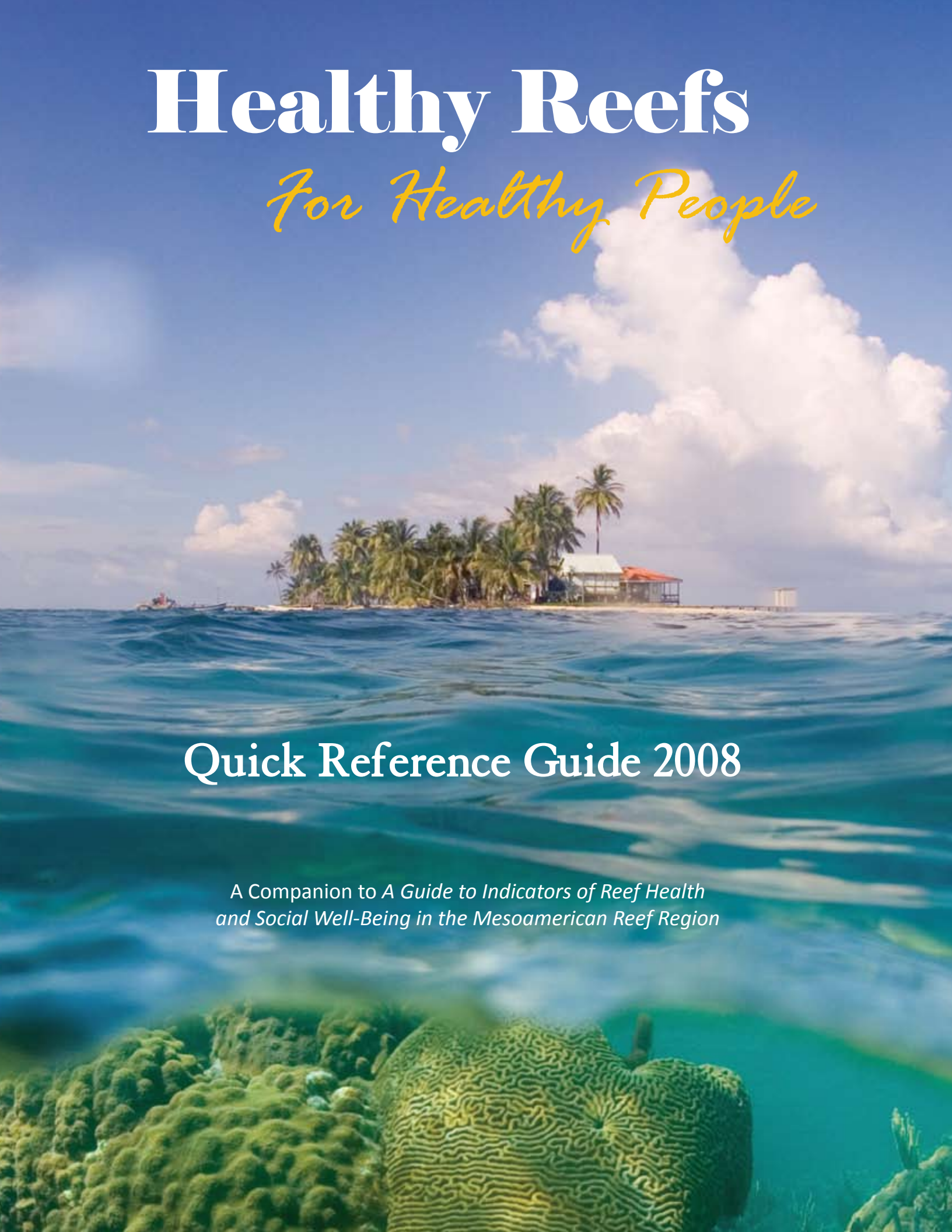
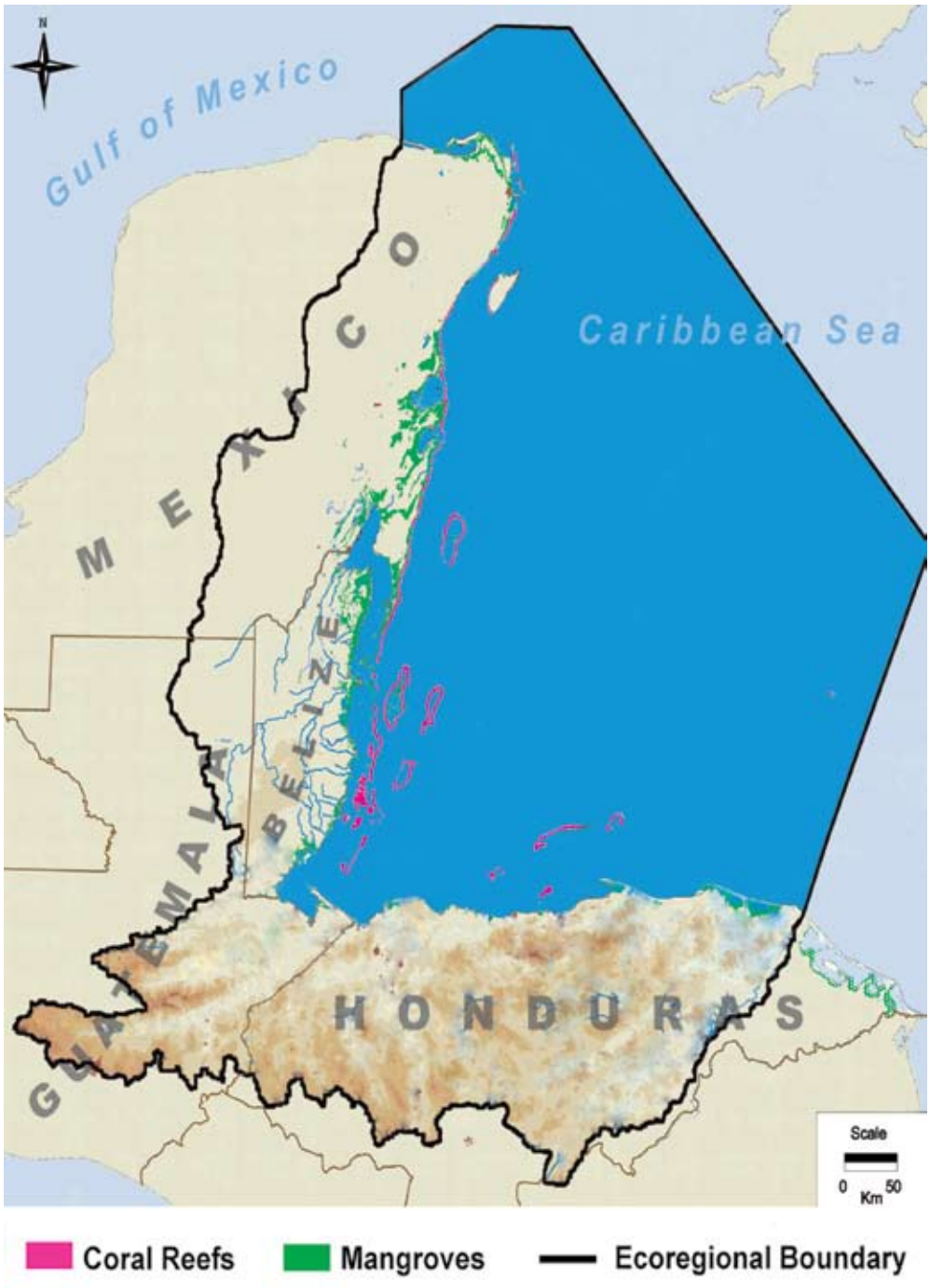
Healthy Reefs

For Healthy People



Quick Reference Guide 2008

A Companion to *A Guide to Indicators of Reef Health and Social Well-Being in the Mesoamerican Reef Region*



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The spectacular Mesoamerican Reef—the Western Hemisphere's longest barrier reef—stretches more than 1,000 km from Mexico to Honduras.

This vast complex, with its neighboring seagrass meadows, deep and shallow lagoons, and shady mangrove forests, forms a dynamic mosaic that nurtures the Mesoamerican "hotspot" of biological and cultural diversity.

Here more than most places, the health of our people—our communities and our economies—depends on our ability to restore, nurture, and maintain our healthy reefs.

Introduction

Key: Data Gap Emerging Issue

In 2007, the Healthy Reefs Initiative published *Healthy Reefs for Healthy People: A Guide to Indicators of Reef Health and Social Well-being in the Mesoamerican Reef Region.* This book described four classes of key indicators by which progress toward a healthy Mesoamerican Reef (MAR) can be quantitatively tracked.[1]

This *2008 Quick Reference Guide* updates and highlights the 20 highest-priority indicators from that framework of 58 indicators (see inside back cover).

What are indicators?

***Indicators* are practical, quantitative measures of reef or human health. Their purpose is to help translate the abstract concept of well-being into a suite of tangible, rigorously defined quantities by which progress can be assessed.**

A Healthy Reef? To provide an initial overview of reef health, we compared modern baseline measurements to the Reference Conditions that spell out short- and long-term goals and warning signals for each indicator.[2] We learned that:

- **20% of the priority indicators were in Red Flag condition.** Among the ecosystem-function indicators half were red flagged.
- **40% were between Red Flag and Benchmark values.** This level of progress was uniformly distributed across all categories, ecological and social.
- **0% were in Target territory, but 5% were getting close.** This near-Target distinction belonged to the ecosystem-function category.

Limited data availability is still an issue:

- **For 15% of the priority indicators, data were so sparse that regional characterizations were impossible.** Data shortages were most severe for indicators requiring knowledge of key animal abundances.
- **For the remaining 20%** of the priority indicators, **basic data have been collected and assessments are underway** (available within the next two years).

Reference Condition Definitions

UPDATED

Status: State of indicator in the MAR region for a given year

Target Optimally feasible goal for ~ 2025

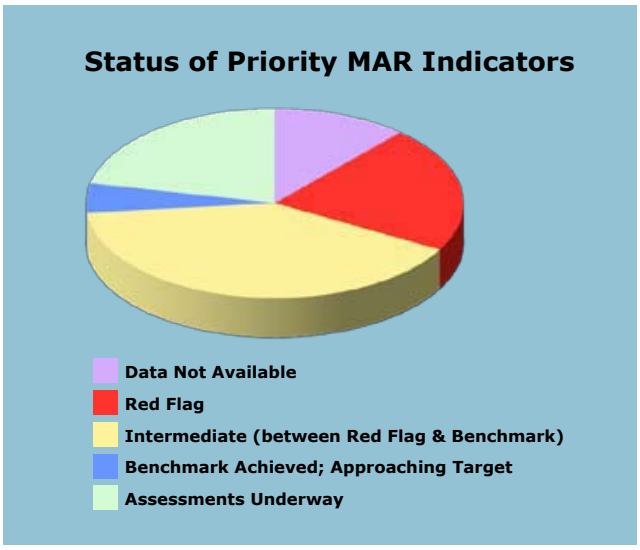
Benchmark Recommended interim goal for ~ 2012

Red Flag Warning: Conditions poor enough to warrant action

Reference Conditions define the baseline and milestones by which progress is measured. Most are presented in terms of MAR-wide averages.
The UPDATED *stamp marks Reference Conditions that have been recently updated.*

The overall picture is one of a reef in danger, in need of immediate protection. Given the tight coupling between environmental and human health, urgency is imperative. At the same time, there is good news in that some elements of reef health are improving and many are responsive to human action.

We believe the best hope for Mesoamerican Reef health lies in widespread public support for data-driven marine conservation and long-term sustainable development. We hope the bird's-eye view presented here and in forthcoming updates will help to inform enlightened self-interest in all interactions regarding the reef.



More than a third of the MAR priority indicators are approaching their recommended Benchmark "healthy reef" milestones. Another one fifth are in Red Flag territory.

Stop the presses! For late-breaking updates—including some good news—on recent reef conditions, see pg. 22 and www.healthyreefs.org

[1]McField and Kramer (2007). The four classes of indicators are ecosystem structure (S) and function (F), drivers of change (D), and social well-being and governance (SW).

[2]The Healthy Reefs priority indicators and Reference Conditions will be updated as we learn more about reef ecology and the connections between environmental and human health. Reference Conditions are usually expressed in terms of MAR-wide averages, but we often show country-level averages as well.

S3 Focal Species Abundance

***Focal species* are animals of special concern.** MAR examples include the critically endangered hawksbill and leatherback turtles, largetooth sawfishes, and goliath and Warsaw groupers. Species considered vulnerable include the charismatic manatees and whale sharks.[1]

Focal species make important contributions to ecological function, economic well-being, and public good will. Decline of a high-profile, nearly one-of-a-kind species can represent a significant loss of biodiversity and income. Because many people take a special interest in focal species, these animals serve as influential "reef ambassadors."

The status of sensitive, multi-habitat species can also hint at general environmental conditions. Hawksbill turtles, for example, roam open ocean waters as early juveniles, then move to reefs as late juveniles and adults; the females nest on sandy beaches. So declining hawksbill populations can be a signal to take a closer look at these habitats and the other less visible plants and animals that live there too.

We recommend that abundances be routinely estimated for at least hawksbill and leatherback turtles, manatees, and whale sharks, and that regional assessments of sawfish and Warsaw and goliath groupers be undertaken as soon as possible. Monitoring programs must be formulated on a species-by-species basis. Sparse populations and remote locations may dictate monitoring by proxy (for example, counting nests if the animals themselves cannot be reliably counted).

In Jan. 2008, Cuba joined its MAR neighbors in banning the harvest of sea turtles, including the critically endangered hawksbill.[2]

UPDATED

Status (2006): NOT AVAILABLE
27 SPECIES TO WATCH
At least 27 MAR marine species threatened (not including birds)

Target
Improved Red List status for ≥ 15 threatened species†
No Red List additions or status declines†
Species populations ≥ avg. of 2002-2006 levels*

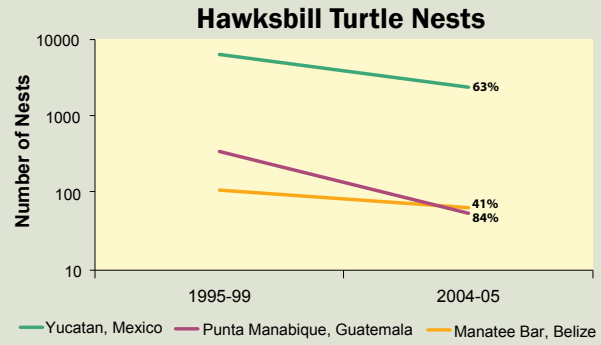
Benchmark
Improved Red List status for ≥ 2 threatened species†
No Red List additions or status declines†
Species populations ≥ avg. of 2002-2006 levels*

Red Flag
Worsening Red List status for any species†
Species populations < avg. of 2002-2006 levels*

†Compared to 2006 IUCN Red List
**For Reference Conditions specific to individual species, see www.healthyreefs.org*

Promising signs of Benchmark recovery would be local population numbers at least as great as those observed in the early 2000s, plus improved IUCN Red List status for two or more threatened species.

- As of 2006, at least 27 MAR marine species (not including birds) were considered threatened: 1 species extinct (Caribbean monk seal), 5 critically endangered, 6 endangered, and 15 vulnerable.[1]
- For information about individual species, see healthyreefs.org.



Between 1999 and 2004, Yucatan hawksbill nest numbers dropped 63% due to unknown causes. This decline, despite three decades of nest protection, indicates key gaps in our understanding of a population still at risk. The most important nesting beaches in Belize and Guatemala also experienced Red Flag declines.[3]

Despite their importance, many MAR processes and animals remain a mystery. For example, no quantitative data are available for the Warsaw grouper—just anecdotal tales from decades ago. Turtle nests are currently the only routinely monitored focal species indicator. Our efforts to understand key indicators and protect reef inhabitants will be greatly aided by data harmonization—the use of regionally consistent methods to collect and report accessible, readily comparable data.

[1]*World Conservation Union (2006)*
[2]*Boadle (2008).*

[3]*Data sources: Abreu-Grobois et al. (2004), Guzmán-Hernández (2006), IAC Belize (2005). Red Flag conditions for hawskbill turtles: consistent population declines over four or more years.*

S4 Coral Cover

***Coral cover* is a measure of the proportion of reef surface covered by live stony coral instead of sponges, algae, or other organisms**. Stony, reef-building corals are the main contributors to a reef's three-dimensional framework—the structure that provides critical habitat for many organisms.

Coral cover is a good measure of general reef health. Every reef has its own "personality," but, in general, a "healthy" MAR reef typically has:

- Relatively high % coral cover
- Moderate % crustose coralline, calcareous, and short turf algae
- Low % fleshy macroalgae

A rapid shift away from coral domination can be a sign of ecosystem stress.

We recommend that benthic cover, including coral cover, continue to be routinely monitored. Coral cover is one of the most common measurements in reef monitoring programs. Well-defined protocols have been published by AGRRA, MBRS, and others.[4] We recommend that a concerted effort be made to synthesize historical data, especially pre-1960.

UPDATED

Status (1999-2000): Intermediate
93% of Benchmark, declines reported
MAR = Live stony coral cover = 14%

Target
Coral cover ≥ 30%

Benchmark
Coral cover = 15-20%

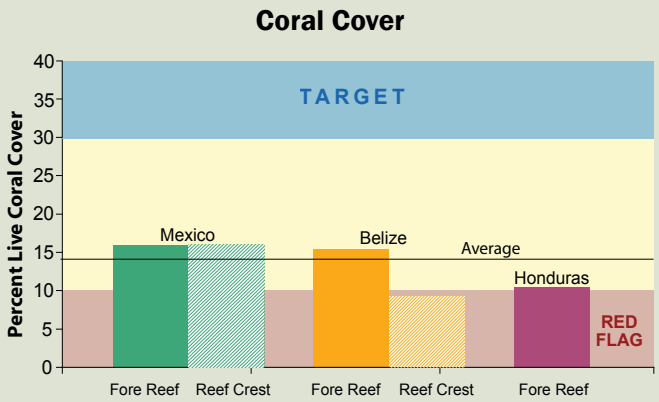
Red Flag
Coral cover ≤ 10%

MAR-wide averages

A good sign of Benchmark reef recovery would be a MAR-wide average of 15-20% live coral cover.

- In the 1980s, coral cover declined significantly in the wake of acroporid (staghorn and elkhorn coral) losses and the *Diadema* (F12) die-off.[5]
- In the 1990s, two bleaching events (1995 and 1998; F7, D14) and several hurricanes (most notably Hurricane Mitch in 1998) caused additional punctuated declines.[6]
- Regional 1999-2000 AGRRA surveys found an average of 14% live coral cover. Average coral cover was slightly higher on fore reefs than on reef crests.[7]

To assess live stony coral cover—a common measure of general reef health—divers quantify what types of organisms cover the reef surface. Healthier reefs are generally characterized by relatively high coral cover.



Regional 1999-2000 surveys found average coral cover to be about 45% of the long-range Target. Sparse cover on Belize reef crests and Honduras fore reefs indicates a need for investigative and protective action.[8]

[4]AGRRA (2005), Almada-Villela et al. (2003), McField (1999), Aronson et al. (1994).
[5]Aronson and Precht (2001).
[6]McField (2002).
[7]Marks and Lang (2006).
[8]Data source: Marks and Lang (2006).

S6 Fish Abundance

***Fish abundance* is a measure of the number or amount of a fish in a given area.** Scientists usually collect both count and size data. Abundance is then presented in terms of fish *biomass* (total weight of fish per unit area).

These two indicators are of particular interest:

- **Biomass of all (total) fish**
- **Biomass of commercially significant fish**

Total fish biomass gives important information about trophic structure and overall reproductive output of fish on the reef. *Commercial fish biomass* gives an indication of overall stock status, fishing pressure, habitat conditions, and recruitment success.

We recommend continued regular monitoring of fish abundances, along with compilation of new and historical data in an accessible database for use in meta-analyses and other studies.

UPDATED

Status (1999-2000):
Intermediate, declines reported
Total Fish: 92% of Benchmark
Commercial Fish: 77% of Benchmark

Target
Total fish biomass ≥ 8500 g/100m²
Commercial fish biomass > 2500 g/100m²

Benchmark
Total fish biomass = 5000 g/100m²
Commercial fish biomass = 1400 g/100m²

Red Flag
Total fish biomass ≤ 3500 g/100m²
Commercial fish biomass ≤ 1000 g/100m²

MAR-wide averages

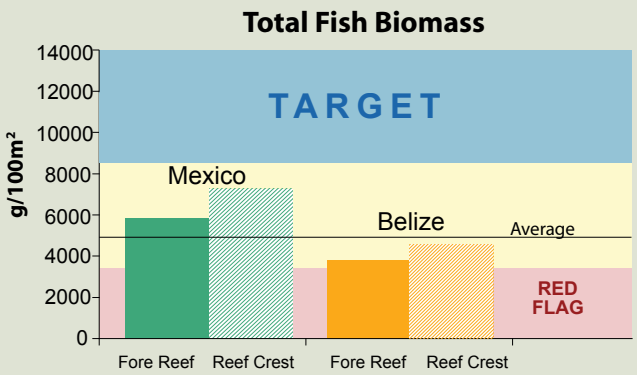
Surveyors should follow established sampling methodologies that take into account species behavior and habitat preferences.[9] Tracking fish assemblages is a core element of any monitoring program.

For total fish abundance, a promising sign of Benchmark reef recovery would be a MAR-wide average biomass of 5000 g/100m². In 1999-2000, regional surveys found that total fish biomass:[10]

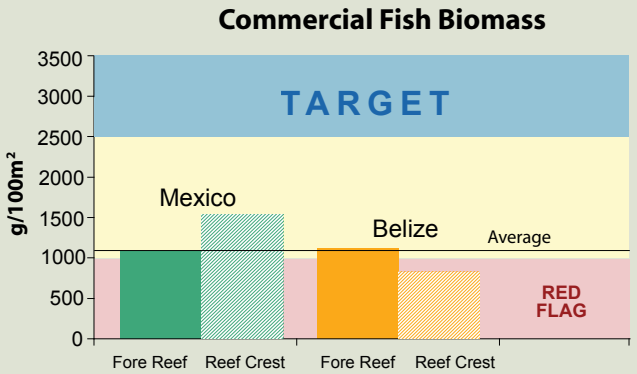
- Averaged 4618 g/100m² (about three-fourths as large as the Caribbean average)
- Was slightly higher on reef crests than on fore reefs

For commercially significant fish, a promising sign of Benchmark reef recovery would be a MAR-wide average biomass of 1400 g/100m². In 1999-2000, regional surveys found that commercial fish biomass:[10]

- Averaged 1083 g/100m² (about three-fourths as large as the Caribbean average)
- Was similar on fore reefs and reef crests



Regional surveys (1999-2000) found average total fish biomass to be about 55% of the long-term Target.[10]



Regional surveys (1999-2000) found average commercial fish biomass to be about 45% of the long-term Target.[10]

Fish surveys focus on counting a well-defined, representative sample. AGRRA "total" fish counts,[11] for example, cover carefully selected species likely to be affected by humans: eight families, plus five additional species, including these hogfishes, a popular, easy-to-catch food fish.

[9] *For example, AGRRA (2005).*
[10] *Data source: Marks and Lang (2006).*
[11] *AGRRA (2005).*

S8 Water Quality

***Water quality* refers to the physical, chemical, and biological properties of seawater bathing the reefs.** Corals and many other reef inhabitants have rather strict water quality requirements for growth and survival.

Of particular interest are:

- **Nutrients** – Corals are adapted to low-nutrient waters and do not do well when "overfertilized."
- **Temperature (T)** – Optimal coral growth occurs when water temperatures are 25-29°C. If waters are too warm, coral bleaching (D14) is likely.
- **Salinity (S)** – Optimal coral growth generally occurs at salinities of 34-37.
- **Water clarity** – Shallow-water reefs thrive in clear waters where abundant light reaches the reef's plants and other photosynthetic organisms. Corals obtain much of their food from light-dependent zooxanthellae (algae).
- **pH** – When water acidity increases, corals and other organisms have difficulty making their calcium carbonate skeletons and shells.[12]

Salinity and water clarity are useful proxy indicators of river runoff. Freshwater runoff can contain nutrients, pesticides, and other hard-to-measure compounds to which reef organisms may be sensitive. During times of high runoff, salinity and water clarity tend to decrease as rivers bring colored, sediment-laden freshwater to the coast. Nutrients may stimulate phytoplankton growth, which further decreases water clarity.

We recommend that the basic parameters temperature, salinity, and water clarity be routinely included as key components of MAR monitoring programs. We also recommend that these data be compiled in an accessible database. Measurements related to pH and nutrient concentrations are at present more challenging and could perhaps be included in less frequent regional surveys. Remote sensing measurements of ocean color and in situ measurements of water clarity can also lend insight into nutrient-related processes.

No regional water quality dataset is currently available for the Mesoamerican Reef. Long-term records are needed to build an understanding of basic reef processes, tolerances, and trends.

[12]*Kleypas et al. (2006).*
[13]*Hoegh-Guldburg et al. (2007).*

UPDATED

Status (2008): Not available
Stakeholders report perceived general decline

Target
Monthly avg. T ≤ 0.5°C above historical monthly avg.
S between 34 and 37
No decrease in "baseline" water clarity (4-yr avgs.)
For inshore reefs, ~ 35% of incident light penetrates to 10 m depth
For offshore reefs, ~ 60% of incident light penetrates to 10 m depth

Benchmark
T = 25-29°C
S between 34 and 37
Develop water clarity norms for various reef classes
For inshore reefs, ~ 35% of incident light penetrates to 5 m depth
For offshore reefs, ~ 60% of incident light penetrates to 5 m depth

Red Flag
To be determined

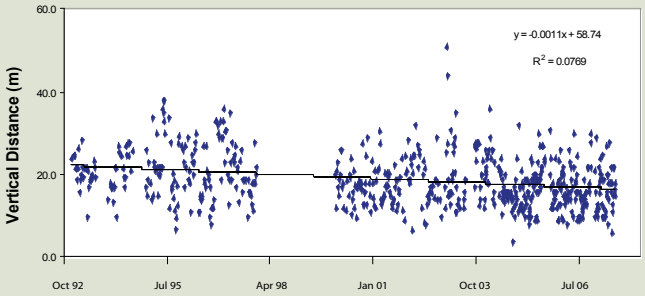
Site-specific conditions

Scientists are growing increasingly concerned about the ecological impacts of high levels of atmospheric carbon dioxide (CO_2)—a greenhouse gas that influences not only planetary climate but also ocean chemistry.

As CO_2 enters seawater, the waters grow more acidic (pH goes down), affecting many chemical and metabolic processes—one being the process of calcification. With even a slight decrease in pH, corals and other reef organisms have difficulty making their calcium carbonate skeletons and shells.[1]

Under the combined stresses of climate change and ocean acidification, corals are expected to become increasingly rare in the 21st century, with "serious consequences for reef-associated fisheries, tourism, coastal protection, and people."[13]

Water Clarity: Ocean Seaward of Carrie Bow Caye, Belize



A long-term decline in water clarity (as measured by Secchi disk) has been observed at one of the MAR's few long-term monitoring stations, located seaward of Carrie Bow Caye, Belize. The higher the "distance" measure, the more clear the water. Secchi depth (distance) has declined from an average of 21.3 m (1970-1992) to 17.7 m (2000-2007).[14]

[14]*Data source: Koltes and Opishinski (in press).*

S12 Mangrove Areal Extent

PRIORITY ONE 1 HEALTHY REEFS FOR HEALTHY PEOPLE

UPDATED

Status (2006): Red Flag
Belize 3.3% loss of coastal mangroves (~1990-2006)
Comparable analysis needed for other countries
General perception of losses in key areas

Target
Area ≥ 1990s coverage

Total Mangroves*	Coastal Mangroves†
Mexico = 224,728 ha	176,064 ha
Belize = 81,156 ha	67,194 ha
Honduras = 40,476 ha	40,452 ha
Guatemala = 3,871 ha	2,311 ha

Benchmark
Identify and formally protect priority conservation areas

Red Flag
Area < 1990s coverage

** As presented in 2007 Guide*
† As presented in graph (coastal defined as being within 10 km of Coast)

***Mangrove areal extent* is a measure of mangrove forest, expressed in terms of the area (or "footprint") of forest.** Four key tree species—buttonwood, white, red, and black mangrove—live in intertidal areas of the Mesoamerican mainland, lagoons, and islands.

Mangrove forests provide a number of important ecological and societal services. For example, mangrove forests:[15]

- **Act as filters**, helping to trap sediments and nutrients before they reach sensitive seagrass beds and coral reefs
- **Enhance biological productivity**, providing critical nursery grounds, habitat, and refuge to a wide variety of plants and animals
- **Act as self-sustaining, resilient barriers and wave buffers,** helping to protect human settlements from hurricane damage

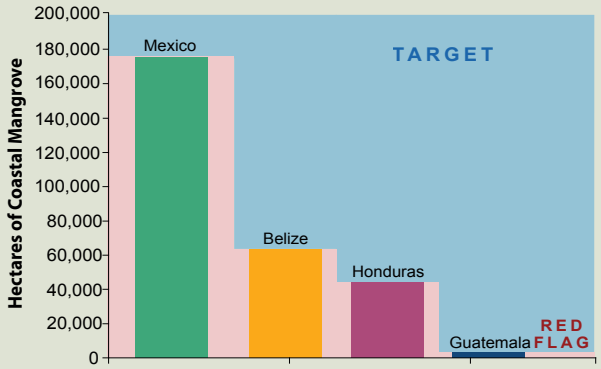
In recent years, some MAR mangrove forests have been cleared for residential and commercial development, and others have been damaged by hurricanes. Some large mangrove areas are fully protected—for example, in the Sian Ka'an Biosphere Reserve. In other areas, protection is spottier. Belize, for example, has identified major gaps in its protection of coastal and marine mangroves, particularly in Turneffe and in mangrove islands off Belize City.[16]

We recommend that a regional monitoring protocol, including ground-truthing and data-sharing, be formulated and implemented for tracking mangrove areal extent. Sensors mounted on satellites and aircraft provide an efficient way to collect data and, in a sense, "take pictures" of mangrove forests and other coastal habitats. ASTER and Landsat satellite images were used for one recent MAR mangrove assessment.[17]

A good Benchmark step toward mangrove preservation would the identification and formal protection of priority conservation areas. Progress is being made, but even protected areas are still threatened by land development activities such as dredging and filling.

- As of the 1990s, there were about 350,000 hectares of mangrove (total) within the MAR ecoregion.[17]
- According to a recent analysis of mangrove areal extent as seen in ASTER and Landsat satellite images, Belize lost approximately 3.3% of its 68,000 hectares of coastal mangrove between ~1990 and 2006:[18]
- Local losses have been high in some areas. For example, almost 30% of the Pelican Cays, Belize, mangrove forests were cleared between 2003 and 2007,[19] primarily for resort development and real estate speculation.

Extent of Mangroves



Any decline from the 1990s levels of mangrove coverage would be considered Red Flag conditions.[17]


Cinthya Flores / WWF

Mangrove forests such as these at Turneffe, Belize, help buffer against wave damage, trap sediments and nutrients, and provide critical habitat and nursery grounds.

[15] US Geological Survey (2004).
[16] Meerman (2005).
[17] World Wildlife Fund (2002).
[18] CATHALAC & NASA (2008). Also data source for graph.
[19] Macintyre et al. (in press).

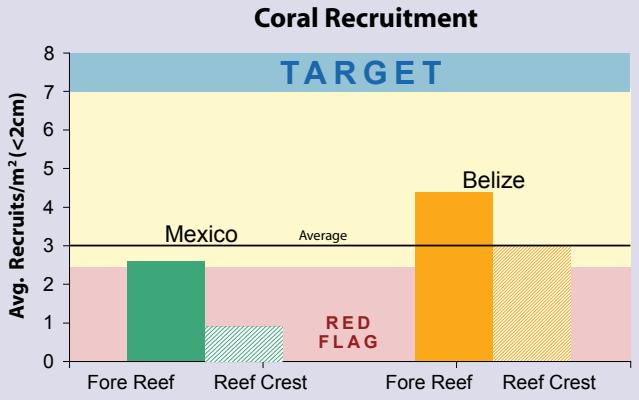
F1 Coral Recruitment

***Coral recruitment* is the process by which drifting planulae (tiny coral larvae) attach and establish themselves as members of the reef community.** Some species tend to settle close to their "mother colony"; others drift for great distances before settling down.

The greater a reef's recruitment success, the greater its potential for future growth and recovery after disturbance. Reef recruitment rates depend upon many factors, some of which have been changing recently in the MAR:

- How many adults are reproducing, and what species are they?
- What is the fecundity of the adults (that is, how fruitful are they in producing offspring)?
- How many larvae survive the treacherous early life phase of drifting?
- How well connected are the larval source sites and the settlement sites?
- How hospitable are the settlement sites, and how many larvae survive after attachment?

Stressful conditions such as bleaching (D14) or exposure to harmful chemicals (D7) can lower a reef's reproductive output and recruitment. Areas with high recruitment potential tend to have abundant crustose coralline algae and little fleshy macroalgae (F13)—an indication of the importance of herbivorous fishes (F11) and urchins (F12) in helping to keep a reef hospitable to new recruits.



In 2000, regional surveys found an average of 3 recruits/m²—about 45% of Target densities.[4]

Status (~2000): Intermediate
60% of Benchmark
Recruits = 3 /m²

Target
Recruits ≥ 7 /m²

Benchmark
Recruits = 5 /m²

Red Flag
Recruits < 2.5 /m²

MAR-wide averages

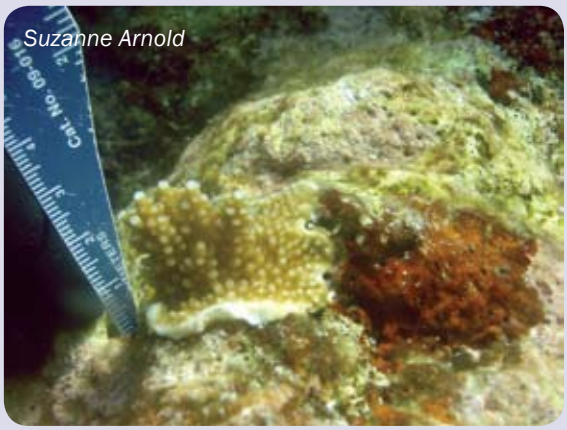
UPDATED

The late 1990s—with the triple blow of coral bleaching (D14), Hurricane Mitch, and *Diadema* die-off aftereffects (F12)—was a tough time for MAR recruitment. Between 1998 and 1999, coral recruitment plummeted 53% on one well-studied patch reef in Belize.[1]

We recommend monitoring coral recruitment with well-defined, standardized methods for surveying and classifying recruits.[2] These methods—of which several are available[3]—all require a moderate to high level of expertise. Currently, few MPAs have the time and money to routinely monitor recruitment.

A promising sign of interim (Benchmark) reef recovery would be a regional average of 5 recruits/m². In 2000:[4]

- The MAR averaged 3 recruits/m ².
- Most recruits were brooding species (species whose larvae settle close to the mother colony). Recruits of major reef-building corals were rare.



Scientists study recruitment, a key determinant of future reef success, by counting small stony corals. This staghorn coral recruit was spotted near Carrie Bow Caye, Belize.

[1]*McField (2001).*
[2]Recruits *is here defined as stony corals < 2 cm max width.*
[3]*For example, AGRRA, MBRS, McField (2001), Mumby (1999), Edmunds et al. (1998).*
[4]*Marks and Lang (2006).*

F5 Coral Mortality

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UPDATED

Status (2001):
Benchmark achieved; Approaching Target
2001: Recent dead = 1.7%
2006: Recent dead = 1.6%

Target
Recent dead ≤ 1.5%

Benchmark
Recent dead ≤ 2%

Red Flag
Recent dead ≥ 5%

MAR-wide averages

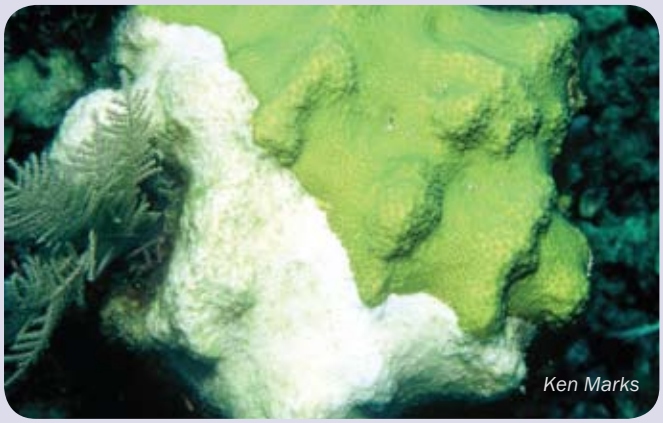
***Coral mortality* is a measure of the recent or old death of part or all of a colony or reef.** A 100% dead colony is counted as *standing dead* if it is identifiable to the genus level. For a colony with living and nonliving sections, the dead portions are classified as either *old dead* or *recently dead*. Mortality extent is described in terms of the percentages of the colony surface area in each class: for example, 75% living, 5% recently dead, and 20% old dead.

We are especially interested in recent mortality, as it is a "bottom line" expression of reef condition during the past year. Causes of recent mortality include disease (F6), fish grazing (F11), algal overgrowth (F13), and extended coral bleaching (F7, D14).[5]

If lesions cover a relatively small area of a colony, tissue regeneration may occur. However, high levels of acute disturbance (such as hurricanes) or chronic insult (such as nutrient enrichment, S8) may prevent regrowth of new tissue or give a competitive edge to other reef organisms (for example, algae, F13).

"Hotspots" of recent mortality can alert managers to a need for investigation and perhaps protective action. Data collected during the first several months after a major disturbance are especially useful, as they help researchers to gauge the event's ecological significance.

We recommend that coral mortality be monitored in the course of regular regional surveys supplemented by special campaigns in the wake of major disturbance events.



About 40% of this mountainous star coral colony is recently dead (white area) due to white plague disease.

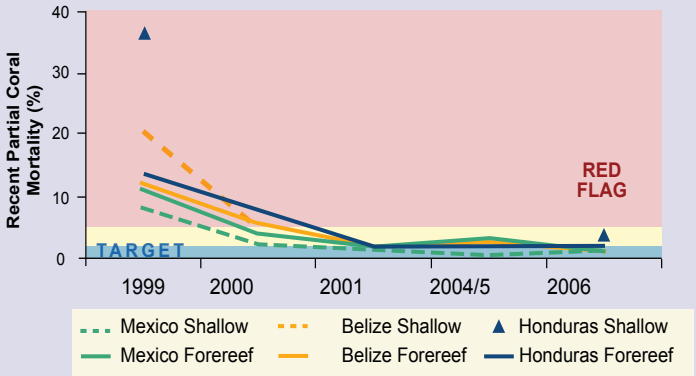
Mortality extent is usually estimated visually by divers. Details are given in the AGRRA and MBRS methods manuals.[6]

A promising sign of Benchmark reef recovery would be a regional average of ≤ 2% partial recent coral mortality.

• The highest partial mortality rates in the last eight years occurred in 1999 due to the 1998 combination of Hurricane Mitch and a coral bleaching event. Honduran and Belizean shallow reefs were especially hard hit, largely due to hurricane damage.

• The 2005 bleaching event did not result in significant coral mortality.[7] Offshore hurricanes and a late start to this event (October) may have helped prevent mortality by cooling the waters bathing these reefs.

Coral Mortality



The year 1999 was a Red Flag one for the MAR in terms of recent coral mortality. Since then, conditions have improved. By 2006, Honduran shallow reefs had reached the regional Benchmark, and Mexico and Belize had achieved the regional Target.[8]

[5]*AGRRA, Coral condition, www.agrra.org/method/methodcor.html*
[6]*AGRRA (2005); Almada-Villela et al. (2003).*
[7]*McField et al. (2008).*

[8]*Data sources: Marks and Lang (2006); MBRS Project Database, The Nature Conservancy, Mesoamerican Reef Program, 2006, Rapid reef assessment (Mexico, Guatemala, Honduras), A Arrivillaga, pers. comm.; World Wildlife Fund, Mesoamerican Reef Program, 2006, Rapid reef assessment (Belize), N Bood, pers. comm.).*

F11 Herbivorous Fish Abundance

***Herbivorous fishes* are fishes that eat plant material.** Surgeonfish and parrotfish are two familiar MAR examples, often seen browsing and scraping on reef algae.

Herbivory is one of the most important processes in maintaining ecological balance on the Mesoamerican Reef. There, the primary herbivores are *Diadema* sea urchins (F12) and large (>30 cm) plant-eating fish. By grazing on non-encrusting algae, these herbivores help keep the algae in check, which in turn helps slow-growing corals to compete for limited reef space.

A change in herbivory rates—due to, for example, a decline in herbivore abundance—can rapidly lead to dramatic changes in reef appearance and function. If algae-eaters are too few in number, reefs once dominated by colorful corals can be quickly overgrown by fast-growing, fuzzy algae.

The abundance of herbivorous fishes depends in part on the abundance and effectiveness of their predators. For some species, like the largest parrotfish (rainbow parrotfish), their abundance depends also on the availability of mangroves (S12) for critical nursery habitat.

One strong point of this indicator is that it is responsive to management action. For example, if fishing pressure (one form of predation pressure) decreases, an increase in fish abundance will be observed (all else being equal).

Status (1999-2000): Intermediate
84% of Benchmark
Parrotfish + surgeonfish = 2110 g/100m²

UPDATED

Target
Parrotfish + surgeonfish ≥ 4000 g/100m²

Benchmark
Parrotfish + surgeonfish = 2500 g/100m²

Red Flag
Parrotfish + surgeonfish ≤ 2000 g/100m²

MAR-wide averages

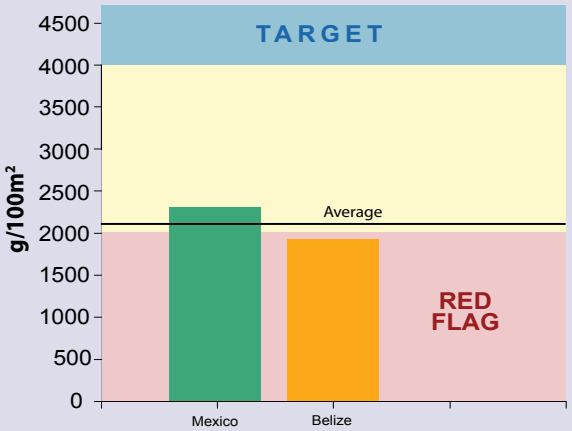
We recommend tracking the fish component of herbivory by counting parrotfish and surgeonfish. Measuring herbivory rates directly is less practical, so the next best thing is counting the fish.

A promising sign of Benchmark reef recovery would be a regional biomass of 2500 g/m² for parrotfish and surgeonfish combined. In 1999-2000:[9]

- The regional average was 2110 g/m² (33% of the Caribbean average).
- In Mexico, the mix was (in terms of biomass) 50% parrotfish and 50% surgeonfish; in Belize, 70% parrotfish and 30% surgeonfish.

At many reefs, few herbivorous fishes larger than 20 cm in length are found.[9]

Herbivorous Fish Biomass



In 1999-2000, the reefs of Mexico and Belize hosted, on average, 53% of the Target herbivorous fish biomass. The Belize reefs were in Red Flag territory.[9]

Parrotfishes are among the most important herbivores on the Mesoamerican Reef.

How can I help? *Reducing or eliminating fishing of parrotfish and surgeonfish is essential in maintaining an ecological balance that allows corals to thrive.*

- ***Leave herbivores on the reef —*** *Don't remove these big-league reef helpers from the ocean.*
- ***Encourage the preservation of mangroves —*** *They serve as critical nursery grounds.*

[9]*Data source: Marks and Lang (2006).*

F12 Diadema Abundance

***Diadema antillarum*, the long-spined sea urchin, is an important reef resident whose presence or absence can change the very nature of a reef.** Urchins are key grazers and bioeroders, and their long spines provide shelter and protection for small fish and invertebrates.

Urchins, along with large herbivorous fishes (F11), help "graze down" the turf algae and macroalgae that compete with corals for precious reef space.

- When urchins are present in optimal numbers, they help maintain a balance between coral and algal growth.
- When urchins are too few in number, algae can take over, sometimes transforming a vibrant coral reef into a dull, algae-dominated one.
- When urchins are too numerous, they can scrape and erode and damage the reef framework.

In 1983, Mother Nature conducted a vast "natural experiment" that convincingly demonstrated the urchin's importance in maintaining healthy coral reefs. That year, almost 98% of the Caribbean's *Diadema* succumbed to disease.[10] Due in part to this dramatic urchin decline, reefs in many areas subsequently shifted from coral dominance to macroalgal dominance.[11] So snorkelers who once visited a colorful coral reef might now see one overgrown by a fuzz of fast-growing algae.

Status (1998-2001): Red Flag
1998-2001: 0.03 *Diadema* /m²
2006: 1.3 *Diadema* /m²

UPDATED

Target
***Diadema* > 1 urchin/m²**

Benchmark
***Diadema* ≥ 0.3 - 1 urchin/m²**
> 50% of surveyed sites show increasing densities

Red Flag
***Diadema* < 0.3 urchin/m²**

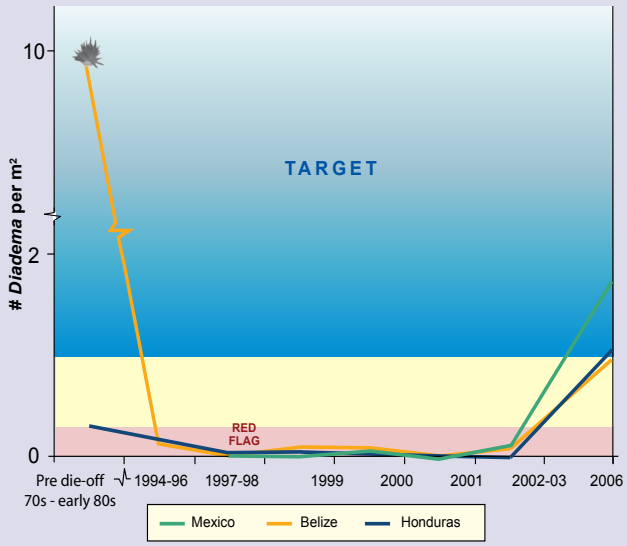
MAR-wide averages

We recommend monitoring *Diadema's* contribution to herbivory by tracking abundances. As with the herbivorous fishes (F11), measuring *Diadema* herbivory rates directly is not practical. The next best thing is this proxy indicator, expressed in terms of *Diadema* numbers per unit area.

A promising sign of Benchmark reef recovery would be a regional *Diadema* density of 1 urchin/m².

- Before the 1983 die-off,[12] MAR *Diadema* densities ranged from 4 to 25 urchins/m².
- Years later (1998-2001),[13] the regional average was still only 0.03 urchins/m²—well within Red Flag territory and only about one-fifth the Caribbean value.
- More recent surveys (2004-2006)[14] indicate some recovery: by 2006, the region as whole had achieved Target status.

***Diadema* Abundance**



Diadema recovery in the wake of the 1983 die-off has been slow, but recent data indicate that recovery is underway. In 1998-2001, MAR-wide urchin density was still well within Red Flag territory. By 2006, the region had achieved Target status.[15]

Diadema antillarum is one of the most important herbivores on the Mesoamerican reef. Urchins such as these on the central barrier reef of Belize (2006) help keep reefs hospitable for corals.

[10]Lessios (1988).
[11]Hughes (1989).
[12]The Nature Conservancy (2004).
[13]Marks and Lang (2006).
[14]The Nature Conservancy, Mesoamerican Reef Program, 2006, Rapid reef assessment (Mexico, Guatemala, Honduras), A Arrivillaga, pers. comm.; World Wildlife Fund, Mesoamerican Reef Program, 2006, Rapid reef assessment (Belize), N Bood, pers. comm.
[15]Data sources: Marks and Lang (2006); The Nature Conservancy, 2006, A Arrivillaga, pers. comm.; and World Wildlife Fund, 2006, N Bood, pers. comm.

F13 Fleshy Macroalgal Index

The *fleshy macroalgal index* (FMI) is a measure of the amount of large, soft, fleshy algae (sometimes called "seaweed") on a reef. Common MAR varieties include *Lobophora* (a type of brown algae) and *Halimeda* (green algae). The FMI is defined as the product of fleshy macroalgal areal coverage and canopy height.[16]

When overly abundant, fleshy macroalgae can compete with corals for reef space, interfere with coral recruitment (F1), and reduce coral survival. In low abundances, these macroalgae are part of a healthy reef community, providing food for a variety of herbivores (F11, F12).

The abundance of fleshy macroalgae, which is relatively easy to measure, can serve as a clue regarding two important reef processes that are more difficult to measure:

- *Herbivory intensity* — Increasing FMI can be a sign of decreased grazing pressure (seen, for example, in the wake of the early 1980s *Diadema* die-off, F12).

- *Nutrient availability* — Increasing FMI can be a sign of increasing nutrients (seen, for example, in 2007 in a Costa Rican bay receiving inadequately treated sewage and golf course runoff)[17].

We recommend that fleshy macroalgal abundance be routinely monitored in terms of the fleshy macroalgal index. Algal height and extent can be measured relatively inexpensively on the same transects used to assess coral cover (S4) and other parameters. As more data become available, habitat-specific FMI goals will be refined to take into consideration factors such as reef type and location.

A promising sign of Benchmark reef recovery would be a MAR-wide average FMI of 30.

- The 1980s urchin die-off (F12), overfishing of herbivorous fish (F11), and increasing nutrient loads (S8) have contributed to dramatic increases in macroalgae—so much so that algae have taken over many reefs formerly covered by corals. (In 2000, every reef surveyed in Mexico had Red Flag levels of fleshy macroalgae.[18])

- Preliminary 2006 data show some declines in FMI.[19]

UPDATED

Status (2000): Red Flag
FMI = 74
Preliminary 2006 data indicate decreasing avg. FMI

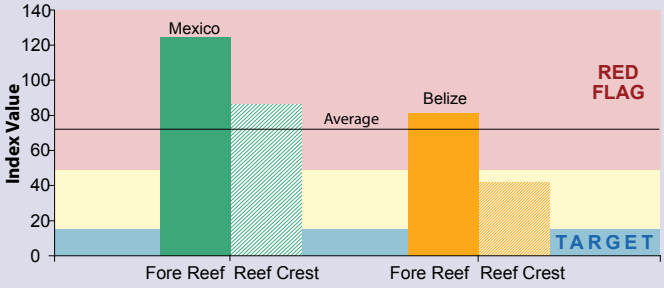
Target
FMI ≤ 15

Benchmark
FMI = 30

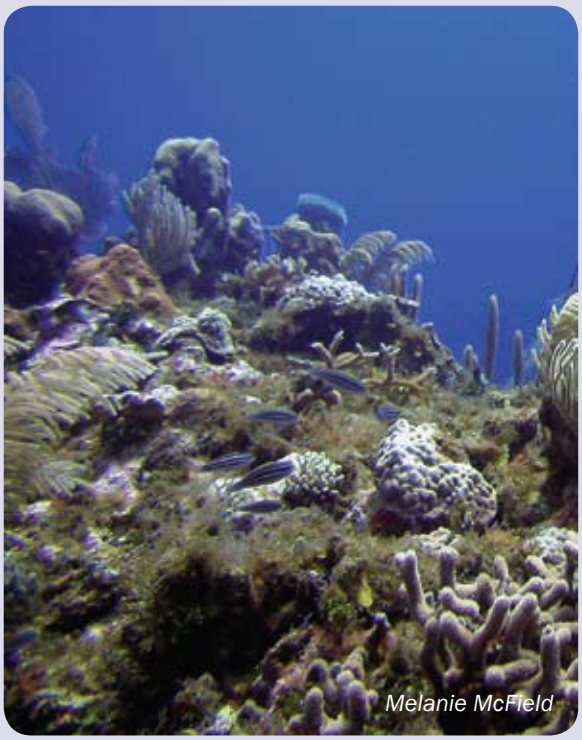
Red Flag
FMI ≥ 50

MAR-wide averages

Fleshy Macroalgal Index



In 2000, the overall FMI average was almost 1.5 times the Red Flag threshold.[18] Preliminary 2006 data (not shown) indicate improving (decreasing) FMI,[19] perhaps tied to recent *Diadema* (F12) increases.



Fleshy macroalgae, mostly *Dictyota*, compete with corals for space on this deeper fore reef slope in Belize's Hol Chan Marine Reserve.

[16]AGRRA (2005).
[17]McPhaul (2007).
[18]Marks and Lang (2006). Also data source for graph.

[19]The Nature Conservancy, Mesoamerican Reef Program, 2006, Rapid reef assessment (Mexico, Guatemala, Honduras), A Arrivillaga, pers. comm.; World Wildlife Fund, Mesoamerican Reef Program, 2006, Rapid reef assessment (Belize), N Bood, pers. comm.

D1 Coastal Development Index

Status (2008): Assessment Underway UPDATED
CDIs anticipated available in 2008

Target
CDI values need to be established

Benchmark
Calculate MAR-wide CDI values

Red Flag
CDI values need to be established

The *coastal development index* (CDI) measures the extent to which humans have altered the landscape in coastal areas. Five factors are built into the index:

- How many people live near the coast?
- How much coastal land area is covered by major infrastructure (for example, shrimp farms or airports)? How much is in agricultural or urban use?
- How much coastal road-building has occurred?
- How rapidly is the coastal population growing?
- How rapidly is natural coastal land (within 10 km of the coast) being converted to a developed state?

One important feature of this indicator is that the data are amenable to GIS[1] analysis and display.

The higher the CDI, the greater the extent of development and, in general, the greater the risk of environmental degradation:

- The lowest possible CDI is 0 — indicates an unpopulated, unaltered area
- The highest possible CDI is 1 — indicates an area of extensive, rapid, "maxed out" development

High or increasing CDI values can alert us to marine ecological pressures that might otherwise go unnoticed, at least for a while. Physical changes on land can directly and indirectly affect the marine environment—for example, by increasing rates of freshwater runoff or coastal sedimentation.

We recommend monitoring MAR coastal development by tracking CDI values every 2-3 years for the coastal region, municipalities, and districts.

Land cover and road density data can be obtained from remote sensing, and population numbers are available from government census reports. CDI values are best interpreted in association with other indicators of development impacts—for example, water quality (S8), sedimentation rates (S10), mangrove extent (S12), seagrass areal extent (S13), safe water and sanitation (SW2), and poverty (SW4).

A beneficial Benchmark step will be the calculation of the first CDI values for the MAR region. We plan to publish preliminary index values for the region and every coastal municipality in the first Mesoamerican Reef Ecosystem Report Card (2008). Revisions to the index formulation will be completed by 2010.

This bird's-eye view of Belize City, Belize, shows evidence of a variety of coastal development activities, including commercial and residential construction.

[1]*Geographic information system.*

D2 Tourism Development Index

The *tourism development index* (TDI) measures the growth and contraction of tourism, currently the fastest growing industry in the MAR region.[2] For each tourism zone or destination, the TDI is calculated from five variables:

- How large is the tourist population compared to the resident population?
- How many hotel rooms are in the area?
- What are the hotel occupancy rates?
- How much money do overnight and cruise tourists spend daily?
- How many cruise ships arrive each year?

The higher the TDI, the greater the extent of tourism activity and, in general, the greater the risk of environmental degradation:

- The lowest possible TDI is 0 — indicates no tourism
- The highest possible TDI is 100 — indicates a high level of tourism dependence and development

If tourism—even ecotourism—is undertaken without a commitment to sustainability, the associated infrastructure and activities can contribute to significant environmental degradation. The construction of resorts, trails, and docks, for example, can alter the sea- and landscape (D1) in ways that directly affect marine ecosystems. The intensity and frequency of tourism-related activities are also important, as "low impact" activities can, over time, have a significant cumulative effect. Even careful hikers and divers, for example, can disturb sensitive wildlife.

Tourism is the primary economic sector shaping the livelihoods of many in the MAR region. Globally, ecotourism is the fastest growing industry segment. Regionally, cruise ship tourism is growing fastest.

UPDATED

Status (2008): Assessment Underway
TDI values anticipated available in 2010

Target
TDI values need to be established

Benchmark
Calculate TDI values

Red Flag
TDI values need to be established

We recommend tracking MAR tourism and its potential effects by calculating TDI values every 2-3 years for the coastal region and tourism zones and destinations. TDI values are best interpreted in association with direct indicators of environmental impact and with complementary tourism data—for example, water quality (S8), sedimentation rates (S10), mangrove areal extent (S12), tourism sustainability (D3), poverty (SW4), and economic contributions of marine-related activities (SW5).

A beneficial Benchmark step will be the calculation of the first TDI values for the MAR region. We plan to calculate preliminary TDIs for the region in 2008 and to establish final values for each country by 2010.

In Akumal Bay, Mexico, conservation groups, resorts, hotels, and landowners are working together to develop and promote sustainable tourism. Such efforts are especially important in areas like this one, where the reef is near a developed shoreline.

[2] McPherson (2006).

D7 Contaminant Accumulation

Status (2008): Assessment Underway
Work is underway

Target
Reductions, to be determined

Benchmark
Measure a variety of compounds to determine baseline concentrations in a number of locations, sediments, and species
Determine short-term milestones for reduced concentrations in tissues and sediments

Red Flag
Any increase (over 2006 concentrations) in organisms or sediment samples

The *contaminant accumulation* indicator gives a direct measure of the identities and quantities of synthetic chemical compounds, metals, stress biomarkers, or other chemicals of interest in the tissues of marine organisms and the sediments of marine environments. Some of these compounds are used primarily for agricultural pest control, while others are associated with golf course maintenance, mosquito control, and urban runoff. In the MAR region, agrochemicals are of particular interest.

Even chemicals applied inland may imperceptibly but perhaps significantly influence coral reef condition. Some chemicals of interest are carcinogens, others are endocrine disruptors, and others may interfere with neurological development or other physiological processes.

It is important to remember that the mere presence of these chemicals in marine life and sediments is only a *potential* problem. Corals and other reef organisms have been the subject of few ecotoxicology studies, and further testing of a variety of species is needed to determine the physiological and ecological significance of a range of chemical concentrations.[3]

We recommend further sampling of a range of chemical compounds to establish baseline values for a variety of locations, sediments, and organisms. Great care must be taken in the field to avoid sample contamination. Likewise, strict laboratory procedures and controls are required to ensure consistent and accurate results. Protocols have been developed by WWF/ICRAN and the MBRS Synoptic Monitoring Program.[4]

We recommend that further ecotoxicological research be conducted on a variety of marine organisms. The responses and physiological pathways of chemical exposure may vary among different organisms such as corals, crustaceans, mollusks, echinoderms, and fishes.

Few environmental and ecotoxicological data are currently available, and Benchmarks and Targets for concentration reductions have yet to be formulated.

This work is underway by WWF and MBRS. Preliminary data indicate that:

- Insecticides and other pesticides have been found in MAR marine organisms, with concentrations ranging from nondetectable to relatively high (~2 ppm).[5] Conservation groups are working with agroindustry to reduce the use of some chemicals.

- Top-level predator fish may be expected to have the highest concentrations of persistent chemicals, while other species with wide-ranging diets (white grunt, for example) might be expected to contain the widest range of compounds.

- Traces of two banned or severely restricted pesticides, chlordane and hexachlorocyclohexane, can still be found in the MAR environment due to their environmental persistence.[6]

This biologist is using a coral punch and hammer to withdraw a small coral plug for chemical analysis. A specialized laboratory will measure agrochemical levels in the sample from this mustard hill coral.

[3]*Although corals and other reef organisms have been the subject of few ecotoxicology studies, they are generally thought to be sensitive to chemical perturbations, particularly in the larval development and settlement phases (Downs and Downs, 2007). Some recent evidence indicates that coral bleaching can occur at lower temperatures if the coral is stressed by agrochemicals or sediments (Jones and Kerswell, 2003; Owen et al., 2002, 2003). Other recent studies have shown detrimental effects to coral planula survival and settlement success when exposed to low concentrations (~ 5 ppb) of some agrochemicals (Downs et al., in review).*

[4]*World Wildlife Fund/International Coral Reef Action Network protocol: Downs (2005). Mesoamerican Barrier Reef Systems Project protocol: Almada-Villela et al. (2003).*
[5]*World Wildlife Fund (2005).*
[6]*Summary maps available at www.mbrs.org.bz*

D10

Conch Abundance

The *conch abundance* indicator gives the number of queen conch (*Strombus gigus*) adults per unit area. This unusual shelled animal has cultural, commercial, and ecological significance in the region. It is protected to some extent by international conservation measures.

The number of adult conchs on a reef reveals a great deal about long-term prospects for the local population—which may in turn have important implications for populations in other areas. Densities lower than 50 conchs/hectare have been found to result in reproductive failure;[7] recent studies indicate that the critical threshold for reproductive success may be as high as 200 conchs/ha.[8]

Long-term survival of this important herbivore depends on:

- Limited fishing, including no-fishing replenishment zones
- Habitat protection, especially of nursery grounds
- Transboundary management that recognizes and protects the animals' early-life dispersal phase

Because queen conch could become threatened with extinction unless its trade is strictly regulated,[9] CITES[10] permits, which require that stocks be stable and sustainably managed, must be issued for all exports.

We recommend that queen conch be monitored through regionally standardized systematic counts and targeted process studies (for example, studies of reproduction and dispersal), inside and outside MPA[11] boundaries. Assessing conch abundance is usually relatively simple and inexpensive. Collecting data on larval dispersal is more challenging but is essential for understanding the effects of management actions.

Fully protected MPAs are an effective tool for managing conch populations. Many marine animals produce larvae that float great distances before settling down to mature, but conch larvae are thought to stay a bit closer to home during their fairly short larval phase. A network of MPAs with areas closed to conch fishing will help replenish populations throughout the region.

Status: Not Available (region-wide data)
The only areas that approach Target abundances are protected or have recovered after a fishing moratorium

Target
Abundance = 300-800 adults/ha

Benchmark
Abundance = 50-300 adults/ha

Red Flag
Abundance < 40 adults/ha
Persistent (3-4 yr.) reduction in avg. conch abundance, esp. when accompanied by drop in fisheries production

Site-specific averages

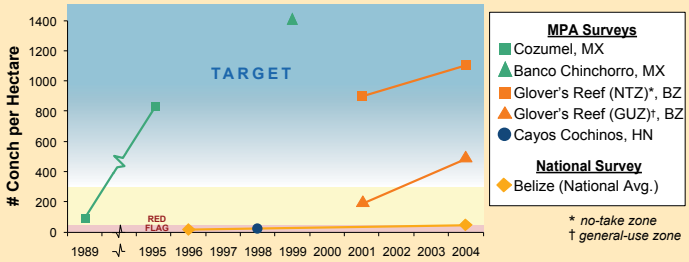
A promising sign of Benchmark reef recovery would be 50-300 conchs/ha, with narrower ranges to be eventually defined according to habitat and management zone.

- The status of queen conch varies widely throughout the region. Most abundance data come from MPAs, which are expected to have higher densities than areas outside MPAs.

- Over the past 30 years, conch populations and catches in many areas have been declining due to overexploitation, illegal harvesting of undersized animals, and a lack of transboundary management.

- Conch numbers, which are highly responsive to protection measures, have made a significant comeback in areas where fishing has been limited or prohibited.[12] In some no-take or highly restricted quota areas, numbers have rebounded to Benchmark or even Target levels.

Queen Conch Density



Conch densities in Cozumel, Mexico, increased almost tenfold in six years, after a moratorium. The highest conch density on record is from Banco Chinchorro, Mexico (a biosphere reserve), which also benefited from the moratorium. In Belize, MPAs (like Glover's Reef) have higher densities, as compared to national-scale surveys. Limited data from Honduras warrant concern.[13]

[7] *Stoner (1997), Theile (2001).*
[8] *R.Glazer (2006) pers comm. Management Recommendations for Conch.*
[9] *NOAA Fisheries Office of Protected Resources (2008a, 2008b).*
[10] *Convention on International Trade in Endangered Species of Wild Fauna and Flora.*
[11] *Marine protected area.*
[12] *Caribbean Fishery Management Council and CARICOM Fisheries Resource Assessment and Management Program (1999).*
[13] *Multiple data sources see pg. 107 in McField & Kramer (2007).*

D14 Coral Bleaching Index

The *coral bleaching index* provides near-real-time information about ocean temperatures in reef areas and the likelihood of associated coral bleaching. Because bleaching events (F7) are usually associated with elevated sea surface temperature, NOAA Coral Reef Watch[14] uses satellite data and historical records to assess thermal stress at 24 "bleaching virtual stations" around the world.

One station is located at Glover's Reef Atoll, Belize. When potentially harmful warming conditions develop, NOAA issues Bleaching Watches, Warnings, or Alerts. Associated regional maps of sea surface temperature (SST) and Degree Heating Weeks (DHW) are also available.[15]

Local managers can do little to prevent bleaching events, but they can, with the Reef Watch "heads up" signal, plan timely responses. As warming conditions develop, managers may opt to minimize other stresses that might lower corals' resistance to bleaching (for example, marine dredging operations). At a minimum, teams can be launched to document the extent and effect of the bleaching event. These data are needed to identify and protect areas susceptible to or resilient to thermal stress (D15).

This bleaching indicator is likely to grow in importance in coming decades. Scientists expect that global warming will continue and that bleaching events will become more frequent and more extreme over the next 100 years.[16]

We recommend that reef managers frequently check the Glover's Reef and other Caribbean Coral Reef Watch indexes and related maps.[17] When a Bleaching Watch is issued, rapid-response teams should be alerted. When an Alert Level 1 is issued, an organized deployment should be launched.

Implementing a MAR-wide rapid-response BleachWatch program will be an important Benchmark step for the region. Good models can be found in the programs of the Great Barrier Reef and Florida Keys.

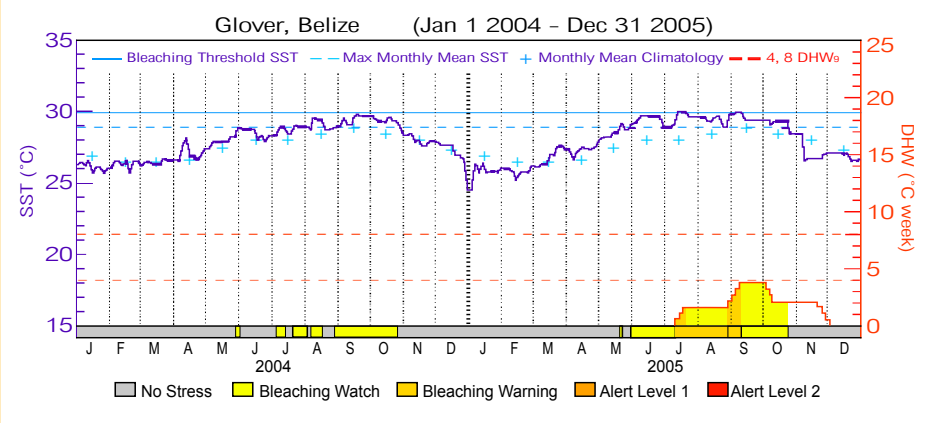
Status (2008): Intermediate
Local efforts to start a MAR BleachWatch program are underway

Target
Every MAR Bleaching Alert met with coordinated regional rapid-response

Benchmark
Establish regional BleachWatch rapid-response program
No increase in bleaching-event mortality rates*

Red Flag
Bleaching Alert issued for any MAR area

**Compared to events of 1995 and 1998*



As waters warmed in 2005, Bleaching Watches (yellow) and Warnings (gold) signaled managers and scientists to prepare for data collection and recovery assistance. Large-scale bleaching did eventually develop in late 2005, affecting most MAR reefs but resulting in less coral mortality (F5) than previous events.[18]

Coral bleaching occurs when a coral's colorful, symbiotic zooxanthellae (single-celled algal partners) are released from the host coral due to stress—for example, unusually high or low water temperatures, high or low salinities, or excessive sedimentation.

[14] Liu et al. (2006).
[15] For details, see osdpd.noaa.gov/PSB/EPS/SST/methodology.html and osdpd.noaa.gov/PSB/EPS/CB_indices/coral_bleaching_indices.html.
[16] Hoegh-Goldberg (1999).
[17] www.coralreefwatch.noaa.gov
[18] Image modified from www.coralreefwatch.noaa.gov. Event information from McField et al. (2008).

SW2 Safe Water and Sanitation

Status (~2000): Assessment Underway
79-90% sustainable access to safe water
74-91% sustainable access to improved sanitation

Target
Reduce by 50% the proportion of people without access to safe water and sanitation*

Benchmark
Reduce by 25% the proportion of people without access to safe water and sanitation*

Red Flag
No improvement in proportion of population with access to safe water and sanitation*

Country averages for coastal populations
**Compared to rates of early 2000s*

***Safe water* refers to improved (clean) sources of drinking water. *Improved sanitation* facilities are those capable of hygienically separating human waste from animal, human, and insect contact.** Examples of safe water could include rainwater or public tap water. An example of an adequate sanitation facility could be a well-designed septic system.

Accessible services are those that people can reach easily and consistently. *Sustainable* access requires that current social and ecological practices do not jeopardize future services.

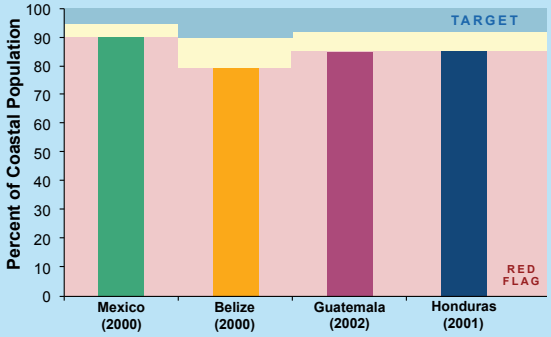
Sustainable access to clean water and safe sanitation are basic requirements in disease control and environmental protection. Inadequate access to clean water and safe sanitation are the primary reasons that diseases transmitted by fecal contact (for example, cholera, SW3) are common in developing countries. Human illness and morbidity in turn contribute to ongoing poverty (SW4).

Inadequate waste treatment can also contribute to coastal water quality (S8) degradation—often in the form of nutrient enrichment, to which coral reefs are sensitive. Corals are adapted to life in low-nutrient waters and do not do well when "overfertilized."

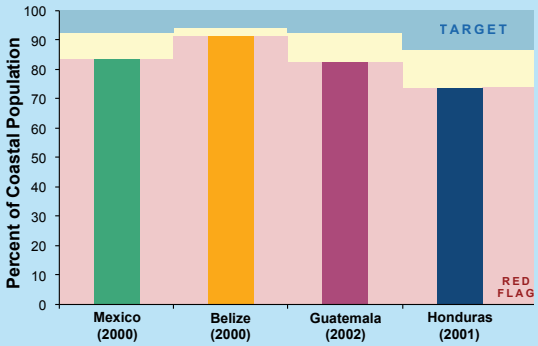
We recommend the continued tracking of access to safe water and sanitation. All four MAR countries collect these data every 10 years via household and population censuses. Additional data are available from national multipurpose surveys. We recommend that these data be augmented by complementary water quality analyses.

A promising sign of Benchmark improvement would be a 25% reduction in the percentage of the coastal population without adequate access to clean water and safe sanitation.

Sustainable Access to Safe Water



Sustainable Access to Improved Sanitation



The Mesoamerican countries provide sustainable access to clean water for more than 75% of the coastal population. More than 70% of the population has access to safe sanitation.[1]

The United Nations Millennium Development Goals include access to safe water and sanitation. In some rural areas, one source of clean water is a community supply pipe, such as this one in Belize.

[1]*Data sources: Central Statistics Office (2000); INE Guatemala (2005), INE Honduras (2001), INEGI.*

SW4

Poverty

***Poverty rates* give the proportion of the coastal population without the economic means to acquire basic goods and services**—for example, a basic "food basket" or housing, water and sanitation, and education and health services.

Coastal poverty rates provide a snapshot of human well-being while also hinting at pressure on local natural resources. Poverty rates indicate whether the local economy, including marine-based activities (SW5), provides coastal residents with a reasonable standard of living. The local standard of living is, in turn, often dependent on local ecosystem health.

In general, if marine-based economic activities are profitable and there is relatively equitable access to and distribution of resources, then poverty-line levels should be lower among coastal communities dependent on the marine environment for livelihood, so long as the resources are maintained.

For example, reef degradation would likely result in a reduction of tourism (D2) and fisheries-related income derived from the reef (SW5), leading to higher local poverty rates. Lower poverty rates might be expected in areas with sustainable reef management practices. Similarly, if commercially valuable species such as lobster (D11) or conch (D10) become scarce, then poverty levels may be expected to increase in the absence of other economic alternatives.

Status (early 2000s): Intermediate
Coastal poverty rates (by country) range from 17% to 60%

Target†
Reduce poverty by 50% in each coastal municipality*

Benchmark
Reduce poverty by 25% in each coastal municipality*

Red Flag
No reduction of coastal-municipality poverty rates*

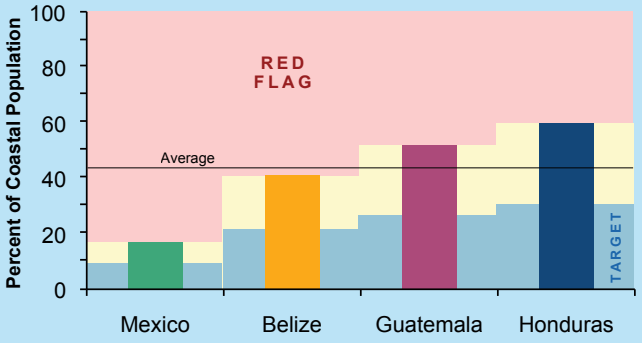
**Compared to rates of early 2000s*
†Longer-term target is to have no poverty

We recommend that coastal poverty rates be routinely tracked. We also recommend that the relationship between local poverty rates and marine resource viability and availability be more fully characterized. At present, no single poverty indicator is directly comparable across all four countries.[2]

A promising Benchmark sign of economic health would be a 25% reduction of the poverty rate in each coastal municipality. As of approximately the turn of the century:[3]

- Poverty rates in coastal municipalities tended to be slightly lower than national averages.
- Coastal areas with greater tourism development (for example, Cancun in Mexico and Roatan in Honduras) displayed lower poverty rates than did areas with lower tourism levels.
- Coastal areas with particularly high poverty rates (for example, Filipe Carrillo Puerto in Mexico and the Gracias a Dios department in Honduras) tended be characterized by relatively large indigenous/ethnic populations and a predominance of small-scale agriculture with little or no tourism or other economic alternatives.

Coastal Poverty Rates



On average, coastal poverty rates are lower than national averages, particularly in Mexico. In Belize, poverty rates are higher in coastal districts, which include both coastal and inland areas. The region's highest poverty rate is in the Toledo District of Belize, which is classified as coastal but also includes many inland villages with high poverty rates and few economic alternatives to subsistence agriculture.[4]

While coastal poverty rates tend to be highest in rural areas, pockets also exist in urban neighborhoods.

[2]*Different countries use different methods.*
[3]*Data sources: SEDESOL (2003); CIMMYT (2006); Government of Belize (2004); INE Guatemala (2006); UNDP (2002); INE Honduras, Mapa de Pobreza; INE Honduras (2001). See also Sistema de Información de la Estrategia para la Reducción de la Pobreza..*
[4]*Data source: McPherson (2008).*

SW5

Economic Contribution of Marine-related Activities

UPDATED

Status (early 2000s): Red Flag
Market forces driving employment with little incorporation of environmental sustainability
Dependence on fishing and tourism (by country) approximately 5% to 20%

Target
Meet sustainable employment goals (to be determined)

Benchmark
Develop community-based targets for sustainable distributions of marine-related jobs

Red Flag
Marine-related employment is market-driven with little consideration of environmental sustainability

The *economic contribution of marine-related activities* indicates a community's level of dependence on marine ecosystems. This indicator is expressed as the percentage of the economically active population (EAP) whose main economic activities are fishing- or tourism-related activities that directly depend on marine resources.[5]

In the event of resource degradation (for example, depletion of the conch fishery or lethal bleaching of corals on a popular dive reef), employment opportunities and economic benefits for local populations might be expected to decline. This indicator, considered in conjunction with indexes of poverty (SW4), human development (SW7), and ecosystem structure and function, can yield insight into the long-term sustainability of resource-based livelihoods.

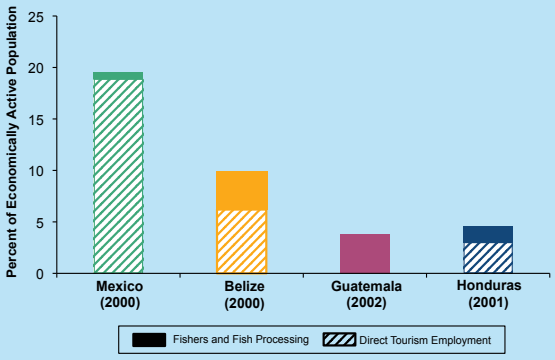
We recommend that marine-related employment be regularly tallied and analyzed in association with complementary indicators of local economic success and resource conservation. This employment information is typically derived from national population censuses, labor surveys, and multipurpose household surveys.

We recommend that these analyses be expanded to include not only *direct* but also *indirect* dependence on marine-related activities. EAP data for Mexico, Belize, and Honduras include only those individuals involved in direct tourism employment, such as hotels, restaurants, and tour agencies. For every one of these individuals, however, likely two or three more are employed in activities that indirectly depend on tourism (construction and transportation, for example).

Developing community-based targets for sustainable distributions of marine-related jobs will be an important Benchmark step in ensuring a healthy, long-term symbiosis between the reef and coastal residents. For example, how many tour guides can a local reef support? How many hoteliers and fishers? In the early 2000s:

- The municipalities in northern Quintana Roo, Mexico, were the areas most highly dependent on marine-based activities overall, primarily due to tourism.
- Coastal communities of Guatemala depended the most on fish and fish processing, with no tourism component recorded.
- Belize and the northern Honduras coast relied on both tourism and fishing, with the former being the larger contributor of income.

Direct Dependence on Marine Resources



Mexico's coastal communities are the most highly dependent on fishing and marine-related tourism—especially tourism. Belize and Guatemala show the greatest dependence on fishing. (Tourism EAP data for Guatemala not available.)[6]

Many communities that once depended on a healthy reef for food now depend on the reef to provide tropical experiences for a growing tourist population.

[5]*The EAP includes all people above a specified age who supply labor for the production of economic goods and services during a specified time period. The threshold age varies by country.*

[6]*Data sources, tourism EAP: Central Statistics Office (2005) (working age is 14 and over); INE Honduras, Censo Nacional de Población y Vivienda 2001 (working age is 7 and over); INEGI, XII Censo General de Población y Vivienda 2000 (working age is 12 and over); comparable Guatemala data not available. Data sources, fishing EAP: Central Statistics Office (2000) (includes individuals occupied in fishing and fish processing); INE Honduras, Censo Nacional de Población y Vivienda 2001; Heyman and Graham (2000); INEGI, XII Censo Nactional de Población y Vivienda 2000 (Guatemala; includes individuals involved in fishing and aquaculture).*

SW11

Environmental Perceptions

Status (2005): Intermediate
No survey of general public available
Limited stakeholder surveys indicate awareness of main threats and generally poor ecological condition of reef

Target
Conduct biennial surveys of environmental perceptions
Results show increasing understanding of threats, values of marine conservation, and links to human health

Benchmark
Conduct baseline survey of regional environmental perceptions
Synthesize results from independent local studies

Red Flag
No surveys conducted for several years or survey results indicate decreasing awareness and support for marine conservation

The term *environmental perceptions* refers to the ways in which individuals, communities, and stakeholder groups perceive, understand, and value the environment. The future of the Mesoamerican Reef—its ecological health and its ability to support local livelihoods and well-being—depends ultimately on the extent to which people value the reef.

Because environmental managers rarely manage the environment—more often they manage human behavior—understanding people's perceptions is essential in achieving a healthy reef. Such awareness is necessary to:

- Identify stakeholders' values and concerns for reefs
- Gauge stakeholder knowledge and interest in different issues
- Tailor broadly acceptable solutions to reef problems
- Design outreach materials that engage the general public
- Monitor the success of educational efforts

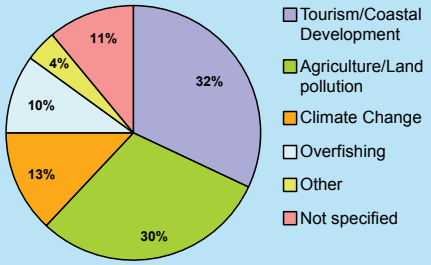
We recommend that environmental perceptions be regularly tracked through a variety of polling and group consultation techniques. In areas with adequate infrastructure, polling can include randomized telephone, mail, or Internet surveys. For much of the region, however, face-to-face interviews will be required. Complementary qualitative data from group consultations can often help explain patterns revealed in the quantitative, statistically rigorous polling data. General sampling protocols agreed to by regional organizations should be followed.[7]

We recommend that further synthesis and analysis of existing survey data be undertaken. A good model may be found in the work of the Ocean Project, which synthesized different United States opinion surveys.[8]

In 2005, the Healthy Reefs Initiative queried more than 100 experts and practitioners from six different stakeholder groups on their perceptions of the Mesoamerican Reef. Among the findings:[3]

- The greatest threats to ecosystem health were said to be (1) unsustainable and unregulated coastal development and tourism and (2) agriculture/land pollution.
- The status of coral reefs, fisheries, water quality, and governance/stewardship was rated "poor."
- Scientists and fishermen, in particular, noted a significant decline in ecosystem health, while tourism operators viewed it as stable.
- Scientists and fishermen also noted significant declines in water quality and fisheries.
- Nongovernmental organizations noted a decline in governance and stewardship, while government participants considered these factors stable.

What is the Main Threat to the MAR?



When MAR experts and practitioners were polled in 2005, a third said that unsustainable and unregulated coastal development/tourism was the single greatest threat to local ecosystem health. Agriculture/land pollution ranked a very close second.[9]

A number of NGOs work closely with local communities on MAR conservation issues, especially near protected areas. These children are participating in a recycling program in Honduras.

[7]*Bunce et al. (2000). See also www.theoceanproject.org and www.seaweb.org/resources/pubopresearch.php.*
[8]*The Ocean Project (1999).*
[9]*Data source: Healthy Mesoamerican Reef Ecosystem Initiative (2005).*

SW14

MPA Management Effectiveness

UPDATED

***Marine protected area (MPA) management effectiveness* is a formal measure of the degree to which an MPA's stated goals and objectives are being achieved.** Every MPA, when established, is assigned specific objectives and protective measures. Some, for example, are designated no-take zones; others are intended to serve as multiple-use areas or as marine wilderness areas.

Establishing MPAs and subsequently monitoring their effectiveness are two key components of building an ecologically representative and functional network of marine and coastal protected areas. MPAs preserve critical habitat, provide refugia and replenishment zones for heavily exploited species (for example, queen conch, D10), and facilitate regulatory enforcement and educational outreach.

We recommend that MPA effectiveness evaluations be routinely conducted according to a regionally standardized method and that the results be used for site-specific and region-wide network management. The results can help inform management decisions, improve project planning, and accountability. Comparisons across the network and analyses of trends can help to elucidate, for example, the effects of MPA size or management style.

One approach to synthesizing a collection of dissimilar effectiveness studies independently scores three fields of evaluation: Biophysical, Socioeconomic, Governance (some mixture of which should be covered in any effectiveness study).

A recent MAR synthesis using this approach concluded that there is a critical need for application of a standardized evaluation methodology in the region.[10]

Status (2000): Intermediate
2000: 50% of Belize MPAs actively managed; 33% performing governance evaluations
2006: 61% of Belize MPAs actively managed; 33% performing evaluations

Target
All MPAs use a regionally adopted, comprehensive protocol to conduct routine effectiveness evaluations and share results; avg. MAR-wide performance ranked as good to excellent (avg. score ≥ 85%)

Benchmark
Develop a regional, standardized method to evaluate MPA effectiveness and a database for sharing results
All MPAs have on-site management; > 70% routinely conduct evaluations

Red Flag
Decline in proportion of MPAs being managed and evaluated
Decline in effectiveness ratings

A promising sign of Benchmark progress toward maximizing MPA effectiveness would be:

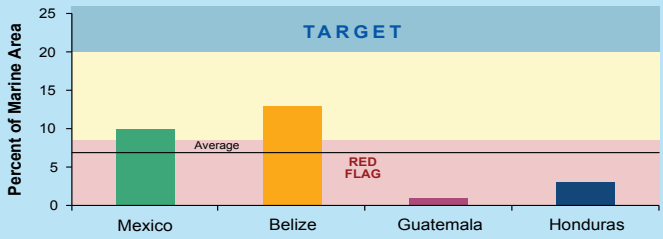
- **Consolidated management at all MPAs**[11] — Between 2000 and 2006, Belize made good progress, adding new MPAs *and* increasing the proportion under consolidated management.[12]

- **Development of a regional, standardized, comprehensive method to evaluate MPA effectiveness** — This method should incorporate all three recommended fields of evaluation (as adopted by the MBRS project, for example).

- **Routine, comprehensive effectiveness evaluations at ≥ 70% of MPAs** — In 2000, 33% of MPAs in Belize performed evaluations, but only for the governance field.[10]

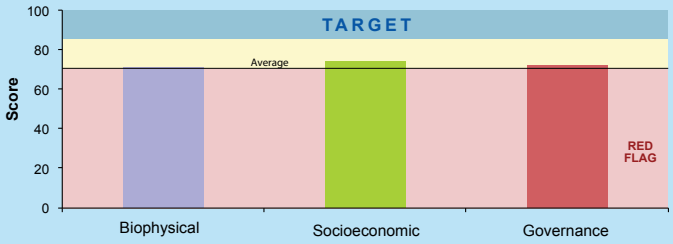
- **Incorporation of all MPA-effectiveness data in an accessible database**

Marine Area Within MPAs



With 32 MPAs, the MAR has less than half its Target area under protection.[13] Belize and Mexico are just over halfway to the SW13 Target. Guatemala and Honduras need to make the legal establishment of additional marine protected areas a higher priority.

Belize MPA Management Effectiveness



A 2006 compilation of effectiveness evaluations for 33% of the MPAs in Belize found an average effectiveness score of 72%.[10]

[10] *Hudina (2006).*
[11] *Under consolidated management, all necessary staff and equipment (boats, for example) are in place.*
[12] *WWF and MAR Fund (2005).*
[13] *SW13 Target: 20% of the MAR marine area within MPAs.*

Transforming the Status Quo

The Healthy Reefs for Healthy People Initiative has taken off, and we invite you to join us. The challenge ahead is to bring together people and data in a meaningful way:

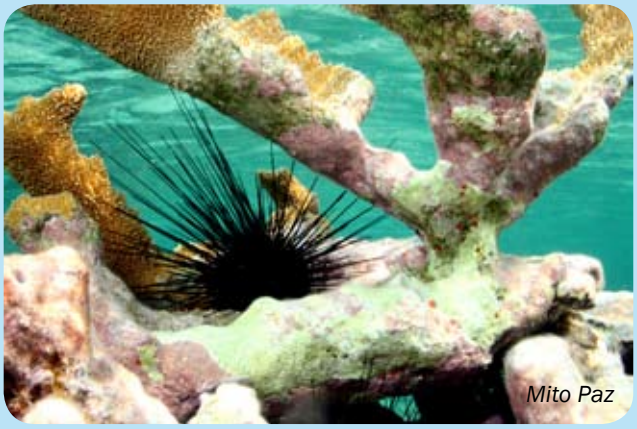
- Further exploring the web of connections between environmental and human health
- Nourishing a widespread appreciation and informed sense of responsibility for our ecological and cultural treasures
- Helping to guide decision-making with relevant science

Through a variety of collaborative efforts, we are creating a "sea change" in the Mesoamerican region—one that will improve our understanding of reef health and increase our collective conservation impact.

Status Quo	Evolving Into...
Local spatial scale	Ecoregional spatial scale
Short-term perspective	Long-term perspective
Eco-centric (ecology only)	Eco-social integration
Single-metric analysis	Multi-metric analysis
Negative perspective	Positive perspective
Exclusionary	Inclusive of stakeholders
Disparate standards for monitoring & analysis	Standardized data analysis
Many separate studies and databases	Common reporting with open-access database
Disparate local or organizational visions	Common vision & definition of reef health
Diffuse, unmeasured conservation impacts	Consolidated, quantified conservation impacts

We invite your participation. Please visit us at www.healthyreefs.org.

Breaking News! As this guide was going to press, news from the latest (2006) regional surveys began to trickle in.


Mito Paz

Among the Highlights:

Rates of recent partial coral mortality, F5, continued to improve, inching this indicator ever closer to its Target value. Coral cover may take decades to recover from the events of the 1980s and 1990s, but we are seeing a welcome step in the right direction.

***Diadema* abundance, F12, improved dramatically—from Red Flag to Target levels**. The return of healthy *Diadema* populations can be expected to contribute significantly to a reduction of reef macroalgae, improvement of coral recruitment success, and, eventually, improved coral cover, biodiversity, and overall reef health. This is big news!

REFERENCES

Abreu-Grobois, A, V Guzmán, E Cuevas & MA Gamio, compiladores (2004) Rumbo a la COP3: Diagnóstico del estado de la tortuga carey (*Eretmochelys imbricata*) en la península de Yucatán y determinación de acciones estratégicas. Memoria del Taller, 4-15 marzo, 2005, Telchac Puerto, Yucatan, MX.

AGRRA, Atlantic & Gulf Rapid Reef Assessment (2005) Methodology: v. 4.0.

Almada-Villela, PC, PF Sale, G Gold-Bouchot & B Kjerfve (2003) Manual of Methods for the MBRS Synoptic Monitoring Program: Selected Methods for Monitoring Physical and Biological Parameters for Use in the Mesoamerican Region. 155 pp.

Aronson, RB, PJ Edmunds, WF Precht, DW Swanson & DR Levitan (1994) Large-scale, long-term monitoring of Caribbean coral reefs: Simple, quick, inexpensive techniques. Atoll Research Bulletin 421:1-19.

Aronson, RB & WF Precht (2001) Evolutionary paleoecology of Caribbean coral reefs. In: WD Allmon & DJ Bottjer, 171-233, Evolutionary Paleoecology: The Ecological Context of Macroevolutionary Change, eds. New York: Columbia Univ. Press.

Belize, Govt. of (2004) 2002 Poverty Assessment Report. National Human Development Advisory Committee.

Boadle, A (2008) Cuba bans marine turtle hunt. Reuters. Jan. 23, 2008.

Bunce, L, P Townsley, R Pomeroy & R Polinac (2000) Socioeconomic Manual for Coral Reef Management. Townsville, AU: Australian Inst. of Marine Science. 251 pp.

Caribbean Fishery Management Council & CARICOM Fisheries Resource Assessment and Management Program (1999) Queen Conch Stock Assessment and Management Workshop, Belize.

CATHALAC & NASA (2008) Analysis of Change in Mangrove Areal Extent in Belize: 1990 - 2006. Report HRI0802 to Healthy Reefs Initiative.

Central Statistics Office (2000) Population Census 2000: Major Findings. Belmopan, Belize.

Central Statistics Office (2005) Belize Main Labour Force Indicators.

CIMMYT, International Maize and Wheat Improvement Center (2006) Mexico Rural Poverty Maps: Mexican Municipalities Below Food Poverty Line 2002.

Downs, CA (2005) Sampling, Biomarker, and Contaminant Chemical Target Analyte Protocols: Assessing the Effectiveness of Agricultural Better Management Practices in the Mesoamerican Reef. WWF and Mesoamerican Alliance of the International Coral Reef Action Network. 60 pp.

Downs, CA & AG Downs (2007) Preliminary examination of cellular toxicological responses of the coral *Madracis mirabilis* to acute Irgarol 1051 exposure: Application of cellular diagnostics. Archives of Toxicology and Contaminant Chemistry 52:47-57.

Downs, CA, E Winter-Kramarsky, E Sega, AG Downs, F Al-Horani, Y Loya & G Ostrander (in review) Toxicological effects of the fungicide chlorothalonil on the coral planula *Stylophora pistillata*.

Edmunds, PJ, RB Aronson, DW Swanson, DR Levitan & WF Precht (1998) Photographic versus visual census techniques for the quantification of juvenile coral. Bulletin of Marine Science 62:934-946.

Guzmán-Hernández, V (2006) Informe técnico final del programa de conservación de tortugas marinas de Campeche, México en 2005. Incluye informe del campamento Isla Aguada, INE/DGVS/TM-007-CAMP y Xicalango-Victoria. SEMARNAT-CONANP, México.

Healthy Mesoamerican Reef Ecosystem Initiative (2005) Stakeholder Opinion Survey on the Health of the Mesoamerican Reef. Conducted for Tulum + 8 Symposium, Cancun, MX, October 2005. www.healthyreefs.org.

Heyman, W & R Graham (2000) La Voz de los Pescadores de la Costa Atlántica de Guatemala. FUNDAECO & TIDE.

Hoegh-Guldberg, O (1999) Climate change, coral bleaching and the future of the world's coral reefs. Marine & Freshwater Research 50:839-866.

Hoegh-Guldberg, O, PJ Mumby, AJ Hooten, RS Steneck, P Greenfield, E Gomez, CD Harvell, PF Sale, AJ Edwards, K Caldeira, N Knowlton, CM Eakin, R Iglesias-Prieto, N Muthiga, RH Bradbury, A Dubi & ME Hatziolos (2007) Coral reefs under rapid climate change and ocean acidification. Science 318:1737-1742.

Hudina, S (2006) Tracking Changes in MPA Performance: The Challenges of Comparison, Integration and Interpretation of Results from Different Management Effectiveness Evaluation Systems; A Case Study of Mesoamerican Reef Region. MSc Thesis, Univ. of Oxford. 106 pp.

Hughes, T (1989) Community structure and diversity of coral reefs: The role of history. Ecology 70:275-279.

IAC Belize (2005) Belize National Report to Inter-American Convention for the Protection and Conservation of Sea Turtles. Isais Majil, Belize Fisheries Dept. 2005.

INE Guatemala (2005) Censos Nacionales XI de Población y VI de Habitación 2002. Caracteristicas de la población y de los locales.

INE Guatemala (2006) Mapas de Pobreza en Guatemala al 2002: Vol I. y Necesidades Básicas Insatisfechas al 2002: Vol. II.

INE Honduras. Censo Nacional de Población y Vivienda 2001: Base de Datos en Redatam.

INE Honduras. Mapa de Pobreza, Honduras. www.ine-hn.org/censo2001/censo2001.htm.

INE Honduras (2001) Linea de Base Intramunicipal2.

INEGI. XII Censo General de Población y Vivienda 2000. Mexico.

INEGI. XII Censo Nacional de Población y Vivienda 2000. Guatemala.

Jones, RJ & AP Kerswell (2003) Phytotoxicity evaluation of photosystem II (PSII) herbicides on scleractinian coral. Marine Ecology Progress Series 261:149-159.

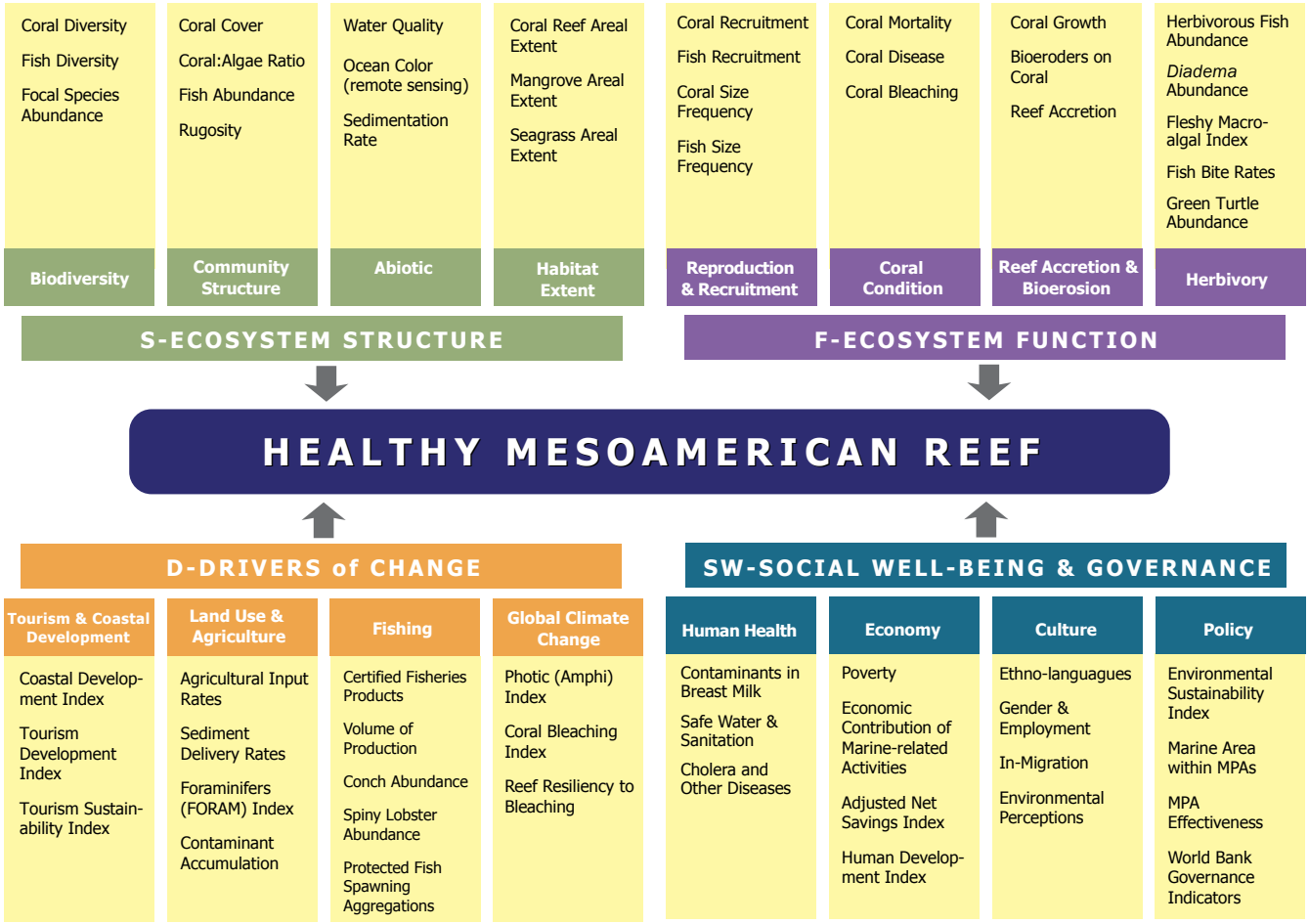
Kleypas, JA, RA Feely, VJ Fabry, C Langdon, CL Sabine & LL Robbins (2006) Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research.

Koltes, KH & TB Opishinski (in press) Patterns of water movement over the forereef at Carrie Bow Cay, Belize. Proc. of 2007 Smithsonian Marine Science Symposium.

Lang, JC & KW Marks (2006) Release of the AGRRA (Atlantic and Gulf Rapid Reef Assessment) Database

and Summary Products for 1997-2004 (v.1.2).
Lessios, HA (1988) Mass mortality of *Diadema antillarum* in the Caribbean: What have we learned? Annual Review of Ecology and Systematics 19:371-393.
Liu, G, AE Strong, W Skirving & F Arzayus (2006) Overview of NOAA Coral Reef Watch program's near-real-time satellite global coral bleaching monitoring activities. Proc. 10th International Coral Reef Symposium, pp. 1783-1793.
Macintyre, IG, MA Toscano, IC Feller & M Fause (in press) Decimating mangrove forests for commercial development in the Pelican Cays, Belize: Long-term ecological loss for short-term gain? Proc. 2007 Smithsonian Marine Science Symposium.
Marks, KW & JC Lang (2006) AGRRA Summary Products (v.10/2006). See also Lang & Marks (2006).
MBRS Project Database. www.mbrs.org.bz.
McField, M (1999) Coral response during and after mass bleaching in Belize. Bulletin of Marine Science 64:155-172.
McField, M (2001) Effects of multiple disturbances on hard coral recruits in Glover's Reef Atoll's Lagoon, Belize. Ch. 3 in: The Influence of Disturbance and Management on Coral Reef Community Structure in Belize. PhD diss., Univ. of South Florida, St. Petersburg, FL, US.
McField, M (2002) Influence of disturbance on coral reef community structure in Belize. Proc. 9th International Coral Reef Symposium, 1:63-68.
McField M, N Bood, A Fonseca, A Arrivillaga, AF Rinos & RML Viruel (2008) Status of the Mesoamerican Reef after the 2005 Coral Bleaching Event. Ch. 5 in Wilkinson, C & D Souter, eds., Status of Caribbean Coral Reefs after Bleaching and Hurricanes in 2005. Townsville, AU: Global Coral Reef Monitoring Network, and Reef and Rainforest Research Centre. 152 pp.
McField, M & P Kramer (2007) Healthy Reefs for Healthy People: A Guide to Indicators of Reef Health and Social Well-being in the Mesoamerican Reef Region. With contribs. by M Gorrez & M McPherson. 208 pp.
McPhaul, J (2007) Invasive algae killing Costa Rican coral reef. Reuters AlertNet, Aug. 29, 2007.
McPherson, M (2006) Livelihood Transition: Toward Sustainable Fishing Communities in the Mesoamerican Reef Region. Report to the Nature Conservancy Mesoamerican Reef Program, Guatemala City, GT. April 2006.
McPherson, M (2008) HRI Socioeconomic Indicator Trends for the Mesoamerican Reef 2008: Grading System and Report Card. Report HRI0801 to Healthy Reefs Initiative.
Meerman, JC (2005) Protected Areas Policy and System Plan: Protected Area System Assessment and Analysis. [Belize]. www.biological-diversity.info/NPAPSP.htm.
Mumby, PJ (1999) Bleaching and hurricane disturbances to populations of coral recruits in Belize. Marine Ecology Progress Series 190:27-35.
Nature Conservancy, The (2004) The *Diadema* Workshop Report, March 19-24, 2004.
NOAA Fisheries Office of Protected Resources (2008a) Queen conch. www.nmfs.noaa.gov/pr/species/invertebrates/queenconch.htm.
NOAA Fisheries Office of Protected Resources (2008b) CITES. www.nmfs.noaa.gov/ia/intlagree/cites.htm.
Ocean Project, The (1999) Review of Existing Public Opinion Data on Oceans. Beldon Russonello & Stewart and American Viewpoint.
Owen, R, AH Knap, N Ostrander & K Carbery (2002) Comparative acute toxicity of herbicides to photosynthesis of coral dinoflagellates. Bulletin of Environmental Contamination and Toxicology 70:541-548.
Owen, R, AH Knap, M Toaspern & K Carbery (2003) Inhibition of coral photosynthesis by the antifouling herbicide Irgarol 1051. Marine Pollution Bulletin 44:623-632.
SEDESOL (2003) Medición del Desarrollo: Mexico 2000 to 2002. www.sedesol.gob.mx.
Sistema de Información de la Estrategia para la Reducción de la Pobreza (SIERP). Secretaría de Estado del Despacho Presidencial, Unidad de Apoyo Técnico (UNAT), Tegucigalpa. www.sierp.hn/sierp.web/site/Globaltable.aspx.
Stoner, A (1997) The status of queen conch, *Strombus gigas*, research in the Caribbean. Marine Fisheries Review 59:14-22.
Theile, S (2001) Queen Conch Fisheries and their Management in the Caribbean. Technical Report to the CITES Secretariat in Completion of Contract A-2000/01. TRAFFIC. Europe.
UNDP (2002) Guatemala: Desarrollo Humano, Mujeres y Salud. Informe de Desarrollo Humano 2002. Sistema de Naciones Unidas en Guatemala: SNU.
US Geological Survey (2004) Belowground dynamics in mangrove ecosystems. USGS Fact Sheet 2004-3126.
World Conservation Union (2006) IUCN Red List of Threatened Species. www.iucnredlist.org.
World Wildlife Fund (2002) Mesoamerican Reef Ecoregional Planning Database CD. GIS data compiled from a variety of sources by P Kramer. Miami, FL: Univ. of Miami, Rosenstiel School of Marine and Atmospheric Science.
World Wildlife Fund (2005) Marine Contaminants Monitoring. Agriculture Program, Mesoamerican Reef Ecoregional Program. Contacts: jvasquez@wwfca.org and mcfield@wwfca.org.
World Wildlife Fund and MAR Fund (2005) MAR Coastal and Marine Protected Areas: Financial Model. Data CD. December 2005. www.marfund.org/intutoriales.html.

Healthy Reefs Indicators



Healthy Reefs for Healthy People Initiative, November 2006

For more information about these indicators, see *McField and Kramer (2007)*, available at www.healthyreefs.org. The 20 priority indicators in this Quick References Guide were identified by scientists, social experts, and local managers:

- The 10 priority ecological indicators (S and F) represent the core of a "bare bones" ecological assessment program.
- The 10 priority social indicators (D and SW) focus on community awareness, management effectiveness, and the main threats to MAR health.

Contributors to this publication are acknowledged in *Healthy Reefs for Healthy People: A Guide to Indicators of Reef Health and Social Well-being in the Mesoamerican Reef Region*, available at www.healthyreefs.org.
We gratefully acknowledge the generous contributions of many organizations and individuals throughout the region and around the world. We offer a special thanks to Alejandro Arrivillaga (TNC) and Nadia Bood (WWF) for news from their 2006 Rapid Reef Assessment.

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Cover Photo Credits: (Front) Tony Rath, trphoto.com; (Back) Wolcott Henry, brain coral; Tony Rath, woman, fisherman; Lisa Carne, people in boat.

Healthy Reefs for Healthy People is a collaborative international initiative that generates user-friendly tools to measure the health of the Mesoamerican Reef ecosystem, delivers scientifically credible reports to assist decision-making, and serves as a networking hub for science and conservation partners to improve environmental management and stewardship of reef resources.

WWF

SAM MBRS

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Perigee

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