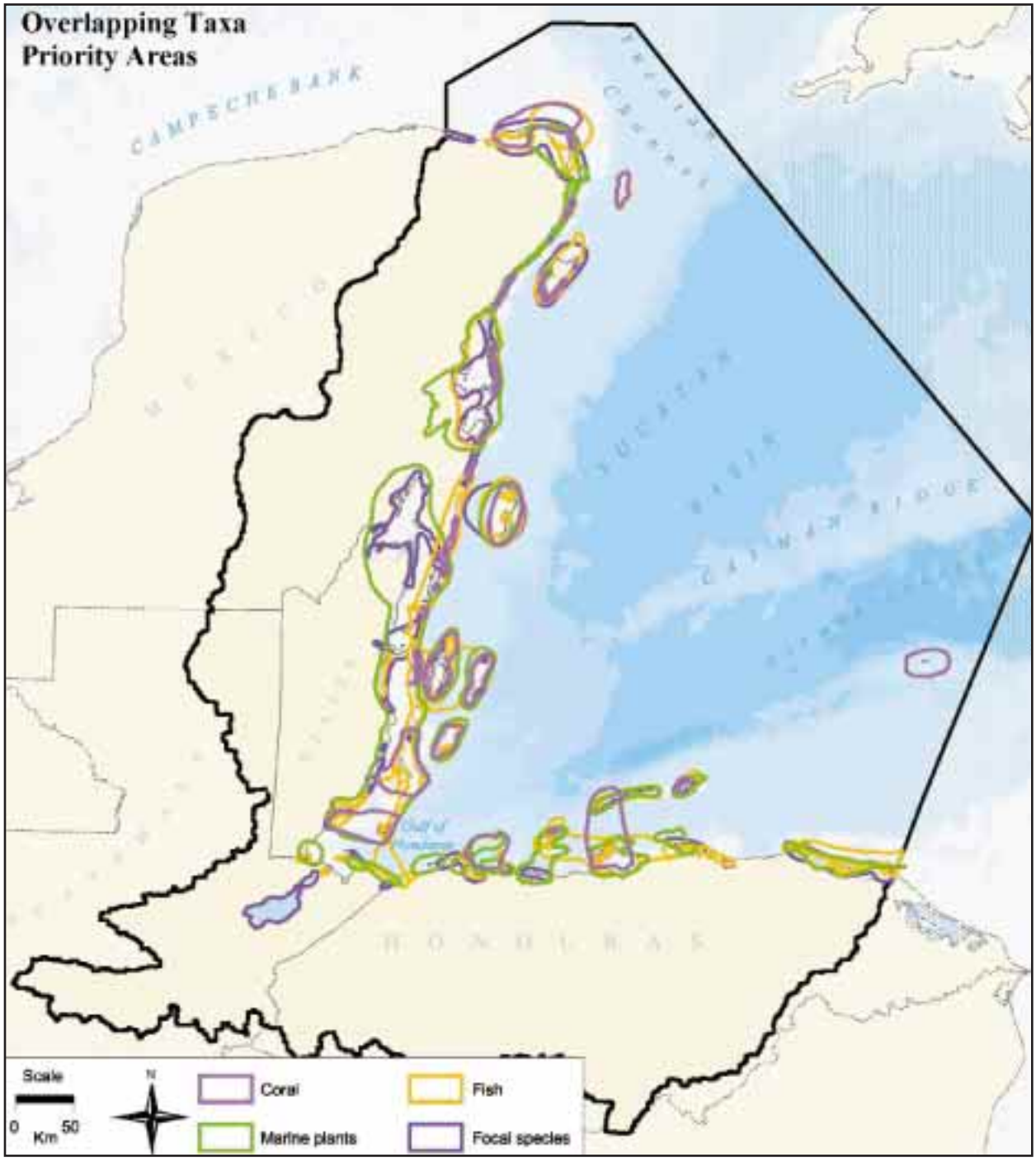
Map ID #: 18
Name: Roatán
Ecological Significance: Subregion
Biological Feature: Island system incorporating mangroves (e.g., Santa Elena), seagrass meadows, diverse and healthy coral reefs, and open ocean habitat

Map ID #: 19
Name: Guaimoreto Lagoon and Punta Caxinas
Ecological Significance: Subregion
Biological Feature: Diverse habitats including mangroves, saline lagoon, dune/beach habitat (on north side of lagoon), freshwater wetlands (south side of lagoon), tropical broadleaf forest, and subtropical cloud forest. Thalassia seagrass beds provide habitat for numerous fish and other biota.

Map ID #: 20
Name: Guanaja
Ecological Significance: Subregion
Biological Feature: Combination of mangrove, seagrass, reef, and open ocean habitats. Mangroves experienced extensive damage from Hurricane Mitch.

Map ID #: 21
Name: Ibans and Brus Lagoons, Puerto Lempira
Ecological Significance: Subregion
Biological Feature: Extensive mangrove and lagoon systems. The Río Platano Biosphere Reserve, to the south, is one of the most intact protected areas in Honduras. Provides important habitat for numerous bird, mammal, and reptile species.

**Since data was lacking on marine plants, the Plants group stratified MACR coastal areas into three dominant habitat complexes: 1) mangroves and seagrasses, 2) seagrasses and coral, 3) mangroves, seagrasses, and coral. Priority areas were selected based on their integrity and on their importance to other biota.*

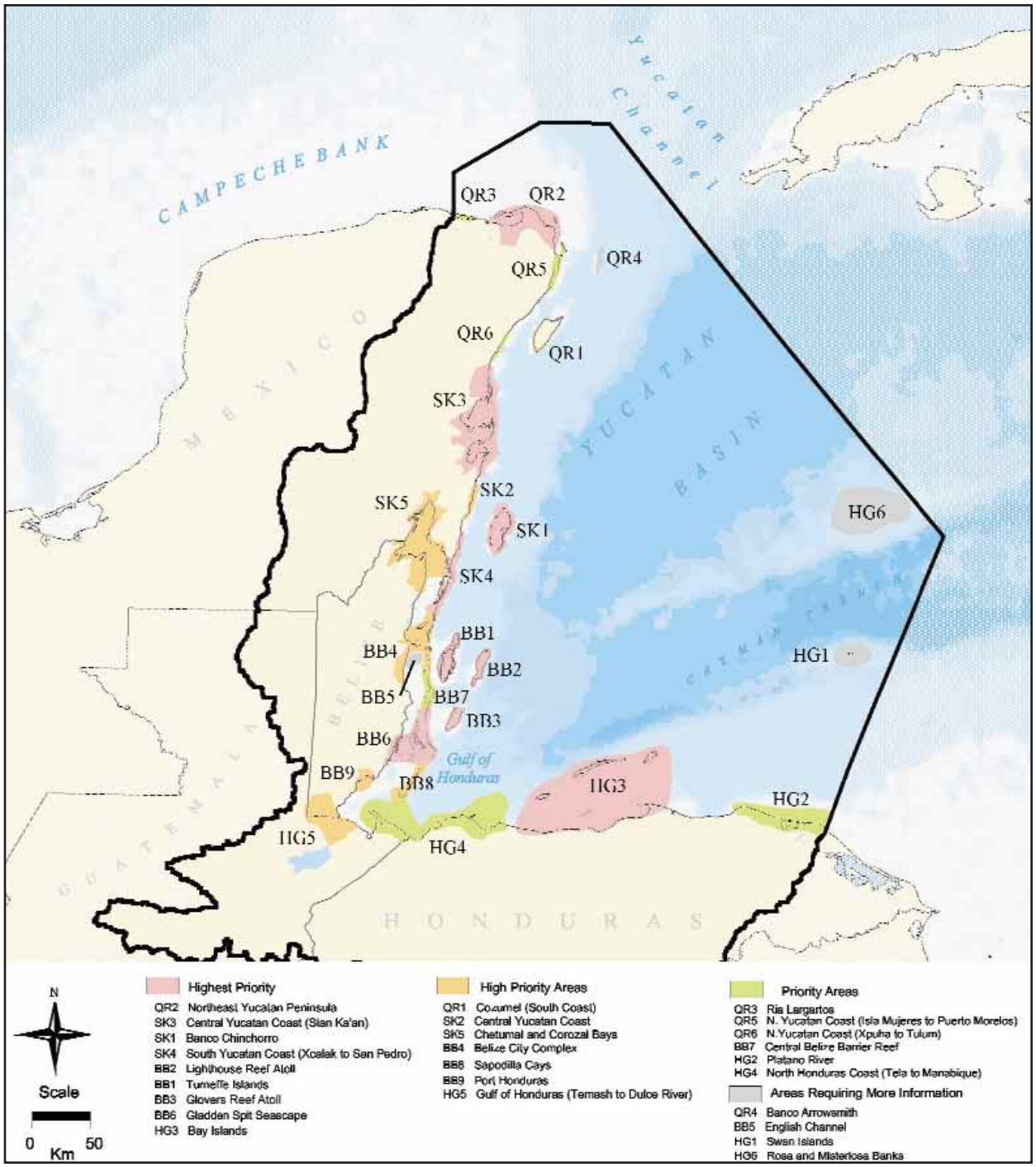

Overlapping Taxa
Priority Areas
CAMPECHE BANK
Scale
0 Km 50
N
Coral
Fish
Marine plants
Focal species

Biodiversity Priority Areas for the MACR: Maps and Descriptions

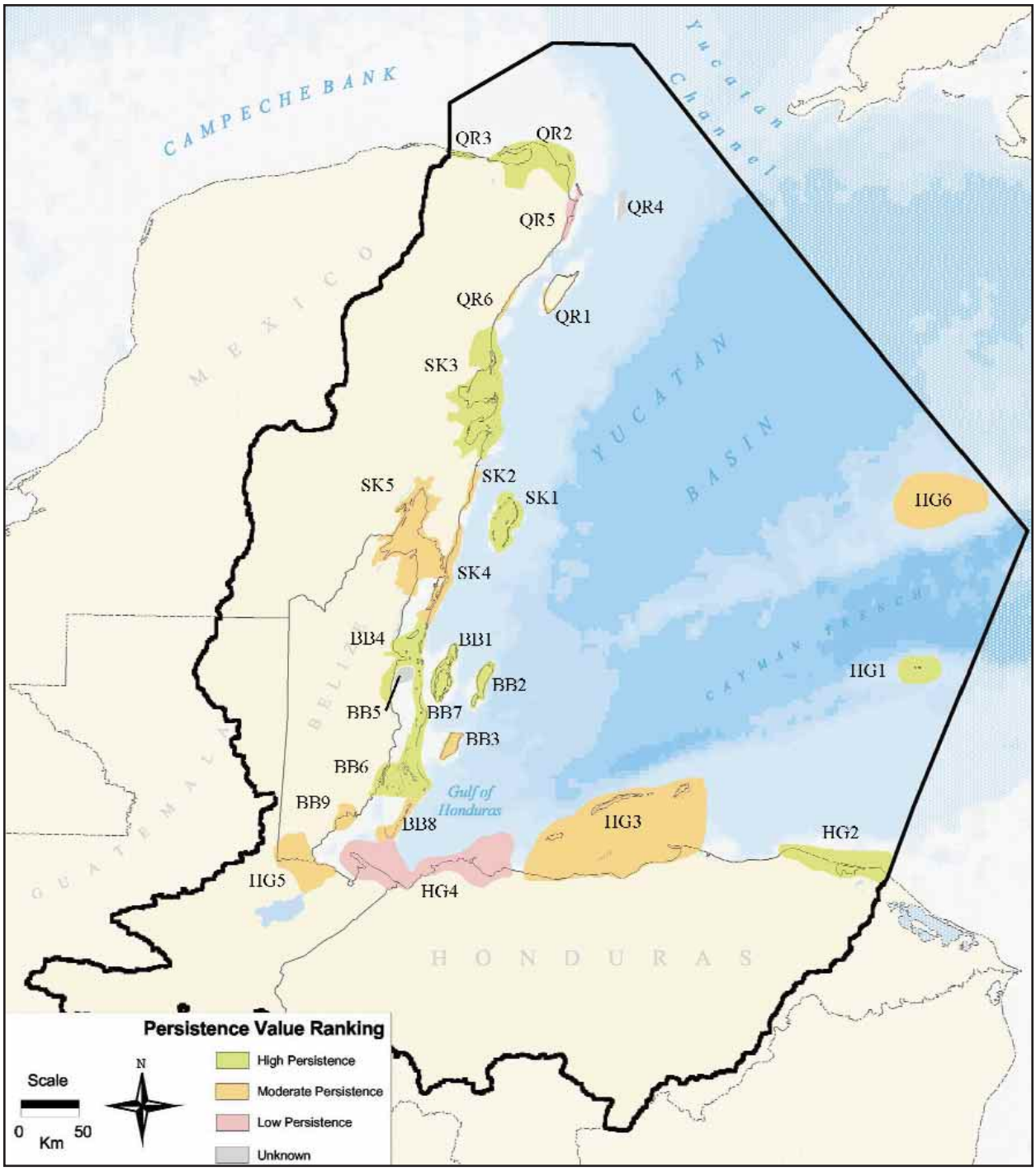
A summary of each Biodiversity Priority Area is given below and includes information on location, approximate size, biological importance, description of the area, outstanding biological features, current conservation status, resource use, threats and data gaps. Summaries are based on a combination of expert knowledge, synthesized from the Cancun 2000 workshop, and are supplemented by available literature or reports.

Map Code	Priority Area Name	Biological Priority Ranking	Page Number
QR2	Northeast Yucatán Peninsula	Highest	C5
SK3	Central Yucatán Coast (Sian Ka'an)	Highest	C6
SK1	Banco Chinchorro	Highest	C8
SK4	South Yucatán Coast (Xcalak to San Pedro)	Highest	C10
BB2	Lighthouse Reef Atoll	Highest	C12
BB1	Turneffe Islands	Highest	C14
BB3	Glovers Reef Atoll	Highest	C16
BB6	Gladden Spit Seascape	Highest	C18
HG3	Bay Islands	Highest	C20
QR1	Cozumel Southern Coast	High	C23
SK2	Central Yucatán Coast (Mahahual)	High	C24
SK5	Chetumal and Corozal Bays	High	C25
BB4	Belize City Complex	High	C26
BB8	Sapodilla Cays	High	C28
BB9	Port Honduras	High	C30
HG5	Gulf of Honduras (Temash and Dulce Rivers)	High	C31
QR3	Ría Lagartos	Priority	C33
QR5	Cancun Corridor	Priority	C34
QR6	Tulum Corridor	Priority	C35
BB7	Central Barrier Reef	Priority	C36
HG4	Tela - Manabique Coast	Priority	C37
HG2	Platano River	Priority	C39
QR4	Arrowsmith Bank	Unknown	C41
BB5	English Channel	Unknown	C42
HG1	Swan Islands	Unknown	C43
HG6	Rosa and Misteriosa Banks	Unknown	C43

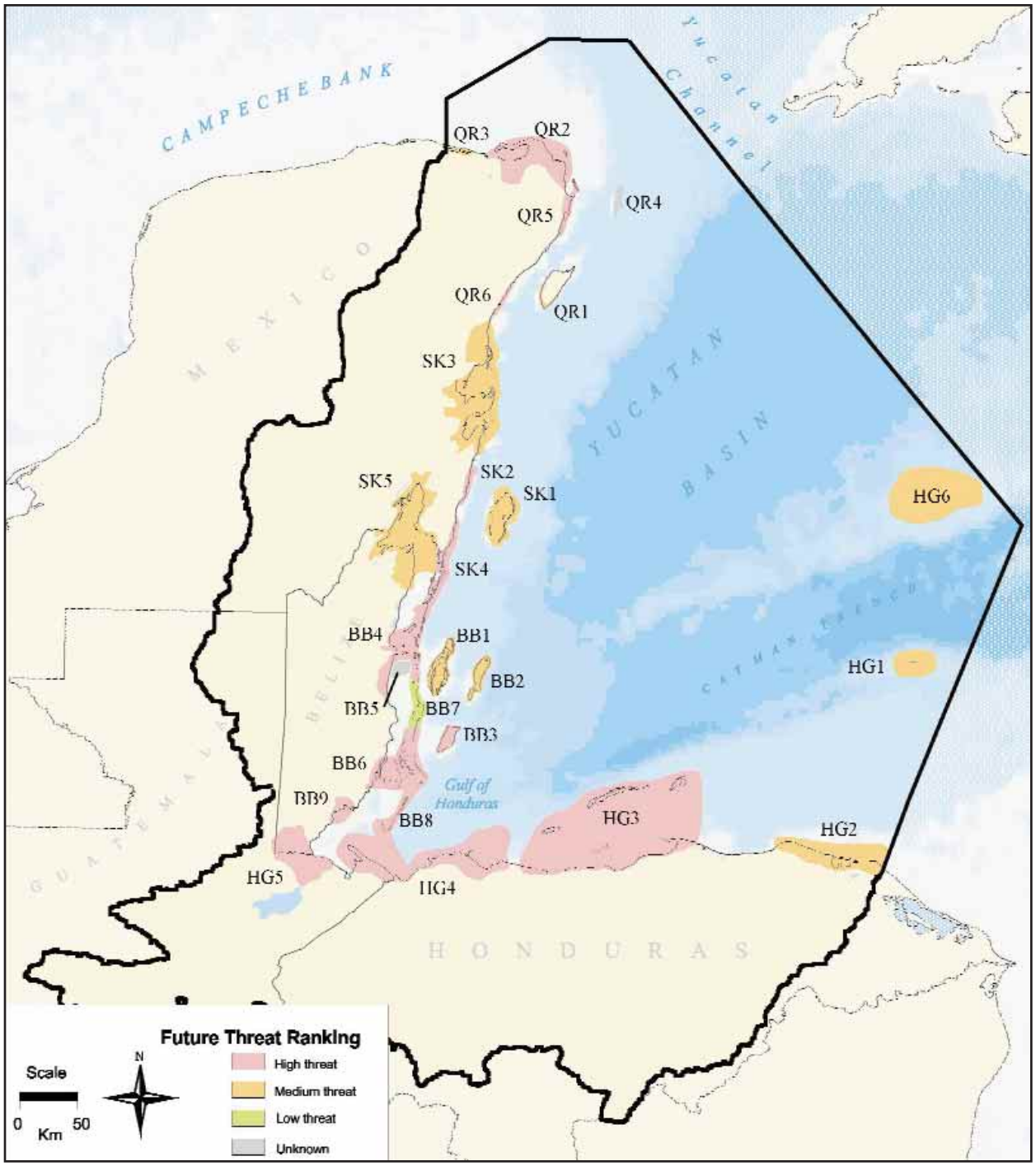
Map C1. Biodiversity Priority Areas



Map C2. Persistence Likelihood Ranking



Map C3. Future Threat Ranking



Highest Priority Areas

Name: Northeastern Yucatán Peninsula
Map ID Number: QR2
Subregion: Northern Quintana Roo
Location: Coastal areas around Cabo Catoche including Isla Contoy extending to Yalahau
Approximate size: 2,189 km²
Ownership: Mexico
Biological Importance: Highest

Description of area

The northeastern tip of the Yucatán Peninsula is a transitional boundary between the Caribbean Sea and Gulf of Mexico. Upwelling produced by the Yucatán Upwelling Zone located just north of the peninsula has a dominant influence in the northern area. The upwelling has a seasonal cycle, rising from the deep layers of the sea entering the photic zone but not reaching the ocean surface; thus, it has a relevant fertilizing effect on water masses (Merino, 1992). The Yucatán shelf is much wider in this area and contains a complex variety of habitats including offshore islands, lagoons, and bays. Coral reefs are poorly developed in this area, with the bottom consisting mostly of sand, algae and occasional patch reefs (Jordán-Dahlgren, 1993). The island of Isla Contoy, located 12.5 km off the coast, is an elongate flat limestone island with excellent beaches and ideal bird nesting habitat. Shallow (1.5-3.5 m) coastal lagoons (Yalahau, Chacmochuc) contain expanses of seagrass and mangrove habitat that serve as nursery areas for many species of fish and invertebrates.

Outstanding biological features

This area is the closest land to the seasonal Yucatán Upwelling Zone, which supports rich marine productivity and is unique in the western Caribbean. As a result, an extraordinary abundance and diversity of seabirds and other species that feed in the productive upwelling zone are found here. The strong northward-flowing currents funnel baitfish along the tip of the Yucatán Coast, attracting numerous pelagic species. Contoy and adjacent islands are critical seabird nesting areas (e.g., brown pelicans and frigate), and an important stopover point for migrating birds. Yalahau, Pájaros Island, and Mojoto Island support aquatic bird roosting and nesting. Pristine coastal dunes and extensive sandy beaches on many islands and portions of the mainland provide excellent nesting habitat for sea turtles (e.g., hawksbill). Mangroves and critical fish and lobster nursery habitat are found in Chacmochuc Lagoon and the area known as "El Contoy."

Current conservation status

Isla Contoy was declared a National Park in 1998. Yum-Balam Área de Protección de Flora y Fauna (154,052 ha) was declared in 1994.

Current resource use

Tourism, coastal development, limited fishing.

Description of threats

The subject of greatest concern is the alteration of fresh water resources due to water that is being drained from south of this area to provide fresh water for Cancun. Expanding coastal development to the north of Cancun City, such as development of Punta Sam and Isla Blanca on the continental side in front of Isla Mujeres Island, threatens this area. If development continues at the current pace, there is a moderately high threat that coastal and aquatic habitats will be degraded by the construction of roads, infrastructure, and sewage treatment.

Information needs

There is a general lack of information about marine mammals and fishes for this area. The physical oceanography and influence of Yucatán Current are also poorly understood.

Name: Central Yucatán Coast (Sian Ka'an Biosphere Reserve)

Map ID Number: SK3

Subregion: Sian Ka'an-Ambergris

Location: Central coast of Quintana Roo, between Laguna de Campechen and north Pulticub, including Punta Herrero, Punta Allen, and Bahias de la Ascención, and Espíritu Santo.

Approximate size: 3,623 km²

Ownership: Mexico

Biological Importance: Highest

Description of area

The Sian Ka'an Biosphere Reserve is located along the eastern Yucatán Peninsula midway between Cancun and the Belize border. Most of the area remains flooded throughout the year, especially during the rainy season, due to its flat terrain and low elevation. A geological fault crosses the Reserve from the southwest to the northeast and is thought to be responsible for the formation of the two large shallow bays, Bahia de la Ascención and Espíritu Santo, that open up to the Caribbean. As in other parts of the Yucatán Peninsula, sinkholes or cenotes are common. Coastal mangrove estuaries are surrounded by small freshwater springs and creeks and support productive lobster and finfish fisheries. The area includes about 90 km of fringing reefs with considerable local variation due to coastal and shelf morphology. Emergent reef crests are found around the land margin or forming narrow barriers in front of the shallow lagoons. Coral growth is restricted primarily to the crest, which often contains dense thickets of *Acropora palmata*. Patch reefs are found in some back reef areas dominated by *Montastraea annularis* and *Agaricia tenuifolia*. Fore reefs have well-developed stretches of rich coral spurs and grooves interspersed with low relief areas of pavement covered with sand and octocorals. Deeper slope reefs are associated with discontinuous shelf escarpments and contain diverse communities of octocorals, sponges and algae, with few scleractinian corals (Jordán-Dahlgren *et al*., 1994).

Outstanding biological features

The Sian Ka´an Biosphere Reserve has excellent terrestrial and aquatic habitat diversity, including well-developed reefs, coastal lagoons, dunes, mangroves, fresh and saltwater marshes, flood forests, cayes, and bays. More than 800 plant species are known and are similar to species found in the Caribbean Islands (Espejel, 1983), although the area also supports several endemic plants. The Bahia de la Ascención and Espíritu Santo support some of the largest spiny lobster (*Panulirus argus*) populations remaining in the ecoregion and provide important nursery habitat for other marine species. At least 339 (120 migratory, 219 resident) bird species are found here, 6 of which are endangered and 14 threatened (Vales *et al*., 2000). Abundant populations of marine and wading birds, including wood storks, roseate spoonbills, flamingos, and jabirus (*Jabiru mycteria*), rely on the high diversity of habitat for breeding, nesting, and/or foraging (Lopez and Ramo, 1992). More than 16 raptor species are known (Consejo *et al.*, 1987). Forty-two species of amphibians and reptiles have been recorded. Excellent sea turtle nesting habitat is found along the 64 km of coastal dunes for loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and leatherback (*Dermochelys coriacea*) turtles. The area also supports nesting and foraging habitat for the endangered American crocodile (*Crocodylus acutus*) and Morelet's crocodile (*C. moreletii*) (Lazcano-Barrero, 1990). At least 1,719 invertebrate species have been observed (Vales *et al.*, 2000)

Current conservation status

The Sian Ka'an Biosphere Reserve includes 1.3 million acres of marine and wetland habitat in Quintana Roo, Mexico and includes Sian Ka'an (declared 1986), the

reefs of Sian Ka'an (1998), and Uaymil (1994). The Reserve has significant ecological and cultural value. The United Nations declared the Reserve a World Heritage Site in 1987 based on the importance of preserving one of the largest untouched barrier island and mangrove ecosystems in the Caribbean. More than 40 prehispanic cultural sites are located within the Reserve.

Current resource use

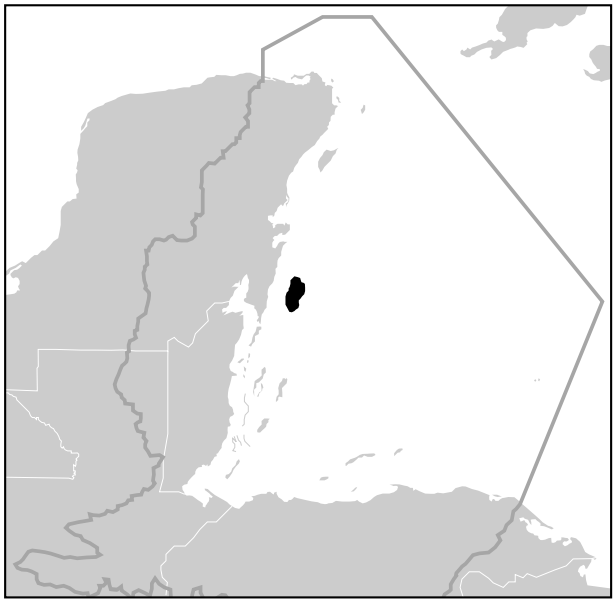
This area is located in the least populated and least developed part of Quintana Roo. Only about 800 people of predominantly Mayan origin live within the reserve; most (~ 450) live at Javier Rojo Gomez on Punta Allen, some live at Punta Herrero (~ 50), and others are along the coastline or forest. Local people rely on fishing (primarily lobster) and agriculture. Tourism is presently quite low because of the difficulty in accessing most of the reserve; however, it is expected to increase soon. There are a number of exclusive fishing lodges within the reserve.

Description of threats

Threats in this area are considered moderate and due mainly to pollution and unregulated urban development. Unregulated coastal development has resulted in a loss of beach and coastal habitat along the barrier beaches. The seemingly uncontrolled urban growth along the Yucatán coast in recent years has led to an increase in the development of tourist facilities both north and south of the reserve. The lack of adequate sewage treatment systems often means direct discharge into the sea. In addition, contaminated groundwater from inland agriculture has a negative impact on near shore communities and reefs. Fishing in this area is currently sustainable, although this may change in light of the uncertain future of commercial and recreational fisheries management.

Information needs

Additional information is needed on larval recruitment, nursery areas, and physical oceanography.



Name: Banco Chinchorro
Map ID Number: SK1
Subregion: Sian Ka'an-Ambergris
Location: Chinchorro and surrounding waters to a depth of 60 m
Approximate size: 1,065 km^2
Ownership: Mexico
Biological Importance: Highest

Description of area

Banco Chinchorro is a large (46 km x 14 km) emergent platform located 31 km off the southeastern coast between Xcalak and el Ubero and separated from the mainland by a 1,000 m deep channel (Chávez and Hidalgo, 1984). Similar to the atolls in Belize, Chinchorro is situated on one of a series of discontinuous fault blocks that tend to the northeast, parallel to the mainland coast (Dillon and Vedder, 1973). As the fault block subsided in the Tertiary, reef growth produced hundreds of meters of carbonate accretion that continues today. The atoll shields the adjacent mainland coast from large ocean waves and swell and has a strong influence on reef development. An almost continuous reef surrounds the shallow lagoon, broken by narrow cuts with strong currents. The windward margin contains impressive ramparts consisting of crests and back reefs dominated with *A. palmata* and *M. complanata*. The high-energy environment and wide, gradually sloping shelf margin limit deep reef development. In contrast, the leeward side has a much shorter shelf

margin characterized by steep steps running parallel to the margin that are rich in coral growth. Mud, sand, algae, patchy hard bottom coral communities, and seagrass beds cover the bottom of the interior shallow (1-5 m) lagoon floor. The lagoon deepens to more than 10 m toward the southern end where abundant, well-developed patch reefs occur. Several islands are located within the lagoon and on the barrier. The smallest island, Cayo Lobos, is named after the now extinct monk seal (*Monachus tropicalis*), which apparently used it as a breeding ground. The largest island, Cayo Centro, is several kilometers in size and contains extensive mangroves and salt-water marshes, as well as lush seagrass beds around the edges. The remains of shipwrecks from many different eras are scattered over Chinchorro's reefs and continue to attract diving enthusiasts and underwater archeologists.

Outstanding biological features

Chinchorro Bank is one of the best-developed atoll-like platforms found in the Western Hemisphere (the other three being in Belize). Habitat complexity is high within the lagoon and in the surrounding coral reefs. The lack of fresh water means that there are no mammals and no amphibians, but the area supports a large number of invertebrate species including 47 hermatypic corals, 48 soft corals, 35 sponges, and 103 mollusks (Vales *et al.*, 2000). Excellent populations of shallow acroporids (*Acropora palmata, A. prolifera,* and *A. cervicornis*) are found on the southwest side. More than 180 species of marine fishes have been counted, and at least two viable grouper (*Epinephelus striatus*) spawning aggregations sites have been documented (Aguilar-Perera and Aguilar-Dávila, 1996). The area also supports one of the largest and last commercially viable conch fisheries in Mexico, as well as a stable spiny lobster fishery. The area is an important reproduction area for birds of the Caribbean region. Over 90 species of birds are found in the area including one endemic, *Rallus longirostris chincherensis.* Species of sea turtle known to frequent Chinchorro include the green, hawksbill, and loggerhead sea turtles. American saltwater crocodiles also utilize Cayo Centro as a breeding and nursery area.

Current conservation status

The Banco Chinchorro Biosphere Reserve (Reserva de la Biósfera Banco Chinchorro) was created in 1996 and a management plan was initiated in 2000.

Current resource use

Fishing and tourism are the principal activities on Banco Chinchorro today. A permanent fishing camp of houses built over the water (palafitos) is located off the southern end of Cayo Centro and used by fisherman from Mahajual and Xcalac. The principal targeted species are lobster, conch, and grouper. The number of tourists who visit the reserve is low (estimated at less than 100 per month), and consists mainly of diving enthusiasts who come for the day or on live-aboard dive boats. A small number of cruising vessels also visits the area, although the lack of protected anchorages and the poor navigability of the lagoon prevents larger numbers. The Mexican Navy has a military station on Cayo Norte with between 30 and 60 soldiers conducting exercises and patrolling the area.

Description of threats

The level of threat is considered moderate, primarily due to the existing management of the area. Tourism is regulated under existing management, although the lack of support leaves the resources vulnerable. Coral bleaching events appear to be increasing in frequency and intensity, placing corals at greater risk to bleaching-related mortality and subsequent disease.

Information needs

Information is needed on connectivity between the atoll and mainland, oceanographic currents, and spawning aggregations. High-resolution bathymetry maps are needed.

Name: Southern Yucatán coast
Map ID Number: SK4
Subregion: Sian Ka'an-Ambergris
Location: Yucatán coast from Xcalak to San Pedro spanning border between Belize and Mexico
Approximate size: 903 km²
Ownership: Mexico/Belize
Biological Importance: Highest

Description of area:

Within this area of the Yucatán peninsula, the paleokarst coast contains an almost continuous chain of shallow lagoons, beaches interspersed with tidal channels, wash over fans, and broad mud flats. There is very little fluvial discharge in this area, so sediments are mostly carbonate material. Ambergris Caye, located on the eastern side of Chetumal Bay, is a spit formation extending southward from the Mexican mainland, whose name comes from whaling activity during the nineteenth century. Bacalar Chico is a narrow channel that represents the border between Mexico and Belize; it was reputedly dug by the Mayans in around 200 BC to connect Chetumal Bay with the Caribbean. In this area, the coastal shelf is only 0.5-1.5 km wide and consists of well-developed segments of fringing barrier reef, numerous patch reefs, and coral heads interrupted by inlets. The reefs around Xcalak are protected from large waves by Banco Chinchorro and have an unusual double fore reef ridge separated by a well-defined 38-43 m deep trench that is oriented parallel to the coastline. The fore reef ridges are characterized by high relief and well-developed reef zones with a similar zonation pattern on both sides of the trench. In general, shallow reef crests contain *Millepora*/crustose coralline algal mounds and corals encrusted with crustose coralline algae. Large heads of *Montastraea annularis* dominate patch reefs behind the barrier. The reef forms an almost continuous barrier along Ambergris Caye, with intermittent channels. The fore reef is characterized by well-developed spur and groove formations, sometimes forming semi-closed canyons. In 1997 coral cover was relatively high along Ambergris (33%), although after hurricane Mitch and the 1998 bleaching it dropped to 15% (McField, 2001a). South of Ambergris, reef development is believed to be affected by the natural effluents from lagoons and Chetumal Bay and by exposure to high-energy waves.

Outstanding biological features

This area contains a high diversity of habitats (lagoons, mangroves, channels, beaches, seagrasses, reefs) interconnected with Chetumal Bay, one of the largest bays in the entire ecoregion. The entire area is a highly important breeding site for marine and coastal birds, while the lagoons are indispensable as a reproductive area for many reef fishes. Some of the region's best examples of highly developed fringing reef occur along this section of the Yucatán, which is characterized by high relief and spectacular geomorphology. More than 250 bird species are found in Bacalar Chico alone and at least one major waterfowl roost occurs in the Laguna de Cantena. Rocky Point, the only place where the barrier reef touches the coastline, is an important spawning/reproductive aggregation site for several species of groupers, snappers, and conch. Beaches support nesting for several species of turtles and have the highest densities of loggerhead nests in Belize, along with some green turtle nests. Manatees (*Trichechus manatus manatus*) from Chetumal Bay also migrate and forage in the area.

Current Conservation Status

Bacalar Chico National Park and Marine Reserve was established in 1996 and covers 10,700 ha of both marine and terrestrial habitat; it is also a World Heritage site. Small portions of this priority area are included in the Chetumal Bay Manatee Sanctuary and

Corozal Bay Wildlife Sanctuary. Hol Chan Marine Reserve is located off the south end of Ambergris Cay. A protected area is being proposed for the southern Mexican coast near Xcalak.

Current resource use

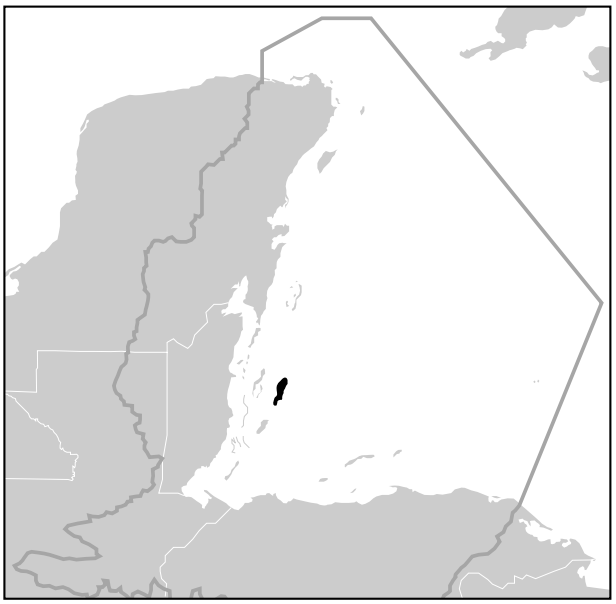
The main town in the area is San Pedro, located at the south end of Ambergris. The town has a population of approximately 4,000, and relies primarily on tourism. Xcalak, on the Mexican border, is a small town (<500 inhabitants) that is home to one of the oldest artisan fishing populations in the region. Some fishermen from Sarteneja, a traditional fishing village on mainland Belize, also utilize the area. Tourism (recreational fishing, diving, site-seeing) is quickly replacing traditional fishing as the main form of employment. Larger fishing vessels from Chetumal also work the coastal areas.

Description of threats

The main threats come from tourism development and associated impacts of urbanization and land conversion. Much of the area is presently over-fished, and this has led many fishermen to become associated with the tourist industry. Fishing pressure will likely continue to increase without implementation and enforcement of strict regulations. Construction of a deep channel into Chetumal Bay threatens both the reef and surrounding area by opening the area up to increased boat traffic and alteration of the hydrographic regime, salinity, etc. Pollution from Chetumal Bay and seepage from septic systems on Ambergris Caye are sources of major concern but the linkages to the coastal areas are poorly understood. Organic-nutrient contamination from coastal and inland drainages can impact fringing, patch, and selected barrier reef ecosystems. Other threats include global warming and continued coral bleaching. Impacts from the 1998 bleaching appear to be much more severe in southern Yucatán than further north (Kramer and Kramer, 2000), suggesting that this area might be more susceptible. Other natural disturbances such as hurricanes are a common occurrence throughout much of the region.

Information needs

More information is needed on the connection between Chetumal Bay east and the reefs, including coastal drainage patterns and the effects of contaminants from the Bay and from coastal communities.



Name: Lighthouse
Map ID Number: BB2
Subregion: Belize Barrier Reef
Location: Located east of Turneffe Islands
Approximate size: 398 km^2
Ownership: Belize
Biological Importance: Highest

Description of area

Lighthouse Reef Atoll, located approximately 100 km east of Belize City, is the smallest of the four coral rimmed atolls found in the MACR. Lighthouse provides shelter from easterly trade winds and direct oceanic waves to Turneffe Islands and portions of the central Belize reef (Stoddart, 1969). The atoll is situated in a NNE orientation and is located on the same fault block as Glovers Atoll (Dillon and Vedder, 1973). Six sandy cayes are found around the atoll, including Sandbore, Northern, Saddle, Long, Half Moon, and Hat Cayes. A well-developed coral barrier encircles the atoll and patch reefs dot the interior shallow (1-8 m) lagoon. The eastern (windward) rim is exposed to strong oceanic waves and receives the full force of hurricanes and storms. The majority of the shallow barrier is emergent at low tide and consists of large dead coral blocks with some live *Agaricia, Millepora,* and *Acropora* on the upper surface. The inner fore reef (3-5m deep) is poorly developed, with only localized areas of coral growth dominated by small colonies of *M. annularis*. Further

out (12-18 m deep), the fore reef becomes better developed, consisting of low-to-moderate relief spur and groove formations dominated by *Montastraea* spp. The deep shelf edge has well-developed spur and groove formations (30 m). The shallow barrier on the western (leeward) rim of the atoll is narrower and has more coral due to the lower energy. The zonation of corals on the leeward side is similar to what is found in a back-reef setting, with patchy colonies of *M. annularis* and *Diploria* spp, and *A. palmata* occurring seaward of the barrier. The shelf slopes off quickly on the leeward side. Fore reefs generally have high coral cover but spur and grooves are generally not as well-developed as on the windward sides, except where sheltered by islands, such as the wall south of Half Moon Caye.

Outstanding biological features

One of the best-developed coral atolls located in the Western Hemisphere, Lighthouse Reef is surrounded by more than 40 miles of coral reefs that provide habitat to numerous marine organisms. Two World Heritage sites, Blue Hole Natural Monument and Half Moon Caye Natural Monument, are located here. Half Moon Caye provides important habitat for more than 120 bird species. One of two unique white-phase nesting colonies of red-footed booby (*Sula sula*) in the Caribbean is found here, with between 3,000-4,000 individuals. The endemic Belizean Atoll Gecko also resides on Half Moon Caye. The well-developed coral reefs form a unique sheltered wall structure and have some of the highest coral cover in Belize. Blue Hole Natural Monument is a cenote (limestone sinkhole) 1,000 feet in diameter and more than 400 feet deep with spectacular stalactites. Two fish spawning aggregations have been reported and sea turtles nest on the low-lying sandy cayes. Little is known about cryptic reef species, although there is a potential for endemic species, given the unique habitat.

Current conservation status

The site was proposed as a National Reserve by the FA0 in 1978. Half Moon Caye Natural Monument was designated a protected area under the National Parks System Act of 1981 and Blue Hole was designated as a Natural Monument in 1996. Belize Audubon Society currently manages the 9,700 ha of Half Moon Caye and the 575 ha of Blue Hole, both of which are fully protected "no-take" zones. Half Moon Caye Natural Monument (17°14'-17°51'N, 87°29'-87°34'W) lies on the south-eastern tip of the Lighthouse Reef, encompassing 3,900 ha of the caye and a substantial portion of the surrounding fringing reef and lagoon.

Current resource use

The Great Blue Hole, Half Moon Caye Wall, and Long Caye Wall are three of the most popular dive destinations in Belize. Half Moon Caye is a frequented picnic site. Local fishermen rely considerably on the fishing resources. Diving and fishing provide important income to tour operators, particularly from Ambergris, Belize City, and live-aboard dive vessels.

Description of threats

Lighthouse Reef is primarily affected by the tourism industry, as some related diving and boating activities have resulted in damage to the reef. Fishing pressures are moderate to high, but efforts are ongoing to manage the fishery resources and educate fisherman. The atoll is affected primarily by oceanic influences and minimally affected by continental impacts (e.g., pollution, sediment runoff). Lighthouse Reef is susceptible to natural catastrophes as well, although the impacts from Hurricane Mitch and the 1998 coral bleaching event caused only moderate reef damage.

Information needs

A low-to-moderate amount is known about species diversity and ecological processes occurring on this atoll. More information is needed on the status of fisheries resources and the reported spawning aggregations. The effects of diver impact on popular sites should also be studied.

Name: Turneffe Islands
Map ID Number: BB1
Subregion: Belize Barrier Reef
Location: Encompassing the entire offshore atoll to the 200 m bathymetric contour
Approximate size: 677.75 km²
Ownership: Belize
Biological importance: Highest

Description of area

Turneffe Island, at 50 km in length and 16 km in width, is the largest atoll and contains an extensive network of mangrove islands. It is located ~ 50 km east of Belize City and is separated from Belize's barrier reef by a deep channel (~ 300 m deep and 10-16 km wide). Turneffe is located on the same N-NE trending fault block as Banco Chinchorro, and has experienced more than 1,000 m of carbonate accretion (Dillon and Vedder, 1973). Several small sandy cays are found near channels on the eastern side, while mangrove cays are predominant on the western side. A chain of islands encompasses two partially enclosed lagoons (North and South Lagoons). The shallow interior contains an extensive network of mangrove cays, seagrasses, and algal meadows, although few interior patch reefs exist. Turneffe has an extensive fringing reef that forms an elongate oval rim around the entire atoll but is best developed on the northern and eastern sides. Lighthouse Atoll protects much of the atoll from direct ocean waves from the northeast.

Outstanding biological features

Turneffe is unique in that it is one of the few atoll-like features in the Caribbean containing excellent reef development around its margins as well as intact mangrove and seagrass habitat in its interior. The reefs and hard-bottom communities support a diverse assemblage of corals, sponges, and fish. Coral cover is moderate (24%) and the greatest abundance of sponges in Belize is found here (McField *et al.*, 2001). Fish spawning sites are also known to exist off both the northern and southern tips of the atoll. Turneffe contains some of the best remaining American salt-water crocodile habitat in the Caribbean, with perhaps the largest population in Belize. In addition, manatees are known to utilize habitat found within the interior network of mangrove cays. The Belize-endemic snail, *Leptophis mexicana hoeversi*, and the rare and cryptic white-spotted toadfish are found here. Potential habitat for the endemic Belize atoll gecko, *Phyllodactylus insularis*, may occur here as well.

Current conservation status

Currently there is no designated protection or management on Turneffe, although the Coastal Zone Management Institute has created development guidelines and a coastal advisory committee.

Current resource use

Commercial and subsistence fishing occur throughout the atoll for conch, lobster, and finfish, although the intensity and status of the fisheries is not well known. Tourism is limited to several exclusive commercial diving and fishing resorts built mainly along the eastern side of the atoll. The University College of Belize Marine Research Center operates a 30 person marine research and education center on Calabash Caye. Day charter boats from Belize City and cruising vessels frequent the reefs.

Description of threats

The level of threats is considered medium. Over-fishing of commercially significant species (e.g., lobster, snapper/grouper) during spawning times and throughout the year is one of the principal threats facing this area. The atoll is also threatened by growth in tourism and the associated dredging and infrastructure development of ports, piers, buildings, septic tanks, and garbage disposal, all of which will result in localized habitat loss. Anchor damage and bilge water discharge will increase as charter and cruising activity increases. There is a low-to-moderate

threat from oil from tankers entering English Channel. Other threats include aquaculture, bioprospecting, mining, and agriculture. Global warming will continue to threaten the integrity of the coral reef community structure with coral bleaching, disease, and increasing algal dominance. Similarly, increased intensity and frequency of El Niño/La Niña events and hurricanes threatens the region.

Information needs

The level of understanding and need for biological inventories were both ranked as medium. There is a need for biological inventories for this area especially for endemism among cryptofauna and sub-species. Studies of ecological processes, particularly the links between mangroves, reefs, and fisheries are needed. The status of reported spawning aggregations should also be studied.

Name: Glovers Reef Atoll
Map ID Number: BB3
Subregion: Belize Barrier Reef
Location: Located 45 km east of the mainland
Approximate size: 299 km²
Ownership: Belize
Biological Importance: Highest

Description of area

Glovers Reef Atoll, about 32 km long and 12 km wide, is located 45 km east of the mainland and 15 km due east of the main barrier reef near Tobacco Cay (Stoddart 1962b; Wallace and Schafersmann, 1977; James *et al.*, 1976). The atoll lies atop the outermost of three fault blocks that trend north-northeast (Dillon and Vedder, 1973). Since the Tertiary, the blocks have been subsiding, forcing upward growth of the marginal reefs and associated infilling of the lagoon with carbonate material (over 500 m on Glovers). Five islands are located on the southeastern side of the atoll including Northeast, Long, Middle, Usher, and Southwest Cayes. Coral reefs have markedly different development on the windward versus leeward sides. The windward margin of the atoll contains shallow spurs encrusted by coralline algae and most with fairly low coral cover (15-24%; McField *et al.*, 2001) This is probably because it faces the open ocean and receives the full force of hurricanes and storms. In addition, terrestrial runoff events and the Gulf of Honduras Gyre may affect this atoll, as seen via remote sensing (Appendix A, Map A11). The reef on the leeward side is narrower and spur and grooves are not well developed with lower coralline algal and *A. palmata* cover. The average depth of the interior lagoon is deeper (>8 m) than the other three atolls and contains at least 700 patch reefs. The atoll provides some protection to the main barrier reef from open ocean waves and swells.

Outstanding biological features

Glovers Reef Atoll is the best-developed coral atoll in the western Atlantic and is designated as a World Heritage Site. The area provides an excellent representation of coral reef habitats in terms of species diversity and density. A large grouper spawning aggregation site is located at the northeastern end of the atoll. The sandy cays provide important nesting habitat for turtles and migrating birds. The endemic Belize Atoll gecko, *Phyllodactylus insularis*, previously only recorded on Half Moon Caye, has been observed here. It is likely that there are endemic cryptic species. The biodiversity of the area may be influenced by circulation associated with Gulf of Honduras Gyre.

Current conservation status

The Glovers Reef Marine Reserve was established as a protected area in 1993 to maintain and manage its 30,800 ha of natural resources through four designated protection zones: wilderness, conservation, seasonal closure, and general use zones. The no-take zone comprises ~30% of the entire reserve; the remaining 70%

allows restricted fishing. In 1996, it was designated as a World Heritage Site. The Wildlife Conservation Society (WCS) purchased Middle Caye to establish a marine research field station and provide a marine park station for the Government of Belize to manage the Marine Reserve. The six cayes within the Marine Reserve are privately owned.

Current resource use

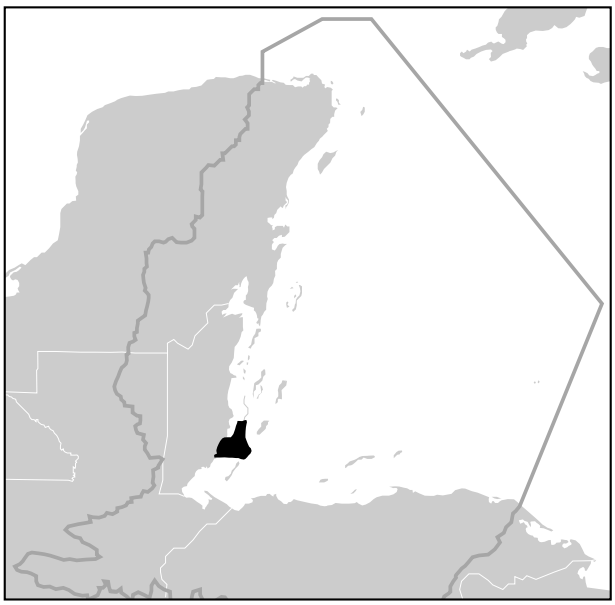
Glovers is an important fishing resource for fisherman, especially from mainland Belize, although extensive illegal fishing by Guatemalan and Honduran fishermen occurs. There are several resorts on the atoll and a marine research station operated by the Wildlife Conservation Society on Middle Caye.

Description of threats

In recent years, the interior lagoon reefs have experienced serious degradation and an increase in macroalgal abundance (McClanahan *et al.*, 1999). The area was also disturbed by the 1998 bleaching event and hurricane Mitch and is susceptible to future events (Kramer and Kramer, 2000). One of the principal threats to the atoll is pollution (nutrients, pesticides, chemicals) transported by currents up from the Gulf of Honduras (FAO, 2000). Over-fishing of commercially targeted species is a concern.

Information needs

Considerable research has been done on Glovers, but there is a lack of synoptic ecological surveys and information on currents and water quality.



Name: Gladden Spit Seascape
Map ID Number: BB6
Subregion: Belize Barrier Reef
Location: Area extending from Laughing Bird and Silk Cayes including Gladden Spit north to Tobacco reef and west to Belize mainland including Placencia lagoons
Approximate size: 1,808 km²
Ownership: Belize
Biological Importance: Highest

Description of area

The Gladden Spit Seascape is characterized by long sections of uninterrupted barrier reef, sand cays on the inner edge of the reef rims, and numerous seagrass flats in the central area (Burke, 1982; Macintyre and Aronson, 1997). The area delineated is a corridor that spans the entire lagoon and includes 1) the freshwater/estuarine areas and lagoons; 2) the unique mangrove/coral pinnacles of great biodiversity in the central lagoon; and 3) the infamous barrier reef platform, including Gladden Spit.

Lagoonal reefs consist of patch reefs and rhomboidal-shaped shoals that range in size from small patches of coral up to several hundred meters across. Most have a seaward-facing steep front slope covered by *M. annularis* or *Agaricia tenuifolia*, a shallow seaward facing crescent of *Millepora complanata* and branching *A. palmata*, a flat top of coral rubble often leading landward to

Thalassia testudinium, and a gentle landward slope covered with thickets of *A. cervicornis* and *Porites porites.* Islands leeward of the reef crest often contain a fringe of red mangroves (*Rhizophora mangle*) with black mangroves (*Avicennia germinans*) in the interior (Koltes *et al.,* 1998). The shallow lagoon floor near Carrie Bow is predominately soft bottom and *T. testudinum*, although other areas contain rubble, patch reefs, and sponges (Rützler and Macintyre, 1982).

Acropora palmata, M. complanta, Agaricia tenuifolia, crustose coralline algae, and *Palythoa* dominate the outer reef crest with a very wide sediment apron extending into the lagoon. Where passes or openings occur through the barrier, the sediment apron is very narrow, probably because return or seaward flow of water breaking on the reef transports sediments into the reef basins and basin-ward through the reef. The fore reef is often divided into an inner and outer slope, which can contain both low- and high-relief spur and groove systems. *Acropora palmata* and *Millepora* dominate the inner slope's shallow spurs (1-3 m). Deeper spurs (3-6 m) are dominated by *A. tenuifolia* framework but may also contain localized thickets of *A. cervicornis*, and *P. porites.* Well-formed, distinct spur and groove reef structure occur along most sections of the reef. The outer fore reef begins at depths ranging from 8-14 m and extends out to a depth of 14-22 m. Coral cover in this zone off South Water Caye was 17% in 1999 (McField, 2001a) and many corals have a platy appearance. The coastal area near Placencia contains numerous fresh water sources and mangrove-lined lagoons.

Outstanding biological features

The Gladden Spit Seascape provides a variety of significant ecosystem processes, including healthy trophic structures, larval supply, and important cross-shelf habitat linkages. One of the most unique features of this area is that it contains the only true barrier reef in the MACR region and the best-developed example in the Western Hemisphere. This area also has the best-developed and most continuous reefs due to its elevation, good water quality, and modified wave regime (Burke, 1993). The area includes an incredible variety of rare and representative habitats (noted above) that are not only linked ecologically (e.g., fish, mammal movements, water flow), but also include unique areas (e.g., Pelican Cayes) and a dramatic representation of the Belize Barrier Reef System. This seascape is probably one of the most biodiverse (i.e., specious) in the MACR region and of the highest priority in the Belize Barrier Reef subregion.

The Gladden Spit entrance, a promontory on the southern reef, provides unique habitat for the largest spawning aggregations in the region as well as significant whale shark (*Rhincodon typus*) concentrations. Fish species that spawn here include Nassau grouper (*Epinephelus striatus*), black grouper (*Mycteroperca bonaci*), red hind (*Epinephelus guttatus*), ocean jack (*Caranx sp.*), schoolmaster (*Lutjanus apodus*), cubera (*Lutjanus cyanopterus*), yellowtail snapper (*Ocyurus chrysurus*), dog snapper (*Lutjanus jocu*), and mutton snapper (*Lutjanus analis*). A notable phenomenon is the interaction between the spawning aggregations and the associated congregations of whale sharks that feast on the spawning material.

The coastal area, with its fresh water sources and estuarine lagoons surrounding Placencia, is an important manatee foraging, calving, and mating area. Between Carrie Bow Caye and Wee Wee Caye to the south are patch reefs and sand bores that rise from the sea floor (30 to 40 feet below) to break the surface at many locations. These exposed pinnacles are a unique habitat for nesting sooty terns. The laughing gull, *Larus artricilla*, historically reproduced on Laughing Bird Caye, but moved to nearby islands to escape disturbance by human visitors.

Current conservation status

Laughing Bird Cay National Park, designated as a protected area (1991) and a World Heritage site, provides protection for 4,300 ha of natural resources on the island and surrounding waters. Unofficially a one-mile radius around the cay is respected as a no-take zone. Gladden Spit Marine Reserve, covering 10,513 ha, was declared a Marine Reserve in 2000, and includes the Silk Cayes. South Water Caye Marine Reserve, designated in 1996, encompasses 29,800 ha. It is also a World Heritage Site. South Water Cay Marine Reserve includes major mangrove cayes, two large mangrove ranges, a large twin caye formation, and many smaller cayes. Man O'War Caye, along the northern border of the South Water Cay reserve, is one of seven Crown Reserves in Belize designated to protecting birds and supports one of the ten largest nesting colonies (~300 to 350) of frigate birds in the Caribbean.

Current resource use

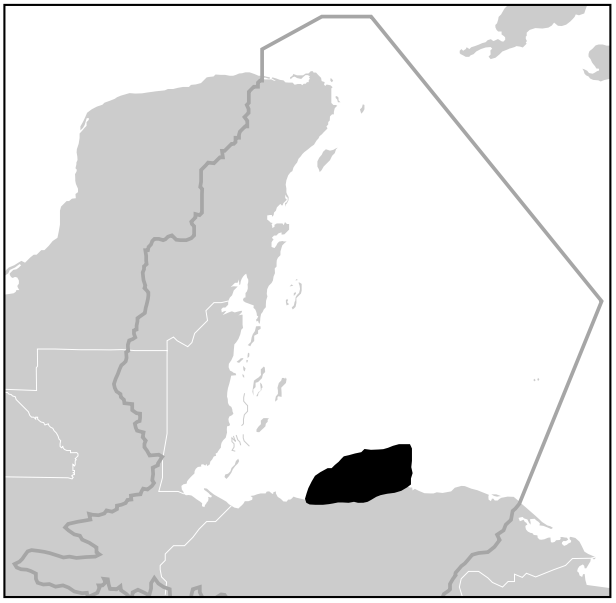
Artisanal and commercial fisherman and tourist operators utilize the entire area. The Gladden Spit area is an important fishing area in Belize. Recently, interest in tourism focused around the whale shark congregations has increased. There are also numerous small resorts scattered among the small cayes in this region. The Smithsonian Institution's Marine Research laboratory, located on Carrie Bow Caye, has been conducting valuable research since 1972.

Description of threats

Urbanization and development of the mainland coast around Placencia will likely degrade coast and coastal lagoons. Nutrients and pollution associated with urbanization, agriculture and shrimp farming are major threats to the area. Unsound coastal development is occurring on some of the small cayes in the region. Over-fishing of marine resources (e.g., lobster, conch, groupers) is one of the principal threats in this area. Over the past 20 years mean sizes have continued to decrease, landings have declined significantly, and several historic spawning sites for snapper and grouper are no longer active. Continued exploitation may disturb the ecological balance of biota in the area. Corals in the inshore reefs of Gladden seascape area suffered massive mortality during the 1998 coral bleaching event (Aronson *et al.,* 2000). These inshore or midshelf reefs appear to be most susceptible to future bleaching events.

Information needs

Physical oceanographic and pelagic biology are poorly known and are of utmost importance in this region. Given the importance of this region, research on a variety of topics and organisms is needed. There is little or no information on reef community structure from the Gladden Spit area. The Smithsonian Carrie Bow Caye Lab is in this region and has fueled a great deal of research. This provides an information base upon which more work should build, particularly ecosystem-level studies and research geared toward conservation science and management. Fisheries research should be focused on population sizes, reproductive and feeding behaviors, and migratory patterns.



Name: Bay Islands Coastal Marine System

Map ID Number: HG3

Subregion: Northern Honduras Coast

Location: A large area encompassing the mainland coast including La Ceiba and Trujillo and extending to the offshore islands of Cayos Cochinos, Roatán Guanaja, and Utila. The area includes numerous small banks and reefs.

Approximate size: 9,979 km²

Ownership: Honduras

Biological Importance: Highest

Description of area

The northern coast of Honduras consists of a Caribbean coastal plain of Quaternary sediments and Paleozioic schist, gneisses, and phyllites, mixed with Cretaceous/Tertiary granitic intrusions (Mills *et al.,* 1967; Donnelly *et al.,* 1990). The high rainfall combined with a mountainous terrain produce significant runoff through several large coastal rivers. A nearly continuous narrow (~ 6 km) belt of turbid, low salinity water occurs near the mainland coast, which inhibits most coral growth. Further offshore, the influence of rivers and near-shore waters diminishes and carbonate-secreting organisms begin to dominate. Although near-shore coral communities are found throughout the area, the predominant reef development in Honduras is associated with the Bay Islands.

The Bay Islands, an archipelago of more than 60 minor islands and several larger islands (Roatán, Utila,

Guanaja, Barbareta, Morat, Helene, Cochino Grande, and Cochino Pequeño) are oriented east-west along the southern edge of the Cayman Trench. The Cayman Trench reaches depths of over 6 km and separates north Honduras from Belize, extending from the Gulf of Honduras to the Windward Passage between Cuba and western Española (Pinet, 1976). Roatán is the largest of the Bay Islands (58 km long, average of 3 km wide) and most populated (75% of the Bay Islands population). Encircling the island are several reef types including shallow fringing crest, patch reefs, and shelf-edge reefs. A discontinuous fringing reef exists on the northern and southern coastlines of many of the islands and is sometimes dissected by channels (>126 ft deep) formed by erosion during glacial times (Wells, 1988). The reef crest is composed mostly of dead *Acropora palmata* and outcrops of coral rock covered by sparse *Agaricia* and *Millepora.* Shallow lagoons are found behind sections of well-developed crests that may have either seagrass or macro-algal-covered rubble bottoms. In general, the northwestern portion of islands has the best-developed fore reef buttresses, which can reach up to 5 m in height. In contrast, the eastern sides have a lower degree of relief and scleractinian coral cover, possibly caused by higher wave energy. The Cayos Cochinos archipelago is located about 35 km south of Roatán and 15 km from the mainland and consists of two larger volcanic islands and 12 sandy carbonate cays, aligned in an east/northeast to west/southwest direction. Turbid water from mainland river runoff influences these reefs.

Outstanding biological features

The Bay Islands are located at the "headwaters" of the MACR ecoregion. The nearshore and oceanic currents in this area likely play an important role in habitat connectivity with the rest of the region. This area also incorporates a good representation of the complex cross-shelf habitats, including upland watersheds, near shore communities, island habitats, coral reefs, open ocean habitat, and a variety of bathymetric gradients. Forty-four coral species (Fenner, 1993) and 96 species of fish (Jaap and Halas, 1982) are reported for Roatán. At least 66 species of corals, 44 species of octocorals, 5 species of antipatharians, and 226 species of fish are known from Cayos Cochinos (Guzman, 1998b; Clifton and Clifton, 1998). Extensive stands of mangroves are found on Careening Cay and George Cay; the most important stands are found between Roatán and Helene, where crocodiles are also found. Sea turtles (leatherback, hawksbill, and green) utilize the entire area and over 120 turtles nested in the Cayos Cochinos Marine Natural Monument area in 1998. Unique island terrestrial species are present on many of the islands. On Roatán, endemic species include opossum (*Marmosa ruatanica ruatanica*), agouti (*Dasyprocta ruatanica*), and several endemic birds. Much of the flora and fauna of Cayo Cochinos is distinct from the Honduran mainland (Bermingham *et al*., 1998). The pink boa is an endemic snake found only on Cayos Cochinos. At least 160 vascular plants, 15 species of amphibians and reptiles, and 43 species of birds are also present. Two seabird species breed on the Cayos Cochinos islands and are the first breeding records for these species on the Honduran coast. Two small colonies of brown pelicans (*Pelecanus occidentalis*) nest on the small island (Cayos Cochino Pequeño) and royal terns (*Sterna maxima*) breed on a nearby sandy cay (Cayo Gallina). Several resident land birds (e.g., white crowned pigeon, Yucatán vireo), migrant seabirds and shorebirds (e.g., laughing gull), and numerous migratory land birds utilize the area. The avifauna is more similarly related to the Yucatán Peninsula than the Honduras mainland. High densities of bats are found on Cayos as well. Little information is available on the near shore mainland biodiversity. Important manatee habitat is located in the rivers and lagoons east and west of La Ceiba (Rathbun and Powell, 1983; Cerrato, 1993 unpubl. report).

Current conservation status

Most of the reefs surrounding the main Bay Islands were declared a national park in recent years, although there is no management authority in place. The Sandy Bay West End Marine Reserve, encompassing 13 km of Roatán shoreline from Key Hole in the south to Lawson Rock in the north, protects a fringing coral reef of ~ 10,400 m^2. The Bay Islands Conservation Association (BICA) manages the Reserve, which has 22 dive sites with buoys and almost 44 dive sites. The Turtle Harbor Wildlife Refuge protects coral reefs and inshore ecosystems along part of Utila. Cayos Cochinos is a proposed Marine Natural Monument, and has a presidential decree to currently protect waters. Conservation and management of the reserve have been in place since 1995. All commercial fishing has been prohibited in the Reserve and only three indigenous Garífuna communities have been granted the right to use the natural resources inside its boundaries. The Garífuna fisherman

have been working with the Reserve staff to develop specific fishing guidelines that limit the species, the amount and size of fish taken, the methods used, and the length of the fishing season. Mooring buoys are in place in key and fragile places of the Bay Islands to reduce anchor damage to the reefs and seafloor.

Current resource use

Tourism and fishing are the two most common activities in this area. The fishing industry is comprised of both small-scale local fisherman and industrial fishing fleets. Industrial fleets fish offshore of the Bay Islands and northern Mosquitia region, as well as areas in Nicaragua and Belize. *Penaeus* shrimps, Caribbean spiny lobster, marine fish, and conch are the primary fisheries on the Atlantic coast. Shrimp and lobster comprise a major portion of the annual export commodities. Many of the Bay Islands have several shrimp export companies. Scuba diving on the myriad of reefs in the Bay Islands is the most popular tourist attraction. The Cayos Cochinos Research Station on Cochino Menor is a well-equipped marine field station providing accommodations for 15 scientists or students. Several private exclusive vacation houses and only one hotel resort are located within the Cayos Cochinos Marine Natural Monument. The Institute for Marine Science (IMS) is a marine education and research facility affiliated with Anthony's Key Resort on Roatán, and is used by many university groups from the U.S.

Description of threats

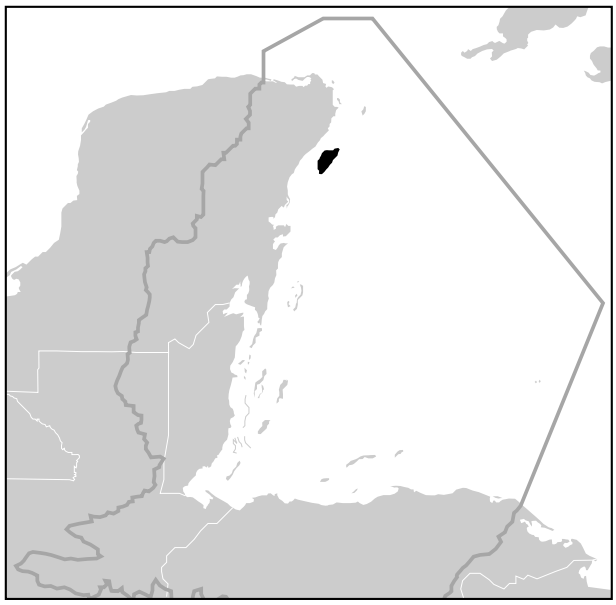
Coastal development including land clearing, deforestation, increased erosion and sedimentation, agricultural runoff, and waste disposal are some of the principal threats to this area. Human activities in the water (dredging, fishing, diving) are also major problems that threaten the integrity of this area and have already resulted in localized sedimentation, eutrophication, and diminished fish stocks. Several reefs on Roatán are thought to have low coral cover, probably because of sewage and sedimentation (Fonseca, 1997). The area is highly susceptible to natural disturbances like hurricanes. Strong winds and waves impacted Guanaja and the adjacent Bay Islands, while heavy rains caused massive flooding on the mainland during Hurricane Mitch (October 1998). Deforestation of the Honduran mainland contributed to record amounts of erosion and sediment runoff into the Gulf of Honduras following the storm.

There is a long history of large industrial fishing trawlers exploiting reef fish of all sizes and types around each individual Bay island, resulting in a dramatic collapse of many of the fish populations. Added to this are numerous indigenous fishermen engaging in both subsistence and commercial fishing. Commercial, industrial, and local fishermen have overfished Guanaja, a main port for industrial fishing boats, for decades without regulations of any type. As a result, it has the smallest populations of fish and the lowest diversity. Reef fish populations at Utila are also small and fishing is unregulated. Shrimp trawling is thought to cause significant damage to seafloor biota. A potential threat is the rapid increase of tourism, supported by governmental policies promoting tourism in Honduras, particularly in the Bay Islands. Large cruise liners are expected to visit Roatán on a permanent basis, thus placing natural resources at risk to increasing coastal development, oil spills, sewage discharges, and immigration.

Information needs

General scientific information on biodiversity and the marine environment is lacking, particularly around the mainland coastline, where surveys are needed. Effects of the mainland on the Bay Island resources are not well understood. For example, the amount and distribution of sediment discharge from rivers (e.g., Río Aguán) and the effects of sediment (and pollutants) on natural resources around the Bay Islands are poorly understood. Information on biophysical oceanographic patterns and their connections between the Bay Islands and the rest of the MACR is missing. The Smithsonian Institute conducted scientific work on the marine-terrestrial flora and fauna of Cayos Cochinos; their findings are published in "Revista de Biología Tropical" 1998 Vol. 46 Suppl. 4. Their work provides a baseline of information on coral reef resources (corals, fishes, algae, echinoids, mollusks, lobsters, crabs), effects of artisanal fishing, socioeconomic information, geology, terrestrial flora and fauna, and sea-surface temperatures. The Cayos Cochinos Research Station also has a NOAA and USGS environmental station (wind, atmospheric pressure, air temp, water temp, precipitation, solar radiation, and vertical and horizontal control) that was installed after Hurricane Mitch in 1999. The Bay Island Environmental Management Project (PMAIB), funded by an IDB loan, has financed comprehensive reef assessments over the last five years on the Bay Islands. Monitoring plots have been established by IMS and Cayos Cochinos through the PMAIB project.

High Priority Areas



Name: Cozumel Southern Coast
Map ID Number: QR1
Subregion: Northern Quintana Roo
Location: Coastal shelf of the southern half of Cozumel Island
Approximate size: 90 km²
Ownership: Mexico
Biological Importance: High

Description of area

Isla Cozumel (48 x 16 km in size) lies about 16.5 km off the northeast Yucatán coast, separated by a deep-water channel with strong currents. Cozumel influences the northward-flowing Caribbean current to form the Yucatán Current, which has speeds up to 4 knots (Gutiérrez-Carbonell *et al.*, 1996). The island is an elevated karst platform with significant coastal wetlands and sandy beaches on both the leeward and windward sides. Reefs are developed along portions of the island, particularly the southwestern side where a nearly continuous shelf-edge reef exists (Fenner, 1988). The windward side has poorly developed spur and groove coral formations dominated by algae and gorgonians. Laguna de Chancanab, a small coastal cove at the southern end, has an underground connection to the sea with some small patch reefs.

Outstanding biological features

Southern Cozumel has spectacular coral reef formations on the leeward side covered by diverse sponge and algal communities. Rich black coral growth is found along deeper walls. Adjacent habitats include intact seagrass flats, mangroves, beaches, and halophytes. The windward side of Cozumel contains one of the only occurrences of algal cup reefs in the western Caribbean (Boyd *et al.*, 1963). The northern coastal lowlands serve as major nursery areas for marine fish. Beaches support some of the highest turtle nesting densities in the Caribbean. The island is a principal stopover for birds migrating on the major North America-South America flyway. At least two endemic bird species are known, as well as several endemic small mammals.

Current conservation status

Parque Nacional Arrecifes de Cozumel was declared a refuge for the protection of flora and fauna in 1980 and as a national park in 1996. The park boundaries cover approximately 12,000 hectares around the southern half of the island and extend from the high water mark down to 50 m.

Current resource use

Cozumel is one of the main diving destinations in the Caribbean, with up to 1,500 dives per day taking place during the high season (Jordán-Dahlgren and Rodríguez-Martínez, 1998b). Tourism is the main activity and most island residents live in the town of San Miguel located on the western side of the island. Building of new coastal resorts and roads continues to take place. Fishing is prohibited in the National Park, but still takes place around unprotected areas of the island.

Description of threats

The largest threats to this area are associated with increased development, tourism, population, and pollution. Coastal and inland habitat degradation is already taking place on eastern Cozumel and effective sewage disposal needs to be improved. Dive tourism is presently well regulated and should not degrade resources. Likewise, fishing intensity is presently regulated and is a relatively low threat. Black coral have been heavily exploited in the past, but are not now considered threatened.

Information needs

Additional information is needed on birds, turtle nesting, and reef condition.

Name: Central Yucatán Coast
Map ID Number: SK2
Subregion: Sian Ka'an-Ambergris
Location: On the Southern Coast of Quintana Roo, Mexico, from Punta Gruesa to Majahual, including El Ubero, El Placer, and Chahuay
Approximate size: 221 km²
Ownership: Mexico
Biological Importance: High

Description of area

This section of the central Yucatán coast has a very narrow shelf (< 1 km) and is protected from prevailing winds by Banco Chinchorro. Reefs are well developed and have spur and groove features on both shallow and mid-depth fore reefs (5-20 m) (Jordán-Dahlgren and Martin 1988). An inshore lagoon with seagrasses and coral patches is found in areas where the shelf margin widens to more than 500 m. Several coastal lagoons lined with abundant mangroves are also found in the area.

Outstanding biological features

This area has a mosaic of well-developed reef formations (back reefs, patch reefs, crest, fore reefs) in close proximity to other habitat types. There is a high number of invertebrate species and locally high coverage of scleractinian corals. At least four known Nassau grouper spawning aggregations sites are located near Río Indio, Majahual, Punta Herradura, and Xahuachol (Aguilar-Perera, 1994). Abundant bird populations exist with at least six endemic species, including one restricted distribution species.

Current conservation status

No conservation measures in place, although a marine park is being proposed for the area.

Current resource use

Historically, the area has had a very low population, but recently constructed roads have allowed greater access for more tourists and laborers. The town of Majahual is a small (<500 inhabitants) settlement of artisanal fishermen who traditionally have fished barracuda (*Sphyraena barracuda*), lobster, and conch, and especially Nassau grouper during the spawning season (Aguilar-Perera and Aguilar-Dávila, 1996). The loss of coastal habitat in Majahual and adjacent areas is presently occurring at a fast pace, as new hotels and resorts are being developed in anticipation of increased tourism for both diving and fishing.

Description of threats

This area's main threats are from tourism and rapid coastal development. Although the permanent population is low, it is projected to grow with increased migration to support tourism development. Associated impacts of population growth and development will continue to influence the resources. Pollution from cruise ship sewage or ship groundings is also a growing threat. Overfishing of resources has already taken place and is expected to increase. Other important threats include hurricanes, coral bleaching events, and diseases.

Information needs

Information is needed on the role of currents and counter currents in larval dispersion and connectivity of spawning species to other parts of the MACR. The current status of reported grouper spawning sites should be determined. Information on groundwater linkage to reefs is also needed.

Name: Chetumal Bay
Map ID Number: SK5
Subregion: Sian Ka'an-Ambergris
Location: Chetumal Bay, Corozal Bay, and surrounding wetlands
Approximate size: 3,209 km²
Ownership: Mexico/Belize
Biological Importance: High

Description of area

Chetumal Bay is a large (2,450 km²) brackish estuary straddling the Belize-Mexico border with a very shallow water depth of 1 to 7 m (average of 3 m). The bottom is covered with fine mud and algae and localized seagrass beds of *Thalassia testudinum* and *Halodule wrightii*. Several fresh water rivers, including Río Hondo and New River, empty into the bay (Morales *et al.*, 2000). Many coastal lagoons with inlets, salt marshes, and mangrove forests are connected to the bay. The city of Chetumal, with more than >150,000 inhabitants, is located here.

Outstanding biological features

Chetumal Bay is the largest estuary in the ecoregion and supports one of the largest populations of manatees in the Caribbean. Outstanding nesting and foraging habitat is available for numerous wading birds. The area around Little Guana Caye has the largest nesting colony of reddish egrets in the Caribbean and is also known to have nesting white ibis, tri-colored herons, and roseate spoonbills. Protected islands in Shipstern Lagoon support two nesting colonies of woodstorks. The shallow estuary also provides excellent nursery habitat for a variety of fishes and invertebrates.

Current conservation status

Corozal Bay Wildlife Refuge encompasses the Belize portion of the bay and much of the Northern shelf lagoon behind Ambergris Caye. The area is declared protected but currently is not being managed. The Shipstern Nature Reserve includes 22,000 acres of wetlands, mangroves, lagoon, cayes, and unique dry hardwood forest. Manatee Sanctuary includes most of Chetumal Bay and San Jose Bay

Current resource use

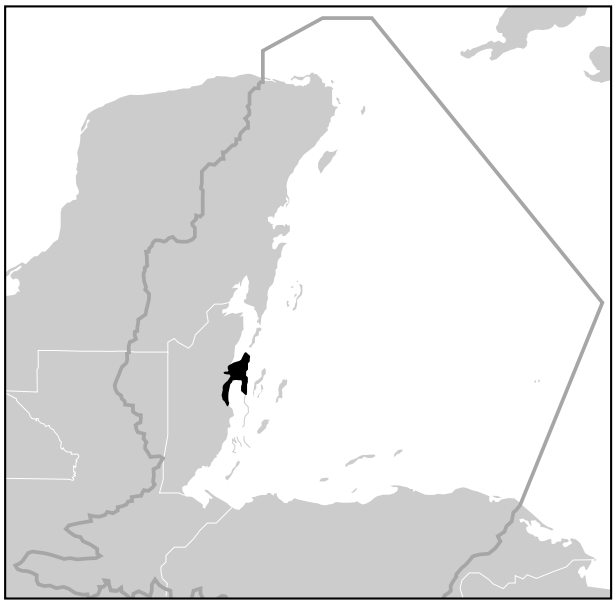
Fishing pressure is high within Chetumal Bay and is a premier destination for sport fishing targeting tarpon, bonefish, and other sportfish. Tourism is low to moderate but growing. The sawfish once aggregated in this area but has apparently been fished to local extinction. Bonnethead sharks also once aggregated in the bay but also suffered from high fishing pressure.

Description of threats

Degrading water quality and pollution associated with urbanization are perhaps the biggest threats this area faces. The City of Chetumal, Mexico discharges 200 cubic meters of untreated sewage into the Bay of Chetumal each day (FAO, 2000). Chetumal Bay acts as a catchement for accumulating contaminants because of the lack of flushing or strong currents. Approximately 2,500 gallons of liquid wastes are discharged from sugar refining and rum distilling operations on the New River in Belize, contributing large organic loads and spent lubricants to the Bay of Chetumal (UNEP, 1994). Poaching and boat collisions continue to jeopardize manatee populations.

Information needs

More information is needed on the connection between Chetumal Bay east to the reefs near Ambergris and south, including coastal drainage patterns and effects of contaminants. Status of historic spawning aggregations should be studied.



Name: Belize City Complex
Map ID Number: BB4
Subregion: Belize Barrier Reef
Location: A broad area in the vicinity of Belize City from Caye Chapel to Bluefield range including the mainland coastal lagoons from Manatee Bay to Rocky Point
Approximate size: 1,403 km^2
Ownership: Belize
Biological Importance: High

Description of area

The northern Belize lagoon has shallow water depths, abundant mangrove, and discontinuous sections of barrier reef. The area delineated extends from the southern end of Ambergris Cay to Bluefield Range including portions of the Belize lagoon to the mainland coast near Belize City. Shelf sediments are quartz sand near the mainland shore but change to Miliolid mud in the center of the lagoon and to *Halimeda* sand near the outer reef (Purdy *et al.*, 1975). Well-developed seagrass beds occur throughout the area, but are less common toward Chetumal Bay where seasonal salinity fluctuations limit biotic cover. The outer reef consists of stretches of barrier reef together with broken patches, shallow pavements with scattered coral colonies, patch reefs, and well-developed reefs fringing small cayes along the reef crest. The major channel through the reef occurs at English Caye and follows the course of a drowned river valley through the shallow inner shelf lagoon. The shallow barrier reef and offshore atolls create a major energy barrier for waves and currents in the lagoon, although water movement does occur within the lagoon in a southward direction parallel to the mainland. Several important rivers occur along the mainland coast including the Belize River, Sibun River, Manatee River, and Mullins River. An extensive mangrove fringe exists along the entire mainland with numerous lagoons, the two largest of which are Northern Lagoon and Southern Lagoon. Belize City, with a population of 70,000, is located at the mouth of the Belize River, which forms a broad estuary surrounded by mangrove cayes.

Outstanding biological features

The Belize shelf in this area contains a myriad of reef types including channel reefs, patch reefs, barrier reefs, algal-covered pavements, and deeper reef communities. The outer fore reef framework consists of well-developed, but discontinuous, spur and groove formations. Hard and soft-bottomed communities occur throughout the interior lagoon and harbor numerous species of fishes and invertebrates. The reef on Goffs Caye Banks has high coral cover and diversity. There are several historical fish-spawning aggregation sites along the outer reef, including the endangered jewfish. This area also contains vast seagrass beds that serve as important feeding grounds for several species of turtles. There is very high density of hawksbill sea turtle nests (>100 nests) along the mainland beaches from Mullins River to Manatee River. The Northern and Southern Lagoons and the Belize River mouth support one of the largest concentrations of manatees and calves in the Caribbean. This area also supports populations of Morelett's and American saltwater crocodiles.

Current conservation status

There are no large marine protected areas in this subregion. A small portion of Southern Lagoon is included in the Manatee Forest Reserve. The Brudon Canal Natural reserve encompasses a canal, which connects the Belize River to Northern Lagoon and is used by many species of birds and the American crocodile. A marine protected area has recently been established for the reefs adjacent to Cay Caulker. Efforts are also underway to provide some legal protection for the mangrove and sand cayes in this region, which are coming under increasing development and tourist pressure.

Current resource use

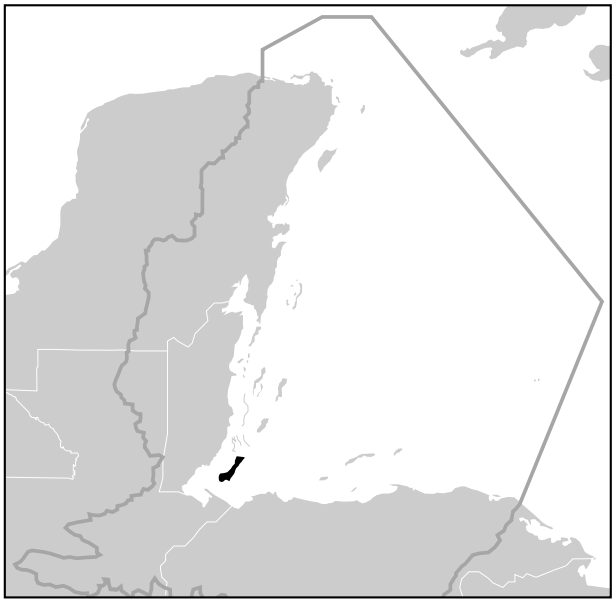
There has been substantial coastal development and urbanization around Belize City and some of the higher elevation islands within the Northern Lagoon such as Caye Chapel (privately owned and developed as a golf resort), Caye Caulker (tourist destination), and St. Georges Caye (private residences) have been developed. Commercial and artisanal fishing occurs throughout this area, with a focus on lobster, fish, conch, and shrimp. Tourism is low to moderate in this area.

Description of threats

Wastewater discharge and polluted effluent around Belize City continue to degrade nearshore waters. Fish kills in the vicinity of Belize City have been attributed to effluent from an industrial galvanizing plant (UNEP, 1994). The large Belize River watershed also contains substantial agricultural development, and contamination by agro-chemicals is suspected. There is a possible impact from contaminants flowing south along-shore from Chetumal Bay toward Belize City. Oil spills and oil contamination associated with oil storage and tankers continue to be a major threat, particularly in the vicinity of English Caye Channel, where several ship groundings have occurred. Other threats include dredging of channels and beaches, tourism, manatee deaths from boat collisions, habitat destruction for expanding urbanization of Belize City, and overfishing of marine resources.

Information needs

More information is needed on water quality and hydrological connections to nearby marine resources. Biological surveys are needed to improve understanding of reef and seagrass habitats, particularly the reefs near English Channel.



Name: Sapodilla Cays Region
Map ID Number: BB8
Subregion: Belize Barrier Reef
Location: Area extending south of the Laughing Bird and Silk Cays including the Sapodilla Cays
Approximate size: 505 km^2
Ownership: Belize
Biological Importance: High

Description of area

The Sapodilla Cayes Region is located in the southernmost portion of Belize, extending south of Laughing Bird and Silk Cays to the terminus of the barrier reef located about 75 km northeast of Punta Gorda. The geomorphology of the reefs is strongly influenced by faults associated with an active plate boundary between the North American and Caribbean plates located only 50 km to the south. The offshore barrier reef is discontinuous in this area and terminates as a unique hook-shaped structure in the Gulf of Honduras (Stoddart, 1963; 1969). Coral rubble derived from the shallow reefs is often cemented to form a pavement or part of small cays directly landward of large reefs. Reef crests are typically composed of crustose coralline algal mounds covered with *Millepora* and coral rubble. Reef development in the southern Belize lagoon has been strongly influenced by flooding during the Holocene rise in sea level, terrestrial runoff, and wave energy (Burke, 1993; Macintyre *et al.*, 1995; Esker *et al.*, 1998). The southern lagoon is deep (~ 20 m) and con-

tains numerous drowned rhomboidal reefs, pinnacles and shoals (Precht, 1992; Macintyre and Aronson, 1997). Coral cover in this region ranged from 22-25% in 1997, but was severely affected by hurricane Mitch and coral bleaching (Kramer and Kramer, 2000), dropping to 3-15% coral cover in 1999 (McField, 2001a).

Outstanding biological features

Located at the southernmost end of the Belize Barrier Reef complex, the coral reef structure here has extraordinary geomorphology and is unique for this region. The Sapodilla Cayes provide important turtle nesting areas and habitat for migratory birds. Surrounding waters support habitat for finfish, conch, and lobster. This area is influenced by the Gulf of Honduras gyre.

Current conservation status

The Sapodilla Cayes Marine Reserve was designated in 1996 under the Fisheries Act and encompasses 2,700 ha. This area is also a recognized World Heritage Site. The Reserve includes a total of eight cayes, five of which (Hunting, NE Sapodilla, Ragged, Seal, and Tom Owen's) are state-owned, while the other three (Frank's, Lime, and Nicholas) are leased and not within the protected area.

Current resource use

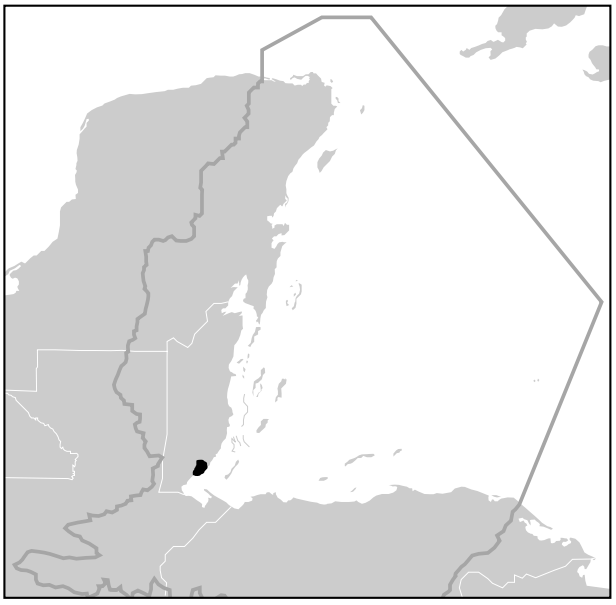
The exposed cays and surrounding waters are heavily utilized for recreational activities and fishing. Extensive illegal fishing by Guatemalan and Honduran fishermen continues to be a problem.

Description of threats

This area is highly threatened by land-based activities and natural disturbances like coral bleaching and hurricanes. The southern reefs experienced some of the highest coral mortality (>50%) in the MACR region (Kramer and Kramer, 2000; McField, 2001a). These reefs were also disturbed by coral disease, Hurricane Mitch damage, and previous disturbance events. Land-based activities and runoff from watersheds in Guatemala and Honduras affect this area through the Gulf of Honduras gyre. Discharges from rivers can carry increased nutrients, sedimentation, pesticides and herbicides from agricultural and urban development activities. As a result, algal overgrowth, pollutants, and increased siltation can harm marine biota. Expanding aquaculture development in southern Belize threatens marine habitat and fishery resources through habitat loss and increased nutrients from pond effluent. The Sapodilla Cayes are heavily utilized for recreational purposes.

Information needs

Currently, there is a medium level of understanding of this area with a high need for more inventories, particularly on turtle nesting sites. Studies on coral reef recovery from the disturbances of 1998 are also needed.



Name: Port Honduras
Map ID Number: BB9
Subregion: Belize Barrier Reef
Location: Area along the coast from Monkey River to Río Grande
Approximate size: 370 km²
Ownership: Belize
Biological Importance: High

Description of area

The Port Honduras priority area is a complex system containing rivers, a marine lagoon with relatively deep basins, shallow banks, islands, coral reefs, mangroves, tidal wetlands, and seagrasses. The lagoon is influenced primarily from oceanic circulation associated with the Gulf of Honduras, although freshwater runoff from a number of nearby rivers occurs. At least 133 islands are found in Port Honduras, ranging in size from 0.2 to 46 ha; some are low-lying mangrove islands while larger, higher-elevation islands support upland plant communities (Sullivan *et al.*, 1995). The Deep-River-Punta-Ycacos watersheds support extensive old growth

mangrove forests, dwarf mangrove flats, and lagoons. The Snake Cayes east of Port Honduras have unique nearshore coral reefs.

Outstanding biological features

A wide variety of complex and diverse environments are found in this area due to the combination of the pelagic and nearshore physical setting. The Snake Cayes are one of only a few areas in Belize where patch reefs are found near the mainland shore. It is an important area for the West Indian manatee and numerous migratory birds. The Punta Ycacos beach is a nesting-ground for sea turtles. Most mangrove stands are still intact and have high species richness. This is one of the most important areas for commercially significant finfish and estuarine fishes. Initial studies found that the number of fish species was higher than it was in similar areas in Mexico and Cuba (Sullivan *et al.*, 1995). Complex circulation patterns in association with regional circulation of the Gulf of Honduras gyre suggest possible importance for fish and invertebrate spawning, larval transport, and recruitment. Some mangrove islands contain salt ponds, a rare natural community often with rare or unique species. Preliminary studies of Deep-River-Punta-Ycacos watersheds found high biodiversity but suggested that additional surveys were warranted (Sullivan *et al.*, 1995).

Current conservation status

Port Honduras Marine Reserve (declared January 2000) covers 847 km^2 and includes seven rivers, nearshore communities, reefs, cays, and a Mayan archaeological site. A ranger's station is to be built on Abalone Cay.

Current resource use

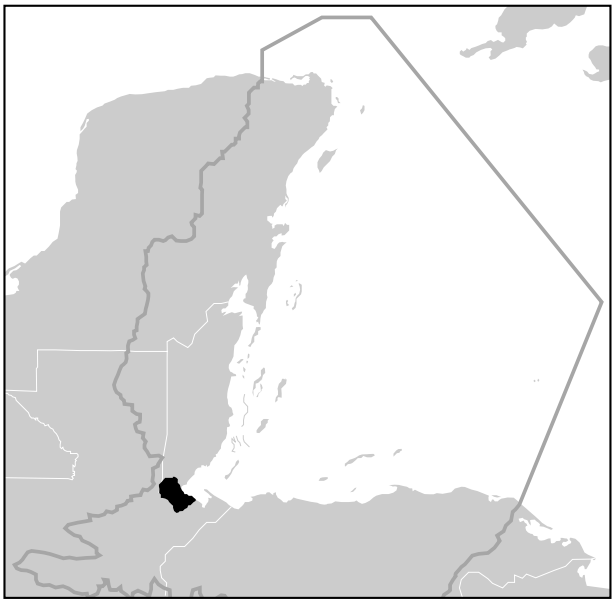
Fishing, hunting, small-scale tourism, subsistence farming, timbering and agriculture are the primary activities that affect this area. A few fishing camps and seasonal dwellings are found on some of the islands.

Description of threats

Threats include over- and illegal fishing, land-based activities, poor water quality, and natural disturbances (hurricanes, coral bleaching). Unregulated exploitation of fish and wildlife resources by Belizeans, as well as illegal use by Guatemalans and Hondurans, threaten this area. Manatees are frequently slaughtered illegally. Land-based activities in Guatemala and Honduras (e.g., logging, agriculture, pollution) result in poor water quality. Due to circulation patterns and association with the Gulf of Honduras gyre, water quality can be affected from outside the lagoon area as well as from upland sources. The inshore coral reefs of the Snake Cayes were heavily impacted by bleaching and are highly susceptible to future bleaching events.

Information needs

Research is needed on turtles, crocodiles, dolphins, manatees, and fish species.



Name: Gulf of Honduras (Sarstún –Temash/Chocón – Río Dulce)
Map ID Number: HG5
Subregion: Gulf of Honduras
Location: Sarstún River/Río Dulce
Approximate size: 1,552 km^2
Ownership: Belize/Guatemala/Honduras
Biological Importance: High

Description of area

This area is part of a large Cenozoic sedimentary basin at the foothills of the Sierra de Santa Cruz mountains that was formed by transform faulting of the nearby Caribbean-North American plate boundary. Amatique Bay is the principal inlet of the Gulf of Honduras and extends about 60 km between southeastern Belize and eastern Guatemala. High rainfall in this region (2000-3600 mm/yr) supports extensive wet subtropical and tropical forests along the coast and nearby foothills (D'Croz *et al.*, 1998). A pronounced wet season occurs from July to October during which river discharge

peaks. Several important rivers drain into Amatique Bay including the Temash, Río Dulce, and Sarstun Rivers, the last of which forms the natural border between Belize and Guatemala. The Río Dulce drains Lago de Izabal, a large freshwater basin, and El Golfeta, a coastal lagoon with brackish water. The anticyclonic circulation patterns in Amatique Bay suggest a possible connection with the southern Belize reef system (Yañez-Aranciba *et al.*, 1995). Dense mangrove vegetation occurs along the banks of the rivers and basins along with outcrops of ancient limestone. Two of Guatemala's largest deepwater ports (Santo Tomas and Puerto Barrios) are located on the southeastern side of Amatique Bay. The town of Livingston is located at the mouth of the Dulce River, and there are numerous small villages and developments spread along much of the coastline.

Outstanding biological features

The many important rivers that discharge into Amatique Bay harbor several unique fresh and brackish water habitats. Lower riverbanks and associated lagoons are lined with mangrove lagoons and provide excellent nursery areas for fishes and invertebrates. Over 45 species of fishes, mollusks, and shellfish are reported in the region (Salavierra and Rosales, 1993 cited in Yañez-Aranciba *et al.*, 1995). The large variation in salinity, dissolved oxygen, organic matter, and suspended sediments creates dynamic conditions that influence the distribution of species and provide critical conditions for different life stages. Ideal shrimp and fish nursery habitat exists along the Amatique Bay shoreline. The shallow lagoons, canals, and abundant submerged aquatic vegetation of the Rio Dulce and associated water bodies (Río Chocon-Machacas, Río Polochic, and Río Oscuro, El Golfete, Lago de Izabal) provide excellent manatee habitat. The area of Punta Cocolí has the only rocky shoreline along the coast of Guatemala. Artificial reefs in Amatique Bay also provide some additional fish habitat.

Current conservation status

A bi-national management agreement encompasses the Río Sarstún National Park in Guatemala and the Sarstún-Temash National Park in Belize. The Chocón Machacas Protected Biotope, Río Dulce National Park, and Bocas del Polochic Wildlife Refuge (all in Guatemala) protect a corridor along the Río Dulce River and encompass critical manatee breeding areas. A watershed protection zone extends around the Santo Tomas de Castilla bay into the surrounding foothills. The PROARCA/Costas project, implemented by TNC, WWF, and the Coastal Resources Center at the University of Rhode Island, worked with local NGO partners in improving coastal and marine resource management at several sites throughout Central America, including the Gulf of Honduras. The project provided technical assistance, training and funding to improve fisheries management, integrated coastal management, and strengthening of institutional alliances for the management of natural resources in the trinational area. TRIGOH is an alliance of local NGOs and selected government agencies (particularly the Fisheries Departments) in the three countries formed to promote sustainable fisheries management, public education, and eco-tourism in this area.

Current resource use

Fishing is mainly artisanal and concentrated along coastal bays and at the mouth of the Sarstún and Dulce Rivers (including El Golfete) with only limited regulation. The main species targeted include mackerel, snook, cahale, jacks, mojarra, and shrimp. Tourism to the area is low and mainly domestic, but substantial numbers of cruising boats use the Río Dulce area during hurricane season. There is a high volume of shipping in and out of Santo Tomas and Puerto Barrios.

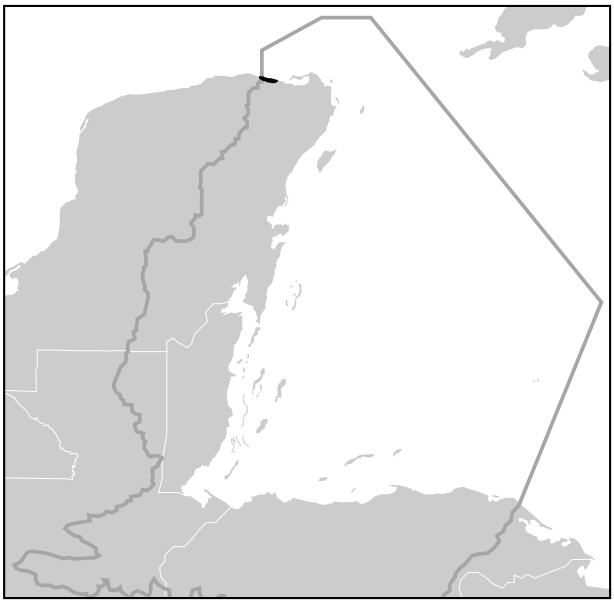
Description of threats

Inadequate agricultural practices, such as slashing and burning of forest and mangrove areas, have resulted in loss of natural habitat, loss of soils, and erosion. Discharge of agricultural pollutants (pesticides, fertilizers) into water bodies that drain into the Amatique Bay is a growing problem that requires more detailed investigation. Coastal development and urbanization with associated wastewater discharge continues to degrade coastal waters. Other impacts include hydrocarbon prospecting and processing infrastructure, dredging, shipping, and illegal hunting of manatees and sea turtles.

Information needs

Water movement patterns between Amatique Bay and the rest of the MACR need to be better established. Sources/sinks and the effects of agricultural pollutants are still not well understood. Impacts associated with port traffic, such as discharge of bilge water from cargo ships, are not well quantified. Additional information on coastal development is needed.

Priority Areas



Name: Ría Lagartos Lagoon
Map ID Number: QR3
Subregion: Northern Quintana Roo
Location: Northern end of the Yucatán Peninsula
Approximate size: 122 km²
Ownership: Mexico
Biological Importance: Priority

Description of area

Located at the extreme northern coast of the Yucatán Peninsula, Ría Lagartos Lagoon is a narrow (1-5 km) coastal lagoon that extends for over 60 km between the mainland and adjacent barrier islands. Campeche bank extends to the north and contains some of the region's most productive fishing grounds. The sub-humid climate and low elevation of the region have formed a complex mosaic of mangroves, lagoons, coastal dunes, salt marshes, and ponds. Brackish lagoon waters extend inland a considerable distance, where they intermix with freshwater lowlands. No coral reefs are found along the northern coast of the Yucatán.

Outstanding biological features

Ría Lagartos Lagoon contains an immense inventory of species, including many endemic plants, amphibians, reptiles, birds, and mammals. At least 315 different bird species in 194 genera have been reported for the Ría Lagartos Reserve. The salt flats bordering the lagoon are one of the most important breeding grounds for pink flamingos in the Caribbean. The lagoon also contains a high diversity of coastal vegetation with over 520 species of plants, of which 50 are endemic (Vales *et al.*, 2000). The lagoon serves as an important nursery for marine fishes and contains many types of seagrasses, seaweed, and algae of limited distribution.

Current conservation status

Ría Lagartos Biosphere Reserve was declared in 1999 and covers approximately 60,348 hectares.

Current resource use

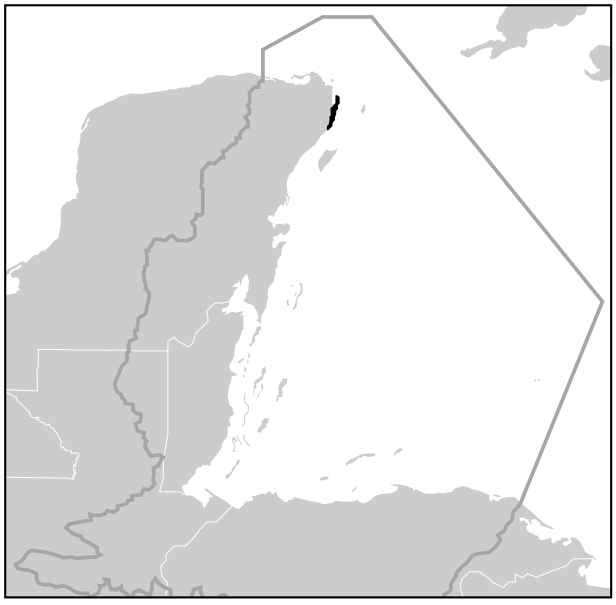
There is currently only limited tourism and visitor use of the area. Limited fishing by several fishing cooperatives occurs within the lagoon.

Description of threats

As the population in the nearby city of Cancun continues to grow, tourism and use of the lagoon area are expected to increase along with associated disturbances. Currently, several roads provide access to the lagoon and more roads and facilities will likely be constructed. Coastal development and road-building also threaten water quality.

Information needs

There is a need to gain a better understanding of the ecology of this area, including fauna and flora surveys.



Name: Cancun Corridor
Map ID Number: QR5
Sub region: Northern Quintana Roo
Location: Yucatán coast from Isla Mujeres to Puerto Morelos
Approximate size: 299 km²
Ownership: Mexico
Biological Importance: Priority

Description of area

The area encompasses an 80 km section of the Yucatán coast from Isla Mujeres south to Puerto Morelos and includes areas adjacent to Cancun, one of the principal tourist destinations in Mexico. The Yucatán shelf in this area is locally varied by erosional terraces and small escarpments, which form a network of coastal lagoons, offshore islands, and fringing reefs. The island of Cancun, (21km long) is a barrier island that now encloses a large shallow (1.5-3.5 m) lagoon, Nichupte Lagoon. Nearby, Isla Mujeres (~ 8 km long) contains a poorly-developed shallow fringing reef on its southwest coast and an undeveloped fringing reef at the northern tip (Lara *et al.*, 1993). Shallow fringing reefs contain relatively high coral cover, while fore reefs consist mostly of small colonies and low coral cover. Reef development improves from Cancun to Puerto Morelos, with several continuous reef crests up to 10 km long and 3 km wide.

Outstanding biological features

The area contains well-developed coral, seagrass, and mangrove habitats. Shallow reef crests are dominated by *Acropora palmata* and *Millepora complanata* as well as smaller coral species. Large thickets of *A. cervicornis* are found near Bajo Finduvet and Tanchacté. The area also supports manatee and sea turtle habitat. Extensive wetlands and seagrass (*Halodule spp.*, *Syringonium spp.*, and *Thalassia spp.*) occur in Nichupte lagoon, although significant losses have been caused by the construction of the causeways that link the Cancun hotel zone to the mainland.

Current conservation status

Reefs between Isla Mujeres and Cancun were declared a flora and fauna reserve in 1973 and later a National Park in 1996. There are also parks at Punta Nizuc and Punta Cancun. A National Park has recently been implemented in Puerto Morelos.

Current resource use

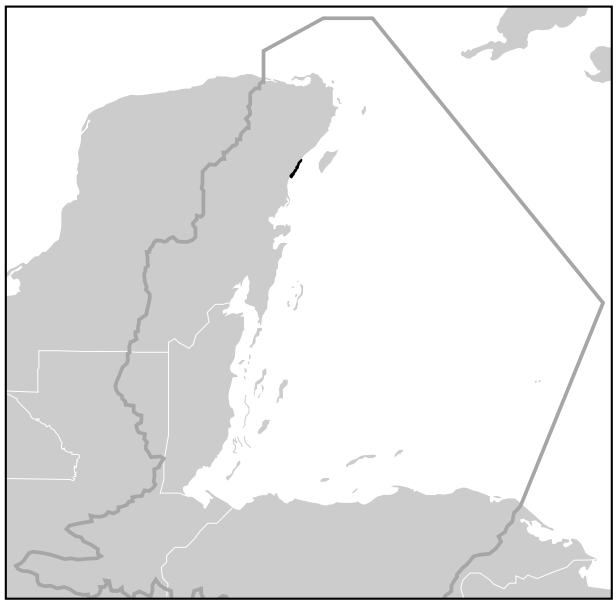
The Cancun area receives approximately 2 million tourists per year, who partake in various water sport activities such as boating, snorkeling, water skiing, and surfing. Punta Nizuc Reef in Quintana Roo, for example, has an average of 1,500 snorklers per day arriving on 21 large tour boats and 650 two-seater jet skis (Bezaury, 1998). Fishing is now prohibited in the parks, but fishing pressure over the past 20 years has left harvestable marine resources (lobster, grouper, conch) from the area severely overfished and in very low abundances.

Description of threats

The development of Isla Cancun into one of Mexico's principal tourist destinations has significantly reduced circulation in Nichupte Lagoon. The area continues to experience a very high growth rate (>6%) with new construction and urban expansion expected to continue. Water quality has already declined in many parts of Nichpte Lagoon and will likely continue to do so. Fishing pressure on commercially significant species is expected to continue, although improved enforcement and a decline in fishery resources has caused many fisherman to switch to the tourism business (Jordán-Dahlgren and Rodríguez, 1998b).

Information needs

This area is well known, except for invertebrates.



Name: Tulum Corridor
Map ID Number: QR6
Subregion: Northern Quintana Roo
Location: Yucatán coastal shelf from Xpuha to Tulum
Approximate size: 113 km²
Ownership: Mexico
Biological Importance: Priority

Description of area

The Yucatán coastline in this area is characterized by flat Eocene-Holocene limestone terrain with alternating sandy beaches and rocky outcrops. The shelf margin is very narrow and typically drops abruptly within several kilometers of the coastline to depths greater than 400 m. A dry climate coupled with the highly permeable limestone terrain results in a lack of rivers. Reefs in this area are characterized by overall low biotic cover and mostly denuded hard grounds, with a few localized patches of high-biotic-cover areas dominated by stands of dead *A. palmata*. Most reef structure is found on reef crests and back reef zones, and the deeper platform reefs are very poorly developed (Jordán-Dalhgren *et al.*, 1981). The shallow reefs are categorized as part barrier and part fringing (Jordán-Dahlgren, 1979). Their occurrence is often related to the presence of elevated topographic features like terraces and escarpments.

The shadow caused by the island of Cozumel appears to depress reef development along the mainland coast for about 35 km. Corals grow on rocky headlands and in isolated bays of Xpu-ha, Kantenah, Xaac, Akumal, Aventuras, Chumuyil, Xcacel, Xel-ha, Tulxayab, Soliman, Tankah, and Tulum. Runoff and groundwater seepage may provide fresh and brackish water into these bays and to nearby fringing reefs in some areas. Seagrasses and isolated coral heads within these bays provide foraging and nursery habitat for numerous species.

Outstanding biological features

This area contains a combination of coastal and submarine habitats, including coastal beaches, rocky shoreline, seagrass beds, and coral reefs. The area supports a number of important turtle nesting beaches and also contains a small transient population of manatees. Fringing coral reefs contain abundant populations of fishes, sponges, algae, and invertebrates.

Current conservation status

A marine protected area is proposed for Akumal Bay.

Current resource use

The area has experienced tremendous growth and coastal development over the past 10 years to support the ever-growing influx of tourists. The coastal area is heavily used for diving, fishing, boating, and snorkeling. Fishing cooperatives still fish for groupers, grunts, barracudas, snappers, snook, Atlantic Spanish mackeral, and lobster, but many fishermen have switched to tourist-related activities because of better pay.

Description of threats

Coastal development, urbanization, increased population, and pollution are the main threats facing this area. Dredging and construction of channels through the reef to allow passenger ships easier access to hotels and tourist facilities poses a major threat. Sewage disposal and groundwater contamination are major problems that potentially threaten reefs and near-shore communities. Large targeted fish species are overexploited and demand is expected to increase. Hurricanes have impacted reefs several times in recent decades.

Information needs

Coral and turtle inventories are available, but quantitative information for fishes, birds, and other invertebrate species is needed. A study of the impact of pollution and groundwater discharge on the area is needed.

Name: Central Barrier Reef
Map ID Number: BB7
Subregion: Belize Barrier Reef
Location North central section of Belize Barrier Reef from Bluefield Range south to Man of War Cay
Approximate size: 418 km²
Ownership: Belize
Biological Importance: Priority *(As part of the Belize Barrier reef, this area is of highest priority, yet relative to other areas within this subregion, workshop participants ranked it a lower priority designation because it did not include coastal habitats.)*

Description of area

This area is dominated by the impressive central Belize Barrier Reef, which contains long sections of uninterrupted reef crest broken by occasional channels. Rubble-strewn pavement and sand derived from the narrow active reef form a wide (up to 100 m) reef-flat apron that extends into the lagoon. Spur and groove formations extend seaward to a depth ranging from 18-22 m, at which point there is a small step, then a steep wall further out at 65 m (James and Ginsburg, 1979). Within the lagoon, patch reefs can be found near cuts and openings in the barrier. Numerous mangrove islands are located behind the main barrier. Many of these islands are surrounded by seagrass beds and contain shallow ponds in their interior.

Outstanding biological features

The outer Belize Barrier Reef is unique within the Caribbean for its size and degree of development. Important nearby habitats include seagrasses, mangroves, patch reef, coastal rivers, and lagoons. A historical snapper-grouper spawning site occurs offshore of Southern Long Key and others are believed to exist at other promontories in the area. Overall the area contains considerable species richness. Manatees have been observed here and there is also good turtle nesting habitat for loggerhead, green, and hawksbill turtles.

Current conservation status

None

Current resource use

Fishermen rely on this area for conch and lobster. The nearest town is Dangriga, located on the mainland approximately 20 km from the barrier. The Southern Long Cay spawning aggregation site continues to be fished even though it no longer produces yields as high as it once did.

Description of threats

The main threats to this area are associated with overharvesting of marine resources and regional/global problems such as coral bleaching and hurricanes. Tourism is low.

Information needs

General information/inventories needed for entire area.

Name: Tela-Manabique Coast
Map ID Number: HG4
Subregion: Gulf of Honduras/Northern Honduras Coast
Location: From Puerto Barrios in Guatemala to the León River in Honduras
Approximate size: 4,376 km²
Ownership: Honduras/Guatemala
Biological Importance: Priority

Description of area

This area includes tropical wet forest sections of Northern Guatemala and northwestern Honduras extending from Puerto Barrios in Guatemala to the León River in Honduras. Tectonic activity associated with the plate boundary between the Caribbean plate and North American plate has played an important role in shaping the metamorphic and sedimentary landforms in this region. Active faulting since Miocene times and as recent as 1976 has occurred throughout the region, resulting in several large sedimentary basins (Lake Isabel, Río Dulce), rocky outcrops, and uplifted mountainous blocks. Four big rivers: León, Ulúa, and Chamelecon in Honduras and Motagua in Guatemala, drain the adjacent mountainous regions of the Sierra de Omoa and Sierra de las Minas. The sediment and organic load input by these and other rivers creates sand bars, sandy beaches, and murky coastal waters in this area. Coral reefs are not common in this area, but isolated offshore coral-encrusted mounds have been reported near Puerto Cortés and Punta Sal. Punta Manabique is an elongate sand spit that forms one side of the Bahia de Amatique and encloses a portion of the smaller Bahia la Graciosa. Seagrasses often occur in the small coastal bays and along the mainland coast. Punta Sal is a rocky spit that extends out into the water forming Tela Bay and Laguna de los Micos. Offshore seamounts are found north of Tela.

Outstanding biological features

Due to its large size, this area contains significant habitat diversity that includes coastal lagoons, sandy beaches, mangroves, localized seagrasses, and tropical wetland forests. Bahia la Graciosa in Guatemala is a highly productive bay with rich seagrass meadows that serve as important breeding areas for fishes, crustaceans, and invertebrates, including four species of shrimp. The sandy beaches along Punta Manabique are an important sea turtle nesting area and at least 380 hawksbill sea turtle nests are estimated per year (Smith *et al.,* 1992). The offshore coral mounds near Puerto Cortés and Punta Sal are rare because of the turbid conditions and high freshwater discharge to the area. Coral species are not well known and the origin of these mounds has not been studied. Laguna de los Micos has around 600 different bird species, as well as the wetlands between Tela and Puerto Cortés. The lower stretches of the Ulúa and Motagua Rivers also serve as critical manatee habitat. The wetlands and coastal lagoons at Punta Izopo, in Jeannette Kawas NP near Tela, and the wetlands between the Alvarado Lagoon near Puerto Cortés and Canal Martinez near Punta Sal, contain patchy mangrove stands that support large bird populations. Overall, the area has a high diversity of migratory and coastal birds.

Current conservation status

Jeannette Kawas National Park near Punta Sal was established in 1993 and covers 178,000 acres. Punta Izopo is another protected area in Honduras that includes lower sections of the León River. The environmental NGO, PROLANSATE, is responsible for managing the protected areas of Lancetilla, Punta Sal, Punta Izopo, and Texiguat. A proposed marine protected area stretches from Omoa to Baracoa in Honduras, encompassing the reefs around Puerto Cortés and the coastal

wetlands. In Guatemala, a protected area extends around Punta Manabique.

Current resource use

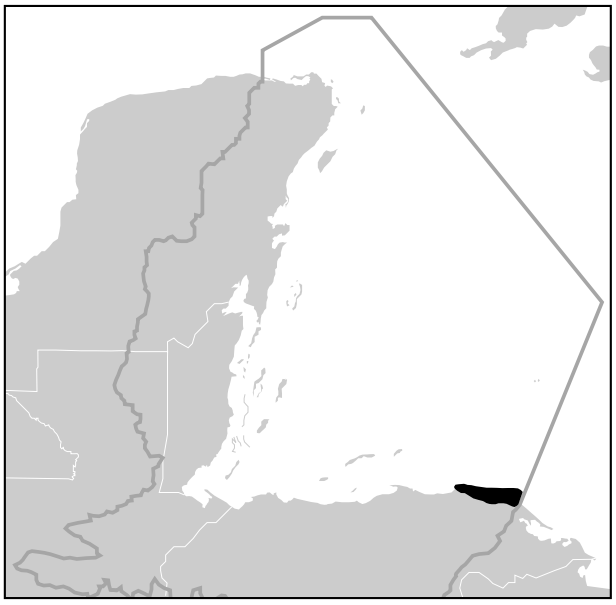
The Honduran portion from Tela west is the most densely populated part of the entire Central American Caribbean coast, and includes intensively farmed coastal plain areas as well as the industrial centers of Honduras. Numerous indigenous Ladino and Garifuna are also found in this area and rely on subsistence fishing and small-scale farming. Puerto Cortés is the site of a large port that serves as the Caribbean terminus of the transisthmian route across the country. The industrial port of Puerto Barrios also receives high amounts of tanker and shipping traffic to and from the Bay Islands and Belize. Tourism is presently not very high in this area, but continues to grow.

Description of threats

This area has some of the highest population densities of the entire region. Draining and cutting of mangrove have degraded many coastal wetlands. Dredging to prevent flooding of cities and intensively farmed alluvial plains has increased sediment and runoff to the Caribbean through coastal rivers. The Motagua and Sula-Chamelecon carry untreated sewage from Guatemala City and the Sula Valley in Honduras, areas that include millions of people. Deforestation of the inland areas has led to increased erosion and sediment loading of the rivers. Heavy farming of the rich alluvial valleys has polluted waterways with pesticides and fertilizers. The industrial ports of Puerto Barrios and Puerto Cortés are the principal locations for shipping to and from Guatemala. These ports are also the principal terminals for oil tankers and contain nearby oil processing facilities and associated infrastructure. Hurricane Mitch caused extensive flooding to this area and continued deforestation has left many areas vulnerable to future flooding. The coastal resources (fish, shrimp) are heavily fished.

Information needs

Biological and geological assessments are needed for the offshore reefs and coastal wetlands stretching from Punta Izopo to the Guatemalan border. Information is needed to better understand these features and to help determine which areas should be turned into protected areas. Information on the impacts of the above-mentioned threats is also needed.



Name: Río Plátano Biosphere Reserve
Map ID Number: HG2
Subregion: Northern Honduras Coast
Location: Coastal ecosystem between Cabo Camarón and Punta Patuca
Approximate size: 2,075 km^2
Ownership: Honduras
Biological Importance: Priority

Description of area

Known as the La Mosquitia or Miskito Coast, this area is located on the northeastern coast of Honduras between the Sico and Patuca Rivers, and includes portions of the watersheds of these rivers, the Tuscruas, and the entire watershed of the Rio Platano. The two large coastal lagoons of Brus (brackish, 120 km^2) and Ibans (freshwater/seasonally brackish, 63 km^2) contain some of the largest expanses of mangroves in Honduras and serve as important nurseries. Coastal habitats include marshes, mangroves, channels, flooded savannahs, coastal lagoons, rocky beaches, sandy beaches, and humid tropical forest. Sandy beaches occur along the mainland and on barrier spits around the river mouths. A broad coastal savanna extends landward consisting of sedge prairie (*Rhynchospora* spp.) in wetter areas and grasses (e.g., *Fimbristylis* sp.) in drier areas, and pine savannas dominated by *Pinus caribaea va. hondurensis*. Broadleaf gallery forests border the Plátano River while mature broadleaf forests cover the majority of the watershed. Coastal mountains occur fur-

ther inland and include some of the last large expanses of intact tropical rainforest left in Central America.

Outstanding biological features

The area contains diverse terrestrial and aquatic habitats supporting high biodiversity, including 39 mammal species, 377 bird species, and 126 reptile and amphibian species (Glick and Betancourt, 1983; Cruz, 1991). These habitats are important to several threatened species such as jaguar (*Panthera onca*), jaguarondi (*Felis yaguaroundi*), puma (*F. concolor*), ocelot (*F. pardalis*), margay (*F. wiedii*), Baird's tapir (*Tapirus bairdii*), and red-rocket deer (*Mazama americana*). Vulnerable aquatic species include manatee, American crocodile, caiman, green, leatherback, and loggerhead turtles, and Central American otter (*Lutra longicaudis*). Bird species at risk include scarlet (*Ara macao*), green (*A. ambigua*), and military (*A. militaris*) macaws, jabiru stork (*Jabiru mycteria*), and harpy eagle (*Harpia harpyia*). Several endemic species and at least five restricted-range species are found within the reserve (Stattersfield *et al.*, in press).

Current conservation status

The Reserva de la Humanidad y Biósfera del Río Platano was declared in 1980 by the Honduran government and designated by UNESCO as a World Heritage Site. Due to numerous threats to the area, it was placed on the list of World Heritage Sites in Danger in 1996. A UNESCO/IUCN mission in 2000 noted that although substantial progress had been made in dealing with some threats, others still occurred and the site remains on the UNESCO list of World Heritage Sites in Danger (Baborak and Salas, 2000). The reserve covers an area of 800 km^2. A participatory zoning process has been undertaken to define community use zones for the cultural and buffer zones of the Reserve, which make up the majority of its area. The area has a new management plan produced in a participatory manner.

Current resource use

Indigenous groups make up about half the population of the reserve and include mainly Garifuna and Miskito with small groups of Pech and Sumo (Tawahka) living in a traditional manner. Small communities are located along the principal rivers and some sections of the coast. Currently levels of tourism are low because of the remoteness of the region. Traditional fishing and hunting take place along with some logging, cattle grazing, and farming.

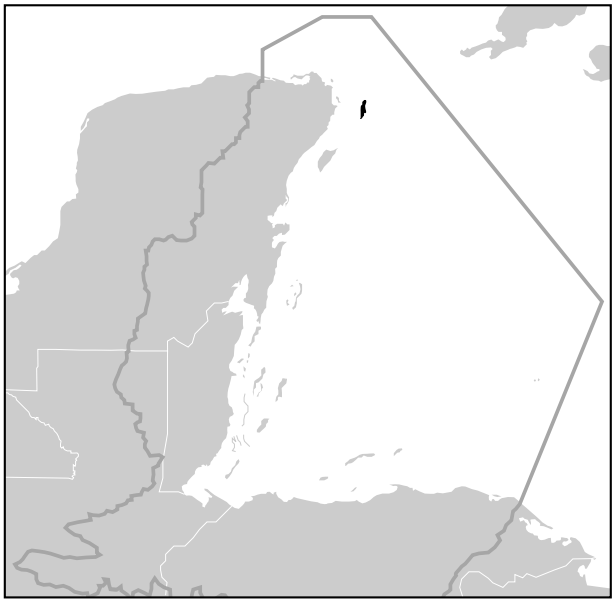
Description of threats

The area is facing increasing pressures on its natural resources. Exploitative commercial fishing, poaching, and unsustainable agricultural practices are the principal threats. The most significant losses have come from the immigration of landless peasants and land speculators from elsewhere in Honduras, as well as the high birth rates of both long-time residents and newcomers. These threats are the result of population growth, poverty, ignorance about the importance of sustainable natural resource use, and ultimately a lack of alternatives for the poor local population.

Information needs

Coastal areas need more intensive mapping and surveys to determine abundance and distribution of key habitats. Inventories of focal species are also needed.

Areas that need additional information



Name: Banco Arrowsmith
Map ID Number: QR4
Subregion: Northern Quintana Roo
Location: Offshore bank and adjacent waters to a depth of 200 m
Approximate size: Not available
Ownership: Mexico
Biological Importance: Unknown

Description of area

Banco Arrowsmith is a submerged platform located 35 km from the Yucatán mainland between the islands of Cozumel and Isla Mujeres. Banco Arrowsmith rises up to 8 - 16 meters depth out of surrounding water that is up to 1,500 meters deep. The strong currents (up to 6 knots) of the Yucatán Current influence this area much of the year, which limits the ability to conduct scientific research of the area (Jordán-Dahlgren, 1993).

Outstanding biological features

A number of endemic deep-water ahermatypic scleractinia and stylasterina species are reported for Banco Arrowsmith. Stylasterina species include *Errina altispina*, *Stylaster inornatus*, and *Stylaster laevigatus*. The strong northward-flowing currents funnel baitfish along the tip of the Yucatán Coast, attracting numerous large pelagic species.

Current conservation status

None

Current resource use

Recreational anglers fish for sailfish and marlin and other pelagics. Commercial fishing is unknown.

Description of threats

Unknown

Information needs

The ecological process and significance of this area is warranted. Several preliminary surveys are presently underway and results should become available soon.

Name: English Channel
Map ID Number: BB5
Subregion: Belize Barrier Reef
Location: Inner shelf lagoon south of Belize City
Approximate size: Not available
Ownership: Belize
Biological Importance: Unknown

Description of area

English Channel is the principal navigable entrance through the Belize Barrier Reef. The channel represents a drowned relict river channel that drained the entire northern Belize lagoon when sea level was considerably lower (Ferro *et al.*, 1998). Some inshore reefs are reported to occur in the area. The reefs off English Caye are reported

to have large stands of *Acropora palmata*. The hydrodynamics of this area are not well understood, but are thought to have a major influence on current patterns, and thus other biological phenomena.

Outstanding biological features

This area may be an important migration route for certain species. Additional information is needed on species and ecological phenomenon. Although not directly located in the area delineated, mutton snappers have been observed aggregating off English Cay between the full and last quarter moons of April and May. Nassau grouper, yellowfin grouper (*M. venosum*), and jewfish (*E. itajara*) also use the area (Arrenguín-Sánchez *et al.*, 1993). Fishermen have historically fished a jewfish aggregation site off English Caye, although numbers have been too low for exploitation in the past several years.

Current conservation status

None

Current resource use

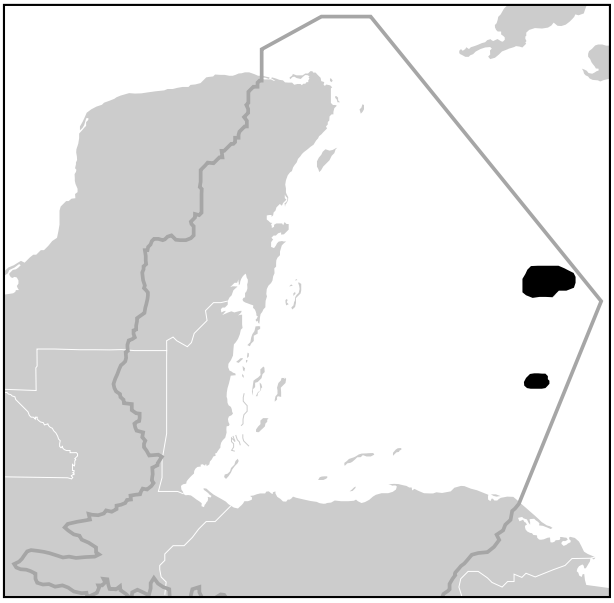
This area is a principal route for shipping to and from Belize. Oil tankers, barges, and cruise ships use the English Channel entrance. Tourism exists on nearby cayes.

Description of threats

Fishing demands are increasing on the reef shelf, as is tourism (recreational effects). Coastal development, aquaculture, and agriculture effects on the marine system are high. Human use in this area is increasing at an alarming rate.

Information needs

This is a poorly studied area from biological, geological, and physical oceanographic perspectives and should be the focus of more intensive surveys



Name: Swan Islands, El Rosario and Misteriosa Banks

Map ID Number: HG1, HG6

Subregion: Open Ocean

Location: In Honduran territorial waters: The Swan Islands are 175 km to the north of the mouth of the Patuca River; the Misteriosa and El Rosario banks are 300 km to the north of the mouth of the Patuca River.

Approximate size: 3,126 km²

Ownership: Honduras

Biological Importance: Unknown

Description of area

The Swan Islands contain three islands, including Great Swan (Isla Grande), Little Swan (Isla Pequeña), and Booby Cay, and cover an area of about 5 sq. miles. Great Swan is nearly two miles in length with a maximum elevation of 68 feet, while Little Swan is about 1.5 miles in length and 78 feet high. Booby Cay is a small cay off the southwestern tip of Great Swan. Great Swan is composed of coralline limestone with cliffs 15-18 m high surrounding it. The east coast is lower in elevation with a few bays and beaches (Wells, 1988). Little Swan has continuous 15-18 m high limestone cliffs on the south coast and 4 - 6 m high cliffs on the northern coast. Fringing reefs surround the perimeter of the islands, with the best reef development located along the northern shores. Coral growth is less abundant and less speciose than in Panama Reefs (Wells, 1988) and contains *Acropora, Porites*, gorgonians, and calcareous

algae. The islands are covered with grasses, trees and underbrush, and little if no fresh water sources. The Rosario and the Misteriosa Bank are submerged carbonate banks located near the Cayman Ridge, a ridge that separates the Yucatán Basin from the Cayman Trench but allows seawater exchange from the surface down to depths close to 4,000 m.

Outstanding biological features

Very little is known about this area, but it is believed to be an important area for nesting seabirds, sea turtles, and marine life, based on its location. The Swan Islands, Rosario Reefs, and Misteriosa Banks are unique in the ecoregion because of their distance from the continent. The likelihood of elevated species richness and endemism is high. Currents flowing past the islands and banks toward the west are likely rich in planktonic life and probably play an important role in larval transport. This area may be an important spawning ground for fish and stopover for migratory seabirds. The brown footed booby, red footed booby, and magnificent frigate nest on the Swan Islands (Halewyn and Norton, 1984). The brown noddy may potentially nest here, as well as other bird species. Green, hawksbill, and loggerhead turtles reportedly nest on the Swan Islands. There is the possibility of unique vertebrate and invertebrate species (terrestrial) on Swan Island. The Swan Islands, Rosario Reefs, and the Misteriosa Bank have highly productive fishing grounds for conch and fish (e.g., snapper, dolphin, grouper).

Current conservation status

Swan Islands were declared a Honduras National Marine Park in 1991 by presidential decree. However, this decree has not been approved as law by the Honduran Congress, which would provide a more permanent and stronger form of protection. The area has always been a paper park with no management presence on the part of the Honduran Protected Areas and Wildlife Department, part of the National Forest Administration (AFE-COHDEFOR). The Rosario and Misteriosa Banks are unprotected.

Current resource use

There is infrastructure on Great Swan Island, originally built as a weather/military station for the U.S. Government. A small Honduran naval contingent is now stationed there. There is also a useable airfield. Only a few military personnel and one rancher live on the island; Little Swan and Booby Cay are uninhabited. The Swan Islands, Rosario Reefs, and Misteriosa Banks are important fishing grounds for finfish, conch, and some lobster for industrial fishermen from Honduras and other areas. A fishing fleet from the Cayman Islands, usually composed of 10 vessels (8 - 10m in length), frequently fish the Rosario Reefs (particularly the Misteriosa Banks) catching primarily blackfin snapper, silk snapper, queen snapper, and dolphin. Other non-Honduran fishermen are also believed to fish the banks.

Description of threats

The greatest current threats to these areas are hurricanes and overfishing. Cattle grazing has impacted the terrestrial flora and fauna on Great Swan. There are some introduced, non-native species (e.g., cats, cardinals) present. Cats are believed to be responsible for the demise of the Swan Island hutia and considerable predation on native iguana and nesting bird populations. After the Nicaraguan revolution in 1979, the U.S. trained contra-revolutionaries on the Swan Islands with unknown direct and indirect impacts, although the Defense Department undertook environmental clean-up activities after the end of hostilities. The Honduran Tourism authorities have proposed tourism development for the Swan Islands (e.g., casinos), but environmentalists have opposed the plans. There are proposed plans to construct a floating city on the Misteriosa banks. Activities associated with this development will be destructive to the surrounding marine life and migratory birds. Because this area is far removed from human impacts other than fishing, the effects of new disturbances associated with this development could be catastrophic.

Information needs

There is a great need to obtain bio-oceanographic information on currents and plankton flow toward the rest of the ecoregion. The importance of this area as fishing and nursery grounds warrants further investigation. Some early research information on tides, currents, and geology is available (Stewart, 1962). Information on the terrestrial communities of the Swan Islands, and particularly on the presence of endemic plants and animals and important populations of migratory birds and nesting sea turtles, is needed.

Tortora and Keith (1980a, b) described octocorals and scleractinian corals and Harbor Branch investigated seaweeds at Misteriosa and El Rosario. The Universidad Nacional Autónoma de Honduras (UNAH) prepared plant and bird inventories (Pilar Thorn and Carlos Cerrato) and the Honduran Ministry of the Environment has sponsored several short expeditions by national scientists to the Swan Islands.

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Additional Resources used include:

FishStat Plus ver 2.3. Fisheries data Analysis Software for Windows

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www.coral.aoml.noaa.gov/agra/ (AGRRA)

www.fao.org (Food and Agriculture Organization)

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www.odci.gov/cia/publications/factbook/ (CIA World Factbook)

www.reef.org (REEF)

www.worldbank.org (World Bank)

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World Wildlife Fund
1250 24th Street, NW
Washington, DC 20037
USA
www.worldwildlife.org
Telephone: 202-293-4800
Fax: 202-293-9211