GCRMN

GLOBAL CORAL REEF MONITORING NETWORK

STATUS OF CORAL REEFS OF THE WORLD: 2004

VOLUME 2

EDITED BY CLIVE WILKINSON

Australian Government

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

Dedication
This book is dedicated to those people around the world who monitor coral reefs and assist in their conservation. Often they do this voluntarily because of a sincere wish to save these magnificent ecosystems. The book is also dedicated to the International Coral Reef Initiative and partners, the Management Group of the GCRMN, and the Australian Government acting through the Australian Institute of Marine Science. A particular dedication is to the Government of the USA, which has provided considerable support and encouragement to the GCRMN though the Department of State, the US National Oceanographic and Atmospheric Administration and Ruth Kelty.

Front Cover: Madang, Papua New Guinea- Amphiprion percula (Photo Courtesy of Dr. Gerald Allen, Tropical Reef Research);

Back Cover: Christopher McClelland © 2004

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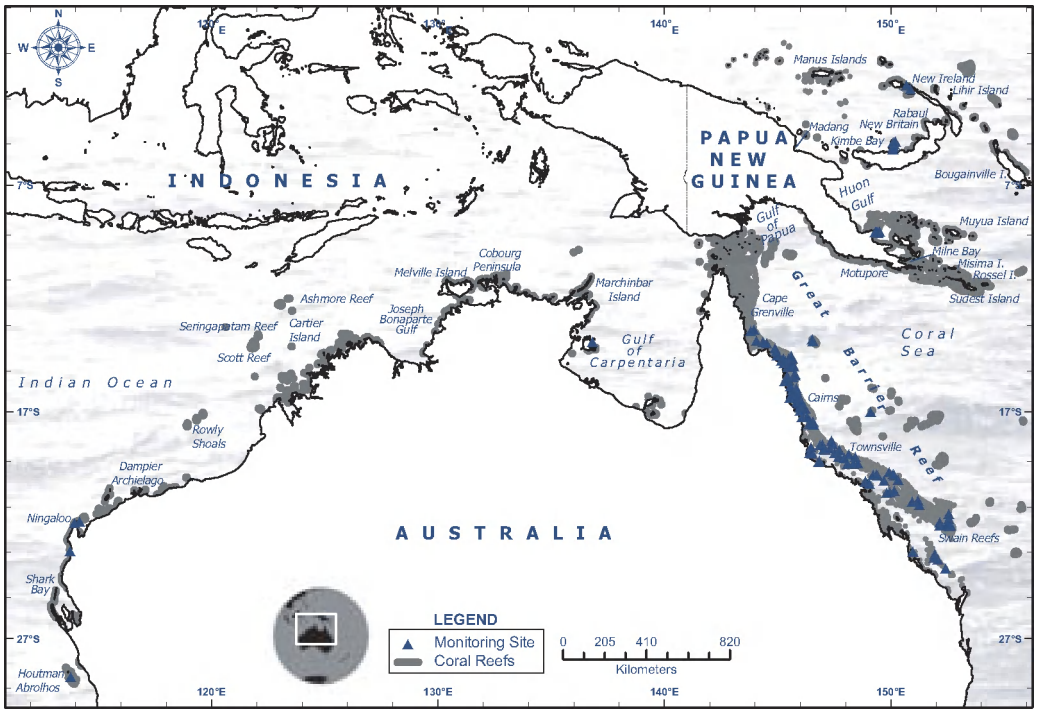
11. Status of Coral Reefs in Australia and Papua New Guinea in 2004

Ian Miller and Hugh Sweatman
With Contributions From: Mark Baine, Paul Chatterton, Andrew Chin, Ben Fitzpatrick, Victor Gomelyuk, Jos Hill, Aaron Jenkins, Geoff Jones, Jeff Kinch, Michael Marnane, Robert Thorn, Hamish Malcolm and Luke Smith

Abstract

The territorial waters of Australia and Papua New Guinea (PNG) are similar in that they contain extensive, biodiverse coral reef systems that remain in relatively good condition, despite some recent setbacks. However there are stark contrasts in the socio-economic environments of the two countries; Australia is a modern developed economy with a high level of affluence, while PNG is still in transition from a basic subsistence economy. The different socio-economic circumstances have lead to a marked difference between the two countries in the way reef resources are used, and consequently, how they are managed. Approaches to reef management have continued to diverge during the past decade. Australia is setting an example to the rest of the world for the conservation of coral reefs through a system of central planning, legislation and enforcement. Conversely in PNG, there is minimal central management, although there is recognition by government of the importance of state controls and legislation. An alternative model is developing in PNG for a decentralised, community-based system for reef resource management driven largely by NGOs, because there are limited resources for national control. Results from established or planned monitoring programs will determine the effectiveness of these differing approaches in the long-term.

Since the establishment of the International Coral Reef Initiative (ICRI) in 1994 and the Global Coral Reef Monitoring Network (GCRMN) in 1996, Australian State and Federal Governments continue to gazette Marine Protected Areas (MPAs) to conserve valuable coral reef habitats. An outstanding example is the recent rezoning of the Great Barrier Reef World Heritage Area, where after an extensive period of public consultation, 33% of the total area has now been protected from extractive industries such as fishing and collecting (Box p 13 and p 325). Smaller, but equally important systems of MPAs have been gazetted recently in Western Australia, Northern Territory, New South Wales and the Coral Sea. This reflects a growing awareness of the economic and social importance of coral reefs by governments, industry and



Map courtesy of The WorldFish Center

stakeholders. The establishment of MPAs has been based on sound science and often-innovative use of information from an extensive history of research and monitoring. Australia has been able to commit considerable resources to the management of its coral reef ecosystems.

Extensive monitoring on the Great Barrier Reef (GBR) in particular shows that the reefs are highly dynamic and generally resilient, with short periods of decline due to disturbance, followed by longer periods of recovery. While Australian coral reefs remain in generally good condition due to relatively low levels of human pressures, there is rising concern about the increasing threats from land runoff from the wet tropical areas, climate change and over-fishing on the GBR. While the major stresses damaging reef resources are 'natural' disturbance events, such as cyclones, floods, coral bleaching and crown-of-thorns starfish outbreaks (COTS), increasing and cumulative human pressures on the GBR could hinder recovery from these disturbances, and could lead to long-term declines in the health of the GBR.

COTS continue to be the major source of coral mortality on the GBR, and currently there is a wave of outbreaks on reefs in the central GBR that originated in the Cairns section, and has 'drifted' slowly south through the GBR reef complex since 1992. A separate, and persistent, outbreak in the isolated Swain Reefs, in the far south, has caused extensive coral mortality. The coral bleaching events of 1998 and 2002 have also contributed to declines in some regions. Damage due to terrestrial runoff, while difficult to quantify, appears mainly to be restricted to the wet tropical regions in northern Queensland. Coral disease is an emerging issue, although the high levels of disease seen in 2002 have not persisted, and mortality from disease is generally low. Coral cover has generally increased on reefs that have not suffered disturbances.

It is debatable whether the GBR complex has declined over the last 40 years. The reef is in a continuous state of flux and diverse historical data sets are particularly difficult to compare with modern ones. Small declines reflected in recent monitoring data are viewed in context of long-term trends in reef condition; thus the prognosis for the GBR remains good. The designation of 33% of the GBR Marine Park (GBRMP) as no-take zones, coupled with moves to improve the sustainability of fisheries and a Reef Water Quality Protection Plan designed to improve coastal water quality over the next 10 years, represent active management to promote the sustainable use of the Marine Park. These initiatives will be increasingly important in supporting the capacity to recover from the major potential threat to all Australian reefs: global climate change and corresponding increases in sea surface temperatures causing frequent and intense coral bleaching events, and a likely increase in the incidence and intensity of tropical cyclones.

The reefs in Western Australia are also in relatively good condition, with the exception of some offshore reefs near East Timor and Indonesia. The combined effects of intense bleaching in 1998, and a series of large cyclones in ensuing years have severely reduced coral cover on some offshore reefs. Similarly in the Coral Sea to the east, major declines in coral cover on some reefs in recent years are due to bleaching and storm activity.

The coral reefs of Papua New Guinea are much less studied than those in Australia and there are few declared MPAs, although the number has increased over the last 3 years. The main reason is a lack of human and financial resources and limited research capacity. The lack of management at a state level is balanced by a strengthening of traditional management practices. On a national scale, reef resources are under-utilised, with most of PNG society being agrarian with relatively few full time fishers. Most reefs are in good condition, with particularly high biodiversity and scenic beauty, although some reefs near the large towns of Port Moresby, Madang and Lae and others in more remote locations such as Kimbe Bay and Milne Bay show clear signs of damage. Major threats to the reefs are over-fishing, sediment runoff from land clearing and mining, pollution from urbanisation and outbreaks of coral predators. In recent years, there have been strong efforts by government, NGOs, tourist operators and local stakeholders to develop strategies for conserving these reefs. The prognosis for these reefs remains good if appropriate management strategies can be implemented.

The key issue for reefs in Australia and PNG is the nature of the stresses, their frequency, intensity and duration. There have been many instances of reef damage over the last decade, but coral cover has remained stable on some reefs and increased on others. If the stresses increase beyond the natural rates of recovery, or if recovery is impaired by other factors, there will be regional declines. Monitoring is essential for the early detection of threats to enable managers to make timely decisions about how to mitigate, ameliorate or remove stresses, so that the essential values and productivity of the coral reefs are maintained.

100 Years ago: Some Australian reefs were already touched by changing land management practices and extractive industries. The true value of reef resources was being realised. The idea that scientific knowledge was mandatory for better economic management of marine resources had also gained currency. Reefs were probably in a similar or better condition than they are now.

In PNG, customary laws and practices, administered by tribal leaders, governed ownership and use of reef resources. Little is known about the condition of coral reefs at that time, but it is assumed that they were in a relatively pristine state.

In 1994: The condition of reefs in Australian waters was similar to today. COTS were considered to be the major management problem for the GBR. Other Australian reefs were in good condition with generally high coral cover and few immediate threats. Fishing pressures were moderate, but causing a decline of key target species.

Coral reefs in PNG remained poorly studied 10 years ago. There were threats from extractive industries, sedimentation due to deforestation and the clearing of mangroves, agriculture and mining. Despite these stresses, the majority of reefs remained in a relatively pristine state with large fish populations.

In 2004: Raised sea surface temperatures due to global warming, and a predicted increase in the frequency and intensity of coral bleaching, and cyclones have emerged as major threats to coral reefs in the region. Australian coral reefs, however, remain in a relatively good state despite episodes of degradation. Management is seen as effective.

Similarly in PNG, the major threat is posed by global warming, but other threats such as pressures from growing coastal populations, increased urbanisation, increasing reef harvesting, and sedimentation from logging and land clearing all pose threats to coral reefs in PNG. Most reefs still remain healthy.

Predictions for 2014: Efforts to strengthen the protection of reefs and reduce human impacts through MPAs, improved fisheries management and holistic catchment management are expected to continue. Provided these programs are adequately supported by education, research, monitoring, legislation and enforcement, the prognosis is good for reefs of Australia and PNG. Nevertheless there is strong potential for major damage from global climate change, which could cause fundamental shifts in coral communities away from dominance by hard corals. This is particularly true for many reefs in Australian waters that have been disturbed in the last decade, and are in the early stages of recovery.

Introduction

The reefs of PNG and Australia include 19% of the world's total reef area and support biodiversity approaching the 'hot spots' of Indonesia and the Philippines. Importantly, the reefs in the region are subject to far fewer human pressures than in many other parts of the world (particularly Southeast Asia). Australian reefs are relatively well researched and monitored and this provides strong support for resource management and rational planning for multiple use zoning. Thus these reefs remain in relatively good condition. Global climate change and coral bleaching represent the most significant threats, with potential impacts exacerbated by any decline in reef resilience caused by declining water quality, over-fishing or losses of biodiversity.

The Great Barrier Reef (GBR) was declared as the world's largest World Heritage Area in 1981. The GBR covers 350,000 km^2, with 2900 reefs over 2000 km of the Queensland coast. The GBR World Heritage Area (GBRWHA) was first provided with comprehensive protection in 1975 under the Great Barrier Reef Marine Park Act. The GBR Marine Park Authority (GBRMPA) recognised that there was mounting evidence that the GBR is coming under increasing pressure. To address this, GBRMPA initiated a process to develop a new zoning plan using available scientific information and extensive consultation with stakeholders (Box p 325). The successful introduction of the resultant zoning plan in 2004 increased control over 33% of

NEED FOR REPRESENTATIVE AREAS PROGRAM AND REZONING OF GBR MARINE PARK

There has been recent, mounting evidence that the Great Barrier Reef (GBR) is under increasing pressure. Independent scientific reviews concluded that the annual flow of sediments and nutrients into the GBR from the land has increased 4-fold, and that these pollutants posed a significant threat to the health of the reefs. Dugong populations adjacent to the Queensland coast have declined by 97% since the early 1960s. Similarly the numbers of nesting loggerhead turtles have declined by 50 - 80% over the last 40 years. Effort in the commercial Reef Line Fishery has doubled since 1995, and recreational fishing has increased with population growth and improvements in fishing and boating technology. Since 1998, the GBR has suffered two of the most severe coral bleaching events ever recorded, as well as a series of cyclones and outbreaks of COTS. These have resulted in significant losses of coral cover across the entire region. Significantly, many of these events occurred within a few decades, thereby magnifying the impact on the GBR. The consensus opinion was that these combined pressures could lead to a long-term decline in reef health and reduce the ability of the GBR to recover from major disturbances. There is evidence that some inshore fringing reefs have already shown signs of significant damage.

The biodiversity, ecological functions and biological connections between the habitats of the GBR need to be preserved in order to maintain the GBR's health and resilience. Under the previous zoning regime, only 4.7% of the GBR Marine Park was highly protected in 'no-take' areas, and these protected areas were specifically focused on coral reef habitats and remote 'pristine' areas. However, independent scientific advice indicated that this zoning system was unlikely to provide adequate protection for the entire range of biodiversity and ecological functions of the GBR. Some regions of biodiversity (or bioregions) were not within highly protected zones, potentially exposing some species to extractive activities throughout their entire geographic range.

To address these issues, the GBR Marine Park Authority formulated the Representative Areas Program by employing the best available scientific information and involving extensive community consultation to develop a new network of highly protected, 'no-take' zones. The working principle of the network was that these 'no-take' zones would make up at least 20% of every bioregion to protect the biodiversity and ecological functions of the GBR. The network would also provide an ecological 'insurance policy' by maintaining 'pristine' areas that could help the entire GBR ecosystem resist increasing pressure and recover from major disturbances. The new GBR Marine Park Zoning Plan was declared on 1 July 2004 as a network of 'no-take' zones covering 33% of the GBR Marine Park. More information on the rezoning of the GBR is on: www.gbrmpa.gov.au/corp_site/management/zoning/index.html. From: Andrew Chin: Great Barrier Reef Marine Park Authority

the GBR Marine Park with designated 'no-take' zones. This process has set a new standard of 'world's best practice' in coral reef resource management (Box p 13).

Western Australia (WA) has many coral reefs scattered along 3,000 km of coast with a wide variety of reef types, predominantly fringing reefs (including Ningaloo, the world's largest) and patch reefs. Most of the reefs are remote from population centres, while some reefs are also remote from land (e.g. over 300 km offshore). The majority of the reefs are near shore in embayments or islands around the coast. The Houtman Abrolhos Islands form the most southern reef system in the Indian Ocean. Western Australia is developing a system of marine parks and reserves to incorporate the large number of reefs not currently within MPAs. Some protection, however, is provided under a number of general Acts (i.e. State Fisheries Act, Environmental Protection Act, Wildlife Conservation Act).

Australia also administers the Cocos (Keeling) Islands and Christmas Island, located south of Indonesia in the Indian Ocean. The reefs of Cocos (Keeling) Islands have not been affected by the recent major coral bleaching events and remain in near pristine condition.

The Northern Territory and the Gulf of Carpentaria include many reefs within coastal waters, but their extent is yet to be fully explored. In 2003, a large new coral reef was discovered in waters of the Gulf of Carpentaria that were previously considered too warm and muddy for such ecosystems. Due to the poorly mapped and remote nature of reefs in this area, there have been few monitoring or baseline surveys, thus little is known of their overall status.

The Coral Sea Islands Territory consists of scattered islands in an area of approximately 780,000 km^2 of the Coral Sea, extending eastwards from the outer edge of the GBR. The majority of Coral Sea reefs are in Australian territorial waters. These include several MPAs: the Coringa-Herald; Lihou Reef; Elizabeth and Middleton Reefs National Nature Reserves; and Lord Howe Island (New South Wales Marine Parks Authority). Elizabeth and Middleton Reefs and those around Lord Howe Island, 150 km to the south, are the most southern coral reefs in the world and come under the influence of the warm East Australia Current. Monitoring has been limited to a few surveys with the most recent in 2003/04. The coastal Solitary Islands in northern New South Wales are included in this broad category, although these are transient coral communities. These reefs have abundant hard coral cover. The Solitary Islands Marine Park was established in 1991 as a multiple use marine park. The first monitoring was implemented in 2000, and in 2002 the area of reef within the most protected zone (sanctuary zone: no fishing or anchoring permitted) was increased considerably.

Papua New Guinea (PNG) includes the eastern half of the large island of New Guinea as well as a series of large islands (New Britain, New Ireland and Bougainville) and numerous small ones. Politically the country is divided into 20 provinces each with its own government. Most of the people live in the 16 coastal provinces, which usually have extensive coral reefs in surrounding waters. The exception being the coastal Gulf and Western provinces, where turbid waters from shallow seas and the outfall of the Fly River estuary limit coral reef development. PNG has a coastline of over 10,000 km and an EEZ of 3.12 million km^2, including an estimated 40,000 km^2 of coral reefs. In the few locations that have been studied in detail (Madang lagoon, Milne and Kimbe Bays), the diversity of reef fishes and corals is among the highest in the world (Box p 322).

Status Of Coral Reefs

Eastern Australia

The GBR: The GBR Marine Park includes a huge variety of reef habitats. By the time the GCRMN was established in 1996, the GBR already had a strong history of research, monitoring and management. Much of the political impetus for this effort was driven by the early recognition of the commercial and cultural value of the GBR. That lead to the establishment of the GBR Marine Park Authority (GBRMPA) through the GBR Marine Park Act of 1975. The process was designed to provide the framework for the establishment, care and ongoing management of the Marine Park. The area was granted World Heritage Status in 1981.

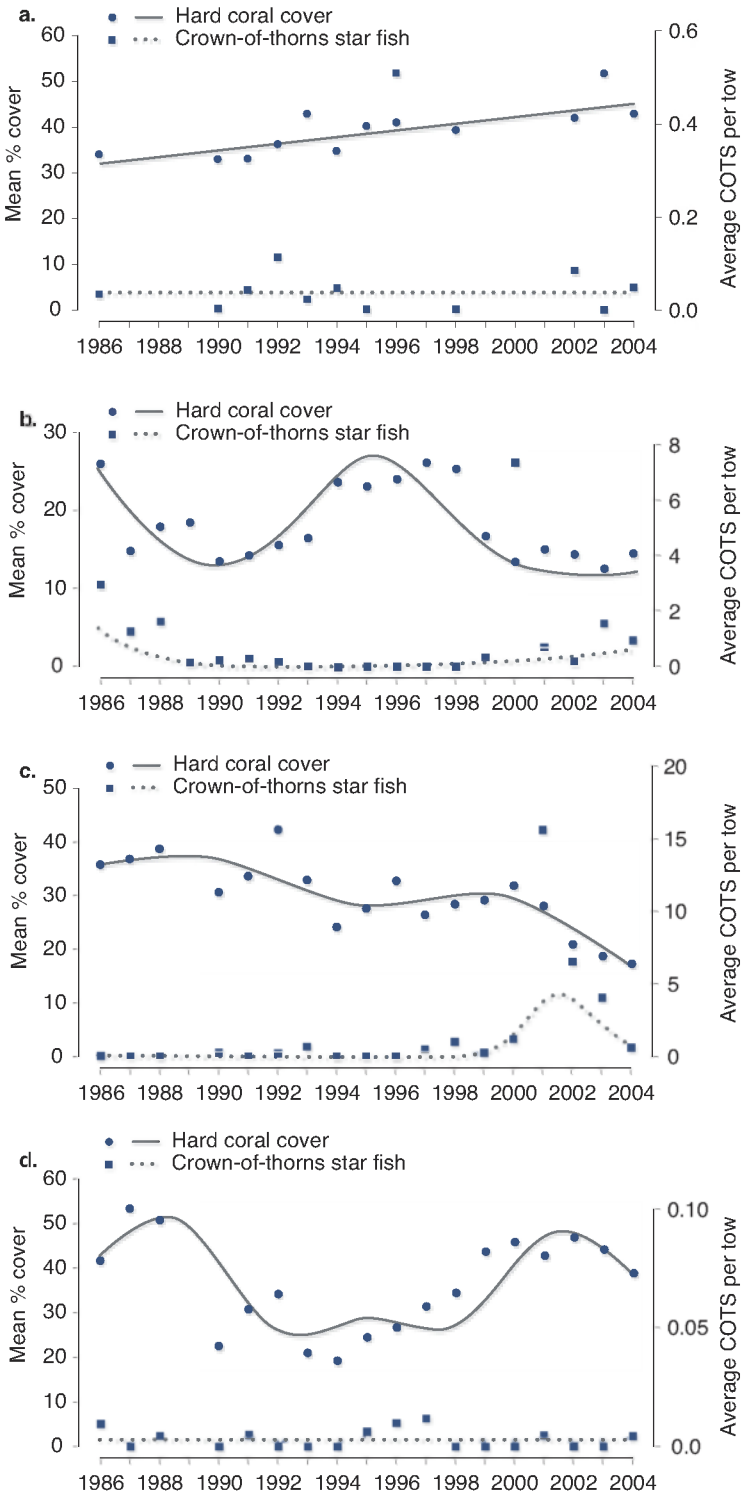
The establishment of a single management authority (GBRMPA) provided a clear focus for research needs. Added impetus for research came from a series of COTS outbreaks (1966 to 1977; 1979 to 1991; 1992 to present) that were initially considered to threaten the viability of the whole GBR; however most outbreaks have been restricted to the central third of the system. This resulted in increased research on COTS on the GBR, but did not include a comprehensive monitoring program with standard sampling methods. There was a piecemeal approach to COTS surveys from the 1960s to the 1980s using a variety of methods and, because the starfish came and went, it was difficult to draw meaningful conclusions. To avoid this problem, the Crown-Of-Thorns Starfish Advisory Research Committee recommended the establishment of standardised COTS surveys in 1986. Later a comprehensive Long-term Monitoring Program (LTMP) by the Australian Institute of Marine Science (AIMS) commenced in 1992. Since then there has been more site and issue specific monitoring implemented by GBRMPA and a Reef Check program has recently been established on the GBR.

The AIMS LTMP provides a broad picture of changes on GBR reefs over 19 years of manta tow surveys of coral cover on reef perimeters, and 12 years of more intensive sampling at fixed sites of fishes and benthic organisms on 47 reefs. The GBR is almost 2000 km long and up to 200 km wide and spans several ecological gradients, thus there are local differences in the reef communities and rates of disturbance. The GBR can be divided into 29 'regions' based on latitude and position on the continental shelf, and the reefs within these regions are similar and respond to similar cycles of disturbance and recovery. Manta tow surveys show that average coral cover has declined by about 5% over the past 19 years on 70 reefs over the length of the GBR. This average decline is the result of a major decrease in 7 of the 29 regions: the mid-shelf reefs in the Cooktown-Lizard Is sector; inshore and mid-shelf reefs near Cairns; inshore reefs near Innisfail and Townsville; and mid-shelf reefs near Cape Upstart and in the Swains. Of these regions only two, the reefs near Cairns and in the Swains, have not shown some recovery. Storms and COTS have frequently disturbed the reefs in the Cairns region, and the Swains mid-shelf reefs have a chronic population of COTS. However, most regions of the GBR are either in good condition or have shown capacity to recover from disturbance in recent years, whereas some regions have received multiple or chronic disturbances and their potential for recovery may have been compromised.

COMMUNITY PARTICIPATION IN REEF MONITORING

Some of the most extensive monitoring programs in the world are on the GBR; but these regularly visit only 5% of the 2900 reefs. Thus Reef Check now provides a meaningful opportunity for communities and stakeholder industries along the Queensland coast to participate in reef monitoring and public education thereby supplementing research monitoring and supporting the management objectives of the GBRMPA. Reef Check teams of 20 volunteers, including university marine science students, monitor over 30 dive sites on 12 reefs within the GBR, and 2 sites at Osprey Reef in the Coral Sea each year. The teams conduct Reef Check monitoring, and also focus on algal blooms, coral disease, coral bleaching, *Drupella* spp. and COTS to provide data for reef management. The status of Reef Check sites has remained stable over the last 3 years, however there was a summer bloom of the nutrient indicator algae *(Chrysocystis fragilis)* at many sites in the Cairns region and a few sites in the Townsville region in 2004. Teams recorded 1-3 COTS at all sites in the Townsville region, but none at most sites off Cairns and further north. However, *Drupella* spp. were observed in low numbers at every site. There were incidences of black-band disease and white syndrome in the Cairns and Townsville regions, and minor bleaching at all sites visited on the GBR in early 2004. There were about 30% of hard coral bleached at 5 m on Osprey Reef in the Coral Sea. Anecdotal reports from dive operators suggest that these corals largely recovered. Reef Check Australia has developed an advanced Reef Check training and assessment program to accredit volunteer teams, and the Reef Check Plus training course will be published for international use in 2005. Course participants are provided with the tools to operate as an efficient team- organise teams, analyse data and prepare reports. Because the participants gain better knowledge about coral reefs, they also develop a strong sense of stewardship, which they share with friends and tourists. The Reef Check 'Great Barrier Reef Project' is funded by the Australian Government Envirofund and is attracting significant support from the dive tourism industry, other commercial businesses, NGOs and government agencies. They have established a non-profit Reef Check Foundation to assist operations in the Indo-Pacific region, with plans to extend monitoring and awareness raising activities, and also include water quality monitoring. From: Jos Hill, Reef Check Australia, Townsville; jos.hill@jcu.edu.au

These 4 graphs opposite - demonstrate major variations in live coral cover and COTS numbers over the large areas of reefs in 4 sectors of the Great Barrier Reef Marine Park. A true indicator of the health of a coral reef system is its ability to recover after disturbance. Reefs in the Cape Grenville (12^0S, a) sector have retained consistently high coral cover, which has steadily increased as there has been minimal disturbance. In the Townsville sector (19^0S, b) there has been decline then recovery followed by further decline, mainly due to two separate outbreaks of COTS. Coral cover on reefs in the Swains (22^0S, c) has declined mainly due to persistent populations of COTS eating corals. Further south in the Capricorn Bunkers (23^0S, d), storm damage in 1989 resulted in massive losses, followed by a rapid increase in coral cover to pre–disturbance levels.


a.
Hard coral cover
Crown-of-thorns star fish
Mean % cover
Average COTS per tow
0
10
20
30
40
50
60
0.0
0.2
0.4
0.6
1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
b.
Hard coral cover
Crown-of-thorns star fish
Mean % cover
Average COTS per tow
0
10
20
30
0
2
4
6
8
1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
c.
Hard coral cover
Crown-of-thorns star fish
Mean % cover
Average COTS per tow
0
10
20
30
40
50
0
5
10
15
20
1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
d.
Hard coral cover
Crown-of-thorns star fish
Mean % cover
Average COTS per tow
0
10
20
30
40
50
60
0.0
0.05
0.10
1986 1988 1990 1992 1994 1996 1998 2000 2002 2004

Despite the relatively good health of the GBR, there are a number of general threats, including:

- Nutrients and sediments: an estimated 4-fold increase in amounts discharged by rivers into the GBR lagoon since European settlement in the mid-1800s;
- Coral bleaching: in 1998 and 2002, the GBR suffered the most severe coral bleaching events recorded due to elevated sea surface temperatures;
- Fisheries: the effort in the commercial reef line fishery has doubled since 1995, coupled with an increase in effort and efficiency of recreational fishing; and
- COTS outbreaks: these continue to be responsible for major declines in coral cover over large areas of the GBR.

GBRMPA has divided the GBR into 4 sections for zoning purposes, and these are discussed from the North to the South.

Far Northern Reefs: Extending from Cape York south to Murdoch Point (approx 500 km), these reefs are remote and rarely visited. They have some of the highest live coral cover (reef-wide) on the GBR (40-50%), due to a lack of major disturbance. The effects of the major bleaching events in 1998 and 2002 were minimal, and there are few cyclones. Reefs in the northern part of the sector have been stable, whereas there has been a decrease in cover further south due to increasing numbers of COTS off Princess Charlotte Bay.

Cairns/Cooktown Reefs: Extending from Murdoch Point south to Mission Beach (approx 400km), the sector includes the major reef tourism industry centred in Cairns. Coral cover has declined over the last decade due to the combined effects of COTS and coral bleaching in 1998 and 2002, particularly on the mid-shelf reefs near Innisfail, which have the lowest reef-wide live coral cover (<5%) on the GBR. This section includes inshore reefs that receive a lot of runoff from the adjoining Wet Tropics World Heritage Area. Coral in this area was also seriously damaged during the bleaching event in 1998. In 2004, COTS were no longer active in this region and recovery was evident on many reefs, particularly those near Cooktown. Outer shelf reefs off Lizard Island presently have a high coral cover (50-60%).

Townsville/Whitsunday Reefs: Extending from Mission Beach south to Midge Point north of Mackay (approx 400 km), the sector includes the popular tourist destination of the Whitsunday Islands and the major urban centre of Townsville. There were many COTS outbreaks in this region in the past few years and reef-wide live coral cover on many reefs near Townsville has decreased (down to 10-20%). COTS continue to move south and outbreaks are beginning to appear on reefs off Cape Upstart. Live coral cover remains stable (10-30%) on the reefs of the Whitsunday region in 2004, despite many reefs in the area suffering mortality from coral bleaching in 2002.

Mackay/Capricorn Reefs: Extending from Midge Point south to Agnes Waters (approx 550 km), the southern end of the GBRMP contains many areas of reefs that are relatively remote and beyond coastal influences. Reef condition varied markedly in 2004 with those in the Pompey and Capricorn Bunker sectors having high reef-wide live coral cover of 40-50%. While Pompey reefs have remained relatively stable, the more southern Capricorn Bunker Reefs have shown a remarkable recovery from a massive loss of coral cover prior to 1990. Many reefs in the more

remote Swain Reef complex have had persistent outbreaks of COTS resulting in a reduction in average regional coral cover values from 30-40% in 1996 to 10-20% in 2004. Numbers of COTS in 2004 are beginning to decline in the Swains, probably due to lack of available coral prey on many affected reefs.

The Coral Sea Islands: Information on status has been limited to occasional surveys of these remote reefs over the last two decades, most recently by AIMS with the support of the Department of Environment and Heritage in 2003/04. There have been declines in coral cover on many of the reefs in the Coral Sea, driven by increases in the frequency and intensity of coral bleaching events and destruction by cyclones. These reefs support unusual reef fish assemblages and are relatively isolated from each other. Given their isolation, self-seeding of these reefs is probably an important mechanism for recovery, and the frequency, timing and success of recruitment events will have a strong bearing on recovery rates. The remoteness of these reefs means that human influences are minimal (e.g. until recently a few people staffed the meteorological station on Willis Island, and approximately 300 live on Lord Howe Island), however there are some commercial fishers operating in the area. Global climate change and the associated increases in water temperature (bleaching) and frequency and intensity of cyclones are the main threats.

Coringa-Herald National Nature Reserve (CHNNR): Surveys by AIMS in 2003 found very low coral cover compared to offshore reefs of the GBR (GBR 30% vs. 4.5% NE flanks CHNNR). Comparisons with earlier CHNNR surveys indicate historically low levels of hard coral cover in the reserve with a maximum of 20% in 1997, followed by a dramatic decline to less than 5%. The surveys reported strong evidence of mortality following the 2002 bleaching event and recent physical damage from storms at exposed sites. There was also evidence of coral predation by COTS and coral eating molluscs, *Drupella* spp. Hard coral diversity was very low compared to similar reefs on the GBR, and there was low diversity and density of reef fishes. The reef fish assemblages were unlike any on the GBR; many species that were common on Coral Sea reefs are rare or absent in similar habitats on the GBR (and vice versa). There is a bêche-de-mer (sea cucumber) fishery on reefs around the CHNNR (Flinders Reef, Holmes Reef, Osprey Reef, Cato Reef and Wreck Reef), and assessments show that stocks have recently declined.

Lihou Reef: Surveys of Lihou Reef have been infrequent (1984 and 2004). Coral cover was generally low (<10%) in 2004 and coralline and turf algae dominated the benthic community. These reefs are exposed to strong oceanic swells so most coral colonies were small. Many corals were bleached and stressed due to elevated sea surface temperatures at the time of survey in 2004, and there was evidence that the reef had bleached in 2002. Based on only two surveys separated by 20 years, there appears to have been a reduction in hard coral cover from moderate (20%) to low levels (<10%).

Elizabeth and Middleton Reefs: Hard coral cover was moderate (10-30%) in 2003, with no bleaching and very few COTS. The 2003 survey recorded 181 fish species with 61 being new records for Elizabeth Reef, to make the total 311, including 45 species as new records for the Reserve. The fish species richness at Elizabeth Reef differed little between 1987 and 2003, and densities of the bêche-de-mer *Holothuria whitmaei* in the Reserve were higher than any reported in other areas in Australia. *H. atra* was also found in high densities.

The Solitary Islands: The corals within the marine park grow as a veneer on a rock basement, with negligible carbonate accumulation and no platform reef development. *Turbinaria* spp., tabulate and corymbose *Acropora* spp., *Pocillopora* spp. and *Goniastrea* spp. dominate the coral communities. Over 90 hard coral species have been recorded, but some of these are probably transient due to the influence of the East Australian Current and variable larval supply. The NSW Marine Parks Authority monitored 16 sites every 2 years since 2000 and mean coral cover varied between 24% and 58%, with most sites between 30% and 40% in 2002.

There were anecdotal reports of coral bleaching in 1998, but this was not measured. No bleaching was recorded in 2002 although there was major bleaching on the GBR, some 400 km to the north. Coral cover has decreased at some locations, apparently due to a 'white syndrome' coral disease, with *Turbinaria* spp. and tabulate *Acropora* spp. being most affected, resulting in mortality of about 10% of tagged colonies. COTS have been seen occasionally in the Solitary Islands Marine Park, but there are no reports of outbreak densities.

There is increasing pressure on the reefs in the Solitary Islands Marine Park, through spreading coastal urbanisation and increasing population growth, with parallel increases in recreational fishing pressure and the use of improved fishing technology. Catchment management and agricultural practices have improved over the past few decades in the very short catchments in this area.

Western Australia

There is increasing effort to manage coral reefs within a system of parks and reserves. The draft Ningaloo Reef Marine Park Management Plan (due for gazettal in late 2004 or early 2005) proposes to increase the proportion of the reef that is highly protected to 28%. Similarly, a management plan for the Houtman Abrolhos Island provides a blueprint for the future use of its valuable marine resources, especially a rich rock lobster fishery. The Ashmore Reef National Nature Reserve Management Plan (gazetted 2002), Cartier Island Marine Reserve (gazetted 2002) and the Mermaid Reef Marine National Nature Reserve management plan (gazetted in 2000), provide further safeguards to these remote reefs. While the area of reef under management continues to expand, the parallel effort of coral reef monitoring has not kept pace. The vast distances involved and remote and wild nature of reefs in WA is an obstacle to increasing monitoring effort, thus the monitoring effort does not match the programs on the GBR.

The status of WA reefs is variable, however the reefs are predominantly in good condition and are exposed to fewer local impacts than other reefs around the world. WA has a very long coastline and the inshore coastal areas north of Exmouth through to the Northern Territory contain vast areas of coral reefs and coral communities. There are comparatively few river systems draining into the reefs and minimal coastal development, thus declining water quality is rarely an issue. Recent impacts were mainly climatic, e.g. coral bleaching and cyclones. Reefs close to Indonesia (e.g. Scott and Ashmore Reefs) may suffer over-fishing, and ponding of coral spawn has caused coral mortality on Ningaloo Reefs. Future threats to coral reefs of WA include climate change and associated coral bleaching, and damage from cyclones.

Timor Sea Reefs: These include a number of emergent oceanic reefs (e.g. Ashmore and Cartier, Scott and Seringapatam and Rowley Shoals), which are well offshore on the margin of the continental shelf and receive insignificant terrestrial input. Ashmore, Seringapatam and Scott

Reefs were heavily damaged by the 1998 global bleaching event with major declines (up to 80%) in coral cover down to 30 m. Mass bleaching of corals at Ashmore Reef in 2003 resulted in a further 15% reduction in coral cover at some sites. There has been slow, gradual coral recovery on these reefs, with the exception of Scott Reef that was hit by the full impact of Cyclone Fay, a category 5 storm, in 2004. Approximately 90% of remaining corals on the exposed section of the reef died.

Historically, Indonesian fishers exploited bêche-de-mer, trochus and shark fins from Timor Sea reefs. The Ashmore Reef system was heavily fished because it is relatively close to Indonesia. The new management plan (2002) bans fishing within the reserve, which when combined with an increased level of compliance through enforcement, should ease pressures on the reef system. Further south, the Rowley Shoals have been protected from fishing since 1990. In 1995, Imperieuse Reef, the most southerly of the Rowley Shoals suffered significant cyclone damage (60% coral cover reduced to 10%), but there has been rapid recovery of coral cover with current levels returning to those before the cyclone. The reefs on the Rowley Shoals are apparently in good condition, and there have been no major recent disturbances.

Cocos (Keeling) and Christmas Island Reefs: Christmas Island is a volcanic island surrounded by a fringing reef, while Cocos (Keeling) Island is a true atoll. These islands are extremely isolated with small human populations. Cocos escaped the major 1998 bleaching event that affected much of the Indian Ocean, however the reefs were affected by bleaching in 1996. Coral communities of the island share a strong affinity with those of Western Australia, although there is a low number of endemic species. Substantial populations of both butterfly fish and sharks (black-tip, white-tip and grey reef) provide a good indication of a healthy fish fauna. Comparisons made between Cocos (Keeling) Islands and other Indo-Pacific atolls reinforce the notion that Cocos is one of the last pristine reefs in the world.

Dampier Archipelago and Monte Bello Islands: These reefs, like many reefs off Western Australia suffered from the effects of the 1998 bleaching event; there has been some recovery since. There is little evidence of human damage. CALM (Western Australian Department of Conservation and Land Management) has developed a conservation plan for the Montebello Islands and is developing a management plan for the Dampier Archipelago.

Ningaloo Reef: This is the longest fringing reef in the world (280 km), with coral cover varying widely along its length, although generally highest in the south. Bleaching, cyclones and *Drupella* spp. have caused some coral mortality in recent years. Decomposing coral spawn has caused coral death. There is minimal runoff from an arid coast and the reefs retain a capacity to recover. The Ningaloo Reef Marine Park is managed by CALM and is being re-zoned. There is a proposal to include 28% of the park (4000 km^2) as 'no-take' zones.

Houtman Abrolhos Islands: The most southern reefs in WA are characterised by a mixture of temperate and tropical fauna; for instance, there is a permanent colony of Australian Sea Lions. The reefs are managed by the Western Australian Department of Fisheries due to the economically important rock lobster (crayfish) industry, which has been recognised as a prime example of a sustainable fishery and a demonstration that science and management can work hand in hand. Coral cover varies, but can reach 100% in places. The reefs generally remain in excellent condition, but there has been no coral reef monitoring.

MASS CORAL MORTALITY INDUCED BY CORAL SPAWN ON NINGALOO REEF

Many coral species spawn simultaneously, within a few hours or a few days each year. This maximises the chance of fertilisation and also reduces the loss to consumers. However, the mass spawning event in April 2002 on the Ningaloo Reef resulted in major coral mortality around Coral Bay. The spawning coincided with calm seas and light on-shore winds, such that the floating slicks of eggs and spawn were not dispersed, but pushed onshore by the winds and currents. The concentrated slicks of spawn up to 2.5 km long rapidly depleted oxygen in the water due to their respiration and then decomposition of the larvae. This caused a mass mortality of corals, with a decrease in cover from 42.9% before the spawning to 9.4% afterwards. In some places, there was total mortality of the corals that had just spawned. The greatest mortality of up to 80% was in species of Acropora (branch and table forms) close to shore and 30% further offshore. The oxygen depletion also killed more than a million fish and many millions of invertebrates. There have been 3 similar incidences of coral mortality in the past 25 years, where the spawning corals resulted in the mass mortality of corals and other reef biota on the Ningaloo reefs. Tim Grubba, Jennie Cary and Ben Fitzpatrick. Western Australian Department of Conservation and Land Management, Ben Fitzpatrick benf@calm.wa.gov.au

Northern Territory

The reefs of the Northern Territory are poorly known, with only limited monitoring of reefs in 4 sites in the single marine park (the Cobourg Marine Park) since 2001 by staff of the Parks and Wildlife Commission. These reefs suffered substantial coral mortality (44-90%) due to bleaching in 2002.

Papua New Guinea

The reefs of PNG have a high conservation value due to high biodiversity and relatively pristine status, but this has not changed the way PNG reefs have been used by communities in the last decade. As most reefs are very close to shore, they are highly sensitive to changes in land management practices (mining, logging, plantations), and terrestrial influences have been responsible for the few major declines that have been documented in the last decade.

PNG has some of the lowest MPA coverage in the Asia-Pacific region. Protected areas with a marine component constitute slightly more than 0.1% of the PNG territorial waters. Many of these were declared in the colonial period before 1972, and with a few exceptions, such as Kamiali Wildlife Management Area, they have minimal or no management for conservation. The case of Bagiai Wildlife Management Area on Karkar Island in Madang province is typical; the community was generally unaware of the existence of this 13,670 ha protected area. Over the past decade efforts to assist communities declare new MPAs, and to improve management in existing ones, have been almost exclusively the initiatives of NGOs, with little assistance from government. Community based protected area legislation can be easily overridden by other development planning, penalties are limited, and there is more management focus on species, rather than on habitats or ameliorating stresses.

There has been an increase in reef research and monitoring recently, but this is from a low base due to a general lack of resources and capacity. Most of the effort is by NGOs supplementing the gap of local marine expertise. There have been few long-term studies in PNG; therefore there is little chance to make definitive statements on how the coral reefs have changed through time. Despite this, studies of coastal communities show extensive traditional knowledge and a high level awareness of the importance of conserving reef resources and managing them sustainably. This traditional knowledge is not well recognised by government, so appropriate management measures are not being adopted nationally. Capacity building to enhance the ability of local people to monitor and manage their own reef resources is critical. This is mainly the role of NGOs, in cooperation with local communities, and to a lesser extent the regional and national governments. There is a need for more logistic and financial resources to match the training and to guarantee the success of monitoring and management programs in the future.

With the exception of reefs in Kimbe Bay and Madang Lagoon, there have been virtually no long-term monitoring studies. There has been a noticeable change in fish communities on reefs around Madang and Lae, with a decline in top predators and a consistent increase in macro-algal cover over the last 8-9 years. Shark populations even on the remote unpopulated islands of Madang, have declined markedly due to unregulated long-line fishing and the growing market for shark fin. There is anecdotal information and NGO reports that show that the reefs continue to be generally healthy in the region with stable populations of corals and reef fishes. The impacts of bleaching appear to have been uneven, with some instances of high mortality, but most reefs remain unaffected. Human activities have caused minimal damage and coral cover remains at 40-50% on most reefs. Subsistence fishing is the predominant activity on PNG reefs, with the effort and level of destructive fishing practices much lower than that in countries to the north and west. For example, an eight year study on reefs within and outside the marine reserves in Kimbe Bay, PNG found that a massive decline in coral cover (due to macro-algae overgrowth) resulted in a decline of fish biodiversity with some local extinctions of rare coral fish specialists

The identifiable threats to PNG reefs include over-fishing (particularly invertebrates such as bêche-de-mer) around large coastal centres, mechanical damage from fishing nets and the collection of coral. Other threats are coral bleaching, outbreaks of coral predators such as COTS, the live reef fish trade, sedimentation from uncontrolled logging and mining and terrestrial runoff. Reefs in the region are rarely subject to tropical storm damage as they lie outside the cyclone and typhoon belts of the Western Pacific. As a result there has been little change in threats to the reefs of PNG over the last decade, however, as coastal populations grow there will be increasing exploitation pressures on these reefs. Thus the main threats to these reefs will continue to be over-fishing, harvesting of coral, pollution from runoff, sedimentation from clearing and mining, bleaching, disease and the effects of coral predators. For example, an 8 year study on reefs in and outside the marine reserves in Kimbe Bay, found that a massive decline in coral cover (due to macro-algal overgrowth) resulted in a decline of fish biodiversity with some local extinctions of some rare specialist fishes that depended corals.

Central and Milne Bay Province: Surveys by the Wildlife Conservation Society (WCS) near Tubuseria and Gaba Gaba Villages in the central province showed high fish diversity and a moderate hard coral cover below that in other parts of PNG. Villagers who were interviewed indicated that coastal resources have declined in the last 5 years and the trend is expected to

continue. There are relatively high fishing pressures on these reefs, which are largely uncontrolled even where recognised fishing rights tenure exists. Threats to reefs are also through mechanical damage from fishing and effluent from inadequate sewage treatment near villages.

Gold mining on Misima Island to the west resulted in widespread coral mortality on adjacent coral reefs due to the dumping of overburden from 1989-1994. These tailings were then diverted away from the mine through deep ocean outfalls, and mining ceased in 2001. Coral cover has shown a strong recovery after the sediment disturbance was removed, and a site restoration plan with revegetation is expected to result in more coral reef recovery.

Milne Bay is noted for extensive coral reefs characterised by a high coral cover and biodiversity. The reefs in the Bay have been damaged by runoff from extensive oil palm plantations, mining activity and logging. A MPA network is currently being designed for this area through the activities of Conservation International. The over-harvesting of sea cucumbers, giant clam and shellfish is a serious concern in Milne Bay Province. Rigorous stock assessments are necessary to assess the current status of these resources to develop appropriate management plans.

Madang Province: Systematic reef monitoring in Madang, began in 1995 as part of the Christensen Research Institute (CRI) program. After CRI closed in 1996 the Wetlands International-Oceania and local counterparts continued the monitoring as a focus of the Madang Locally Managed Marine Area (LMMA) network. This and the Kimbe Bay program are the only two long-term reef monitoring programs in PNG. In the Madang Lagoon, the reefs continue to have high diversity and abundance of fishes and corals. However, top-level predators are declining and macro-algae continue to increase, with corresponding declines in coral cover. However, the coral cover is still 35-40% on most reefs. The LMMAs in the Lagoon seem to be working to increase abundance and diversity of fishes; however, these fishes are mainly algae and plankton eating fishes. The protection does not appear to be reducing the growth of macro-algae. Reef assessment near Madang by the WCS has shown high fish diversity and corresponding high coral cover (35-40%) on all reefs surveyed. The biomass of fish was the highest recorded for any area, due to relatively low levels of net fishing and periodic closures of specific areas based on traditional practices.

Several LMMAs were established in the north of the province in the 1970s, without any monitoring. Permanent monitoring sites were established in 2 of these older LMMAs (Bagiai WMA, Karkar) and Crown Island WMA, which are in excellent condition despite an apparent lack of sharks. Wetlands International (WI) and the LMMA Network established permanent monitoring sites in Christmas Bay on Bagabag Island in 2000, and at other sites in 2004 as a component of the Madang LMMA Network. Since 2000, 3 additional LMMAs have been gazetted within Madang Lagoon and several others within the area are seeking assistance. The reefs are predominantly in good condition, although reefs in the Christmas Bay LMMA are showing signs of declining coral cover. The Madang LMMA Network continues to work on capacity building and the establishment of LMMAs.

New Britain (West and East Province): This includes the well-studied, highly biodiverse, region of Kimbe Bay. These reefs are some of the few in PNG that have a history of monitoring. There has been a dramatic decline in coral cover over the last decade, attributed to the combined effects of coral bleaching, COTS outbreaks and sedimentation from terrestrial runoff, logging

and expanding oil palm operations. Annual surveys between 1996 and 2003 (including 4 marine reserves established in 1999 and 4 areas open to fishing) documented a decline in coral cover from 66% in 1996 to a low of 7% in 2002. This decline has been matched by a corresponding decline in fish species diversity. The Nature Conservancy has assisted local communities to establish specific no-take areas to conserve marine resources.

The Rabaul Lagoon is also on New Britain and was the location of a massive and destructive volcanic explosion in 1994 that devastated a once vibrant coral community. These communities are starting to recover from that disturbance, although residual volcanic sediments and a shifting ash base are hampering recovery.

New Ireland Province: The reefs around Kavieng are in relatively good condition with high cover (40 to 50%) and diversity of corals. A survey by the WCS indicated a decline in the condition of both corals and reef fish stocks in recent years and they consider that the trend will continue. Unlike many coastal areas of PNG, the residents of Enuk and Kavieng are dependent on coral reef resources, and the level of fishing pressure in some areas is causing mechanical damage to corals. Increased sedimentation from the construction of an open cut gold mine on Lihir Island, beginning in 1995, was responsible for localised coral mortality on affected fringing reefs and was considered a threat to local coral reefs. Since this time Lihir Gold has taken steps to mitigate the effects of mining on local reefs by a variety of strategies, including disposal of mine waste at sea from barges and deep ocean outfalls. The mine has also been proactive in capacity building and employs members of the local community to conduct environmental monitoring.

Manus Province: Manus has the smallest land area and population of any province. Its people are fishers and subsistence farmers. Recent surveys by WCS show that, as in New Ireland, there is a strong dependence on marine resources governed by a complex system of marine tenure. As a result of this dependence, fishing pressure was relatively high causing some depletion in reef resources. Of particular concern was the high economic dependence on Andra Island on the production of lime, produced from branching *Acropora* spp. corals; these are now depleted in the harvesting areas. Coral cover is about 30%, and diversity is relatively low compared to other parts of PNG, however his may be because the surveys were conducted in the lagoons rather than the outer reefs.

Changes In Awareness Reef Conservation 1994-2004

Over the last decade, there has been a clear divergence in the way reefs have been managed in Australia and Papua New Guinea. There are increasing levels of management for reefs in Australian waters, whereas management controls for reefs in PNG waters remain limited. This is mainly due to a severely under resourced government structure in PNG, with little national leadership or political will for resource management and environmental conservation. PNG also lacks trained scientists and technicians, which perpetuates the low levels of coral reef monitoring and management. There is an urgent need to build capacity for coral reef conservation in PNG through training in baseline monitoring methods, such as Reef Check, and methods recommended by the GCRMN.

KIMBE BAY, WEST NEW BRITAIN, PAPUA NEW GUINEA

Kimbe Bay is a spectacular land and sea area on the northern coast of West New Britain, Papua New Guinea. Kimbe is a large bay (140 km by70 km), with several active volcanoes almost 2000 m dominating the coast. The Bay consists of a wide variety of shallow (coral reef, mangrove, and seagrass) and deepwater (oceanic, seamount, canyon and possibly deep hydrothermal vent) marine habitats in very close proximity. This combination is of high conservation value. For example, the coral reefs are considered part of the high diversity area known as the 'coral triangle' (the area encompassing the world's highest coral diversity that also includes Indonesia and the Philippines), and the deep oceanic waters are part of a globally significant area for toothed whales. Therefore, Kimbe Bay provides a unique opportunity to protect both shallow and deep-water marine habitats of high conservation value in one area.

The Nature Conservancy (TNC) has worked with the local communities and NGOs to facilitate marine conservation in the area for the last 10 years. This has included two Rapid Ecological Assessments (REAs) in 1994 and 2002, which have confirmed that the Bay has high biodiversity with more than 800 species of fish and 400 species of hard corals. The reefs in moderate to exposed locations (the eastern side and mid to outer parts of the western side) are in good condition, whereas there has been serious damage to the reefs in the more sheltered areas (particularly the southwestern corner) due to the combined effects of coral bleaching and sedimentation from poor land use practices. REAs have also demonstrated that Kimbe Bay is an area of high importance for cetaceans (whales and dolphins), because of the close proximity of the deepwater habitats to the nearshore environments, with 11 species confirmed in the Bay.

Mahonia Na Dari (a local NGO) and TNC have helped local communities create their first Locally Managed Marine Areas (LMMAs) and have supported long-term monitoring programs by scientists at James Cook University (Queensland, Australia) to monitor the success of the LMMAs. The LMMAs are starting to show some fisheries benefits for at least one target species. However, there has been serious damage in the southwest corner due to the combined effects of coral bleaching and poor land use practices. TNC and its partners are now working to establish a functionally connected network of Marine Protected Areas in Kimbe Bay based on Reef Resilience Principles (Box p106). From: Alison Green and Jeanine Almany, The Nature Conservancy.

In addition to the need for baseline monitoring, the best mechanism to conserve PNG reefs lies in reinforcing the strong traditional ownership of most regions, combined with the encouragement and support from major NGOs. The World Wide Fund for Nature, Conservation International, The Nature Conservancy, Wildlife Conservation Society, Wetlands International – Oceania, MacArthur Foundation and the Packard Foundation have all launched major projects to conserve reefs in PNG in recognition of their high biodiversity, low immediate threats, and potential for major threats in the future. These initiatives are based on strengthening community-based protection of local areas through consultation and assessment of the community's needs as well as a program of education; the Milne Bay, Madang Lagoon and Kimbe Bay projects are good examples of this approach.

TRADITIONAL MANAGEMENT IN PAPUA NEW GUINEA

An integrated socio-economic and ecological assessment of coastal communities and coral reefs was undertaken throughout PNG by the Wildlife Conservation Society, in order to: build the capacity of local scientists; identify threats to coral reef ecosystems; determine which management strategies were effective in achieving coral reef conservation; and determine socio-economic factors that influence the success or failure of these strategies. The major threats to coral reefs include destructive fishing, over-harvesting of invertebrates, and a lack of awareness in communities of their impacts on coral reefs. They studied several management regimes for effectiveness: i) national park systems; ii) community-based protected areas (created and/or managed with the input of outside experts); iii) traditional management systems (instigated and managed by the community as part of their culture); and iv) customary marine tenure regimes (where enforced ownership over the reefs existed but no other management regimes were present). They found that management appeared to be ineffective in improving the condition of reefs in the majority of sites over most of the variables of coral and fish diversity, coral cover and total fish abundance. There was little difference inside versus outside protected areas. However, two variables (fish biomass and average fish size) were higher inside 4 of the management sites; 3 of these 4 were traditional management regimes. However, none of these traditional management regimes included permanent reef closures. There were periodic closures, and one allowed line fishing inside the protected area throughout the year. Moreover, these communities did not obtain external assistance to either instigate or maintain these systems. The fourth site with better fish was a community-based protected area with a system of permanent reef closure; and there was significant external assistance to establish and maintain the management and run community awareness programs. One national park had marginal, but significantly greater, average fish size and hard coral cover in the protected area compared to outside.

Socio-economic data suggest that management success was due to the level of compliance; when there were high levels of acceptance and awareness, there was greater compliance and more effective conservation. The greater awareness and acceptance of the management probably resulted from the integration of the management within in the cultures and traditions of the community. Greater compliance was also probably influenced by the knowledge that the community would reap the benefits of management by being able to periodically fish these areas. This would not happen in systems with permanent closures. In many countries, permanently closed marine protected areas are the best way to conserve reef resources, however, in countries without resources to enforce management, the alternative traditional systems of management are a valuable alternative for conservation. Traditional management regimes show significant conservation benefits for coral reef fishes. From: Tim McClanahan, Wildlife Conservation Society, Kenya.

In contrast, Australia continues to enhance protection for coral reefs within its territorial waters. The National Oceans Policy includes strong commitments to protect marine biodiversity and is supported by financial and human resources to plan MPAs and provide considerable enforcement of legislation. The area of coral reefs under protection has increased recently and

CONSERVATION IN BIODIVERSITY RICH MILNE BAY, PNG

The Milne Bay Community Based Marine and Coastal Conservation Project was launched in 2002 by the United Nations Development Program (UNDP), Global Environment Facility (GEF), the Japanese Human Development Trust Fund, Conservation International and the Government of Papua New Guinea. The Project focuses on the conservation and sustainable use of marine resources in Milne Bay Province, the southeast corner of the main island. Central to the project is the creation of a community-managed MPA system to protect important marine ecosystems, preserve biodiversity, and protect commercially valuable species. The partnership of national, provincial and local-level governments, and CI-Melanesia works with local communities to promote the sustainable use of marine resources, improve community health, enhance livelihoods, and alleviate poverty within the province. The anticipated outcomes of the project are:

- A representative network of community-based marine conservation and sustainable near-shore resource management areas across the Province;
- Improved management regimes in large areas of the coral reefs and fishing grounds within the three-mile zone;
- New policies and a legislative framework on environment and resource management;
- Creation of environmental education programs and conservation awareness campaigns targeting students in formal and informal settings; and
- Conservation objectives overlaid onto land use strategies on densely populated small islands.

From: Peter Mackay, p.mackay@conservation.org and Bena Seta, b.seta@conservation.org

the human pressures that damage reefs are being addressed (Box p 13). Although there is still concern about the effects of terrestrial runoff, over-fishing and continuing COTS outbreaks, the major specific threats to the GBR and other Australian reefs are from global climate change, with rises in sea surface temperatures and concentrations of dissolved carbon dioxide, and more frequent and intense cyclones.

Legislation and Regulation

While there are adequate laws and legislation to conserve and manage natural resources in PNG, most of these do not specifically recognise traditional rights, are not specific for coral reefs, and are spread across different sectors (e.g. fisheries, mining, environmental protection). This leads to confusion over priority of laws and responsibility for management, and causes inter-sectoral disputes. The Government has minimal will or capacity to enforce laws, quotas or regulations. Local communities often assume the role of enforcing fisheries and MPA regulations. Initial results from a review of PNG's protected areas show that MPAs are not generally managed for conservation objectives, and that support from government is largely non-existent. A national surveillance strategy has also been suggested, which would involve all sectors, but the most effective enforcement would appear to be through local communities and by the expansion of community based management programs. Revisions of the protected area policy and legislation are being explored to strengthen formal protection provided by MPAs and to enhance community leadership

There are laws and legislation specifically aimed at managing coral reefs in Australia. A single organisation has the authority to manage the GBR, the GBR Marine Park Authority, in association with the Queensland State Government (reviewed in previous Status reports). Similar laws are being enacted to manage the reefs off Western Australia. Fisheries are managed by both national and state/territory governments, with the latter being responsible out to 3 nautical mile limit, and the former managing fisheries beyond that to 200 nm (EEZ). There are several examples of commercial fisheries that are managed to achieve sustainability e.g. the Western Rock Lobster fishery on coral and rocky reefs of Western Australia, and the Gulf of Carpentaria prawn fishery, but most others are showing clear signs of over-fishing with stock sizes and populations decreasing. This is leading to increases in government regulations for both commercial and recreational fishers, through input controls limiting the number of vessels, the time and place of fishing, bag/size limits and the permissible type of gear. A major focus of management of the GBR has been to reduce the damage done by bottom trawling in inter-reef waters, as evidence of damage to the environment became available. A mechanism for sustainable management has been implemented to increase protection for all habitats, other than just the coral reefs, within the GBR World Heritage Area, through the new zoning system which provides critical protection to defined bioregions (Box p 307). There are also specific laws to protect endangered species and to limit unintended marine catch, as well as to reduce the line fishing effort. The developing trade in live reef fish for the Chinese restaurant market, principally in Hong Kong, is coming under more strict regulations to ensure sustainability.

Status of Reefs in the Past and Predictions for the Future

100 Years Ago: Australia was an independent nation and commercial extractive industries based on reef resources were well established. These were focused on 5 major products: bêche-de-mer; turtle shell; turtle meat; pearls; and pearl shell. Governments had made attempts to legislate for the sustainable economic use of resources (particularly the pearling industry), however these were nearly impossible to police. The start of the 20th century saw the realisation that reefs were not just navigational hazards and resources to be mined, but unique natural assets to be respected and conserved. Much of land in the coastal catchments adjacent to the GBR had been cleared for development, thus many reefs were already under pressure from sediment and nutrient runoff. The level of exposure was generally lower and the coral reefs were presumably in a similar or better condition to what they are now. Reefs in Western Australia and the Northern Territory were largely untouched except for some resource exploitation, and there was almost no development on lands adjacent to the reefs.

PNG was under colonial administration (first Britain, then Germany, and Australia from 1906 to 1972). Commercial exploitation of PNG natural resources and the beginnings of a cash economy had just started, with the harvesting of timber, copra and bêche-de-mer for international markets. Local communities remained isolated and there was no sense of a national PNG identity. Unwritten customary laws and practices administered by the leaders of various tribes, governed ownership and use of reef resources. While very little is known about the condition of coral reefs 100 years ago, it is assumed that they were in relatively pristine condition, with large populations of fishes and invertebrates.

In 1994: The condition of reefs in Australian waters in 1994 was similar to these reefs today. Comprehensive management plans existed for many areas and there were few immediate or major threats. The reefs were in relatively good condition, with the major concerns being

focused on specific issues on specific reefs. Reefs on the GBR were recovering from the impact of a major COTS outbreak (1979-1991) that had caused widespread coral mortality, particularly in the central section. These COTS outbreaks were considered to be the major management problem for the GBR. However, many areas had remained unaffected, despite the massive size of the outbreak elsewhere. The large bleaching event 1982 was regarded as an isolated event, and the GBR appeared to be undergoing continued growth and renewal. Similarly in Western Australia, reefs had been damaged by predator outbreaks during the 1980s (*Drupella* spp. at Ningaloo Reef) while small populations of COTS had caused isolated damage in the Dampier Archipelago. There was ongoing exploitation of Timor Sea reefs by Indonesian fisherman, which was causing concern. However, the reefs appeared to be in good condition with high coral cover and apparently few immediate threats.

Coral reefs in PNG still remained poorly studied 10 years ago. Little had changed on these reefs and the nearby lands over the century, with the primary human use remaining subsistence and artisanal fishing. Formal planning of MPAs was rudimentary. Fisheries resources were under-utilised on a national scale, although some over-fishing had occurred in areas adjacent to cash markets. Reefs faced threats from sedimentation due to forestry and the clearing of mangroves, agriculture and mining. In some areas, bomb fishing was also a problem, along with pollution from urban areas. Despite these stresses, the reefs remained relatively undisturbed and predominantly pristine.

In 2004: Vigilance has become a key issue, as new and emerging threats to the long-term health of coral reefs in the region became apparent. In some areas, a combination of pressures has resulted in massive declines in coral cover on many reefs, including some in Australia. Raised sea surface temperatures from global warming resulted in increases in the frequency of coral bleaching, with mass bleaching events on the GBR and other reefs of Australia in 1998 and 2002. Bleaching emerged as the number one threat to coral reefs in the region. The bleaching coincided with a new outbreak of COTS on the GBR, with accelerated coral loss. Impacts of cyclones were a factor on many reefs recently in Australia, and the threat of increases in coral diseases was recognised; disease was a relatively minor issue in 1994. Management of reefs is focused on the direct threats of water quality and over-exploitation, and the indirect global threats highlighted in Chapter 1. Nevertheless, Australian coral reefs are generally in a relatively good state, although some reefs, especially those close to land are degraded. Monitoring data is now available to inform managers that the reefs have strong recovery potential, provided there is enough time between disturbance events. The key issue remains the intensity and frequency of the disturbance events. Management authorities are implementing stronger zoning plans for many reefs in the Australian region to strengthen reef protection.

Reef resources in PNG also remain in good condition, but face similar threats to those of Australian reefs. Global warming is the major threat, but there are also threats from growing coastal populations, increased urbanisation and corresponding increased pressures on reef resources. Logging, clearing of mangroves and mining pose threats to the integrity of coral reefs in PNG. Increased recognition of the importance of the reefs of PNG has stimulated major efforts by NGOs to assist in capacity building to manage reef resources in a sustainable manner, however there is little baseline information on the reefs and many have not been assessed. The partnership between NGOs and the Government is facilitating the establishment of Locally Managed Marine Areas to provide vital sanctuary zones for large reef areas.

REZONING OF THE GREAT BARRIER REEF AND 31,000 SUBMISSIONS

The recent rezoning of the Great Barrier Reef (GBR) was a huge and complex task, and included a requirement to process 31,000 public submissions. The task, however, was not without some humour during community consultation. Deliberately no maps of possible new no-take zones (known as green zones) were made available as part of the first public consultation. A common reaction was often; *"Just show us your maps of proposed Green zones... you bureaucrats MUST know where you want them."* In reality the GBR Marine Park Authority (GBRMPA) had no preconceived ideas about the location or size of green zones, but had stated a number of zoning principles for the Draft Zoning Plan including:

- ensure representation of all 70 bioregions in no-take zones (Box p 13);
- use all the 'operating principles' for guidance in planning (include a minimum of 20% no-take per bioregion); and
- consider all public submissions when developing the Draft Zoning Plan.

Over 10,000 public submissions were received in the first consultative phase. Many stated, "No more green zones", but also contained useful information that assisted in the planning process. When the Draft Zoning Plan was released for public comment, there was an immediate outcry from some fishers who realised the proposed extent of no-take zones (an increase from 5% of the existing Marine Park to 30% in the Draft Plan). A common claim at public meetings and protest rallies was *"You put one of your zones over my special fishing spot!"* but they also admitted they had not put in a submission, fearing that their 'special fishing spot' would be zoned as a green zone. Of course the reef managers were unaware of every special fishing spot, and their intention was to develop the most acceptable Draft Zoning Plan and not antagonise fishers unnecessarily. The prime concern was to meet biodiversity principles and minimise impacts as far as possible.

Accepting that GBRMPA needed to know about important fishing areas in order to revise the Draft Zoning Plan, over 21,300 public submissions were received in the second round. Every submission was logged into a computer database, spatial submissions were entered in a Geographical Information System and all recommendations considered. This was a transparent process and critics were able to see just how their submission was processed. It was also probably the largest public input into any coral reef planning task. Gradually there was a change in public understanding about the 70 bioregions and the need for biodiversity conservation. Initially there was some confusion between the various protection zones and bioregions, but GBRMPA undertook a huge public education program on the bioregions, including brochures, and detailed briefings with explanations about the importance of bioregions. Public understanding increased enormously, and the term 'bioregion' became widely known and understood as the basis for planning. For example, the two old fishermen were overheard in a bar arguing about a proposed 'green zone'; *"Ya can't put it over there, mate, 'cos that's the wrong F*#*#* bioregion!"* From: Jon Day, Great Barrier Reef Marine Park Authority

THE MANY VALUES OF SUSTAINABLE DIVE TOURISM

A study on the Great Barrier Reef and Coral Sea has asked scuba divers what attracts them to coral reefs, and what they value most about their diving experience. This information will assist coral reef managers in determining the relative values of ecotourism, compared to extractive uses such as fishing, shark finning, live-fish and aquarium trades in coral reef areas that are potentially high value dive sites. From preliminary results it appears that scuba divers visiting the Great Barrier Reef and Coral Sea dive sites most value :

- megafauna, especially sharks, manta rays and turtles;
- diverse, colourful, and healthy corals as the backdrop to the coral reef scene;
- large fish such as grouper, mackerel and tuna;
- the overall quality of the site and the diversity of marine life;
- good water quality and visibility; and
- a large diversity and abundance of colourful and active fish life, like schools of fusiliers, anthias, and snapper.

Scuba diving is a rapidly growing component of international tourism, and is recognised as an industry of great importance for communities reliant on coral reef. It is non-extractive and causes minimal damage as compared to collecting, destructive fishing and coastal development. Dive tourism, if managed well, is a more sustainable option than virtually all other commercial activities. The key is to maintain the environmental quality and conditions that the diver seeks and the industry can market. If some of the key features in the list above are lost or degraded, there can be a drop in visitor numbers and reduced income. Moreover, conflicts will arise between the users of coral reef resources; especially between those removing the features that divers pay to see. Even a sustainable harvest regime will result in the loss of the larger predators, which are near the top of diver's preferences.

Dive tourism can assist in the conservation of coral reefs through increased public awareness, while providing essential incomes to local communities. It makes little sense to deplete a population of sharks in an area by fishing, when they are of high economic value to the dive tourism industry as living animals. Yet sharks are being continually depleted from coral reefs around the world. Divers will travel large distances and pay high prices to see pristine environments, especially when there are sharks, manta rays and turtles. Maintaining diversity and ecological integrity is essential, not only for the sustainability of coral reef ecosystems, but also for the growing dive tourism industry. From: Dean Miller, James Cook University, Townsville, dean.miller@jcu.edu.au.

Predictions for 2014: The prognosis for the reefs of Australia and PNG over the next decade is good. This is provided that the strengthening of management plans continues and there is ongoing support for monitoring programs to judge the performance of these plans. This is a critical issue for PNG where it is essential that capacity building be implemented to provide the expertise for reef resource management. There is a clear understanding by governments and stakeholders throughout the region of the value of conserving coral reef resources. This is stronger in Australia than PNG, but is developing there. This is reflected in continued efforts

to conserve reefs and protect them from extractive industries and other human pressures in a bid to enhance their resilience. There is also clear recognition that direct human pressures are probably the major cause of damage to the environment that can be managed. Such human pressures can rapidly degrade or destroy the coral reefs, often through ignorance. The current strategy for Australian reefs is to minimise direct human threats of poor catchment management delivering poor water quality and over-exploitation of fisheries resources and associated fishing damage to the reefs, so that natural reef resilience is enhanced to cope with the pressures from global climate change and plagues of predators. It is predicted that reefs will recover from periodic stresses, provided that chronic disturbances are reduced. Monitoring is an essential component of an early detection system to enable managers to adjust acceptable use levels. Effective monitoring and management is in place in Australia and is needed in PNG to ensure an optimistic outlook for the future. PNG in particular needs to develop a coherent framework for supporting and providing legislative protection for community based MPAs. Thus the outlook for Australian reefs is good, whereas the optimism is more guarded for PNG.

However there is one major caveat. The threat of warming seas from global climate change is the major threat facing coral reefs. There is considerable current research in Australia on the threats posed by global climate change, and more needs to be done to determine whether corals will adapt to new temperature regimes. In the worst-case scenario, it is conceivable that some coral reefs will suffer major reversals over next decade, which will be exacerbated as many of these reefs are currently recovering from previous disturbances.

Recommendations

The future for the reefs of Australia and PNG remains relatively bright. Except for the unknown extent of the effects of global climate change, the essential conservation values of these reefs may be reasonably expected to persist. This depends on successful mitigation of the effects of terrestrial runoff and reduction in fishing pressure (particularly on parts of the GBR). Already steps are being taken to address these issues and enhance the ability of reefs to withstand the threat of climate change.

The greatest immediate threat remains for the biodiverse reefs in PNG where there are very limited human, financial and logistic resources and political will to combat the problems. Unless there is strong support for the following recommendations by the international community, there is a strong likelihood that there will be widespread degradation of many more reefs over the next decade. The threat of permanent degradation will spiral unless the increased pressures on coastal reef resources, due to economic development and growing populations in coastal areas, are ameliorated. The threats will most likely be evident as a loss of biodiversity and declining harvests, resulting from increased fishing pressure (for instance bomb fishing is apparently increasing in PNG, as is the illegal capture of live fish for markets in Hong Kong). Pollution from sewage, runoff from uncontrolled forestry and agriculture, coral mining, industrial pollution, mine waste, land reclamation, ship groundings and oil pollution are all increasing.

Papua New Guinea

- Current strategies to build scientific and management capacity for coral reefs in PNG need to be enhanced. Incentives (such as long-term employment) are required to retain the current capacity for assessment, monitoring and to support the training of future marine scientists and managers.
- Greater transparency, consultation and integration are needed between environmental planning, community aspirations and any economic developments that threaten reefs. Effective management of urban development, watershed degradation and large-scale commercial activities and their impacts on adjacent coral reef resources requires much greater capacity in provincial and national government agencies.
- Monitoring initiatives need to be supported and developed to provide an effective and ongoing assessment of reef health. An integrated monitoring program involving the University of PNG, relevant NGOs, PNG Divers Association and the Office of Environment and Conservation could provide an effective monitoring network with links to management agencies.
- Monitoring is urgently needed in areas likely to come under stress from coastal development, commercial agriculture, especially oil palm plantations, and other terrestrial activities. Support is needed for diver and technical skills training, routine monitoring trips, quality control, data assessment and dissemination.
- High quality mapping of PNG reef resources, combined in Geographic Information Systems, are important for conservation initiatives and appropriate management of coral reef and associated fisheries resources. Continued support for biodiversity assessments conducted by appropriate experts and basic biological and ecological research is important for the long-term sustainability of coral reefs of PNG.
- Community-based programs should be extended and enhanced within a network of MPAs and LMMAs. Addressing the needs of local communities and integrating them in the development, management and enforcement of protected areas is likely to yield success. Continued community support and recognition of appropriate traditional management systems is important for the success of MPAs and LMMAs.
- A policy framework that supports community managed MPAs needs to be developed. This should recognise the ability of NGOs, in particular, to support communities in the protection of reefs. Revision of the protected area legislation is urgently needed to establish MPAs as habitat protection mechanisms and to strengthen penalties.
- Effective methods of enforcing fisheries regulations are urgently needed. This is particularly important for any re-introduction of the live reef-fish trade. Community education and alternative income programs can help reduce destructive fishing practices. Increased commitment is also needed at provincial and national levels.
- Continued collaboration is needed with the National Fisheries Authority on rigorous stock assessments of commercially harvested species and to influence the formulation of species management plans e.g. Milne Bay.

Australia

- Most Australian reefs are well protected against most anthropogenic pressures, both by law and by capacity to enforce those regulations. This situation needs to be maintained.

- The development of networks of highly protected areas that preserve biodiversity will increase the resilience of reefs to cope with increasing pressures from factors such as climate change.
- There are growing numbers of reefs under management plans, thus the implementation and maintenance of effective monitoring is essential to assess the effectiveness of these plans in an environment of changing human pressures and climate change.
- The long-term effects of chronic pollution from river runoff and coastal activities are difficult to detect. However, it is clear that declining water quality constitutes a major threat to the GBR and the Reef Water Quality Protection Plan has been developed to address this issue. This needs to continue and be strengthened.
- Chronic fishing pressures, both commercial and recreational, have the potential to alter the fish populations on coral reefs by selectively targeting key predator species, such as groupers and snappers. Such changes may have follow-on ecological impacts, and conflict with the values placed on such fishes by international tourists. Management attention is required to ensure the sustainability of Australia's coral reef fisheries resources, and balance their use by different stakeholders.
- The GBR is relatively well studied. The major pressures identified are fishing (trawling and line fishing), climate change and declining water quality, due to the development of agriculture in the catchments of rivers that flow into GBR waters. The major research programs investigating these impacts and coordinated by the Cooperative Research Centre for the GBR require ongoing sustainable funding as political and societal environments change. There are strong links between research and management that need to be maintained and included in future management plans.

Reviewers

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Supporting Documents

Useful web addresses for further information: www.environment.gov.au - Environment Australia; www.gbrmpa.gov.au - Great Barrier Reef Marine Park Authority; www.aims.gov.au - Australian Institute of Marine Science; www.calm.gov.au - Western Australian Department of Conservation and Land Management; www.mpa.nsw.gov.au - New South Wales Marine Parks Authority; www.wcs.org - Wildlife Conservation Society.

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WHS

THE GREAT BARRIER REEF, AUSTRALIA - WORLD HERITAGE SITE

The Great Barrier Reef World Heritage Site (GBRWHS) is the largest world heritage area and marine protected area on the globe, and also the world's most extensive stretch of coral reefs. It covers 34,870,000 ha and extends more than 2,000 km along the east coast of Australia, from south of the Tropic of Capricorn to north to the tip of Cape York. It extends from a low water mark on the mainland coast to the outer (seaward) boundary of the GBR Marine Park beyond the edge of the continental shelf. The GBRWHS includes more than 2,900 coral reefs, 300 coral islands and 600 continental islands. The GBR Marine Park comprises 99 per cent of the GBRWHS, the balance being the majority of islands, as well as exclusions for port areas and internal waters of Queensland.

The GBRWHS is a critical global resource, and was inscribed on the World Heritage list in 1981 as one of few sites satisfying all 4 World Heritage criteria for natural heritage; namely:

- an outstanding example representing a major stage of the earth's evolutionary history;
- an outstanding example representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment;
- containing unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty; and
- providing habitats where populations of rare and endangered species of plants and animals still survive.

These criteria for natural heritage have since been amended (refer to the UNESCO World Heritage website). The GBRWHS would also satisfy criteria for cultural heritage listing, although these criteria were not included in the 1981 listing.

The GBRWHS contains many rare and threatened species e.g. endemics, and species that may not have viable populations elsewhere in the world. The species list includes: 1,500 fishes; 400 corals; up to 8,000 molluscs; 242 birds; and a large diversity of sponges, anemones, marine worms and crustaceans. The GBRWHS contains 15% of Australia's dugong population, as well as cetaceans (humpback, minke, and killer whales; bottlenose, Irrawaddy and Indo-Pacific humpback dolphins). The site contains 6 of the world's 7 species of marine turtle, and major nesting areas for green turtle and loggerhead .

The Australian (Federal) Government coordinates management of the GBRWHS, and reports periodically to the World Heritage Committee (www.gbrmpa.gov.au/corp_site/key_issues/conservation/docs/gbr_wh_part_ii.pdf).

The Great Barrier Reef Marine Park Authority (GBRMPA) is the Commonwealth agency responsible for the overall planning and management of the Marine Park. GBRMPA has created a management framework that allows reasonable human use alongside

conservation measures. However, the increasing use and development of or by the Marine Park and World Heritage Site remains a concern. Key issues are the management of commercial and recreational fishing, shipping, urban growth, coastal development, increasing tourism and recreation, and the downstream effects of land use. These cumulative impacts place critical pressures on the World Heritage Site and require significant management inputs. The Marine Park was recently rezoned (Box p 13 and p 307) and now more than 33% is protected in 'no-take' zones, with 'representative' examples of all broad-scale habitat types (or bioregions) being highly protected.

Ecological monitoring: Research on the GBR started with the Great Barrier Reef Committee (now Australian Coral Reef Society) in 1922 and the British Great Barrier Reef Expedition to the Low Isles in 1928-29. Research became more necessary after the GBR was included as a World Heritage Site, after coral bleaching events and COTS outbreaks, and with intensifying human demands on the resources. The Cooperative Research Centre for the Great Barrier Reef World Heritage Site (CRC Reef), James Cook University and the Australian Institute of Marine Science (AIMS) have extensive coral reef research and monitoring programs covering many scientific disciplines and parameters. The AIMS Long-term Monitoring Program on the GBR has been in operation since 1992 and 48 'core' reefs across the continental shelf and along the length of the GBR are monitored for benthic organisms and 191 fish species each year. The whole perimeter of these reefs and 50 others are surveyed to record COTS densities and reef-wide coral cover. There are also many specific research and monitoring programs by government agencies, research institutes, universities and industry groups, which take place in, or are directly relevant to, the GBRWHS.

Socio-economic monitoring: Social and economic data on communities and industries in or adjacent to the GBRWHS are collected by various government agencies. The CRC Reef, the GBRMPA and various academic institutions also conduct targeted social and economic research programs.

Monitoring effectiveness: The GBRMPA relies heavily on monitoring data for management decisions. The CRC Reef is the primary research coordinator and facilitates a large-scale, coordinated, multidisciplinary research program. GBRMPA also uses data generated from research programs conducted by universities, independent consultants and other government agencies.

Contact: Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, QLD 4810. (phone: 61 7 4750 0700, fax: 61 7 4772 6093, email: registry@gbrmpa.gov.au) (http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/world_heritage.html).

Coral reefs comprise only **6%** of the GBRWHS, yet are a critical component of the natural resources requiring a considerably greater level of management input.
Ecological Monitoring is **substantial.**
Socio-economic Monitoring is **effective.**

WHS

LORD HOWE ISLAND MARINE PARK, AUSTRALIA - WORLD HERITAGE SITE

Lord Howe Island is an isolated oceanic island 700km northeast of Sydney in the South Pacific Ocean. The entire island region of 350,000 hectares, including Lord Howe Island, Admiralty Islands, Mutton Bird Islands, Balls Pyramid and associated coral reefs and marine areas, was inscribed on the World Heritage List in 1982. There is currently a resident population of 320 people on the island. Tourism is the major component of the island economy and about 300 to 400 tourists may be present simultaneously during the summer. Walking, nature study, bird watching or photography, are the major recreation activities, with the coral reefs attracting many scuba divers and snorkellers. Lord Howe Island has attracted considerable scientific interest ever since its 'discovery' and a succession of scientific expeditions in the 19th century quickly established its unique natural history.

Complementary to its status as a World Heritage Area, it is also a Marine Park that consists of State and Commonwealth waters. The management plan for the Commonwealth component of the Park came into effect in September 2002 and designates 30% as a no-take area. There is no commercial fishing in the parks and limited recreational charter fishing operations. The strategic objectives of the Lord Howe Island Marine Park focus on conserving marine biological diversity and habitats, maintaining ecological processes, providing for ecologically sustainable use of fauna and flora, and providing opportunities for public appreciation and understanding.

Ecological Monitoring: Because of the remoteness of the island, research and monitoring programs are generally small-scale, conducted in collaboration with visitors, or conducted by external agencies. Most of the area is not extensively studied, other than bathymetric mapping and near shore species inventory. Previous research has focused on taxonomy rather than distribution patterns, seasonal change, or ecosystem function. Monitoring of total catch records is being undertaken. Most other monitoring programs (water quality, exotic species, habitat condition, population desities and distribution of selected sessile invertebrates) are at the baseline establishment stage.

Socio-economic Monitoring: No socioeconomic monitoring is planned at this stage.

Contact: Lord Howe Island Marine Park (phone: 02 6563 2359, fax: 6563 2367)

Coral reefs are **1%** of the natural resources.
Ecological Monitoring is **planned.**
Socio-economic Monitoring: is **not planned**

RAMSAR

COBOURG PENINSULA, AUSTRALIA – RAMSAR SITE

The site is located in the Northern Territory, 163 km northeast of the city of Darwin. Cobourg Peninsula covers 220,700 hectares and supports a number of threatened animal species including dugongs and marine turtles. The site is a marine and coastal wetland, which covers most of Cobourg Peninsula to low water mark and includes an extensive intertidal area. The peninsula is predominantly unmodified with numerous extensive tidal flats, estuaries, mangroves, and fringing and rocky coral reefs.

Almost the entire peninsula is Aboriginal land declared as a Sanctuary and managed as a National Park. The majority of Cobourg Peninsula is freehold Aboriginal Land and this abuts the Arnhem Land Aboriginal Reserve. The management authority of the National Park is the Conservation Commission of the Northern Territory, which acts on behalf of and subject to the traditional Aboriginal owners. The National Park has important social and cultural values as ceremonial life and semi-traditional hunting and gathering are still important to the local culture.

Cobourg Peninsula was the first site designated under the Ramsar Convention. A management plan has been implemented that places restrictions on local human activities and development. Visitors to the National Park require a permit, with permit numbers being limited. The sea surrounding the Peninsula has been declared the Cobourg Marine Park and a management plan is being prepared. Cobourg Peninsula is a destination for tourists seeking a remote wilderness experience. Due to the remoteness and limits on visitor numbers the educational potential of Cobourg Peninsula is small; however, there is a visitor information centre.

Existing uses of the Marine Park include traditional Aboriginal hunting, conservation, commercial fishing, pearl culturing and recreation. Studies on coastal, intertidal and subtidal habitats were conducted in 1998. There are negative effects on the marine park from a tourist resort and from feral animals (pigs, water buffaloes, cattle and deer). The traditional owners believe that dugong numbers are decreasing in some areas because of the effects of prawn trawlers working in the area.

Ecological Monitoring: No information provided.

Socio-economic Monitoring: No information provided.

Contact: Conservation Commission of the Northern Territory, P.O. Box 496, Palmerston NT 0831. Phone: (089) 894411; Fax: (089) 323849.

Coral reefs are **10%** of the natural resources.
Ecological Monitoring is **planned.**
Socio-economic Monitoring: is **unknown.**

RAMSAR

PULU KEELING NATIONAL PARK, AUSTRALIA – RAMSAR SITE

Pulu Keeling National Park was proclaimed in 1995 and is Australia's smallest Commonwealth National Park, covering 2600 hectares. The park is part of the Cocos (Keeling) Islands, located in the Indian Ocean approximately 2,950 km northwest of Perth, comprising 27 coral islands which form 2 atolls. Over 520 species of fish and almost 100 coral species have been recorded from the islands. Corals of the southern atoll have received considerable attention, partly because the atoll was the only one visited by Charles Darwin and partly because of the intrinsic interest in the atoll's geographic isolation. Many common and widespread Indo-Pacific taxa have not been recorded and are almost certainly absent. Pulu Keeling represents an island atoll in its most natural state. It supports globally threatened turtle species and acts as an internationally significant seabird rookery. In recent times periodical large-scale natural disturbances including outbreaks of Crown-of-thorns starfish, cyclones and deoxygenation of lagoon waters tentatively linked to El Niño events have reduced the abundance of corals.

The Director of National Parks, assisted by Parks Australia within the Australian Department of Environment and Heritage is responsible under the Environmental Protection and Biodiversity Act 1999 for managing the Park in accordance with the Management Plan. The Cocos community is involved closely in the management of the Park through their representation on the Pulu Keeling National Park Community Management Committee. This Committee has 10 members, with 6 representing the Cocos Malay community, the Director of National Parks, and 3 people from West Island. For the next 7 years Pulu Keeling National Park will be managed to preserve its flora, fauna and marine environment, whilst providing controlled visitor access. Although tourism infrastructure may develop on the southern atoll outside the National Park, the Management Plan will ensure that the Park's pristine condition is maintained. The council hopes to develop tourism as an essential part of the islands economy.

Ecological Monitoring: An annual long-term Reef Check and turtle monitoring program by Parks Australia staff and researchers from James Cook University are adding to knowledge of the marine fauna. Long-term monitoring is required to determine the effects of natural disturbances, such as cyclones, outbreaks of crown-of-thorns starfish or El Niño events, and to measure any changes caused by the potential increase in tourism.

Socio-economic Monitoring: A program to monitor the reefs and conduct surveys of the effects of Park visitors and assess the levels of harvesting is planned.

Contact: Government Conservator PO Box 1043 Cocos (Keeling) Islands Indian Ocean 6799 (phone: 08 9162 6678, http://www.deh.gov.au/parks/cocos/index.html)

Coral Reefs are **20%** of the natural resources.
Ecological monitoring is **effective.**
Socio-economic monitoring is **planned.**

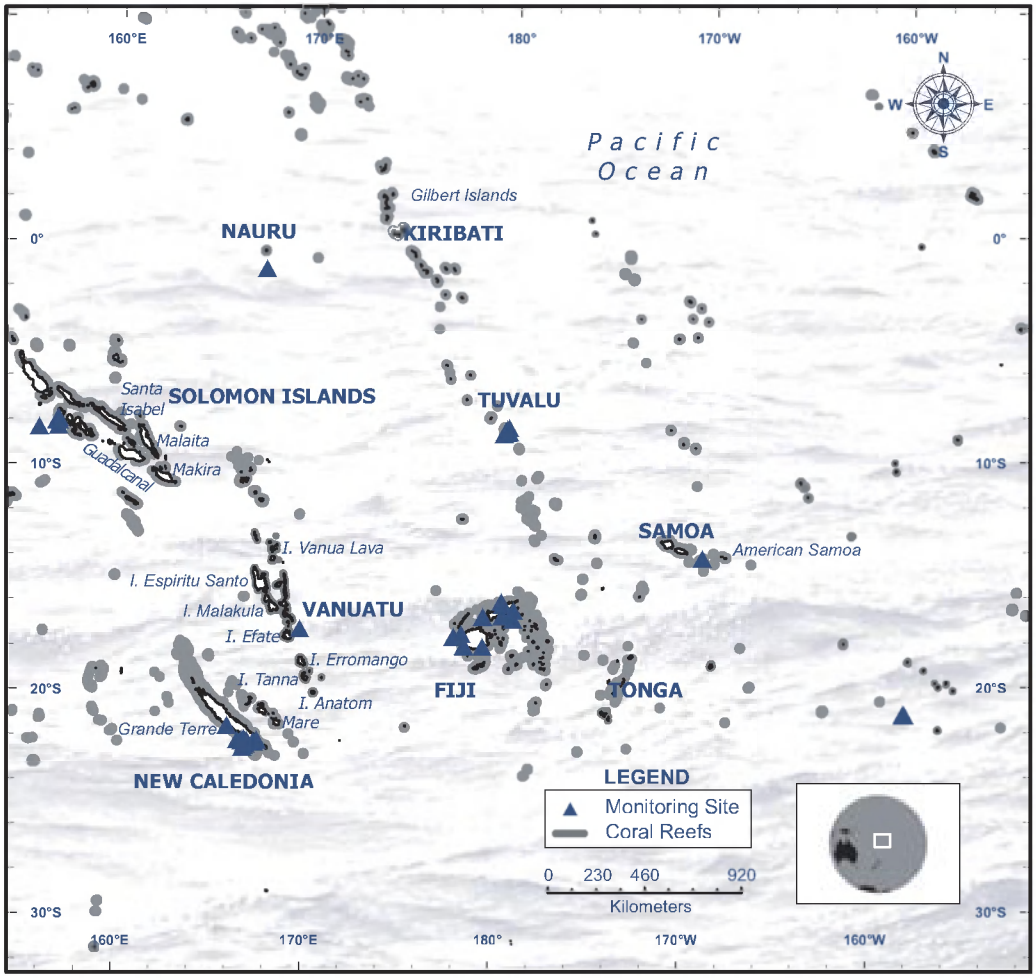
12. Status of Coral Reefs in the South West Pacific: Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu

Edward Lovell, Helen Sykes, Margo Deiye, Laurent Wantiez, Claire Garrigue, Sabrina Virly, Joyce Samuelu, Anama Solofa, Tupulanga Poulasi, Kalo Pakoa, Armagan Sabetian, Daniel Afzal, Alec Hughes and Reuben Sulu

Abstract

Coral reefs in the Southwest Pacific are generally in good condition. There was extensive coral bleaching during 2000-2002. Since then coral reefs have shown highly variable recovery with some reefs recovering fully to pre-bleaching levels of live coral cover, whereas others have shown virtually no recovery. Nauru experienced coral bleaching and mass fish kills in October-December 2003, possibly due to unusually high sea surface temperatures. The greatest threats to coral reefs of the region continue to be human activities and cyclones, with reefs of New Caledonia, Samoa, Solomon Islands and Vanuatu having been damaged by cyclones since the 2002 status report. Cyclone Erica in 2003 destroyed 10-80% of live coral cover on New Caledonia. Cyclone Heta struck Samoa in 2004, damaging 13% of the coral reefs, and in mid-2004 an unprecedented number of seabirds were found dead on Nauru; the cause is unknown. The momentum in the protection and conservation of coral reefs in the region has been boosted by increased participation of governments, NGOs, scientists, volunteers and local communities, especially in the implementation of resource management strategies to mitigate human pressure. A series of damaging bleaching, crown-of-thorns starfish, disease and cyclone events in the past 10 years has generated a greater awareness of the need to conserve coral reefs. The SW Pacific Node has established an important network and conducted training, which will contribute greatly to coral reef management in the Pacific. However, these initial investments and initiatives could be seriously compromised after 2004 without ongoing financial support for coordination and monitoring. Monitoring surveys are only useful if they are conducted on a regular basis and tied to relevant issues such as over-fishing, MPA establishment and coral reef management. This report summarises the status of coral reefs of the SW Pacific region and has been compiled from the national reports of the 7 member countries. These national reports will be published in their entirety in December 2004; more information is on: www.usp.ac.fj/imr

100 Years ago: Coral reefs in the Southwest Pacific were in pristine condition around islands with low human populations. Exploitation of reef resources was for subsistence and governed



Map courtesy of The WorldFish Center

by traditional practices. The only destructive practices were occasional use of poisons and fish stampeding to catch fish for traditional feasts.

In 1994: The coral reefs were still in good condition, however, human populations were growing which resulted in over-exploitation of coral reef resources near population centres. The remote coral reefs were healthy. Some MPAs had been established but there was no coordination of coral reef activities in-country and across the region, and virtually no coral reef monitoring. There was little awareness of the potential problems facing coral reefs.

In 2004: Most coral reefs are healthy, while others are recovering after coral bleaching in 2000 and 2002. The major signs of reef stress are around the major towns due to over-exploitation and pollution from sediments and nutrients. Global climate change is recognised as a major threat to the coral reefs, and awareness of the problems facing coral reefs is increasing, but more political will is needed. Coral reef monitoring is expanding, but lacks sustainable funding and support.

Predictions for 2014: Large areas of coral reefs will remain healthy, with only those around the larger towns damaged. However, as populations increase, so will the pressures, and when combined with climate change increased damage to many coral reefs of the region is likely. Effective management will ensure that most coral reefs will be in good condition, but where conservation management is not applied, the reefs will be damaged and coral bleaching will exacerbate the decline. The allocation of resources will increase and there will be stronger political will, but still probably not enough to prevent some reef damage and local extinctions.

Introduction

The Southwest Pacific Node consists of 5 mostly high island countries (Fiji, New Caledonia, Samoa, Solomon Islands and Vanuatu), the limestone island of Nauru and the 9 coral reef atolls of Tuvalu. Coral reef monitoring in the SW Pacific has made good progress since the last Status of Coral Reefs of the World report in 2002. This has been made possible through the support of many organisations, governments and donors mentioned in the Acknowledgements.

The need for increased training within the regional node was detailed in the 2002 status report, and recent training activities for the region include:

- Reef Check training in Vanuatu in mid-2002, and early 2004;
- A train-the-trainers workshop for 13 participants from the region in Fiji in September-October 2002, funded by Canada, France and New Zealand;
- In-country training in the Solomon Islands in March 2003; in Nauru in May 2004; and in Tuvalu in July 2004.

This complemented in-country training for Fiji, New Caledonia and Samoa held earlier in 2000-2002. To date more than 80 participants have been trained in coral reef monitoring methodologies through national and regional training.

The major challenge for the SW Pacific Node is to continue this important role of coordinating training, monitoring, data analysis and reporting. Whilst funding has enabled the building of capacity within the countries, the salient role of assisting the members and coordinating activities nationally and regionally has been predominantly voluntary. The SW Pacific Node is grateful to the Canada-South Pacific Ocean Development Program Phase II (C-SPODP II) for support over the last 3 years. Funding will conclude in December 2004. IFRECOR (French Coral Reef Initiative) is providing funds for GCRMN activities in New Caledonia for 2003-2005. However, there are no concrete funding offers to continue the coordination of the SW Pacific Node, and such assistance is urgently needed.

Status of Coral Reefs and Marine Resources

Coral reefs in the SW Pacific are generally in good condition. Some coral reefs that were bleached during 2000-2002 have recovered to just 10% of pre-bleaching levels, while others are fully recovered. Unfortunately, some have not recovered especially those subjected to cyclones, crown-of-thorns starfish (COTS) and *Drupella* outbreaks, and direct human destructive and over-exploitation activities. Nauru experienced coral bleaching and mass fish kills in October-December 2003, possibly due to unusually elevated sea surface temperatures. In 2003, Cyclone Erica destroyed 10-80% of live coral cover in several areas of New Caledonia. Cyclone Heta struck Samoa in 2004, causing damage to 13% of the coral reefs and in mid-2004 an unprecedented number of seabirds were found dead on Nauru; the cause is unknown.

Coral reef resources form the basis of the subsistence and artisanal fisheries in the SW Pacific region. The economic value of these resources was estimated at US$71.04 million in 2002. Harvesting of the reef resources using traditional methods and materials is rapidly being replaced by more modern methods, e.g. the use of motorised boats. Fishers can fish longer, fish more efficiently and exploit areas beyond traditional fishing grounds. This is increasing pressure on the fisheries stocks and the coral reef environment. Most of the countries, except New Caledonia, have reported overfishing, especially around urban areas.

Fiji

Serious coral bleaching occurred in 2000 and 2002, with 40 - 80% coral mortality on many reefs. Inshore and deep-water corals were less affected than those on the outer-reef slopes. Many reefs are now improving, and monitoring before the 2000 bleaching event is showing that half of the sites monitored are now within 3% of the pre-bleaching hard coral cover in shallow areas (< 5 m) and 7% in deeper areas (> 5m). This illustrates strong levels of new coral recruitment and growth. Recovery is slow in some damaged areas, such as Beqa Barrier Reef and the western Astrolabe Reef.

Coastal developments continue to be a major stress on Fiji's coral reefs. Coastal pollution such as excessive nutrient load from tourism facilities and rural dwellings is compounded by the lack of adequate waste disposal facilities and sewage treatment systems. In urban areas, industrial pollutants continue to flow directly onto the reef. Poor agricultural practices, logging, land clearing, and building of marinas in mangrove areas add to the stress on near-shore coral reefs.

Over-fishing and the use of destructive methods continue to deplete the resources and damage coral reef habitats. The increasing coastal population and the high urban migration exacerbates this over-exploitation. The use of duva (Derris root) is now complemented with the use of chemical poisons, such as chlorine and fertilisers. Night spear-fishing using scuba and poaching from MPAs are an increasing problem. Bomb fishing has also been reported, although it is generally not considered to be widespread.

The task of reversing the degradation of coral reefs and resources is the responsibility of the Government of Fiji, through the Departments of Environment and Fisheries. The Worldwide Fund for Nature (WWF-South Pacific) in partnership with the Wildlife Conservation Society is promoting marine conservation using an eco-regional approach. The Fiji Locally Managed Marine Areas (FLMMA) works with indigenous communities to manage marine resources. Partners for Community Development - Fiji works on reef conservation and restoration activities with the tourism industry and villages. The University of the South Pacific through the Marine Studies Program, the Institute of Marine Resources and the Institute of Applied Science provide education and training in marine science for Fiji and most other countries of the Node. The Marine Aquarium Council (MAC) has developed a certification program for the aquarium trade, and to develop sustainability and socio-economic assessments. The Reef Check program is active in coral reef assessment and has developed the Marine Aquarium Trade Coral Reef Monitoring Protocol (MAQTRAC - Box p 97). UNEP and the International Coral Reef Action Network (ICRAN) have teamed with FSPI to develop the Coral Gardens Project. The Canada International Development Agency (CIDA) through Phase II (C-SPODP II) sponsored a 3 year (2002-2004) project of coral reef training and surveying and established a long-term reef monitoring program.

The perceived threats and the relative severity of those threats to some of the coral reefs of Fiji have been assessed on a scale showing the level of pressure from non-existent to very high.

	INTEGRATED THREAT INDEX					
Reef Area	Coastal Development	Pollution	Sediment Damage	Over-fishing	Destructive Fishing	Overall
Taveuni Somosomo	None/ Low	Medium	Low	Low	None / Low	Low
Taveuni Waitabu	Low	None/Low	Low	None / Low	None / Low	Very Low
Savusavu	Low/Medium	Medium	High	High	Medium	Medium
Namena	None / Low	None / Low	Low	Low	None / Low	Very Low
Lomaiviti	None / Low	None / Low	Low	Medium	None/ Low	Low
Suva	Medium	High	High	High	Medium	Very High
Kadavu	Medium	None / Low	Low	High	Low	Medium
Beqa	Medium	None / Low	Low	High	Low	Medium
Coral Coast	Medium	None / Low	High	High	High	High
Momi Bay	Medium	Low	Medium	High	Low	Medium
Mamanucas	Medium	Medium	Medium	High	Low	Medium
Lautoka	Medium	High	High	High	Medium	High
Yasawas	Medium	None / Low	Medium	High	Medium	Medium
Vatu-i-Ra	None / Low	None / Low	Low	Low	Low	Very Low
Rotuma	Low	None/Low	None/Low	Low/ Medium	None/Low	Low

Nauru

The Nauru Coral Reef Monitoring Network (NCRMN) was established following scuba training in early 2004, and has established 7 long-term monitoring sites. The task of the NCRMN is to address the limited amount of available information on the structure and distribution of coral communities. Recent surveys showed high mortality of *Acropora* colonies on Nauru, whereas massive and encrusting (non-*Acropora*) coral species have now become dominant. The most common species were *Porites australiensis, P. heronsis, Fungia* spp., *Pocillopora eydouxi* and *Millepora* spp. *Acropora spicifera* and *A. palifera* were relatively common. Reef development is generally poor and coral communities are either sparse or contain mostly dead corals, especially near the populated and developed coastal areas of Nauru. Small encrusting colonies grow on the reef slope and live coral cover is 0-20% in areas from Uaboe District to Gabab Channel and Boe District.

Most fisheries in Nauru are either subsistence or small-scale commercial, but the status of the fisheries and the fish stocks remains unknown. There is anecdotal evidence that some species are now rare or locally extinct and there are declines in most fish stocks and fish sizes. Results from an underwater visual census in 2004 have not been analysed. Continual monitoring of the fisheries, including performing market and household creel surveys, is important for future assessments and to develop management regimes.

A MASSIVE FISH KILL ON NAURU

One morning in September 2003, the people of Nauru were surprised to find a thin black line of dead fish along the beach…probably tons of dead fish. Some of the older folks recalled a similar event more than 50 years earlier. There were fish from many families (Balistidae, Scaridae, Serranidae and even moray eels); but no sharks were found. Staff from the Nauru Fisheries and Marine Resources Authority were even more surprised when they saw tons of dying fish, floating helplessly from the surface down to 20 m depth. The fish appeared intoxicated as they floated into the divers' faces. The water was warm, clear and bright, and the corals were beginning to bleach. Divers reported that there were warm up-welling currents containing large air bubbles down at 30 m. The fishes swam upside down with their mouths gaping as they drifted across the reef at low tide. The tuna were not affected and feasted on the stunned fish, and the local fishers feasted on the tuna. There were no other signs of damage to the fish, except the swim-bladders were inflated and the internal organs were covered with mucous. Other than that, they appeared fat and apparently in good condition. Cautiously the locals checked to see if the dying fish were poisonous. They were safe to eat and there was no evidence of ciguatera poisoning, and no red tides or *Trichodesmium* blooms had been seen. These weak and dying fish became an important food supply from September-December 2003. A search of the US Government websites showed that there were unusually elevated sea surface temperatures around Nauru at that time, and combined with the strong warm upwelling suggested decompression or major drops in dissolved oxygen concentrations in the water. The Nauruans could find no satisfactory explanation, many suggested that it was 'manna from heaven'. From: Margo Deiye, GCRMN country coordinator Nauru

New Caledonia

The reefs of New Caledonia are generally satisfactory, but the diversity and density of invertebrates and fishes (especially the commercially important species) are higher inside MPAs than outside. Live coral cover averaged 27.5% (range 6% to 75%) with many different corals making up the communities. Non-living substrates were dominant in all stations. Only 3 stations could be described as having medium status: Akaïa station in the Bourail site; Récif intérieur station in the Thio site (high-sedimentation and fishing); and Luengoni1 in Luengoni site (tourism, fishing, sandy sites selected as a result of random selection of monitoring sites). The most recent coral reef survey was conducted between October and Decemeber 2003 covering 32 stations at 11 sites.

The fishery resources of New Caledonia do not appear to be seriously over-fished. The increasing level of fishing in parallel with the expansion of the population and the planned development of industrial and mining activities in new areas are all causes for concern for environmental and resource management. The fishing effort is concentrated predominantly in the SW lagoon around Noumea, and the greatest concern is for targeted benthic species.

There are 3 types of reef fisheries in New Caledonia: small-scale full-time artisanal fishers; recreational fishers and traditional fishers. The **small-scale full-time artisanal fishers** use 386 registered vessels and target inshore species. Total weight of the landed catches for inshore

fisheries in 2001 was 1212 metric tons (mt). The catches are sold at the local markets, stores and restaurants. Fishes are the main target group (57% or 690.5 mt), followed by spiny lobsters and mud crabs (23.1 mt combined). The lobsters are fished from the barrier reefs, whereas the crabs are taken from mangrove areas around the main island and constitute a substantial income for some traditional villages. Sea cucumbers are fished and exported (69 mt dry weight exported in 2003), as well as trochus (100 mt exported in 2003) and aquarium fish (7.3 mt in 2001). The level of fishing has remained relatively stable since 2000, but the fishing pressure has increased around urban centres due to increases in human populations. Artisanal fishers now need to target new areas to maintain or increase their yields. This is resulting in an increasing number of trips to Chesterfield Islands (more than 700 km from Noumea).

Recreational fishers are concentrated around the major cities, whereas traditional fishing is widespread around the islands. A survey in 2000 found that more than 99% of the people were engaged in traditional fishing; 50% reported that they fished 1 to 3 times a week and 70% fished from boats. The main gear used were hand lines and spear guns. The local population consumed 95% of the catch; 60% being given to their family or relatives, 10% of the catch is exchanged and 25% sold in the local markets.

Samoa

Coral reef assessment and monitoring has been sporadic over the past 20 years. Some monitoring has been conducted under short and medium term projects. Recently, monitoring activities have been coordinated in 3 major programs: the Community Based Fisheries Management Plan Program of the Fisheries Division; the SW Pacific Global Coral Reef Monitoring Network; and the Samoa Marine Biodiversity Protection and Management, an IUCN project.

Monitoring data from 2003-2004 showed that live coral cover was reasonably high. The average live coral cover in 2003-2004 at the permanent monitoring sites within MPAs and selected sites around Samoa was 34.5%. Live corals were dominant on the reefs of Savai'i (47.5%) and Manono (32.6%) Islands, whereas sand, rubble and rock dominated the substrate of Upolu Island. The high dead coral cover was a result of coral breakage from storms. An insignificant number of bleached corals were recorded; this was probably due to COTS or other localised causes, rather than warm water bleaching. Algal cover on Upolu was high with *Sargassum* spp., dominating. Observations during rapid surveys show coral diseases appear to be increasing, but this needs to be assessed further.

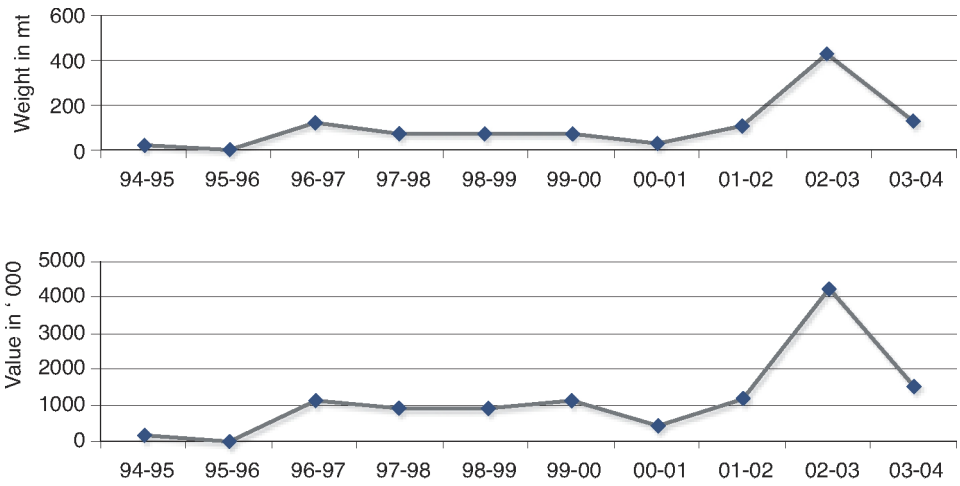
These summary data on corals and other life-forms indicate that the reefs of Samoa are predominantly healthy with reasonable levels of coral cover and little incidence of bleaching.

Islands	Live Coral %	Dead Coral %	Algae %	Abiotic %	Other %	Corals Bleached %
Upolu	23.2	9.2	21.5	41.2	0.6	3.9
Savai'i	47.5	15.6	7.1	27.4	2.0	0.4
Manono	32.6	6.0	15.1	26.9	0.0	0.0
Mean	34.5	10.3	14.6	31.8	0.9	1.4

More than 70% of Samoan villages are located on the coastal fringe of the islands, with inshore subsistence fisheries being one of the main activities. A household fisheries survey in 2000 found that each person caught an average of 2 kg of fish per hour. Based on these data, average seafood consumption was estimated at 57 kg per person per annum, and landings from the subsistence fishery were estimated at 7000 metric tons per annum, valued at SAT$45 million (US$16 million). The official statistics on the landed fisheries estimate that 134.4 mt of inshore fishery products valued at SAT$1.51 million (~US$0.5 million) were landed during 2003-2004; 72.5% of this was traded locally and 27.5% was exported either for commercial purposes or for the personal use of overseas relatives. Finfishes from the reefs and lagoons were the dominant product within the total inshore fishery, especially unicornfish (*ume*), parrotfish (*fuga*), surgeonfish (*pone, alogo*) and mullet (*anae*).

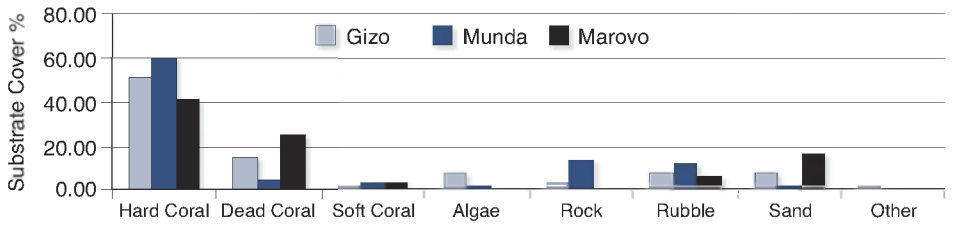
Solomon Islands

The Solomon Islands Coral Reef Monitoring Network is a partnership between the Department of Fisheries and Marine Resources (DFMR), Department of Environment and Conservation (DEC) and the SW Pacific Node of the GCRMN. Funding for the SICRMN is provided by C-SPODP II and WWF Solomon Islands. In 2003, WWF and DFMR trained 20 representatives from the Government (DEC), NGOs and dive shops in standard GCRMN survey techniques: line intercept transect; underwater visual census; Reef Check methods; and basic coral reef organism identification. Three monitoring sites, Munda, Gizo and Marovo, were established following recommendations from WWF, DFMR, DEC, WorldFish Center, and several dive shops. These surveys showed higher coral cover in Munda and Gizo, than in the Marovo lagoon.



Top: Inshore landings from 1994-2003; Bo Hon Value of inshore landing from 1994-2003 in Samoan SAT 1000

The graphs illustrate variations in inshore fisheries landing and value over ten years. The general trend fluctuates over the years, with a huge rise to 463.71mt valued at USD$1.6 million in 2002-2003 because of the increased fishing effort coupled with improved fishing technology, before a drop to 134.4 mt valued at US$0.5 million in the 2003-2004. Overall, there is still an increase in fish landings today compared to 10 years ago.



Live hard coral dominates bottom cover at the 3 sites surveyed in 2003/2004 in the Solomon Islands.

In June 2004, The Nature Conservancy (TNC) collaborated with a range of community, government, and NGO partners to conduct broad scale rapid ecological assessment of the biodiversity and status of the marine ecosystems of Solomon Islands (Box p 35). The biodiversity of the Solomon Islands was similar to that found within the 'Coral Triangle' of Indonesia, the Philippines and PNG. The focus of the study was biodiversity of corals, fishes, and key invertebrates especially those targeted for the local and export fisheries. Several areas were recommended as high priority targets for conservation, and the data collected, especially on the bottom cover, will contribute to a national baseline for long-term monitoring of the coral reef communities of the Solomon Islands.

Pressure on the marine resources has increased due to the growing demand in urban and semi-urban areas of the Solomon Islands. The ethnic crisis of 1999-2002 caused the closure of prawn, poultry, pig, and cattle farms, increasing the pressure on marine resources as people went in search of food for subsistence and income. The most serious human threat to coral reefs in the Solomon Islands is over-fishing, especially to generate a cash income. The Department of Fisheries and Marine Resources have yet to carry out proper stock assessments of the commercially important species within the country, however anecdotal reports from fishing communities are indicating that over-fishing is a growing problem.

Bomb fishing was previously a problem in Langa Langa lagoon and in the Ngella Islands region; however this practice has slowed with increasing awareness, although a few isolated incidents are occasionally reported. The rise in population in provincial centres has resulted in an increase in coastal development. This usually has direct effects on the reef systems from coral mining, sedimentation and sewage outfalls into reef waters. The lack of planning from provincial development divisions has seen much of this development go unchecked. Mangrove forests have been cleared to create more land for urban development and this is now a growing problem in provincial areas. The result has been an increase in turbid waters during rainy seasons and resuspension of sediments during rough weather. In areas where there has been rainforest logging, such as Marovo and Vella Lavella, a loss of coral cover and fishing grounds has been reported due to the effects of sediment running off deforested lands. There also has been an increase in coral bleaching due to the added stresses on the coral colonies. These logging companies are also big consumers of marine products and purchase large quantities, including species which are prohibited such as turtles, dugongs, giant clam, plus popular reef fish species such as snapper, grouper, lobster, bumphead and humphead wrasses. These species are in decline at locations in Marovo lagoon where there is significant logging activity.

Coral bleaching from global climate change has rarely been reported in the Solomon Islands. However, during 2000 there was widespread bleaching around Gizo, Marovo and Ngella. There

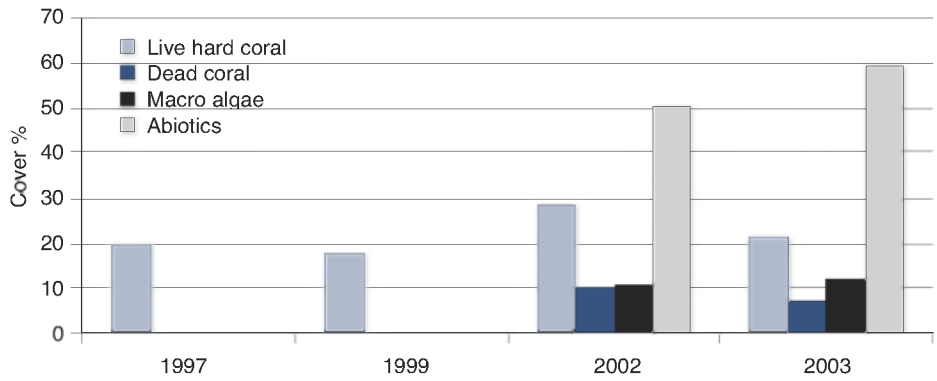
is a growing problem of COTS outbreaks in the western Solomons, parts of Guadalcanal, Ngella and parts of Malaita, with the outbreaks probably occurring at more frequent intervals. This has raised concerns among the local conservation organisations and tourism dive operators.

Tuvalu

Coral reef monitoring is conducted by the Departments of Fisheries and Environment, and the Funafuti Conservation Area. Recent surveys revealed live coral cover to be very variable (0-70% cover). The highest coral cover occurred outside managed reserves, compared with low coral cover in the Tefala Reserve and Fualopa Reserve (6.5% and 6.2%, respectively). Good coral cover can be found on the western side of the atoll and reef slopes possibly due to the presence of several deep channels into the lagoons.

Branching *Acropora* spp., were the most common coral species followed by table *Acropora*, usually on the slope and floor areas of the reef. Massive corals (*Porites* spp.) were sparsely distributed on reef flats and gentle reef slopes. There was a significant cover of blue coral (*Heliopora*) at Fuafatu and Teafualiku. Total algal cover was generally low except at Fualopa and Tepuka, with *Halimeda* species growing on the reef flat, sandy areas and among corals. The coral cover has declined by 9% since the last surveys. This may be due to strong wave action created by stormy conditions in late 2002, and destructive fishing. The overall trend shows considerable variation between the sites. The trends in coral cover since 1997 show reasonable stability between 20 and 30% average coral cover with a large component made up of sand, dead coral and coral rock. Predation of table *Acropora* species by coral eating molluscs (*Coralliophila radula*) is evident, but COTS were uncommon with only 2 individuals collected inside the Reserve.

Reef fishes are targeted by both subsistence and commercial fishers on all islands. Subsistence fisheries contributed 5.5% of the GDP in 1998, with the majority of these based on Funafuti (44 artisanal fishers). The National Fishing Company also on Funafuti owns and operates 3 launches, each about 9 m long. These launches are prohibited from fishing inside the Funafuti lagoon because of their large fishing capacity. There are now cold storage and processing facilities on all the islands, and both fresh fish and fish products from the outer islands are supplied to the main market at Funafuti.



Live coral cover at monitoring sites on reefs of Tuvalu appear to be relatively stable around 20% to 30% over the 6 year monitoring period.

Among the most sought after fishes are the snappers (Lutjanidae); which are found all year round and are most abundant on the atoll islands. Heavy fishing has threatened some snapper stocks, in particular *Lutjanus kasmira* and *L. gubbus* inside lagoons, especially on Funafuti. In addition, some pelagic species such as trevally and scads are also favourite food fish, but they are not always available. Lobster and some molluscs including giant clams are also highly favoured, but are specifically reserved for special feasts. Longer search times and severely limited catches are some of the anecdotal evidence indicating that populations of these species have been significantly reduced, especially in reefs around Funafuti.

Vanuatu

Monitoring was initiated in 2002 with 2 sites being established on Efate, at Malapoa Point and Hat Island. There was an increase in monitoring in 2003-2004 with the support of the South Pacific Community ProcFish Project, the Marine Aquarium Council and Reef Check Australia. This increase was in response to a request for assistance, from Vanuatu, to develop a management plan for the aquarium industry. Surveys were conducted on 3 islands, Efate, Epi and Santo, with 80% of the effort at 22 sites on Efate. These data provide baseline information for future assessments.

The coral reefs of Efate have low live coral cover, averaging 25%. Cyclone Danny damaged coral reefs on the western side of Efate, reducing the coral cover from 80% to 25%. The recovery is slow, but because the reefs are exposed to good oceanic circulation it is anticipated that recovery will increase. Although the reefs of Efate show signs of damage, there is a need for more data to determine their long-term status. At other sites such as Bukura, Devils Point, Pango and Pele there is excellent coral growth with no evidence of damage or stress. Live coral cover in these areas is high (60-75%), comparable to Nikaura Reef on Epi Island (63%). In Santo, a recent COTS outbreak has killed 15% of hard corals in Luganville Harbour. The recent COTS invasion could cause more damage on South Santo Reefs in the future. The assessment of water quality at Luganville Harbour and Port Vila indicated high coliform bacterial concentrations (between 5-50 per 100 ml), but the Harbour waters are still considered safe for recreational use.

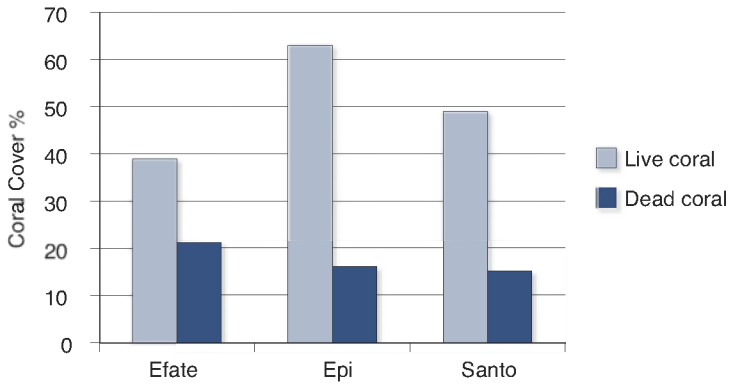
Vanuatu has recognised the potential of the aquarium industry to provide income for local communities and is exploring ways to make this fishery sustainable. Reef food fish resources are under considerable pressure from over-exploitation near populated areas of Efate, Maskelynes, Tanna and Luganville. Preliminary results from a joint fish assessment by South Pacific Community, International Marine Life Alliance and Vanuatu Fisheries Department (VFD) indicate very low stocks of food fish species. This prompted an initiative to discourage the entry of the live reef food fish trade into Vanuatu. In 2003, ProcFish found similar results. Resources in remote areas of Vanuatu are relatively stable, but many of these remote areas have limited reef resources and therefore cannot withstand heavy fishing pressures.

AQUARIUM FISH ASSESSMENT AND MANAGEMENT ON EFATE, VANUATU

Aquarium fish exports from Efaté,Vanuatu increased from 20,000 to 70,000 fishes between 2001-2003,and there are plans for this trend to continue.This is a non-traditional and totally new fishery to the country, about which communities and the Government know very little. It had traditionally been a small fishery over the past 13 years so this major increase in fish exports in 2003 attracted attention.The Vanuatu Department of Fisheries recognized the potential economic benefits of this fishery for rural communities if properly managed, and the risks if not managed well. There was an urgent need to increase management capacity, but the Department had limited resources.The solution was to collaborate with the private sector and local communities to involve these communities in monitoring their resources.This allowed the Government to focus on developing and implementing sustainable management policies - the National Aquarium Trade Management Plan.A group of organisations including Efaté Scuba Association, and Reef Check Australia conducted resource assessments at fish collection and dive sites on Efate, with the support of the Department and funding from Australian aid agency (AusAID). MACTRAQ was used to assess the fish populations (Box p 35) and the Secretariat for the Pacific Community conducted socio-economic assessments in the communities. These assessments were also combined with detailed training in coral and fish surveys for dive operators from the Hideaway Island Marine Sanctuary and staff from the Nguna-Pele MPA.The surveys showed that there were large variations in total fish abundance between sites, but the abundance of the major traded species ('indicator species') was not different between collection and non-collection sites. Unfortunately there were insufficient data to draw definite conclusions, and more long-term assessments are required. Some species such as flame angelfish *(Centropyge loriculus)* are highly specific to certain habitats and deserve special attention, and the information collected was sufficient to develop a policy on flame angelfish for Efate.There was no evidence of coral damage at the collection sites, which indicates that the aquarium fishermen were collecting in an environmentally sensitive manner. However, the abundance of key food and curio fish and invertebrates was low at all sites visited, which is an indication of over-fishing. The new fishery management plan will aim to guide development of the industry and ensure that impacts on other resource users and the environment is minimal, as well as continuing to build community capacity and monitoring throughout Vanuatu. From: Mike Lameien, Peace Corps - Vanuatu airwalker66@hotmail.com; Jos Hill, Reef Check Australia, jos.hill@jcu.edu.au; and Kalo Pakoa, National Coordinator for Vanuatu, kmpakoa@hotmail.com

Effects of Climate Change

Between 2002-2004, Nauru experienced coral bleaching and mass fish kills. There was no coral bleaching in the other member countries, however, cyclones caused damage to coral reefs in parts of Solomon Islands, Samoa, New Caledonia and Vanuatu during this period. The effects of climate change in 2002-2004 were not as severe as those in 2000-2002, when there was major coral bleaching and mortality.



Live coral cover is very high on the three sites surveyed by Reef Check-Australia on Vanuatu in 2004.

Status of Reef Conservation

Fiji

Coral reef conservation has largely been the responsibility of the Fiji Government. Because of the centralisation of the Government's infrastructure in urban centres, conservation in rural areas has largely been neglected. The involvement of the University of the South Pacific and conservation NGOs has led to the development of a framework for community-based reef management. Currently there are more than 100 small community-based marine managed areas on coastal fringing reefs, and mechanisms for larger protected regions are being investigated. At the community scale, the effectiveness of management plans varies with the level of community involvement and understanding. Usually the successful MPAs are those which have been prepared using extensive consultation and sound science and are provided with adequate support. The main issue is the delicate balance between conservation for the future, and the current needs of the communities. The immediate needs often outweigh conservation measures. Legislation being prepared will help in the conservation of coral reefs and marine resources.

Nauru

Awareness of coral reef conservation has increased in Nauru following a public awareness campaign during the coral reef monitoring project. The public discussed problems facing Nauru's reefs and resources, especially over-fishing of benthic organisms. There was an overwhelming interest in conservation and preservation measures and they supported establishing MPAs to manage coral reef resources. A follow-up workshop is needed to assist plans for ecological assessment of the coral reefs and socio-economic assessments on the Nauruan communities.

New Caledonia

There have been 13 MPAs declared in New Caledonia, with most concentrated in the Southwest lagoon as the 'South Lagoon Marine Park'. The major exceptions are the Bourail Reserve and the La Foa Reserve created in 2004. All MPAs are no-take zones where people can visit, with one exception, the Merlet Reserve, which is completely closed to visitors.

OVER-FISHING OF TROCHUS, GREEN SNAIL AND BECHE-DE-MER IN VANUATU.

The major marine exports from Vanuatu are shells of trochus and green snail, and dried beche-de-mer (sea cucumber). These species are in danger. The commercial trochus and green snail fishery began in the 1920s with the demand for raw material for buttons, jewellery and ornaments, and inlay work for furniture; however the shells were also a traditional source of food protein. Trochus, green snail and beche-de-mer are important income sources for remote island communities, which lack adequate transport, refrigeration, and markets for fish and agricultural products. The exports have earned the communities more than 40 million vatu (US$3.7 million) in the last 10 years. Beche-de-mer is exported mainly to Southeast Asia; the processed shells are also exported to Asia as button blanks, rims and scrapes and cuts. The only surviving shell processing company cannot find enough raw material to remain viable, which was confirmed by recent surveys showing that shell populations have crashed. The few viable stocks in remote areas are seriously endangered. Green snail populations are also verging on localised extinction because their growth and reproduction rates are slow, and populations have not recovered from exploitation, even though there has been a ban on green snail export for 6 years. There have been attempts to transplant brood stock, but there is no evidence of success. The attempts to mariculture the trochus and release larvae on the reefs has yet to show a population boost, and green snail culture is not an option until they can find suitable natural food for the juveniles. The Government is enforcing existing management measures and developing new measures to conserve the remaining breeding stock. Support is also needed for the local communities to provide alternative livelihoods.

Marine Protected Areas (MPAs) in New Caledonia are virtually all strict "no-take" areas to conserve biodiversity.

Name	Status	Surface (ha)	Date Established
Ilot Signal	No-take zone	181	January 1989
Ilot Larégnère	No-take zone	362	January 1989
Ilot Bailly	No-take zone	314	January 1989
Ilot Canard (d)	No-take zone	50	January 1989
Ilot Canard extention	No boat-fishing or spearfishing	125	January 1989
Ilot Amédée (e)	No-take zone	154	January 1989
Grand Récif Abore (f)	No-take zone	10960	July 1981
Ilot Maitre	No-take zone	610	July 1981
Dieppoise	No-take zone	13	August 1990
Yves Merlet	Closed to all visitors	16700	May 1980
Baie du Prony (2 sites)	No-take zone	145	June 1993
Bourail (3 sites)	No-take zone	3004	June 1993
La Foa	No-take zone	3669	June 2004

THE FUTURE OF FIJI'S LIVE ROCK TRADE

The aquarium trade is booming around the world and most aquarists want 'live rock', which is dead coral rock covered with pink or purple coralline algae and other organisms. Fiji is a major exporter to the global aquarium market, shipping 800,000kg of live rock in 2001 to the USA, the industry's major customer with 1 million hobbyists. The aquarium industry is growing at 12–30% and provides a valuable alternative livelihood for coastal people, alleviating the pressure on fishing. The villagers break off slabs of live rock covered with light - to dark-pink coralline algae from the edge of the reef, and load these onto *bilibili* (bamboo rafts). On shore, they trim and grade the rock by shape, weight, and cover of coralline algae before air freighting it to the USA. Much more rock is harvested than recorded in the official figures because a lot is wasted. Large-scale removal of live rock can destroy habitats for fish and invertebrates and damage the reef structure, leading to increased coastal erosion. The trade, including live coral and fish, is crucial for some Fijian villages, where the only alternatives are low-skilled jobs on sugarcane plantations and tourist resorts. A third of the 150 people in Malomalo village, just a few hours west of Suva, harvest live rock as their main source of income. They earn US$0.70 per kg, which is divided among the collectors (US$0.50), the traditional custodians (US$0.10), and the marine reserve within the traditional fishing grounds (US$0.10). Full-time harvesters collect 150 kg to 200 kg per week, or about 7500 kg per year contributing US$3750 to the household.

After 9 years of live rock collecting the villagers became concerned about the long-term consequences and requested help. In 2001, the Fiji Government requested an environmental assessment to guide their policy on the trade. Simultaneously, WWF and the Marine Aquarium Council (MAC) launched a trade certification system, and started a project to:

- develop community-based processes for wise coral harvesting and management; and
- help the Government develop sound policies and legislation to support a sustainable aquarium trade.

WWF held community workshops in Malomalo to raise awareness on monitoring, evaluating, and marine resource management. The villagers agreed that the productivity of their reef areas was being damaged, and designated part of the traditional fishing grounds as a *tabu* area, where extractive use was banned. WWF scientists monitor Malomalo regularly and in October 2002 conducted the first Biological and Socio-economic Assessment of the area, looking at the status of the environment and aspects of the live rock trade. The main focus has been to develop a Collection Area Management Plan as a prerequisite for MAC certification, and raise awareness within the community of the need for management. The dialogue between those with traditional and scientific knowledge is making encouraging progress towards establishing an industry with long-term stability for the people of Malomalo. From: Aliti Susau WWF Project Officer Fiji

Samoa

The three main conservation strategies in Samoa are:

1. The Community-Based Fisheries Management Program (CBFMP) was initiated by the Fisheries Division under the Fisheries Extension Training Project in 1995-2001. The model used for the CBFMP is now used to manage the commercial fisheries. The CBFMP is well established on Upolu, Savai'i, and Manono Islands with 83 villages having developed and accepted Village Fishery Management Plans; 60 villages have established Fish Reserves (No-take Zones) in their traditional fishing grounds;
2. The Samoa Marine Biodiversity Protection and Management Project was developed in collaboration between The World Conservation Union (IUCN) and the Ministry of Natural Resources and Environment. The 5-year project focuses on the districts of Aleipata and Safata, with the aim of empowering the communities to conserve and sustainably use their marine resources through the establishment of multi-purpose MPAs; and
3. The local NGO, Matuaileo'o Environment Trust Incorporated (METI) developed the Coral Gardens Project to grow corals at selected sites where coral reefs had been damaged. Coral transplants have been successful at one site (Matautu, Lefaga). Collaboration between METI and the Fisheries Division is now under discussion so that some of the Fish Reserves under the CFBMP could also be used to grow corals. Community support will be needed to ensure that this initiative succeeds.

Solomon Islands

There is only one MPA in the Solomon Islands. The Arnavon Marine Conservation Area in the Manning Strait was established because it is a major turtle nesting ground. During the recent TNC led rapid ecological assessment, Arnavon was shown to be outstanding because of the large populations of commercially important fishery species, including reef fish and invertebrates such as giant clams and beche-de-mer. This provides a positive stimulus for MPA management activities in the Solomons as these coral reefs are amongst those with the highest biodiversity in the world. This global attention should provide the incentive to establish more MPAs. WWF is currently in the process of implementing an MPA network in Gizo with plans to have the network fully endorsed by the end of 2005.

The establishment of 17 locally managed MPA systems in Roviana and Vonavona lagoon by the Roviana and Vonavona Development Project, through the University of California was a major initiative. Biological monitoring has not been completed to determine the effectiveness of these MPAs, however there is strong general acceptance amongst the local communities of the closures, indicating promising signs for success. There are attempts to establish a Solomon Islands Locally Managed Marine Area Network, however it is currently facing constraints. It is hoped that the problems delaying the establishment will be addressed to allow greater participation of local communities in managing their own coral reefs.

More NGOs are establishing coral reef monitoring programs with the focus on different areas of the country. A meeting between government officials and NGOs is planned to discuss collaborative activities and attempt to seek consensus on the standardisation of methods. The establishment of a coral reef monitoring body has been planned to oversee monitoring activities and ensure that data are being collected across all areas of the Solomon Islands to provide a representative data set on the status of the coral reefs. This body will be responsible for assembling the summary data and for producing a status report every 2 years.

Tuvalu

Four marine reserves have been declared; Nui; Vaitupu; Funafuti; and Nukulaelae. The Island Council (*Kaupule*) administers the conservation areas jointly with traditional owners, however the direct management of the reserves varies. For example, the Funafuti and Nui Reserves forbid the taking and killing of animals without prior knowledge of the Island Council. At the Nukulaelae Reserve, the use of certain fishing gear, such as gillnets and spearfishing, is prohibited, and anchoring in areas of coral is also forbidden. Three Reserves (Nui, Vaitupu and Nukulaelae) have been successful in gaining the support of the communities. The Funafuti Reserve, an outcome of a regional project from 1995-1999, was highly successful when funds were available for enforcement and management. When the project ceased, enforcement weakened and reports of abuse increased dramatically. Because the Reserve lies close to the urban centre, there is no sense of community ownership and is therefore open to abuse.

Vanuatu

No new coral legislation has been enacted recently, except for a law maintaining the existing ban on the harvest of live corals. This ban is being heavily criticised as it is focused on controlling the human use of corals while large tracts of corals are being lost to natural disasters such as cyclones and coral bleaching. A new regulation resulting from a Ministerial Order of 2000 has been enacted to protect wild stocks of the giant clam *Tridacna crocea* and limit the harvest of other clam species. Enforcement has since been effective. Other new management measures and regulations proposed include: the establishment of maximum sizes for green snail and trochus; a moratorium on export of some invertebrates by companies; a limit on the number of aquarium operator licences; and the restriction of sale of some resources in favour of the local market only.

Marine conservation is a high priority in the country but Government commitment has been limited by budgetary constraints. With support from other stakeholders and communities, two new MPAs have been listed, Nguna-Pele and Crab Bay; the latter is being listed for the International Waters Project pilot program to establish MPAs. The establishment of MPAs is promoted by Vanuatu Fisheries Department as a mechanism to support traditional 'taboo or tabu' area practices for better conservation outcomes. Mistry Island has gained recognition, while Hat Island is pending the resolution of land ownership issues. Registration of 'Taboo' areas has increased from 15 in 1998 to 80 in 2005, indicating that people are becoming more conscious of the need to conserve and manage their resources.

Gaps in Monitoring and Management

The countries have expanded existing coral reef monitoring programs and commenced some new monitoring initiatives during the last 3 to 4 years. This has been facilitated by funding assistance from Canada (C-SPODP-II to the SW Pacific Node) as well as assistance from other donors directly to individual countries and scientists. The expansion in coral reef monitoring in some countries has not been matched in other countries. The major constraints are a lack of funding and trained people, such that much of the monitoring is focused on a few sites that are not representative of the entire country. For example, monitoring sites in Solomon Islands are concentrated in the western Solomon Islands. The SW Pacific Node has established an important network and undertaken training, which will contribute greatly to coral reef management in the Pacific, but in the absence of ongoing financial support for coordination and monitoring, these initial investments and initiatives could be seriously compromised after

LOCAL COMMITMENT TO CONSERVATION: A SUCCESS STORY IN VANUATU

Prior to 2001, artisanal fishing pressure was high around the islands of Nguna and Pele in Vanuatu, and food resources were on the decline. A Peace Corps project was established to facilitate a community-based management program to protect resources and develop additional livelihoods. These villages set up their own self-governing committees for the management of the area, and developed alternative livelihoods through tourism and the aquaculture of giant clam and trochus. The Nguna-Pele MPA was established in 2001 to protect food resources from over-harvesting and poor waste disposal, and to attract tourists to the area. Each MPA has its own staff that is selected from the local communities. These staff members conduct monthly Reef Check surveys at 40 sites, monitor the clam and trochus populations and report on their findings at monthly village meetings. The surveys indicate a 15% increase in the abundance of large food fish and a 38% increase in new coral recruits since the start of the reserves. Marketing the MPA through local tourist resorts has attracted international visitors. A team of Reef Check volunteers from Australia visited Nguna-Pele in 2004 and conducted surveys with the MPA staff. This visit strengthened community awareness and appreciation of their program. Such community participation in resource monitoring coupled with the flow-on benefits from tourism have been valuable in sustaining motivation and support for conservation. From: Christopher Bartlett, Nguna-Pele Marine Protected Area, cybartlett@hotmail.com and Jos Hill, Reef Check Australia, jos.hill@jcu.edu.au.

2004. Experience of member countries has proven that monitoring surveys are only useful if they are conducted on a regular basis and tied to relevant issues such as over-fishing, MPA establishment, and coral reef management.

Recommendations

The SW Pacific Node has made good progress in the last 3 years. The recommendations made by the SW Pacific Node in the Status 2000 and 2002 reports have largely been addressed: more training and capacity building in coral reef monitoring techniques; establishing MPAs; and conducting biodiversity assessments. There is, however, considerable room for improvement and expansion.

- Capacity building: While the level of capacity in coral reef monitoring has improved, more effort is required, especially in data analysis, reporting and integration of data into coral reef management policies.
- Socio-economic surveys: The recent devolution of marine resource management from the State to the community may impose more pressure on family daily responsibilities. There is little information available on the socio-economic status of those communities that now have responsibility for marine conservation. The member countries of the SW Pacific Node urge partners, donors and supporters to assist in addressing this issue.

- Community based MPAs: Considerable progress has been achieved in most member countries in establishing community-based MPAs. Plans to develop similar MPAs in other countries are progressing and all stakeholders, including governments, NGOs, scientific communities, the private sector and donors are encouraged to assist. Specific research is needed on the effectiveness of these MPAs in order to develop adaptive management strategies.
- Biodiversity Surveys: There have been no coordinated surveys and documentation is fragmented. There has been considerable documentation of biodiversity in the Solomon Islands, Fiji and New Caledonia, but there continues to be a lack of expertise within the region, especially taxonomists. There is a continuous reliance on experts from Australia, America, France and UK. To address this, governments need to be encouraged to make this a national and regional priority through the higher education system (Universities of the South Pacific, New Caledonia, and Samoa). Biodiversity surveys remain a high priority for the SW Pacific Node, and the scientific community and politicians are encouraged to assist.
- Pacific Islands Marine Reference Collection: The Pacific Islands Marine Reference Collection at the University of the South Pacific remains an important repository of marine organisms from the Pacific. The Collection is a teaching reference for all Pacific Island students; however, institutions in developed countries have undermined this Collection. There is need for stronger collaboration between developed country institutions holding Pacific Island marine biodiversity collections and the Pacific Collection. Furthermore, regional and national strategies for the protection of intellectual property rights of Pacific Island communities must be developed.
- Pacific Islands Coral Reef Network: The three island nodes of the Pacific Islands, excluding the Hawaiian Islands, have made considerable progress since the late 1990s. There is a need to develop closer cooperation and collaboration between the different nodes in the Pacific.
- Degraded Coral Reef Sites: More attention needs to be focused on managing and where necessary, rehabilitating, highly stressed coral reef areas, particularly those around urban and coastal areas where anthropogenic pressures are concentrated.
- National Policies: The development of appropriate national coastal management plans, and policies is required. All countries should incorporate coral reef issues into national climate change strategies under the UN Framework Convention on Climate Change (UNFCCC). Legislation and regulations for the management of coral reefs need urgent upgrading, especially the incorporation of integrated coastal management and sustainable fisheries, and the enforcement of management and protection policies
- Coral Reef Monitoring: There is a need to find ongoing support to ensure the future of the monitoring program, without the reliance on volunteers for the monitoring and coordination.

Conclusions

The status of coral reefs in the Southwest Pacific is generally good. Coral reef monitoring and conservation has made progress, however more effort is still required. Two major factors, which will affect the coral reefs in the future, are anthropogenic pressures and climate change impacts. If proper management regimes are instituted, the condition of coral reefs should still be in generally good condition in ten years time. However, in the absence of effective management strategies, coral reefs will degrade. Support from all stakeholders including governments, NGOs, donors and communities is required to ensure the protection of coral reefs.

100 years ago: Coral reefs in the Southwest Pacific were in pristine condition, and the human population on the islands was much lower. There was no market economy, coral reef resources were harvested only for subsistence purposes, and traditional management practices were employed to manage the reef resources. There was probably some form of destructive fishing in some communities such as the use of *Derris eliptica* vines, *Barringtonia* seeds, sea cucumber intestines and other fishing techniques such as Visi and Kwarao (fish stampeding). However, the use of these practices was restricted to important, ceremonial feasts when large quantities of fish were required. These would not have had a significant effect on the coral reefs. There was some documentation about the reefs by early explorers.

In 1994: The coral reefs were in 'generally good' condition, with considerable variations between locations. The human populations were between 6000 and 500,000 in the different countries. Reefs close to urban, development and logging centres showed significant damage due to anthropogenic impacts, with localised over-exploitation of coral reef resources for subsistence and income generation. Coral reefs in more remote areas were generally in very good condition. Some MPAs had been established by some of the countries, but the only coral reef monitoring was conducted by Fisheries Departments. There were, however, many studies by different organisations and government departments on different aspects of coral reefs, but there was no mechanism for coordination or consolidation of data and information. There was no coordinated regional coral reef monitoring network. Many NGOs were engaged in coral reef work across the region, supplementing the activities of governments. Restocking and stock enhancement programs for some over-exploited coral reef invertebrate species were starting.

In 2004: Coral reefs are recovering from major losses due to coral beaching in 2000 and 2002. Most coral reefs remain in generally good condition, however the level of exploitation of reef resources around the major towns continues to increase resulting in considerable localised reef damage and the collapse of resources. Global climate change and direct human pressure are the most significant threats to coral reefs of the region. There is now more awareness of the problems facing coral reefs and increasing political will to implement corrective action. Many more organisations and stakeholders participate in coral reef conservation and management. The coral reef monitoring network established 4 years earlier is functioning well but is threatened by insufficient resources for ongoing training and monitoring. More funding support and stronger political will are required to perpetuate coral reef monitoring in the region in the future.

Predictions for 2014: Increased human populations and climate change damage will be the two most significant factors affecting coral reefs of the region. Coral reefs near urban areas will continue to become significantly degraded, and the efforts of governments and NGOs will

be partially effective in slowing and even reversing some of the degradation. If management regimes are effective, most of the coral reefs will still be in good condition, with increased coral bleaching and cyclonic storms being the major threats. However, if the conservation and management regimes are ineffective or not supported by strong political will and the allocation of sufficient resources, the coral reefs will continue to decline and there may be local extinction of some species.

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ICRAN

CORAL GARDENS PROJECT, FIJI – ICRAN DEMONSTRATION SITE

With the assistance of Partners in Community Development Fiji (PCDF, formerly FSP-Fiji) the communities of the 9 Cuvu and Tuva Tikinas villages on the Coral Coast of Fiji have taken substantial steps in managing their marine resources. The communities have developed and implemented community based coastal management plans, which have involved the establishment of 5 MPAs (including traditional Tabu areas as no-take zones), training of more than 20 Fish Wardens, clam restocking and partnerships with a resort to restore coral and mangrove habitats essential to both community and resort livelihoods.

The success of this initiative has been due in great part to the inclusion of all stakeholders; from fisher women to Chiefs, the Provincial authorities, natural resource government ministries (in particular the Fisheries Department), and the private sector (in particular the Shangri-la's Fijian Resort). A Cuvu District Environment Committee has been established to follow through on implementation of activities. The Committee recognises the need for a healthy environment for both future generations and tourists, and aims to restore the natural resources that have been damaged to set an example for other villages in Fiji. PCDF will continue to support the initiative by providing project facilitation and technical assistance.

ICRAN recognized the Coral Gardens Project as an example site not only for other villages in Fiji but for other communities globally. This success has led ICRAN to begin the Solomon Islands Coral Gardens Initiative based on the Fiji project. The work of the communities of Cuvu-Tuva has also attracted international media attention, with the BBC broadcasting a documentary on the project's achievements to global audiences in both radio and film formats. This initiative is financially supported by the New Zealand Agency for International Development, UK Darwin Initiative, Mac-Arthur and Packard Foundations, and the Shangri-la's Fijian Resort.

Ecological Monitoring: Several experiments were initiated in Cuvu Bay to examine coral reef restoration, including test coral plantings for habitat enhancement, tide pool enhancement with UV and temperature tolerant corals, and coral aquaculture trials. These were initially successful until a COTS outbreak and coral bleaching resulted in the loss of the test plantings.

Socio-economic Monitoring: Community participation will begin with the establishment of an Environment Committee. The Coral Garden Project is allied with the MacArthur Foundation-sponsored 'Learning Portfolio' on community-managed MPAs.

Contact: Austin Bowden-Kirby (austin.bowden-kerby@fspi.org.fj)

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Coral reefs are **80%** of the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **planned.**

ICRAN

SUSTAINABLE MANAGEMENT OF AQUARIUM HARVESTING OPERATIONS, FIJI - ICRAN DEMONSTRATION SITE

Unethical methods of harvesting, particularly the use of cyanide and other chemicals to stun fish, leads to considerable mortality of corals and fish. Such destructive methods are often used in the aquarium fish trade. Although these practices are largely confined to Southeast Asia, Pacific Island countries are becoming aware of the potential environmental problems associated with the aquarium fish trade.

In the Pacific region, Fiji is the major exporter of aquarium products. More than 500 village-level collectors are involved in the trade and in some villages it is the only source of income. However, there is minimal management of the harvest operation. For example, all species of coral can be collected and there is no limit on size, numbers, or harvesting methods. Fiji is now seeking a balance between the community benefits of aquarium animal collection and reef health with help from the South Pacific Regional Environmental Program. They have been working with the Government to ensure the future ecological sustainability of the Fijian coral trade industry. The initiative began in 2001 and helps coastal communities to benefit from a flourishing industry without damaging their ecosystems. Moreover, this Fijian project is an example case study which can demonstrate the possible benefits to other Pacific Island Countries already in the trade, such as Vanuatu, Tonga and the Solomon Islands.

Ecological Monitoring: The University of the South Pacific and local NGOs aim to implement long-term monitoring programs in collection areas to improve knowledge on impacts of coral and fish removal from reefs. Reef Check Australia recently completed a survey, with the results due to be published in the near future.

Socio-economic Monitoring: Local NGOs assist with the socio-economic aspects of this project, aiming to:

- study the aquarium trade industry in Fiji, the companies involved, the type of trade in which they are involved, the type of contracts between companies and collectors, the types of products from each area, the volume exported and wasted, the methods of coral harvesting, etc…
- analyse the economics of the industry to ensure that there is equity in the percentage of revenue paid to resource owners, the government, and the traders.

Contact: Alison Glass, (icran@icran.org)

Coral reefs are **100%** of the natural resources
Ecological Monitoring is **planned.**
Socio-economic Monitoring is **effective.**

ICRAN

SAMOA MPA PROJECT – ICRAN DEMONSTRATION SITE

The 2 major islands of Samoa, Savai'i and Upolu, and many tiny islands are circled by diverse fringing reefs, as well as mangroves and some seagrasses. Over-fishing, destructive fishing and poor land management threaten the reefs and fish stocks, on which the Samoan people are heavily dependent. To counter these threats, the Districts of Aleipata (11 villages) and Safata (9 villages) established community-based, multi-use MPAs including Village Fisheries Reserves under a World Bank-IUCN initiative. Aleipata and Safata MPA District Committees are responsible for reviewing completed work, management plans, and developing future workplans. Both District Committees consist of a senior matai representing and selected by each participating village. District Officers attended the Regional Locally-Managed Marine Area (LMMA) Network meeting in Fiji and joined as an associate members.

Samoa's 2004 phone book cover features Aleipata MPA's logo and is a good example of growing private sector support for MPAs. The MPAs established a 'transparent' trust fund to support the ongoing operations and are able to receive donations. The MPA Marine Education in Schools program has benefited from 80 sets of donated snorkel gear and from Peace Corps volunteers helping with the Secondary Schools program. There are plans to expand the program, broadening MPA initiatives and further raise awareness of the MPA no-take-zones. Tourist visits to the MPAs are growing and the increased tourism levies are paid to the MPA Trust Fund by Samoan tour operators. Fees from USA university study tours resulted in a 75% profit for MPAs and the local communities, generating income and building pride for the villages.

Ecological monitoring: Community meetings and restoration activities are ongoing, with long-term sites monitored every 3 years to provide performance indicators for management plans. Community-based monitoring to provide more immediate feedback is being trialled. Baseline data from all major reef habitats (lagoon, channels and outer slopes) show that the reefs were in good health, despite many natural and anthropogenic pressures. Damage caused by cyclones in the early 1990s, COTS outbreaks 20 to 30 years ago, erosion from sea urchins preventing the establishment of new coral recruits, and dynamite fishing is still evident. There was low coral cover on the inner lagoons (10-20%), but very high cover on the outer slopes (80-100%) and outer lagoons (50–60%). Fish abundance was low, with small individuals, indicating strong fishing pressures. However, fish were more abundant and diverse in less frequented areas as were prized species such as giant clams, sea cucumbers and edible molluscs.

Socio-economic monitoring: Incorporation of socio-economic monitoring into the baseline assessment and community monitoring is being developed.

Contact: Sue Miller, Apia, Samoa (sue.miller@samoampa.com).

Coral reefs are **80%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **planned.**

WHS

EAST RENNELL, SOLOMON ISLANDS – WORLD HERITAGE SITE

East Rennell is part of Rennell Island, the southernmost island of the Solomon Islands group in the western Pacific. It is the largest raised coral atoll in the world and contains Lake Tegano, the largest lake in the Pacific islands. The Solomon Islands have a greater diversity of animal species and higher degree of endemism than almost anywhere else in the Pacific. Rennell is largely undeveloped and coral reefs occupy 12 square km. There are more than 300 coral species and these communities have not been affected by human populations. The fish populations are also rich in both diversity and abundance, reflecting low fishing pressures in spite of 10,000 tourist visits every year.

About 500 Polynesians live within the World Heritage Site and all of the land and reefs are under customary ownership. Locally, the Tegano Management and Conservation Committee establishes the rights of resource owners and users and screens business applications to ensure sustainability. The people live a largely subsistence lifestyle and a draft resource management plan is being prepared with input from provincial members, the Council of Chiefs, and the Paramount Chief. Management is based on traditional knowledge and data gathering, not on formal processes of scientific monitoring. The East Rennell Resource Management Plan focuses on local desire to generate income through ecotourism and other sustainable environmental activities.

Ecological Monitoring: Rennell has been the focus of 8 major scientific expeditions but there are currently no scientific facilities on the island. A rapid ecological assessment of the coral reefs, fishes, shellfish and other reef resources of Rennell Reefs was made in 1995 by external NGOs. There has been no scientific monitoring since this assessment, and any monitoring programs on Rennell by outside organisations would likely be viewed with suspicion and would require involvement of the Council of Chiefs and the Paramount Chief.

Socio-Economic Monitoring: Participatory Rural Appraisal (PRA) surveys have been conducted at most of the villages, with the emphasis on assessing the subsistence and cash lifestyle. Cash derived from fishing and reef resources has been very important to the economy in the past, but there are currently no marine-based industries at present.

Contact: Ministry of Culture, Tourism, and Aviation, PO Box G.20, Honiara, Solomon Islands **and** Paramount Chief of East Rennell, c/o Tigoa, West Rennell, Rennell and Bellona Province, Solomon Islands

Coral Reefs are **10%** of the natural resources
Ecological Monitoring is **occasional.**
Socio-Economic Monitoring is **occasional.**

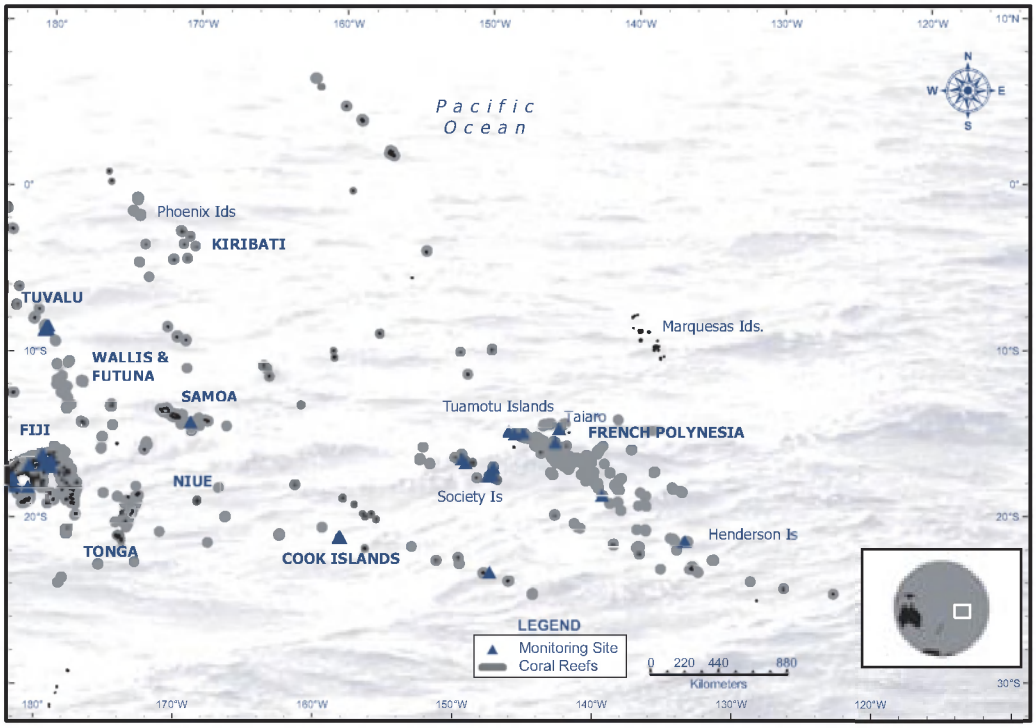
13. A Century of Change in Coral Reef Status in Southeast and Central Pacific: Polynesia Mana Node, Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga, Wallis and Futuna

Caroline Vieux, Annie Aubanel, Joanna Axford, Yannick Chancerelle, Dave Fisk, Paula Holland, Mathieu Juncker, Taratau Kirata, Mecki Kronen, Craig Osenberg, Brendon Pasisi, Mary Power, Bernard Salvat, Jeff Shima and Vavia Vavia

Abstract

The Polynesia Mana Node of the southeast and central Pacific contains 7 independent or autonomous countries or territories with only 6,000 km^2 of land on 347 islands, but surrounded by 12 million km^2 of EEZ. These seas contain 13,000 km^2 of coral reefs as the main natural ecosystem providing food resources and opportunities for development, especially for tourism and pearl culture for 500,000 inhabitants. During the 19th and first half of the 20th centuries, there was major exploitation by the colonial powers of mother-of-pearl oysters for the button industry, as well as guano, sandalwood and trepang. The Polynesian people were largely involved in a subsistence economy and all coral reefs and lagoons were healthy. During the last two decades of the 20th, all countries experienced rapid development and urbanization, rising populations, and some increased agriculture. These developments were limited to a few islands of each country (i.e. 15 islands amongst the 347) with resulting degradation of the coral reefs around these sites. The other islands remained mostly uninhabited and pristine, and continued with a subsistence economy. Generally, there was more damage to the coral reefs through natural events such as cyclones and coral bleaching, than by human activities. There is however, an urgent need to combat the threats on some islands from increased sedimentation, over-fishing, dredging and nutrient pollution.

The coral reefs of Polynesia Mana are predominantly healthy and at low threat risk in the immediate future. These coral reefs are probably the least degraded and endangered in the world as they are remote from continents and in the middle of the largest ocean. The largest threat is still controversial; predicted global climate change threats of more frequent and intense cyclones, and rising sea surface temperatures causing more coral bleaching mortality. Monitoring programs are developing in each country, with some having regular programs running for decades whereas others are just starting. The Node is now a functional reality with countries signing on as partners and authors contributing to status reports. The optimistic predictions are based on increased involvement of national authorities in coral reef protection and resource management. There are many MPAs currently being planned as awareness is



Map courtesy of The WorldFish Center

raised and monitoring progresses. Local populations are participating more and reviving their culture and traditions as a basis for sustainable reef management. The pessimistic predictions will apply if governments fail in their efforts towards coral reef resource management for these coastal communities, and if they do not remedy the causes of human stresses to the reefs around the heavily populated islands.

100 Years ago: Virtually all coral reefs were healthy with normal fish populations, although pearl shell and trepang were heavily exploited from some lagoons.

In 1994: Only French Polynesia had a monitoring program and there was little awareness for coral reef management and few MPAs. The reefs were largely healthy, but there were warning signs of degradation on reefs near populated areas.

In 2004: All countries have monitoring in progress or planned and all are developing plans for stronger reef management based on raised awareness of the need for sustainable development of their resources. Reefs are damaged near centres of population, whereas remote reefs remain healthy. Climate change effects are the major threat on the horizon.

Predictions for 2014: Most reefs will remain healthy, unless the adverse predictions for global climate change of more cyclones and bleaching come to pass. Human stresses around populated islands will continue but most countries will have active programs of harm minimisation and MPA development.

Introduction

The coral reefs of Polynesia Mana (Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga, and Wallis and Futuna) are remote from most of the damaging human stresses to reefs closer to large land masses. Thus, most are in generally good condition with a few near the expanding urban centres and heavily used lagoons showing signs of damage with low fish populations, low coral cover and algal overgrowth. Another supporting feature of Polynesian countries is that traditional management practices away from the capital cities are still strong, as expressed in the term 'Mana' which symbolises the stewardship relationship between the Pacific peoples and their resources. Most of the people in this Node are of Polynesian origin, although some of the islands of Kiribati are populated by Micronesians.

These countries have vast areas of coral reefs, surrounded by deep oceanic waters, which provide ideal conditions for coral growth. There are also small human populations (< 0.5 million) on 347 islands with a total land area of 6,000 km^2, scattered over 12 million km^2 of EEZ. Coral reefs grow around the many mountainous islands, atolls, uplifted atolls and low coral cays, but because they are remote from the centres of coral reef diversity, they usually have only half to a third the number of hard coral species found in Southeast Asia e.g. 115 on Kiribati, 192 on Tonga. Politically, Kiribati, Niue, and Tonga are independent countries, whereas the Cook Islands and Tokelau are associated with New Zealand, and French Polynesia, and Wallis and Futuna are French Overseas Territories. Kiribati, Niue, Tokelau, Tonga, and Wallis and Futuna have small, developing economies, whereas the economies in the Cook Islands, and French Polynesia reflect more tourism and black pearl oyster income, as well as the funds contributed by their family members overseas. Foreign aid often contributes more than 50% of GNP in some Pacific countries.

Since the last report in 2002 there has been considerable progress in coral reef monitoring and conservation, but capacity building for monitoring and management is still needed. Many of the trained staff are drawn away from the tasks of environmental conservation to comply with the requirements of the many international and regional Multilateral Environmental Agreements designed to assist these countries conserve their natural resources. Therefore support is needed to train people to conserve natural resources through field activities and manage their field staff, as well as negotiate their way through the UN Conventions to gain maximal benefits in minimal time.

This report is based on national Coral Reef Status Reports produced by most of the countries in 2004. The many experts on the region listed above provided additional information. Some of these national reports are available on www.reefbase.org. The theme for this chapter was to determine how the reefs have changed over the past century or more, specifically focusing on recent decades. This coincides with an increased global awareness of the need for coral reef conservation and management and the formation of the International Coral Reef Initiative (ICRI) in 1994. In many parts of the world, there is considerable pessimism about the immediate future for coral reefs, thus the Chapter ends with both pessimistic and optimistic scenarios for the coral reefs of Polynesia Mana and recommendations to move towards an optimistic scenario.

Polynesian Reef Status Prior to 1994

During the 19th and early 20th centuries, the colonial powers exploited the once flourishing mother-of-pearl oyster populations in Pacific coral reef lagoons. Vessels sailed from Sydney to cross the Pacific through the Cook Islands and French Polynesia and arrived in Europe carrying large cargos of the black-lipped pearl oyster, *Pinctada margaritifera,* to be made into buttons. As early as 1865, there were reports of depleted stocks and calls for regulations to conserve the resource. From the earliest times, most Pacific Islands were governed under 'Customary Marine Tenure', which had largely been developed as a marine conservation mechanism to ensure that the harvest of resources, especially fish and giant clams was sustainable. Those mechanisms now form the foundation for many Pacific Island fishing regulations. In Kiribati for example, this system "underpinned villagers' resource management, providing them with the incentive to look after their marine resources by ensuring that they could retain for themselves the future benefits of doing so" (from Johannes and Yeeting, 1995). In French Polynesia and Cook Islands, *Rahui or Ra'ui* (a system of taboos) was imposed by chiefs on some marine areas, in a bid to turn them into temporary no-take zones to protect fish spawning, or to ensure that there was suitable food for upcoming celebrations.

In Tokelau, *inati* was the traditional communal resource distribution system. The *taupulega* (village council) controlled the harvesting and distribution of all resources and each family would receive the same amount of fish, irrespective of the amount of land they owned. This *inati* system was an important form of resource management because it generally avoided waste, enhanced food security, and conserved energy because not all villagers needed to fish.

When traditional management prevailed on Niue, the elders reported that reef resources were more plentiful, and less effort was required to catch sufficient for the needs of the community. Now they report that there has been a reduction of 70% in hard coral cover on the reef flats in the last 30 years, and that key target species of invertebrates and fishes have declined along with the corals on the slopes. These stories of the elders over the past 60 years, confirm the measured decline in status of the reefs and their fisheries resources, and illustrates a breakdown in the management systems.

In the 1950s, major changes in the status of key marine resources became apparent, even though colonization had been on these islands for many decades. Initially the British colonial leaders in Kiribati accepted customary sea tenure "to prevail and ensure that the long-term fishing interests of the Kiribati people were protected from outside interests"; however, in the 1950s, the colonial administration introduced the European principle of open access fishing, 'anywhere and at any time', thereby over-ruling traditional norms. In Tonga, the end of the customary marine tenure and the beginning of open access to marine resources dates from 1875. Despite these rule changes, community resource management continued to play a key role mostly through transmission of traditional knowledge between generations, but this has slowly faded and there is now open access to marine resources. Furthermore, the introduction of cash economies in the 1950s removed the sacred and protected status from some species so that they became just another source of food and income for the community, irrespective of past traditions.

Economic development is starting to impact on the marine habitat, not only because of open access to the resources. In French Polynesia, the 1960s represented the beginning of economic

development linked to nuclear testing in the atolls of Mururoa and Fangataufa. Building development and urban growth also lead to modification of the coastline and massive habitat degradation and loss around the main town Papeete on Tahiti. French Polynesia was only just ahead of other Pacific countries with the development of large population centres in the following decades in Tonga, Kiribati and Cook Islands.

The major threats to coral reefs of Polynesia Mana countries prior to the mid 20th century were through mother-of pearl exploitation, as well as guano mining, sandalwood deforestation, and trepang collection. Most islands had subsistence economies with a reasonable balance between natural resource generation and human exploitation because their cultures and traditions were closely linked to coral reefs. The major factors degrading reefs were natural, such as tsunamis (which have left only geomorphological evidence) and cyclones such as those in 1903-1906, which claimed hundreds of lives in French Polynesia. The other 'natural' disturbances such as crown-of-thorns starfish (COTS) plagues and coral bleaching have only been recorded since the 1950s. These coincided with the first examples of local commercialisation of coral reef products (fish, shells for curios), followed by pearl culture and tourism development.

In the decades prior to 1994, reefs in Polynesia Mana countries were predominantly healthy, because of the relatively low populations on most islands and the use of traditional management systems. Then increases in commercialisation put more pressure on the resources. These increases were to have more serious consequences in the following decades as increasing urbanization put heavy pressures on reef resources without any measures being taken to find alternatives to traditional management practices.

Polynesian Reef Status and Management in the 1990s

In 1994 the coral reefs were coming under increasing pressures from rapidly rising human populations, urbanization, and agricultural and industrial development. These human impacts varied from virtually nil or minimal on remote outer islands and reefs, to intense pressures around urban areas. Marine environmental management was minimal in all Polynesia Mana countries in the early 1990s, and there was little awareness about threats to coral reefs, both among local populations and other stakeholders. Although there were usually sound regulations, no efforts were made to enforce the rules.

Tonga

The most disturbed areas in Tonga now are: Faga'uta lagoon in Tongatapu (eutrophication, major coral mortality and collapse of fisheries); and Nuku'alofa and adjacent northern Tongatapu (physical disturbance, loss of habitat, eutrophication, over-fishing, coral mortality); inner Neiafu harbour in Vava'u (sedimentation, COTS, over-fishing, coral mortality); and Pangae harbour on Lifuka Island in Ha'apai (eutrophication, high coral mortality) are locally disturbed. There were 9 MPAs off Tongatapu in the 1990s, but these had no management, education or enforcement programs. Tonga, like French Polynesia, Kiribati and Niue, had limits on catch sizes for fishes, invertebrates and shellfishes, but enforcement was usually poor.

Kiribati

The problems are similar in Tarawa (Gilbert Group, Kiribati), where the dense population of the atoll affected the lagoon through intense fishing pressure and the construction of causeways that closed the small passages between islands in the southern and eastern sides of the atoll. Another effect in Tarawa is poor human health due to very poor sanitation e.g. more than 90%

of the population have contracted hepatitis. Reefs around the concentrations of people show clear signs of eutrophication with little live coral remaining, whereas reefs in the north and west of the lagoon appear healthier.

French Polynesia

A decade after the first big natural disturbances of the El Niño years in the early 1980s when there were 5 cyclones and a major COTS outbreak, many of the outer slopes have recovered with near normal coral and fish populations returning. However, fish populations were clearly depleted in the lagoons, which had not been affected by the natural disturbances. There were significant coral reef population changes between 1971 and 1992 on Moorea, which were closely linked to human pressures. In 1995, the outer slope reefs were still dominated by hard corals due to a lack of human disturbances; the top of the barrier reef was an intermediate case where corals were less abundant compared to the past but still dominant and were able to compete for space with macro-algae; whereas the fringing reefs, which had been dominated by corals, changed into a macro-algal dominated community, especially near the sources of human disturbance. At that time, Moorea was not typical of French Polynesia as a whole, but this example demonstrated the growing concern about the status of lagoons of the major populated islands of Tahiti, Moorea and Bora-Bora; these were only 3 islands out of 118.

As early as the 1970s, the Government of French Polynesia started working towards better planning and focused on the high biodiversity and threatened ecosystems, especially on Tahiti, Raiatea, Moorea, and Huahine of the Society Archipelago. They were aware that establishing MPAs in lagoons adjacent to high levels of human activity was futile, but still they wanted regulations to ensure a sustainable use of the resources. Thus in 1971, 6 MPAs were established in the uninhabited atolls of Scilly and Bellinghausen and in 4 islands of the Marquesas (Eiao, Hatutu, Sable and Motane) after a regional conference in Noumea suggested that 39 islands of the Pacific should be become special reserves. The Taiaro atoll in the Tuamotu Archipelago was declared as a UNESCO 'Man and Biosphere' reserve in 1977 (Box p 380). These MPAs were launched before the development of strong economic and political pressures to exploit coral reef resources. These protective measures for the future were effective, even though there were no management plans and some conflicts occurred such as in the Scilly Atoll which contained the only protected natural mother-of pearl oyster stocks.

Tokelau

News of the declining status of some reefs in the Pacific in 1994 had no effect on Tokelau as the problems did not seem relevant. At this time there was a report on the status of the environment which warned the population to be careful not to over-exploit the resources. The main concern was the use of modern fishing methods which increased fish capture while reducing effort. There were also reports of decreasing numbers of turtles, giant clams, black pearl oysters and coconut crabs. The use of modern fishing techniques (introduction of aluminium boats with outboard motors, monofilament gill nets, steel fishing hooks, fish aggregation devices) was disturbing as it contributed to non-sustainable harvesting of specific species. In addition, the authority of the Elders to impose effective management methods had been reduced. More recently, rusting old shipwrecks on the reef flats may be poisoning fish, and there have been calls for assistance to remove these wrecks.

Niue

The reefs were still recovering from the large 1990 cyclone 'Ofa' when in 1994 it became apparent that some highly prized species of invertebrates had been significantly over-fished

(clams, lobsters, some shellfish). Furthermore, some of the previously plentiful ornamental shells were quite rare. The people all reported reduced catches of shellfish, and there were growing perceptions that many reef resources were declining. However, as the human population on Niue was also declining due to out-migration to New Zealand, it was believed that the resources would recover as fishing pressures reduced. The Government's mission statement and objectives aimed for sustainable management of the resources, but these initiatives and plans were not publicised, enforced or effective.

Monitoring and Management of MPAs in 1994 and Now

When the International Coral Reef Initiative was launched in 1994, there were very few MPAs in Polynesia Mana countries and these were predominantly 'paper parks'. Some were effective, but mostly because they were on uninhabited and remote islands. A Kiribati fishery officer explained: "a *paper park* means that it is known only to the people in the environment and fisheries departments who are interested in conserving their resources. The general attitude of the locals was - go out fishing at any desirable place, take whatever you catch and be a real fisherman".

Ten years later, things have improved as many MPAs have been established or planned in all countries; although, the level of management, monitoring and effectiveness varies considerably from one country to another. Very few of the established MPAs are monitored, thus, it is difficult to evaluate their effectiveness and use them to demonstrate the benefits of protecting these areas to the local communities.

An exception is Kiribati, where there are no MPAs, not even 'paper parks' despite many attempts since the late 1980s to introduce them. According to the Fisheries Department, this lack of MPAs is due a lack of funds. There is, however, a de facto MPA on Kiritimati (Christmas Island) since the islands are government owned and people found poaching before 1994 were sent back to the Gilbert Group. Now there is no incentive to poach resources from Kiritimati.

In Niue, the first MPA was established by the Fisheries Department in 1998, as a precautionary approach as no declines in resource stocks had been demonstrated. A baseline resource survey was conducted via the Secretariat for the Pacific Community (SPC) in 1998 with the view towards regular monitoring every two years. Due to a lack of resources and staff, the first follow up survey was conducted in 2004 following cyclone 'Heta'. Additional MPA assistance is being provided by the International Waters Project.

In Tokelau, MPAs were set up by the Council of Elders in the 3 atolls a few years ago. However enforcement is not effective, despite very strict traditional rules, these areas are still harvested for occasional celebrations. ICRAN started a program in Tokelau in 2003 to attempt to improve the effectiveness of their marine conservation.

In Tonga, efforts are now under way to conduct baseline and monitoring studies in a number of areas and analyse all existing data. Similar efforts are in progress to implement MPAs that were planned by the Environment Department. However, there are considerable constraints due to poor capacity for monitoring, surveillance and enforcement.

In the Cooks Islands, there are 13 MPAs around Rarotonga which are managed by village chiefs using the traditional *Ra'ui* system. Monitoring in 2002 showed that fish stocks have recovered

TOWARDS BETTER COASTAL RESOURCE MANAGEMENT IN NIUE

Little has been published about the coral reefs of the small raised coral island of Niue or the people who live there. Two major cyclones in 1990 and 2004 battered the island and reefs causing major damage. A 7-year GEF International Waters Project (IWP) has been implemented to assist the communities develop sustainable coastal fisheries and establish MPAs, because there has been destruction of fisheries habitats and over-fishing. National activities have included: establishing a National Task Committee with key stakeholder representatives from fisheries and government; a project development team to work with communities to find solutions; in-depth consultations on the key fisheries problems and causes; selection of Alofi North and Makefu as target communities for fisheries management; assessing the status of fisheries in these two host communities; and developing an awareness-raising campaign. Potential solutions to fisheries problems include the establishment of local rules and penalties to protect fisheries (possibly via new by-laws) and a series of MPAs, as well as introducing new income-generating activities to support reductions in fishing. Similar activities are underway in other Pacific island countries to address the root causes of environmental degradation.

in the protected areas. The remaining issue is the absence of sewage treatment, which has resulted in high nutrient levels in the lagoon that prevented the recovery of corals in the MPAs. This problem remains in 2004 but the Government is drafting regulations to ensure that effective sewage treatment is implemented for commercial businesses and private dwellings.

In Wallis and Futuna, the traditional chiefs approached the environment administrators in 1999 and requested the creation of MPAs. Three areas were chosen to include varied ecosystems (seagrass beds, barrier reefs, reef slopes). Mooring buoys were installed in 2002 to make the boundaries clear but there has been no monitoring.

In French Polynesia, the 'Marine Area Management Plan' (called the PGEM) was based on strong community consultation and launched in Bora-Bora and Moorea in 1998. The Plan aims to: involve all lagoon users in determining the regulations; ensure that the marine resources are sustainably exploited; preserve the high value and threatened ecosystems; and ensure that all lagoon users maintain harmonious relations. The biggest problem has been the conflict between the local user community and the tourism industry that is important for the economy of French Polynesia. The Plan was launched 6 years ago and there are still no clear zone boundaries in the lagoons of Moorea and Bora-Bora, but there is a strong political will to finalise these plans, at least for Moorea. A monitoring program in the 8 MPAs in Moorea started in 2004 following BACIPS protocols (Before After Control Impact Paired Series), in which islands with an MPA (the 'Impact' site) are compared with islands without an MPA (the 'Control' site) at least several times 'Before' and 'After' establishment of the MPAs. Comparison of islands with and without MPAs may estimate regional effects of MPAs, while comparison inside and outside of MPAs may estimate local effects. Such a design has never been fully tested; the islands of French Polynesia provide an outstanding opportunity to scientifically evaluate the concept through a research project. Fish, invertebrate and coral samples are currently monitored inside and outside the proposed reserves under the Moorea PGEM. Similar

A MARINE RESOURCE MANAGEMENT PLAN FOR TOKELAU

The 3 atolls of Tokelau are virtually unknown, except to the Tokelauans. The 2001 'World Atlas of Coral Reefs' includes only a brief reference of Tokelau. In 2004, a multi-disciplinary assessment team assembled under the ICRAN program and SPREP visited Tokelau to assist its government develop a program of MPAs. They completed a rapid assessment of the significant marine resources, surveyed fishing activity, conducted workshops with the community and traditional leaders to identify their requirements and wishes for the marine environment. They also canvassed actions needed to ensure the sustainable use of their marine resources, and recommended measures to be included in the Marine Resource Management Plans for each atoll. There were clear signs of overfishing and over-exploitation in the 3 lagoons, with many species being rare, and other species in low abundance and reaching maturity at smaller sizes. Although there is less subsistence fishing, the marine resources are under greater pressures because of more efficient fishing gear, motorised fishing vessels, and increased fishing for 'export'. Until recently, Tokelau was particularly isolated, but there are new market forces, as fish are being sent to family members overseas, especially in New Zealand, because there is regular transport connecting Tokelau to the wider Pacific. The communities were aware of the decline of their marine resources but did not recognise that their fishing methods, including the use of fine mesh nets, were responsible for this decline. The community leaders welcomed assistance to set up MPAs and acknowledged that the existing MPA was largely unsuccessful. The ICRAN team suggested new Conservation Areas building on the results of the ecological assessment. The Tokelauans showed strong interest and concern for their resource sustainability during consultations at community meetings. A report on the findings, and recommendations for potential new locations for MPAs, and the establishment of a long-term monitoring program will be presented in Tokelau in 2005.

data from other islands without MPAs will be used as controls. This program is expected to significantly advance our understanding of the effectiveness of MPAs.

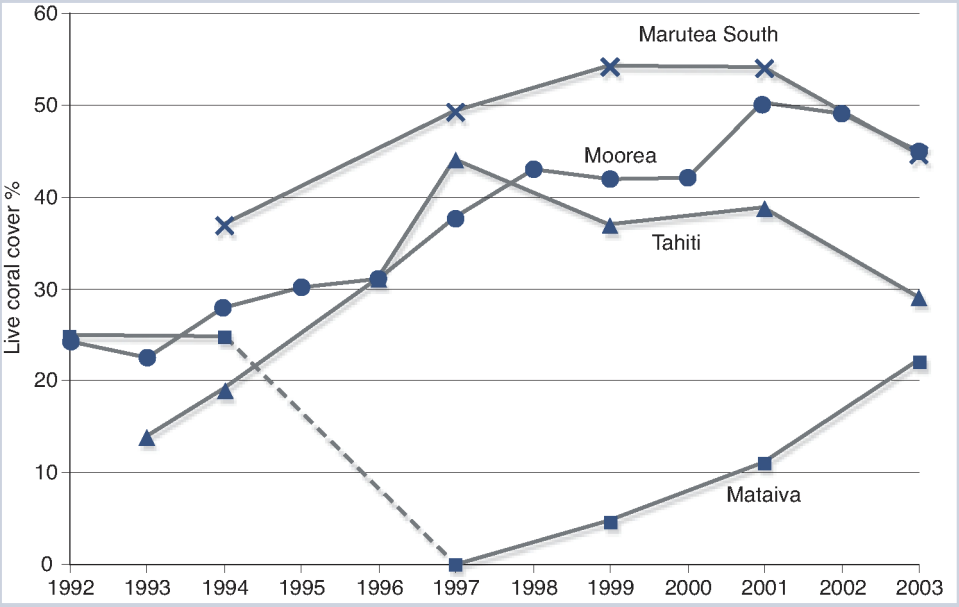
Status of Polynesia Mana Reefs in 2004

Niue

Cyclone 'Heta' battered the island in early 2004 with disastrous impacts on both the island and coral reefs on the western side. About 20 to 90% of the reefs were flattened on this coast where most of the economic activities occur, especially reef fisheries and tourism ventures, including diving. There is only one dive shop and all of its dive spots were destroyed. Prior to that, the reefs were in good condition as it had been almost 14 years since cyclone 'Ofa' and the coral cover had recovered to be very healthy in previously impacted areas. Cyclones are the major threat to the small island of Niue and the reefs have suffered considerably in the last 30 years from 6 large cyclones in 1959, 1960, 1968, 1979, 1990 and 2004. The last 3 were the most severe and all impacting on the same sites.

LONG-TERM MONITORING PROGRAMS IN FRENCH POLYNESIA

Long-term monitoring programs of outer reef slopes in French Polynesia have shown that: coral cover is relatively stable on Moorea at about 50% cover; there have been new bleaching events in Marutea South and Tahiti between 2001 and 2003; there is almost complete recovery of Mataiva reefs since the devastating cyclone in 1998 (25% cover in 1994, 22% in 2003); and coral cover on Tahiti has dropped from 40% to less than 30% in 6 years. The monitoring network of French Polynesia is upgrading to assess fish populations as well as the substrate on the 14 islands.



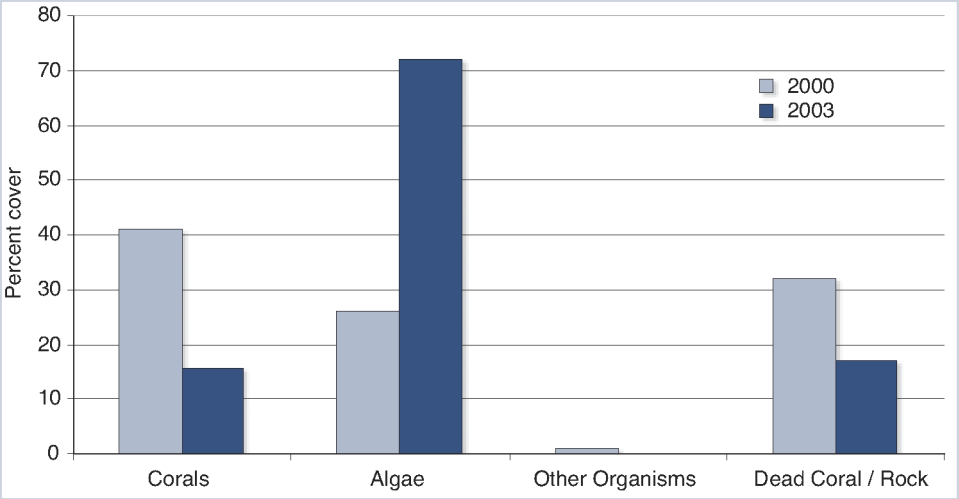
Live coral cover on 4 French Polynesian reefs shows a contrasting pattern since 1991, with sudden declines from major stress events, followed by long periods of recovery. Coral bleaching in 1991 resulted in major losses on Moorea and possibly on some of the other reefs, and another bleaching bout in 1994 combined with a cyclone reduced cover on Mataiva. A localised bleaching event on Tahiti in 1997 reversed some of the earlier recovery.

Wallis and Futuna

The outer slopes were first monitored in 1999, but only one set of repeat data were collected in 2002. These 2 surveys show a decrease in live coral cover on Futuna West from 16% to 12% in 2002, and Alofi dropping from 19% to 9% in 2002. By contrast, coral cover increased in Wallis West from 22% in 1999 to 38% in 2002. The first status report in 1999 warned that anthropogenic threats of massive sediment inputs, dredging, land reclamation, blast fishing etc. were damaging the reefs and recommended specific conservation measures. But 3 years later, no conservation measures have been implemented and the coral cover continues to decrease. The increase in coral cover on Wallis is probably due to the large lagoon that buffers the outer slopes from the polluted island waters (there is no lagoon on Futuna). Coral bleaching was observed in early 2003 down to 20 m but there has been no assessment of coral mortality.

STATUS OF REEF SLOPES AROUND RAROTONGA, COOK ISLANDS

There was a decrease in coral cover on the fringing reefs of Rarotonga between 2000 and 2003. This decline was not due to polluting industries as there was no significant nutrient loading stress on these outer slope reefs. Therefore the likely causes are global stresses such as seawater temperature increases and predation by crown-of-thorns starfish. Currently, the coral cover at 10 m is relatively stable with no evidence of recent mortality, however the coral cover and diversity are low. There is some evidence of unusually slow recovery and echinoderm numbers are significantly higher, possibly due to increased algal cover. There are few crown-of-thorns starfish, probably due to a lack of suitable coral food for them. From S. Lyon.



Coral cover has decreased in parallel with increases in macro-algal cover on the fringing reefs of Rarotonga. It is suspected that a combination of bleaching and predators has killed some corals.

French Polynesia

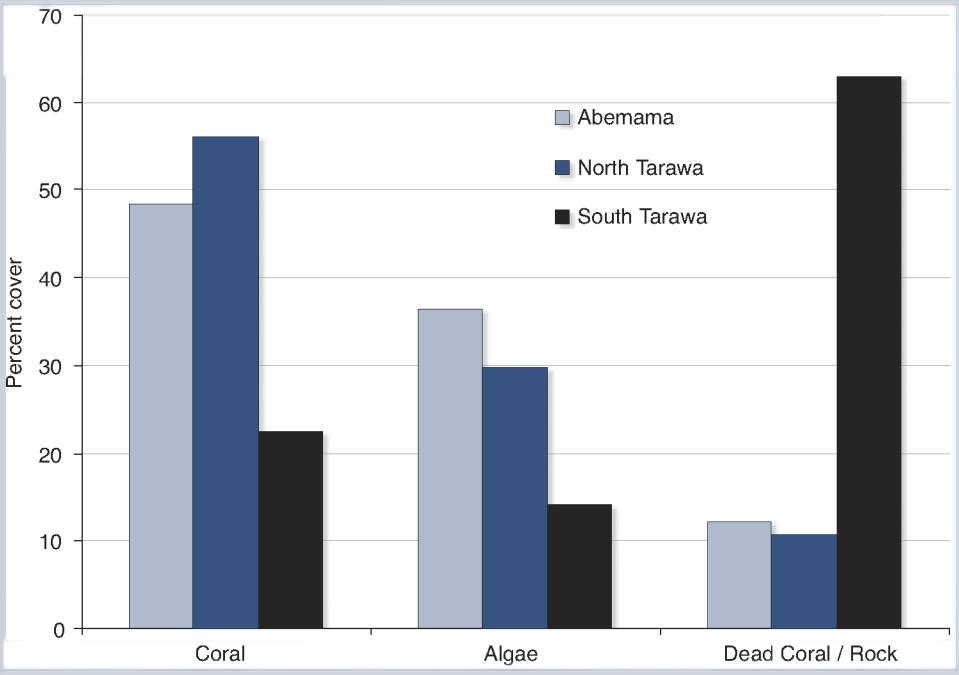
The reefs are generally in very good condition, especially the outer reef slopes of the high volcanic islands and atolls, as there have been no major natural disturbances during the past decade. Some of the lagoons of the more developed Society Islands are under increasing pressure with evidence of degradation near urban concentrations and excessive tourist resort development. The French Polynesian government is particularly concerned about the pearl industry, which is expanding in the lagoons of Tuamotu atolls. Monitoring programs have been implemented to follow water quality and the health of the environment and the pearl oysters.

Cook Islands and Tokelau

Rarotonga has experienced several COTS outbreaks and there is recent evidence of bleaching damage on Tokelau. Fish poisoning is a growing concern in Tokelau with a rusting old shipwreck suspected of poisoning fishes in the atoll of Fakaofo. Locals have requested assistance to remove it, however, a clear relationship between this wreck and fish poisoning has not been established.

CORAL MONITORING DATA NOW COMING FROM KIRIBATI

Six long-term sites were set up for annual monitoring in the Gilbert Group of Kiribati in May 2004, by the Fisheries Department and the 'Polynesia Mana' coordinator in collaboration with the Procfish program of the South Pacific Community. The sites on the outer slopes at 6 m will be surveyed annually as part of training in data collection and analysis. The first results show significant differences in the coral cover around Tarawa, with the North reef slopes having up to 50% cover including 30% cover of the blue coral, *Heliopora*. The slopes of South Tarawa have a substantial amount of dead coral cover (60%) and virtually no cover of calcareous coralline algae. This difference is probably linked to the much higher human population on South Tarawa, compared to the North. Coral cover is close to 50% on Abemama, an outer island, and similar to North Tarawa but with less blue coral and very few dead corals. On the nearby island of Kuria, there is lower coral cover (13 to 30%).



Coral cover on South Tarawa is much reduced compared to other areas, probably reflecting the direct pressures from the larger concentration of people.

Fish poisoning is also recorded in the two neighbouring atolls of Nukunonu and Atafu where there are no shipwrecks.

Kiribati

There was massive fish mortality in some atolls of the Gilbert Islands in November 2003. Various species of fish were killed, including small herbivores and larger carnivores, moray eels and even some dolphins. A toxic algal outbreak was suspected but this was not confirmed

as there was no follow up analysis. Live coral cover appears to be negatively influenced by the proximity of the massive urban sprawl of Tarawa, but some of the low populated outer islands also show low coral cover.

The countries of Polynesia Mana have not been involved in any major export or import of coral reef resources (excepting pearls). The harvesting of live fish, especially groupers for the restaurant trade in East Asia (especially Hong Kong), is presently limited to countries of the Southwest Pacific.

Predictions for Polynesia Mana Reefs

Optimistic

Optimistic predictions arise from the motivation of Fisheries and Environment authorities to seek involvement in monitoring networks and conservation programs, and from the increasing awareness of local communities about the decline in their marine resources. It is hoped that such increased motivation will attract more donors to support management programs, so that by 2014, there will be many more trained staff in all Polynesia Mana countries managing an effective network of MPAs. The optimistic position includes regular monitoring programs that are producing data to assist managers assess the effectiveness of protected areas, and used in adapting management measures to ensure resource sustainability. Enforcement is currently a major issue in Polynesia Mana countries, and it is hoped that punishment, which is becoming necessary in many islands, will not be required, as people will realise the benefits of protecting the resources. Natural disturbances will have fewer consequences for the reefs because effective management will mitigate damaging human stresses. Coral bleaching events

CLIPPERTON ATOLL INTEGRATED INTO POLYNESIA MANA

The 'Polynesia Mana' node and the French Coral Reef Initiative (IFRECOR) will expand to include Clipperton - one of the most remote and strange 'atolls' in the world. There is a 30 m high basaltic rock rim that is 12 km long and totally encloses a 30 m deep lagoon that smells strongly of hydrogen sulphide. The first visitor was the English pirate, Clipperton and the next real exploration was by Jacques-Yves Cousteau. The atoll is 1100 km to the west of Acapulco, Mexico, 4018 km from the Marquesas of French Polynesia, 4940 km from Hawaii, and 2390 km from the Galapagos Islands. It is so remote that the only inhabitants are numerous birds and red crabs. Ownership was disputed between France and Mexico until 1931 because of the 200 mile exclusive economic zone, which is rich with tuna. However, it is impossible to control exploitation due to the remoteness of this uninhabited island. Although there is much information on the flora and fauna, there have been no systematic assessments and no monitoring. Monitoring will now be conducted by the French explorer and documentary maker, Jean Louis Etienne and WWF France, and will commence in early 2005. An expedition of 40 specialists from Mexico and the Moorea Research Center will rotate on the island and monitor 2 sites at 12 m on the outer slope to assess corals, fishes and other prominent organisms. The Clipperton reefs have no anthropogenic impacts with the only threats being cyclones and possible bleaching events, although these have not been recorded.

NEW INITIATIVES IN FRENCH POLYNESIA AND WALLIS AND FUTUNA

There has been increased emphasis on coral reef ecology, social science and management initiated in French Polynesia and Wallis and Futuna through the French Coral Reef Initiative (IFRECOR) since 1999. A guide for restoration of degraded coral reefs in French Polynesia has been published in French and English after field studies on Bora Bora and Tahiti. All old coral mining sites around Moorea have been surveyed, and projects have commenced to rehabilitate landscapes for the benefit of fishermen and tourists. Management plans have been developed to include protected areas that are being monitored in Moorea, Bora Bora and Fakarava. There have been no declines in fish catches by the local communities on Moorea over a 10-year period (49 tons per year in 1992 vs 78 in 2002). Fishing is the main activity for about 20 families amongst 13,000 with most of the fish sold by the roadside. The environmental impacts of hotel sea bungalows have been studied (lagoon ecology and landscapes), to assist in determining carrying capacity by local authorities.

Reef fishing is an important activity on Wallis, with 34% taken for home consumption, 21% for exchange and 42% for sale. Coral reef protected areas covering 50 ha have been planned and are currently being considered for ratification within local and customary laws. Human pressure on these islands is high with 34 km of the 52 km coastline altered with human constructions (including low wall and rocks to protect private property and roads). Only 18 km of coastline is uninhabited. The Polynesia Mana node is now conducting coral reef monitoring.

will cause less damage to healthy corals and there will be better recovery of reefs after events such as COTS outbreaks or cyclones, because effective management systems will avoid other damaging pressures.

Pessimistic

The pessimistic position is based on a projected failure of countries in the region to establish effective management systems by 2014**.** Reef resources will be insufficient to provide sufficient food for coastal communities of the region. When the alarm is raised, it will be too late because the reefs will have declined to such a poor state that it will be impossible to reverse due to the accumulated effects of pollution and fishing pressures, combined with bleaching events, cyclones etc.

Conclusions

100 Years ago: The only pressures on the coral reefs were natural and through exploitation of pearl shell and trepang by colonial seamen in many lagoons. The reefs were predominantly healthy with normal fish populations supporting subsistence livelihoods of small populations of predominantly Polynesian, and some Micronesian, people.

In 1994: There were clear signs of damage to coral reefs around the main islands in all countries from sediment runoff, nutrient pollution, over-fishing, and shoreline modification and dredging. The remote reefs were predominantly healthy although there had been recent

damage from cyclones and some coral bleaching. The only coral reef monitoring was on a few reefs in French Polynesia, and there was generally little awareness within governments and local populations of the need for coral reef management or the establishment of MPAs. Traditional and customary knowledge and management practices were being eroded and largely ignored, except on the remote islands.

In 2004: Damage to coral reefs near populated centres continues and there have been major warnings of potential global climate change impacts with recent strong cyclones and several bouts of coral bleaching. The GCRMN Node is now functional with all countries undertaking some coral reef monitoring and all have plans for more monitoring to support stronger reef management. There is increased awareness within governments and island communities of the rising levels of damage to their coral reefs, and the need for sustainable management of their resources. Efforts are being made to reverse the damage near centres of population by removing the causative stresses. The remote reefs continue to remain healthy, but there are repeated signs of coral bleaching.

Predictions for 2014: Most reefs will remain healthy, unless the adverse predictions for global climate change or more cyclones and bleaching come to pass. Human stresses around populated islands will continue but most countries will have active programs of harm minimisation and MPA development.

Recommendations for an Optimistic Outcome in 2014

People with many years of experience in Polynesia Mana countries have formulated the following recommendations to move towards the optimistic scenario in the next 10 years. They recommend:

- Stronger cooperation between countries, especially in formulating inter-governmental environmental decisions and seeking regional funding to solve shared environmental problems;
- Establishing stronger political and public recognition of the important value of coral reefs in the lives of the people who rely on them for food security and income, as well as the contribution of reefs towards protecting fragile shorelines of the islands;
- Convincing all sectors of the population of the current and future threats to reefs and their resources and the roles that the population can play to ensure they are well managed and conserved;
- Ensuring that adequate resources and technical assistance are provided to assist Pacific Island countries in effective assessment and monitoring of coral reefs and associated marine resources;
- Incorporating traditional and modern resource management practices to form a comprehensive and integrated community-based Resource Management Plan;
- Training local agency staff (e.g. in Fisheries Departments) to effectively manage the reefs and their resources thus forming the basis for long-term sustainability of management and monitoring programs; and
- Making sure that sufficient capacity and resources are available to support community-based management initiatives and programs.

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WHS

HENDERSON ISLAND, UNITED KINGDOM - WORLD HERITAGE SITE

Henderson Island is one of the few raised atolls in the world that remains virtually unaltered by man. It has an area of 37 km^2, a maximum height of 33 m, and is part of the particularly remote Pitcairn Islands in the southeast Pacific. There are fringing reefs around half of the islands, although live coral cover is low, ranging from 5-30% on the fore-reef slopes. There have been scientific missions to record species on Henderson's reefs, however many species remain unidentified. Approximately 1% of the total French Polynesian green turtle population uses the island for nesting. Although home to 183 species of fish and 305 species of marine molluscs, there are few endemic species.

The island is uninhabited, but Pitcairn Islanders visit Henderson Island occasionally to collect timber for curio making. The only other visitors to the island are scientists and cruise ship visitors. Its pristine state and isolated location are suited to the study of the dynamics of island biological evolution and natural selection. The Pitcairn Island group is a dependant Overseas Territory of the United Kingdom and Henderson Island is Crown Land. Access to Henderson requires a licence issued by the Governor, following approval by the Pitcairn Island Council. Henderson Island has not been declared a protected area, although it receives *de facto* protection due to its isolation. The island was inscribed as a World Heritage Site under the World Heritage Convention in 1988. The UK Joint Nature Conservation Committee has published a management plan recently to establish a management committee, investigate feasibility of a permanent ranger, and stimulate scientific research.

Ecological Monitoring: There are plans to encourage research activities and to develop a monitoring program for native species of conservation importance as well as threatening alien species. There are ongoing discussions between the French Research Center on Moorea and the UK Joint Nature Conservation Committee to establish monitoring sites on fore-reefs of the island, with the results to be integrated in the Polynesia Mana node of the GCRMN.

Socio-economic Monitoring: There is no current monitoring, as the island is uninhabited, but management is focused on long-term sustainability of forestry operations and the tourism industry.

Contact: www.ukotcf.org or admin@pitcairn.gov.pn

Coral reefs are **20%** of the natural resources:
Ecological Monitoring is **occasional** with more **planned.**
Socio-economic Monitoring: is **planned.**

MAB

ATOLL DE TAIARO, FRANCE - MAB SITE

Atoll de Taiaro, Tuamotu Archipelago, French Polynesia, was declared a Man and Biosphere reserve in 1977, and is now considered a core area for the future Tuamotu Biosphere Reserve. This enlarged reserve will include 6 other atolls (Aratika, Kauehi, Niau, Raraka, Toau and Fakarava), all belonging to the Fakarava community, and the adjacent ocean to 1,000 m. Taiaro is an almost circular, completely closed and uninhabited atoll, with a raised coral reef rim enclosing a 5 km-wide, 15 m deep sandy lagoon. Outside, the bottom drops to 500 m within 700 m from the shore. There is a well-developed algal crest on the windward side of Taiaro, but the coral and mollusc communities are richer and more diverse on the leeward sides. There are also whales, dolphins, and 3 turtle species (green, hawksbill and leatherback) in the reserve.

Fakarava is the largest atoll (1220 km^2, 700 inhabitants) and management plans will focus on the land and lagoon resources, especially the community's traditional activities e.g. support the re-establishment of management tools such as 'rahui' or seasonal taboos to manage fish stocks. Monitoring on the Aratika outer slope since 1997 shows slight changes in coral cover: 28% in 1997; 20% in 1999; 24% in 2001; and 28% in 2003. Monitoring will start on Fakarava when the management plans are adopted, and socio-economic monitoring on Aratika and Fakarava will focus on fish exports to Tahiti and pearl aquaculture. Other human activities include fishing, black pearl cultivation, and minimal tourism. Pearl cultivation is authorised by the Consultative Commission of Public Affairs.

The earliest science on Taiaro was by the U.S. Exploring Expedition in 1839, and in 1972, the Muséum National d'Histoire Naturelle (Paris) and Ecole Pratique des Hautes Etudes assessed the ecology, geomorphology, and hydrology of the reef and lagoon. There were also scientific expeditions in 1992, 1994 and 1996. There is close cooperation between the traditional owners, the sanctuary administrative committee, the High Commissioner of France and the Government of French Polynesia to protect the atoll, lagoon and buffer zone. Access to the reserve is restricted to scientific researchers who have a permit from the committee. Harvesting turtles, tritons, other molluscs and black coral is prohibited.

Ecological monitoring: The Atoll de Taiaro continues to be a focal point for biological and physical research. Long-term monitoring is planned.

Socio-economic monitoring: Fakarava, Niau, Aratika and Kahuei atolls have small resident communities. Socio-economic monitoring is in the management plan.

Contact: Miri Tatarata, Délégation à l'Environnement, Papeete, Tahiti, delegation@environnement.gov.pf.

Coral reefs are **80%** of the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **planned on adjacent atolls.**

14. Status of the Coral Reefs in Micronesia and American Samoa

Editors: Ruth Kelty And Jason Kuartei
Authors: Tony Abraham, Maria Beger, Dave Burdick, Erica Cochrane, Peter Craig, Guy Didonato, Doug Fenner, Alison Green, Yimnang Golbuu, Jay Gutierrez, Mike Hasurmai, Christopher Hawkins, Peter Houk, David Idip, Dean Jacobson, Eugene Joseph, Terry Keju, Jason Kuartei, Steve Palik, Lolita Penland, Silvia Pinca, Kerat Rikim, John Starmer, Michael Trianni, Steven Victor and Leslie Whaylen

Abstract

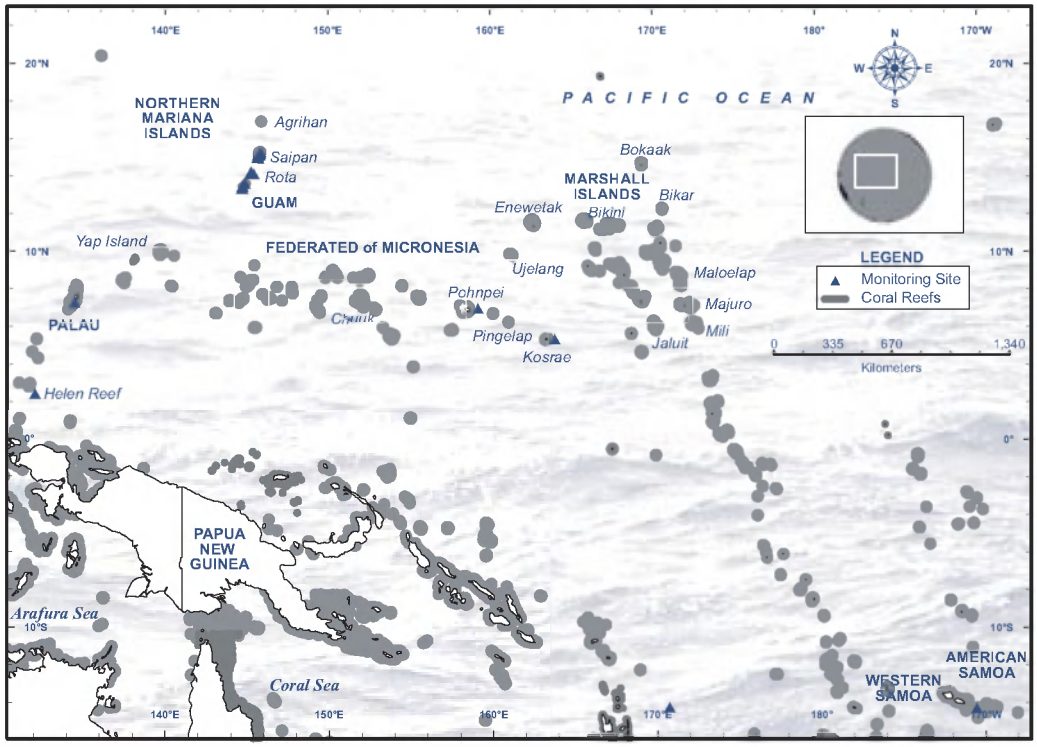
This report on the status of Micronesian coral reef ecosystems has been summarised from more detailed reports in 'The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2004', which will be available at www.nccos.nos.noaa.gov in February 2005. Previous summary details are also contained in 'Status of Coral Reefs of the World: 2002' on www.reefbase.org.

American Samoa

The diverse Samoan reefs provide food, infrastructure, and shoreline protection. Crown-of-thorns starfish (COTS) outbreaks, hurricanes, and mass coral bleaching episodes have caused declines in hard coral cover, but coral reefs now show good recovery. Hard corals are in good condition after the COTS outbreak in 1978, however, coral cover declined by 78% between 1917 and 2001 in the industrialised Pago Pago harbour. Climate change impacts such as warm-water coral bleaching and coral diseases pose the major threats to the structure and function of the reefs, along with over-fishing. The high population growth rate (2.1% per year) is adding pressure with threats of extensive coastal development, increasing fishing, loss of wetlands, soil erosion and coastal sedimentation, inadequate solid and hazardous waste disposal, and pollution.

Northern Marianas - CNMI

There has been little recent change in coral and other invertebrate communities, however polluted runoff from the populated southern islands is degrading the coral reefs. Natural disturbances (typhoons, predator outbreaks, thermal bleaching) have damaged some reef communities, and recovery has been slowed by pollution. The intensive coastal development around Saipan is damaging some of the best reefs (Lau Lau Bay and Obyan), whereas the



Map courtesy of The WorldFish Center

less developed Tinian is healthy but should be protected prior to future development. Rota is marketed as a tourist destination with healthy reefs, but these were significantly damaged by two major typhoons. Erosion and runoff threaten the recovery. Erosion of the Talakaya cliffs is causing sedimentation problems on adjacent reefs. Aguijan Island is unpopulated and has extensive coral growth, while the former military target of Naftan Rock is now home to nesting seabirds. The threats to the northern reefs are volcanic disturbance and feral animal populations increasing sediment runoff. There is a need for more monitoring collaboration as few reefs have been surveyed.

Guam

The health of Guam's coral reefs varies significantly. Reefs unaffected by sediment, nutrient loading, and freshwater runoff in the northern part of the island and between river outflows, have relatively healthy coral communities. The reefs have not suffered the large scale bleaching events and coral diseases seen in other parts of the world. Unfortunately, some reefs have been damaged by land-based sources of pollution and heavy fishing pressure. Sedimentation, algal overgrowth due to decreased herbivorous fish stocks, and low coral recruitment rates must be addressed. Despite some relatively healthy and diverse coral reefs around the island, reef fish populations have declined and larger fish are increasingly rare. The exceptions are within the 5 marine reserves on Guam, where significant increases in fish density and diversity have occurred since full enforcement began in 2001.

Federated States of Micronesia (FSM)

The reefs in the FSM are generally in good to excellent condition although there are problems in some areas with sedimentation and over-fishing. There have been a few cases of localised

bleaching around the Pohnpei lagoon, but these are associated with unusually heavy rain. Traditional leaders (Chiefs or their equivalent) and community groups are active in governance in addition to the democratically elected officials. This dual system provides both opportunities and challenges for reef and marine resource protection.

Marshall Islands

The reefs are predominantly in good condition and those surveyed at Likiep, Rongelap, Ailininae, Bikini and Mili in 2001 - 2003 were mostly pristine, with many large fish, healthy corals, algae and key invertebrates. Abundant mega fauna such as sea turtles, whales, rays and humphead wrasse were also recorded. Damage from bleaching and white band disease was only seen on the capital atoll in 2003 and 2004. Monitoring and management capacity is increasing through a new partnership between the College of the Marshall Islands and government agencies to support resource monitoring, management, and planning. Coastal managers and marine biologists are using results from the 2001-2003 surveys to recommend that MPAs be established at sites in pristine health with high biodiversity.

Palau

Palau has the most diverse coral fauna of Micronesia, and the highest density of tropical marine habitats in the world. The Palau International Coral Reef Center is continuing comprehensive long-term monitoring that began in 2001. Remote reefs are generally healthy, whereas the reefs closer to population centres or near development are showing signs of degradation. About one third of Palau's corals died during a 1998 bleaching event, with coral mortality as high as 90% in some areas. Many areas affected by the bleaching have not fully recovered. The Protected Areas Network Act of 2003 supports local government efforts directed at protecting marine resources and encouraging designation of new MPAs by the State Governments.

100 Years ago: Virtually all coral reef ecosystems were healthy with normal fish populations. Human pressures on the reefs were well within sustainable limits.

In 1994: Coral reef monitoring was conducted on an ad hoc basis, mostly by the research community with short-term funding. There was no comprehensive monitoring program in place, and no integrated assessment of reef condition. Many reefs and fisheries near populated areas were showing signs of degradation, but generally the reefs were healthy.

In 2004: The Pacific Island states and territories continue to improve coral reef monitoring and management. Reefs are damaged near centres of population, whereas remote reefs remain healthy. Climate change effects are the major threat on the horizon, along with damage associated with coastal development. Progress in coral reef management has been made including, significant regulations to ban scuba-assisted fishing and 'live rock' harvesting, and establishing a local government sanctuary for turtles and marine mammals. Interagency management efforts are focused through 'Local Action Strategies' to address over-fishing, land-based pollution, population growth, and climate change. Each Strategy includes specific time-lines, and there is progress in developing coordinated monitoring programs and networks of MPAs.

Predictions for 2014: Reefs away from population centres will remain healthy, unless the adverse predictions for global climate change of more tropical storms and bleaching eventuate. Human stresses around populated islands will continue, but if governments maintain or build their capacity and commitment to improving reef ecosystem management, these stressors and the associated damage should be minimized.

Introduction

American Samoa

The Territory of American Samoa is a group of 5 volcanic islands and 2 atolls in the central South Pacific Ocean. The islands are small, ranging in size from the populated high island of Tutuila (142 km^2) to the uninhabited and remote Rose Atoll (4 km^2). The total reef area is 296 km^2 and consists of fringing reefs (85%), a few offshore banks (12%), and two atolls (3%). The fringing reefs have narrow reef flats (50-500 m) and depths of 1000 m within 2-8 km of the shore. These reefs contain a diverse assemblage of 890 fish, 200+ coral, and 237+ algal species; and there are many other invertebrates.

Commonwealth of the Northern Mariana Islands

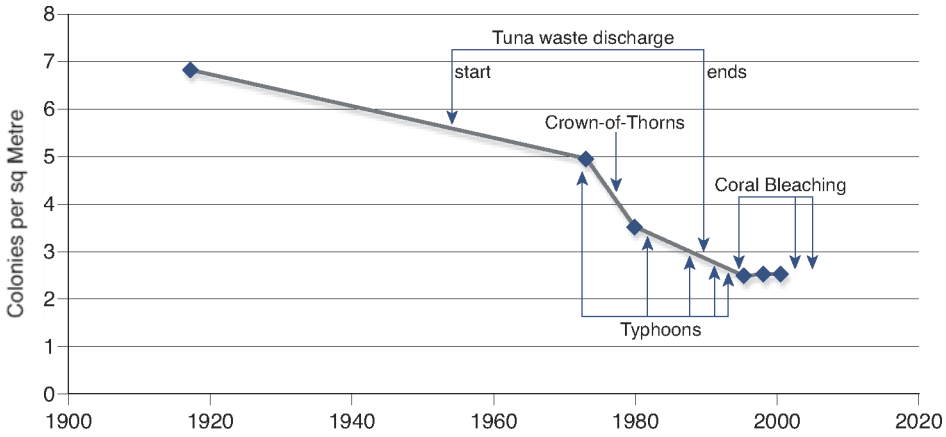
The Commonwealth of the Northern Mariana Islands (CNMI) is a chain of 15 islands divided into 2 sections, with large variations in the coral reef resources between the south and the north. Estimates of the total area of coral reefs in the CNMI are lacking, but most of the 417 km shoreline is potential coral habitat, although active reef development may not occur in all areas. The southern islands (Saipan the capital, Tinian, Agijuan, Rota, and Farallon de Medinilla) are mostly raised limestone blocks with sloping coastlines protected by barrier reefs and well-developed fringing reefs on the western coasts. The largely uninhabited northern islands (Anantahan, Sariguan, Gugan, Alamagan, Pagan, Agrihan, Ascuncion, Maug, Uracas, and Farallon de Pajaros) are primarily volcanic, including some active volcanoes, and have much less reef development.

Guam

This U.S. territory is the most southern island in the Mariana Archipelago and the largest island in Micronesia (560 km^2, maximum elevation 405 m). The northern part of the island is relatively flat and is mainly uplifted limestone, while the southern half is more rugged and primarily volcanic, and has large areas of highly erodible laterite soils. There are fringing reefs, patch reefs, submerged reefs, offshore banks, and a barrier reef surrounding the south. The reef margin varies in width, from tens of metres along some of the windward areas, to well over 700 m. The combined area of coral reef and lagoon is 69 km^2 in nearshore waters between 0-3 nautical miles, with an additional 110 km^2 in federal waters more than 3 nm offshore.

Federated States of Micronesia

The FSM consists of 4 states: Kosrae; Pohnpei; Chuuk; and Yap. Each island or group has its own language, customs, local government, and reef tenure system. The FSM has high volcanic islands and atolls, and a strong economic and cultural dependence on coral reefs and marine resources. There are 3 basic reef formations, which correspond to the stages of reef development on each island: fringing reefs; barrier reefs; and atolls. Kosrae is a single island of 109 km^2, highest elevation of 629 m, and surrounded by a fringing reef with a single harbour. Pohnpei is the FSM capital island and the largest island at 345 km^2, and has a well-developed barrier reef and associated lagoon. It includes 8 nearby smaller island and atolls to form Pohnpei State. Chuuk State (formerly known as Truk) is 15 inhabited islands and atolls, and famous for the Japanese wrecks sunk in the lagoon during World War II. Yap State has a main island of 100 km^2, and 15 other islands and atolls. These islands are the most traditional, with a highly sophisticated marine tenure and associated marine resource management system.



The number of hard coral colonies on the Aua Transect, in Pago Pago Harbor, has dropped dramatically from 1917 to 2000. The main reasons are tuna cannery wastes; COTS, Typhoons and coral bleaching. (Data are from Mayor, 1924; Dahl and Lamberts, 1977; Dahl, 1981; Birkeland and Green, 1999; Birkland and Belliveau, 2000).

Marshall Islands

The Marshall Islands encompass 1,225 islands and islets with 29 atolls and 5 solitary low coral islands. The land area is only 181.3 km^2, however, the Republic covers 1,942,000 km^2 within the Exclusive Economic Zone (EEZ). There are 11,670 km^2 of lagoons in the atolls, and these atolls vary in size from Kwajalein, the world's largest with 16.4 km^2 of land and a lagoon of 2,174 km^2, to Bikar with only 0.5 km^2 of land, but a 37.4 km^2 lagoon, and Namdrik with 2.7 km^2 of land but only 8.4 km^2 of lagoon.

Palau

The Republic of Palau is the most western archipelago in Oceania; 741 km east of Mindanao, southern Philippines and 1,300 km southwest of Guam. There are 20 large and intermediate islands and over 500 small islands stretching across 700 km. The biggest island, Babeldaob, is volcanic. Koror (the capital) and the other islands are separated from Babeldaob by a 30-40 m deep pass, Toachel El Mid. The outer islands are 339 - 599 km southwest of the main Palau archipelago. A 144 km, well-developed barrier reef protects the Western coast. Ngchesar and Airai have barrier reefs, Ngiwal has a submerged barrier reef at 5-10 m deep, and the total shallow-water coral reef area of Palau is 1,661 km^2.

Status of Coral Reef Benthos

American Samoa

Extensive studies by the Carnegie Institute of Washington between 1917 and 1920 provide excellent baseline data to determine coral reef changes in Pago Pago Harbor. Re-surveys of the 1917 transect show the trends at the reef at Aua over 83 years, the longest quantitative reef monitoring anywhere. A 28% decline in average colonies per square metre was recorded in 1973, with a more severe drop (30%) between 1973 and 1980. The decline of 78% in average colonies per m^2 between 1917 and 2001 indicates that natural and anthropogenic disturbances in Pago Pago Harbor have degraded the reefs. Although there is no clear cause and effect

relationship, the major factor behind the decline is probably eutrophication from tuna cannery discharges between 1954 and 1991 and construction of roads and other infrastructure. A COTS outbreak in 1978 and coral bleaching in 1994, have contributed to reef decline in the Harbor. These reefs are showing the first signs of recovery, with the first *Acropora* recruits for decades. There are still problems with water quality (e.g chronic fuel spills), and these reefs are the worst in American Samoa, with no evidence of the lush coral growth seen early last century.

An improvement in reefs in Fagatele Bay National Marine Sanctuary was observed between 1995 and 2001, with large increases in coral cover and colony size at all survey depths. However, the composition was skewed towards faster-growing, opportunistic species. Coral cover in 2001 exceeded that seen in 1985 at 77% of the survey sites, with nearly 70% of these sites having higher levels of coral density in 2001 than in 1985. Fagatele reefs are now in their best condition since the devastating COTS outbreak in the late 1970s. In contrast, reef flat coral cover and density in 2001 remained lower than 1995. This trend was confirmed in the 1998 survey, and was probably caused by a low-tide event that caused mass-mortality in reef flat corals in 1998. Coral cover around the other islands increased during the first half of the 1980s, then decreased through the 1990s. Since then, coral cover around the islands has increased strongly, and currently is higher than the peak levels in the mid-1980s. Cyclone damage is the major cause of irregular but recurring patterns of coral loss and recovery. American Samoa was hit by 4 cyclones in the past 18 years (1987, 1990, 1991, 2004). A major COTS outbreak that peaked in 1978 resulted in large losses of coral populations, but has not recurred. Mass coral bleaching episodes in 1994, 2002 and 2003 correlated with high water temperatures also killed significant numbers of corals.

Northern Marianas - CNMI

There are 256 hard coral and 41 octocoral species, and new species are expected as surveys continue. Coral diversity is higher in the southern islands where the reefs are older, more developed, have more diverse habitats, and are free from volcanic disturbances. The local interagency Marine Monitoring Team (MMT) has surveyed the southern reefs for 4 years, and NOAA completed a major survey of the more remote reefs. The long-term monitoring program has focused on areas associated with potential water quality disturbances (runoff, sewage outfalls, urban development) and other reference locations. Results indicate that reefs range from very healthy to disturbed. Two sites in Lau Lau Bay show decreases in coral cover, diversity indices, and shifts in the relative abundance of species from branching to massive and encrusting corals over the past two decades. Sea urchins and sea cucumbers have decreased in abundance at both sites between 1991 and 2004. A decrease in mean coral diameter for several coral genera and the relative frequency of large branching corals observed at one site in 2001 was attributed to the 1983 COTS outbreak, and poor subsequent recovery. Reefs associated with the Talakhaya watershed in Rota Island show similar trends of decreasing reef health since the first surveys in 1989. Upland burning practices have led to declines in reef health. Natural disturbances such as typhoons, COTS, and climate related bleaching have damaged various coral reef habitats in different ways. The natural disturbances usually damage the fast growing table and branching corals which are most susceptible, and the loss of these means that the reef becomes more two dimensional, e.g. flatter with fewer habitats for fishes. COTS are present in low numbers on most reefs, but several areas have retained persistent populations since 2001, including Obyan Beach and Lau Lau Bay on Saipan, and Unai Babui on the eastern side of Tinian. Water quality on Saipan's beaches is consistently good with few microbiological and chemical problems. Diseases are uncommon on CNMI reefs, with the exception being

ciguatera and coralline lethal orange disease. Coral tumours have been observed, with a high prevalence in *Isopora* west of Managaha Island.

Over 150 species of algae, 3 seagrass species, and 1 species of mangrove have been identified from Saipan Lagoon, and more species are found as more areas are surveyed. There have been local extinctions of seagrasses on southern reef flats on both Rota and Saipan, however a small stand was recently discovered on Rota. Two small areas of mangrove habitat near the commercial port areas in Saipan are the most northerly mangrove communities in the western Pacific.

Guam

Guam is close to the centre of coral reef biodiversity and has 403 hard coral and 119 soft coral species, 237 marine macro-algae species, 110 sponges, 117 ascidians, 3 seagrasses, and 303 foraminifera. The health of Guam's coral reefs varies considerably, depending on: the geology; human population density; level of coastal development; level and type of marine resource use; oceanic circulation patterns; and frequency of natural disturbances.

Widespread bleaching and disease have not damaged the reefs on Guam, but many of the reefs have declined in health over the past 40 years. Average live coral cover on the fore-reef slopes has decreased from approximately 50% in the 1960s to less than 25% cover at most sites in the 1990s. An even more distressing indicator of coral health in Guam is the marked decrease in rates of coral recruitment. In 1979 there were 0.53 coral recruits on experimental fouling panels, but this number fell to just 0.004 recruits per panel in 1989, and to 0.009 recruits per panel in 1992. Sedimentation, freshwater runoff, and algal overgrowth due to decreased fish stocks are believed to be important factors in these changes.

Coral cover on the Orote Peninsula Ecological Reserve Area (ERA) was generally low, ranging between 4 - 19%, with turf algae dominating the bottom cover at over half of the sites. However, at the Haputo ERA, coral cover was higher at 37 - 64% followed by turf algae. A coral-killing sponge *Terpios hoshinota* was very prominent in the Haputo ERA.

Another concern has been COTS outbreaks, although there have not been any large outbreaks recently, but some aggregations of about 500 individuals have been seen at some sites recently. The COTS feed preferentially on *Acropora, Montipora*, and *Pocillopora* and this may have resulted in a shift in the reef community towards species like *Porites, Favia,* and other more massive species over the last 20 years.

Federated States of Micronesia

Coral reef biodiversity and complexity is high on reefs in FSM and this diversity increases from east to west away in the direction of the centre of marine diversity in Southeast Asia. There are more than 300 species of corals: 150 in Kosrae to the east; 200 in Pohnpei and Yap; and 300 in Chuuk. There are more than 1,000 fish species, 1,200 mollusc species, and 143 species of algae in the FSM.

Reefs in Kosrae have been damaged by coastal development, specifically the construction of an airport built over a reef. Unregulated mangrove clearing over the past 2 decades has resulted in shoreline erosion along the coast, which has caused increased sediment flow onto the adjacent reef flats and seagrass beds. Data from permanent monitoring sites over the past 3 years show that coral cover averaged around 65% over 5 permanent monitoring sites from 2000 to 2002.

The reefs around Pohnpei vary in condition, with coral cover ranging from 15% to more than 60% at selected sites. A bleaching event in 2003 affecting several *Acropora* species on the north-eastern fringing reefs. The large annual rainfall, and steep volcanic slopes mean that erosion and sedimentation rates can be high. In addition, there has been clearing of forests on the slopes to grow sakau (a pepper root crop used to make an intoxicating drink, like kava) and dredging; these have resulted in landslides along the coastal areas and increased sediment input into the major rivers.

The coral cover in Chuuk is indicative of generally high water quality; however over-fishing is resulting from the activities of foreign commercial fishers. Destructive fishing practices, including the use of explosives taken from the wrecks, have caused some local damage. Hard coral cover averaged about 25% on inshore reefs in 1998, but typhoons in 2002 and 2003 caused major damage to large sections of coral reefs in the lagoon.

Surveys of 18 sites around Yap in 1995 and repeated 16 months later found mean coral cover at 28.8% and 28.7% respectively, even though a typhoon hit the Island between the surveys. Crustose coralline algae were also abundant on the reefs. Typhoon Sudal hit Yap in April of 2004 causing widespread damage on the island as well as on the adjacent reefs, but the amount of damage to the coral reefs in Yap has not been measured.

Marshall Islands

There are at least 362 species of corals and coral like animals, as well as 40 sponge, 1,655 mollusc, 728 crustacean, and 126 echinoderm species on the coral reefs of the Marshall Islands. Surveys of reef health and fishing potential were conducted in Likiep in 2001, Rongelap and Bikini in 2002, and the atolls of Mili, Rongelap and Ailininae in 2003. These reefs were in virtual pristine condition, with high abundance of large fishes (especially on the uninhabited atolls of Ailininae and Rongelap), healthy corals, algae and other species were present and abundant. There were abundant mega fauna such as turtles, whales, rays and Napoleon wrasses.

Coral cover is generally high in the Marshall Islands, with the peak areas on the leeward ocean sides of the atolls. Patch reefs inside the lagoon also have high coral cover and diversity. The highest mean coral cover was 57 – 68 % on west ocean leeward sides of several atolls. Rongelap was the highest with 79% cover. The most common coral species groups were *Porites lobata* and *P. australiensis* in Rongelap, and *Acropora* sp., *Isopora palifera/cuneata* in Mili. New range extensions for several species of corals and fish were recorded during 2002 and 2003 surveys, and a new coral species was found in Rongelap on pinnacles in the lagoon: *Acropora rongelapensis*. Coral diseases occur on the Majuro ocean side corals; one disease found on ocean reefs is caused by bacteria with a rapid spreading rate of more than 2 cm per day, and often co-exists with high densities of a coral eating ciliate protozoan. Other diseases occur in Majuro lagoon. A severe COTS outbreak occurred in September 2004 on lagoon and pass sites in Majuro Atoll. *Drupella* is locally abundant, causing mortality in small *Acropora* colonies. Finally, CLOD (coral lethal orange disease) occurs frequently on the ocean side of Majuro, near Delap.

Macro-algae, especially *Microdyction* and *Halimeda*, and coralline algae are abundant and coexist with healthy hard corals. Algal cover is higher at the West Ocean and South Ocean sites in Mili and East, South and North ocean sites in Rongelap. West Ocean sites in Likiep are dominated by coralline algae, and 222 macro-alga species, 3 species of seagrass, and 5 species of mangroves have been identified in the Marshall Islands.

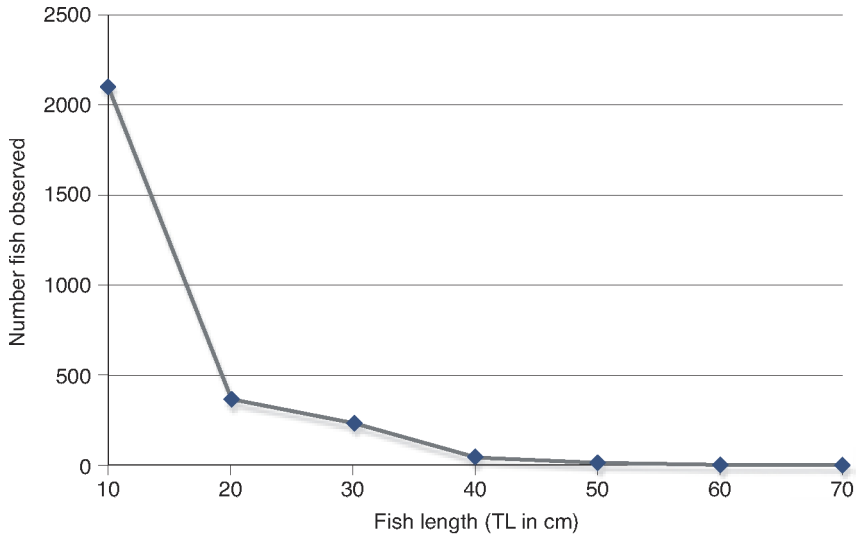
ACANTHASTER PLANCI EFFECTS ON CORAL COMMUNITY STRUCTURE

Tanguisson Reef in Guam has been monitored since the early 1970s to follow recovery after a 1967 outbreak of *Acanthaster planci* (crown-of-thorns starfish or COTS). Coral cover increased after the outbreak through new coral recruitment and growth of existing corals. COTS preferentially consumed *Acropora, Montipora,* and *Pocillopora* species, while *Astreaopora, Cyphastrea, Goniastrea, Pavona,* and *Stylophora* were medium-preference corals. The diet of the COTS depended on the relative abundance of corals; if the preferred species were relatively abundant, they were the main food source, while medium-preference corals were only eaten when preferred species were not abundant. Non-preferred corals were eaten only when the others were relatively rare. While there was no change in total coral cover on the submarine terrace and a slight decrease on the seaward slope, there was a change in community composition due to feeding by COTS. Non-preferred corals had significantly greater cover than preferred or medium-preference corals on the seaward slope and the submarine terrace. Preferred corals increased slightly in cover and abundance on the reef front, but not as much as the other preference groups. This study suggests that selective feeding by COTS has driven large-scale changes in the coral communities at Tanguisson Reef over the last 20 years. Seasonal algal blooms are an additional stress that may prevent the settling of larvae of *Acropora, Montipora,* and *Pocillopora* species that spawn in the summer. This combination was probably exacerbated by increased nutrient input into Guam's coastal waters and a reduction of herbivorous fish stocks due to over-fishing. While Guam has not had any recent outbreaks of COTS, aggregations of 500 individuals have been seen and the feeding behaviour of these aggregations may modify the coral community composition on Guam. The reefs at Tanguisson were re-examined in 1981 and 2001. There has been a shift in the reef community towards *Porites, Favia,* and other non-preferred species, probably at the expense of *Acropora, Montipora,* and *Pocillopora* species, which are preferred species. Better land management is recommended as the best way to protect Guam's reefs from future shifts in coral communities as the reefs continue to be threatened by COTS.

Palau

The coral diversity here is comparable to the Philippines, Indonesia, and Australia and is probably 25% higher than on Guam. Palau has 425 named species of hard corals, and 120 species of octocorals. The presence of many new recruits and juvenile corals at most monitoring sites suggest that Palau's reefs are recovering well from the 1998 bleaching events, however, there is not full recovery of coral cover and species diversity compared to the reefs before 1998. Rapid spot checks of 217 sites in 2001-2002 show that: only 1% of sites had *Acropora* cover greater than 50%; only 9% of sites had greater than 50% non-*Acropora* coral cover; 68% of sites had non *Acropora* coral cover of less than 25% cover; and 87% of the sites had 0-5% *Acropora* cover. Thus most sites still have very low coral cover.

Significant differences in coral cover are showing up among reef types and depths in Palau during the last 2 years of monitoring. Coral cover at 3 m depth was highest at Nikko Bay



The lengths of the main target fishes (surgeonfish, unicornfish, parrotfish, snappers, emperors, groupers, jacks and sharks) on Tutuila in 2002 shows that there are very few fish larger than 40 cm and a preponderance of small and juvenile fishes (From Green 2002).

(49.1%), a fringing reef site in the Rock Islands; and the highest coral cover at 10 m depth was on Nikko Bay and Ngemelis (a western barrier fringing reef), 38.1% and 38.6% respectively. The lowest coral cover at 3 m and 10 m depths was on the Airai fringing reefs on the east coast (5.45% at 3m and 2.6% at 10m) and Ngaremlengui patch reef sites on the west coast of the main island of Babeldaob (5.4% at 3m and 2% at 10m). Sandy bottoms dominate both sites and high levels of sediment resuspension occur during windy conditions.

Status of Coral Reef Fishes and Invertebrates

American Samoa

The coral reef fish fauna in American Samoa is quite diverse with 890 species; approximately twice the number that occur on Hawaiian and Caribbean reefs, but half the number found on the more diverse reefs of Indonesia and northern Australia. The small size and steep slopes of the islands, which contain relatively few shallow water habitats, limit reef fish populations.

Major changes in the fish communities on Tutuila and Aunu'u correlate with the changes in the coral communities and fishing activity. Some fish species populations are in good condition, but others are seriously depleted (small size and low abundance) by targeted over-fishing of groupers, parrotfishes and snappers.

Fish surveys are showing that there are few large fish on the reefs around the 5 main islands, which indicates serious over-fishing. This depressing situation was not sudden, as surveys in 1996 and 2004 show that there have been few large fish on local reefs for at least 8 years. Additionally, surveys by NOAA in 2002 show that densities of large fish on the main islands (Tutuila and Manu'a) were much lower than the remote atolls (Rose and Swains), which were

much lower than on the unfished Northwestern Hawaiian Islands. A six-fold decrease in fish density between the main islands and remote atolls is further evidence for over-fishing. American Samoan reefs still have an abundance of small herbivorous surgeonfish and parrotfish, which help graze the macro-algae and prevent them overgrowing corals.

Reef fish are harvested by subsistence and artisanal (small-scale commercial) fishers on the 5 main islands. Artisanal fisheries include night-time free divers who spear reef fish, and small boat fishers who fish for deepwater bottomfish. Spear fishermen started using scuba gear around 1994, and quickly doubled their catch rates; the practice was banned by executive order in 2001 following evidence of dramatic declines in reef fish. The fish harvested are usually eaten by the families or sold at local stores; there are no exports. Bumphead parrotfish, which were never common, were last seen in 1995, and are now presumed to be locally extinct. Bottom fishing flourished briefly in the early 1980s when the fishery was subsidized, but it declined after the subsidies were removed and the few available fishing grounds were fished out. Most of the remaining bottomfish boats converted to longline fishing for albacore in 2001.

Two trends in these fisheries are that subsistence fishing has been declining steadily over the past two decades as villagers shift from a subsistence, to a cash-based economy, and coral reef fish and invertebrate resources have declined significantly in abundance and size due to over-fishing. Giant clams and parrotfish are over-fished, and there has been heavy fishing pressure on surgeonfish. Monitoring teams see fewer and smaller groupers, snappers and jacks; the NOAA divers confirmed the low abundance of large fishes and sharks around the main islands in February 2004.

Northern Marianas - CNMI

So far 1,019 pelagic and bottom fish species have been recorded in the CNMI, dominated by the families Gobiidae, Labridae, Serranidae, Pomacentridae, Muraenidae, Apogonidae, Blennidae, Carangidae, Acanthuridae, and Chaetodontidae. The yellow-crowned butterflyfish (*Chaetodon flavocoronatus*) and 2 Guam reef damselfish (*Pomachromis gumaensis, Prealticus poptae*) are endemic species. The fisheries are generally in very good condition, but there is local depletion of reef and bottom fish in the southern islands, particularly around the Saipan-Tinian population centres. Although the near shore resources of Rota are in good condition, many offshore banks have been depleted due to fishing from Saipan and Guam. Local laws and regulations have been recently developed to protect the stocks of coral reef fishes throughout the CNMI. Spear fishing using scuba and hookah was prohibited throughout the CNMI when Saipan and the Northern Islands District joined Rota and Tinian to pass local laws to ban their use in 2003. In addition, the CNMI Division of Fish and Wildlife regulations were amended to ban the use of monofilament gill, surround and drag-nets. Following these changes, the Interagency Marine Monitoring Team conducted a baseline survey of the fish resources in Saipan Lagoon to track any trends in fish abundance, biomass and diversity.

The invertebrate resources in the CNMI are not commercially harvested. A sea cucumber fishery targeting *Actinopyga mauritiana* was active in the southern islands of Rota and Saipan in the 1990s. But the fishery was stopped in 1997, and a 10-year moratorium on the harvest of all sea cucumbers started in 1998. The introduced topshell, *Trochus niloticus*, was harvested for 2 months in 1997, but harvest is now banned by law until stocks recover. Subsistence harvests of other invertebrates are mainly through gleaning by Chinese, Filipino and Thai workers, and some locals. Most invertebrates harvested are soft sediment bivalves, giant clams, chitons,

gastropods, crustaceans and sea urchins. There have been few efforts to assess subsistence harvesting, but an inshore creel survey program will target both fish and invertebrates. The Western Pacific Regional Management Council developed a Coral Reef Ecosystem Fisheries Management Plan for CNMI and other Central and Western Pacific states to manage the harvest of all plants and animals from coral reefs within the Federal EEZ.

Guam

There are 1,019 reef fish species, 3 turtle species, and 13 marine mammal species in Guam territorial waters. Fishing for reef fish and invertebrates is an important cultural and economic activity by both subsistence and commercial sectors. There was a significant decline in the catch per unit effort (CPUE) for inshore fisheries during surveys by the Division of Aquatic & Wildlife Resources (DAWR) in the 1980. CPUE remained low throughout the 1990s and this stimulated the creation of 5 marine preserves: Tumon Bay Preserve; Piti Bombholes Preserve; Sasa Bay Preserve; Achang Reef Flat Preserve; and Pati Point Preserve.

DAWR has monitored reef fisheries through creel surveys and visual census techniques for 20 years to estimate harvest and CPUE (kilograms per gear hour). Bottom fishing was the most popular method accounting for 20% of the total harvest in 2002 and 27% in 2003. This was followed by snorkel spearfishing with 18% in 2002 and 25% in 2003, and hook and line with 16% of the total harvest in 2002 and 14% in 2003. CPUE was highest for gill net fishing in 2002 and for scuba spearfishing in 2003. Hook and line was the least efficient method for both years. Visual censuses suggest that fish communities outside the 5 marine preserves are less diverse and less abundant than expected, and there is a marked absence of large fish. The most abundant fish families at Haputo ERA were the damselfish (74%), surgeonfish (10.1%), and wrasses (6.7%).

Guam has diverse invertebrate assemblages with: 59 flatworm; 1,722 mollusc; 104 polychaete; 840 arthropod; and 196 echinoderm species. The invertebrate harvest showed an increase of 188% between 2002 and 2003, due mainly to an 11% increase in snorkel spearfishing targeting invertebrates with an 85% increase in CPUE. Octopus harvesting was top of the invertebrate species harvested in 2002 and 2003, and the others included the spiny lobster *Panulirus penicillatus*, which increased 245% between 2002 and 2003, the mangrove crab *Scylla serrata* with 508 kg in 2002, and *Carpilius maculatus* with 145 kg in 2003.

Federated States of Micronesia

Most of the marine fish species recorded for the FSM are reef-associated (873 of 1,125). There are few catch and export data, but some market information suggests that the fisheries may be substantial. The gross value output of FSM fisheries was estimated at US$86.4 million in 1998, and while commercial export has the greatest impact on FSM fisheries, over-fishing by foreign vessels has also been documented. The limited exports from Yap and Kosrae are mostly through shipping coolers of fish to family members on Guam and the CNMI. Recent surveys of bumphead parrotfish in Kosrae show serious declines in the abundance and interviews with locals show there is strong support for protective measures. Chuuk had the largest commercial export and export of fishes, and crabs were exported from Pohnpei until a recent cholera outbreak shut it down. Destructive fishing practices, including the use of explosives taken from the wrecks, have caused local damage, but better assessments of fisheries resources within the FSM are needed.

Republic of the Marshall Islands

The highest abundance of fish is on the northern and southern ocean sides of Likiep and Mili atolls, and on the east ocean side in Rongelap. Surgeonfish, snappers, wrasses, fusiliers, parrotfishes, snapper, and grouper are the most abundant food fish families, and 7 of the 860 reef fish species in the Marshall Islands are endemic. A total of 373 fish species were recorded from Mili Atoll in 2003, with the richest areas in the central pinnacles of the southern lagoon and the north-east ocean area that is being considered as a sanctuary. Rongelap Atoll had 397 species with the richest area being the tip of Jaboan at Rongelap Island, also recommended as a sanctuary. The passes generally had more fish species because they had both outer reef and lagoonal habitats. There were lower fish abundances in sheltered sites in the lagoon, but there were many unusual species. Humphead wrasse were observed in the eastern part of Rongelap Atoll at the edge of the drop-off, and on lagoon pinnacles near passes. They were slightly less abundant in Likiep, and least abundant in Mili Atoll.

There are large numbers of sharks on RMI Atolls, especially grey reef sharks and white tip sharks. Silvertip sharks were common in deeper waters. Nurse sharks were only seen at three sites in Rongelap Atoll, and a tiger shark was observed along with a few black tip sharks. Sharks were also common on the lagoon side in relatively shallow depths (6-10 m). However, a low number of sharks were seen on Mili at sites where the locals reported that there were previously high concentrations. Large pods of spinner dolphins were seen either in the lagoon, in passes or on the ocean side. Small giant clams were significantly more abundant at the leeward ocean sites than at any other areas. However, many giant clams of the 5 species were recorded for lagoonal sites and pinnacles in Rongelap. Sea urchins are abundant only at windward ocean sites, and sea cucumbers were present in very high numbers on the lagoon side of the East of Likiep Atoll.

Palau

Palau has the highest reef fish diversity in Micronesia, with 1,278 known species and the number is expected to rise with more searches. The most common fish found during detailed surveys were surgeonfish, parrotfish, rabbitfish and snappers. The highest density of fish was on Ngerdiluches; and Nikko Bay in the rock islands had the lowest density. Surgeonfish were the most common fish in all sites. There are higher numbers of snappers on the barrier reefs compared to sheltered fringing and patch reefs. Abundance data for rabbitfish show opposite patterns to snappers, and parrotfish are evenly distributed among all monitoring sites.

The Bureau of Marine Resources report that 835 people, or 16% of Palauans, sold their catch to the local fish markets in 2001. Subsistence fisheries surveys indicate that 87% of households in Palau have someone that fishes either for subsistence or commercially or both. The total inshore fisheries production has averaged 1,800 metric tons annually over the past 20 years, with 20% being sold at the local markets, 14% exported, and 66% for direct consumption. Field surveys, fish aggregation studies, and observations by fishermen all indicate a decline in fish populations and average catch size. In 2002, 31% of key informants perceived that the inshore fisheries were being unsustainably over-harvested and communities perceived their catch to be at least 3 times less than a decade ago, however, commercial landing data from 1988 to 2001 show no significant trend in the amount of catch, possibly indicating that effort has increased.

Anthropogenic Threats to Coral Reefs

Threats from fishing and climate change are addressed in other sections.

American Samoa

The Coral Reef Advisory Group identified population growth as a major threat to coral reefs, especially on Tutuila where there are more than 1000 people per km^2. Streams carry sediments and nutrients to coastal waters and most villages have experienced major flooding, stream sedimentation, and damage to reef health. Many point sources of pollution have been identified and mitigated, and non-point sources of pollution are now the major stress in coastal areas. The sources of nutrients in local streams include faulty or improperly constructed septic tanks and concentrated animal waste from small family-owned pigsties. Industrial, commercial, and military activity in Pago Pago Harbor degraded water quality and reefs, but limited evidence suggests that harbour reef habitats may be recovering in response to reduced pollution.

Ten 30 m foreign-flag longline fishing boats grounded in the territory between 1991 and 1993. Monitoring of the 1993 damage site on Rose Atoll indicated the grounding killed about 30% of the atoll's base of crustose coralline algae and caused a phase shift from a coralline algae base to one of fleshy blue-green algae, most likely due to iron enrichment. The phase shift is still visible 11 years later, even though most of the debris has been removed.

Northern Marianas - CNMI

Sediment and nutrient pollution affect many of Saipan's western and southeastern reefs. The development boom of the late 1980s and early 1990s left a legacy of over-burdened and failing sewerage and solid waste management systems, increased sedimentation, and higher fishing pressure. Land-based, non-point source pollution has been identified as the primary source of reef degradation in the CNMI. The 3 southern islands have unpaved secondary roads that funnel soil and sediment into nearshore waters during heavy rain increasing turbidity of nearshore waters. Treatment of secondary roads with crushed limestone without addressing drainage problems created chronic sedimentation problems along Lau Lau Bay and Obyan Beach. In 2000 and 2001, most microbiological, water quality violations occurred in areas with heavy stormwater run-off. The impact of two sewage outfalls on Saipan (Agingan and Sadog Tasi) is not well known, but it is hypothesised that the Sadog Tasi outfall is partially responsible for the poor condition of the reefs outside Garapan. Reverse osmosis units discharge nitrate and phosphate at concentrations 100 times above accepted limits into the lagoon. The EPA will soon require these discharges to be treated to meet accepted water quality standards.

Anchor damage occurs at popular fishing and dive sites in the Marianas, although permanent moorings have reduced damage at dive sites around Saipan, Tinian and Rota. More than 20 commercial vessels have grounded in the CNMI over the past 20 years, with the majority of these due to typhoons or operator error. Some of these vessels have been removed, but nearly half remain in the water. The island of Farallon de Medinilla is still used by the US Navy for bombing practice, which is accelerating soil erosion.

Guam

The reefs are damaged by many factors related to population growth and poorly managed development. Road construction and development have decreased since the early 1990s, but rates of upland erosion have accelerated due to wildfires, road construction, feral goats, off-road vehicles and clearing and grading of forested land. This has lead to increased sedimentation on

nearshore reefs. The high clay content of Guam's soils exacerbates the impact of this erosion, as the small clay particles travel easily to the coast, and are resuspended each time by storm swells and smother juvenile corals.

Increased urban runoff is associated with sealed surfaces and reduced vegetation in the northern densely populated urban areas. Nutrients and chemical pollutants from agriculture, septic tanks, and illegal dumping seep through groundwaters onto the reefs. Chemicals include metals, pesticides, oil and grease and industrial solvents. The US Navy is still assessing and restoring a number of their sites close to the coast, and the Orote Landfill may be the source of PCBs that have contaminated marine life near Gabgab Beach and resulted in seafood warnings. Three sewage outfall pipes discharge near coral reefs and probably cause as much damage as stormwater that leaks into old sewer lines. During heavy rain the sewerage plants divert untreated wastewater directly into the ocean outfall pipes.

Apra Harbour is the largest and the busiest US deepwater port in the Western Pacific. The large numbers of ships and ship groundings are a constant threat to Guam's reefs e.g. 130 vessels were listed in the Abandoned Vessel Inventory database for Guam in 2004. Funds to remove vessels are limited, so most of them will remain and deteriorate or be moved during storms. Invasive marine species do not appear to be damaging native species, although they are abundant on artificial substrates.

Recreational damage from jet skis, divers, and snorklers have occurred at popular sites such as the Piti Bomb Holes Preserve, and there are paths worn through seagrass beds and damaged corals from physical contact. Jet ski use has been limited to 3 areas and a study to monitor their affect on reefs will start in late 2004.

Federated States of Micronesia

The primary human damage to reefs in the FSM result from fishing, coastal development, and ship groundings. Sediments from road construction, infrastructure development, and unsustainable land-use practices have polluted reefs adjacent to the main populated islands. Some dredging and road construction projects have also damaged nearby reef areas. There were local sediment runoff events from the capital, Weno, and over-fishing by foreign commercial vessels has been documented on Chuuk.

Marshall Islands

There is evidence of eutrophication in front of villages facing the lagoon in Likiep and a live fish enterprise may have depleted some areas in 2001. No human stresses were reported in Mili, except for the assumed illegal fishing of previously abundant sharks. Some human damage was recorded in Rongelap in the form of illegal fishing evidence: longlines were found entangled on corals at 4 outer reef sites on the leeward site of the atoll. Long-line shark fishing activities were operating in RMI at the time, but were only permitted beyond 5 miles of the coast. Although long-line shark fishing is prohibited, there is anecdotal evidence of ongoing illegal shark fishing by both traps and long-lines in Likiep and Mili.

Palau

Sediment runoff from coastal development poses a serious threat to water quality around Babeldaob, the biggest island in Palau. Unfortunately there are no pre-development data, but villagers on the coast of Babeldaob attribute the increase in sedimentation to development. A study in Ngerikiil watershed showed sedimentation exceeding 1500 mg per litre during floods

after road construction and farming development. Sediment monitoring in the Ngerdorch watershed shows a direct link between the level of water clarity and the runoff coming from the Compact Road Project. The increase in sedimentation has resulted in the death of some seagrass habitats and coral reefs, and this will probably reduce the rate of coral recovery in Palau by blocking recruitment of new larvae.

Population and development continues to increase in Palau. In the capital Koror, raw sewage is occasionally poured onto the reefs because the sewerage system cannot handle the load. A new sewage treatment plant is being built in Koror; however, there are no treatment plants elsewhere on Babeldaob and many households use septic tanks. A treatment plant in Babeldaob is needed to handle the expected rise in development that will occur when the capital is relocated there. Other potential sources of pollution are animal manure, pesticides, herbicides, oil spills, and other chemicals. Many of these potential sources are small, but if left unchecked can pose potential threat to the fragile marine environment.

Ship groundings occur on the western barrier reefs, the southern lagoons and on the surrounding reefs of Palau. The container ship 'Falcon' ran aground in 2001 causing extensive damage to the reef. A large dive boat, the 'Big Blue Explorer' ran aground on Bailechesengel reef in the Ngemelis complex in 2002. This is a famous dive site and the reef was damaged, but restoration has been attempted on these damaged reefs. Palau is making major efforts to limit damage from tourists on reef resources, e.g. mooring buoys, laws preventing the collection of corals, and diving tour operator education help conserve the culturally and economically important reef resources. Now the largest direct stresses on some reef sites is the large number of divers, with many having little experience.

Current and Potential Climate Change Impacts

Guam

Large-scale coral bleaching and mortality events are not common on Guam. There have been only 2 recorded bleaching events since the University of Guam Marine Laboratory was established in 1970. In 1994, 68% of surveyed corals bleached on Guam with considerable variation in bleaching responses by the different corals, however there was little mortality. The bleaching did not appear to be associated with above-average sea surface temperatures. There have been cases of coral bleaching on Guam every year for the past 7 years, but there was little mortality. Recent bleaching in Pago Bay is probably linked to freshwater flows from record rainfall during Tropical Storm Tingting.

Northern Marianas - CNMI

The 2001 bleaching event caused greatest damage on the back-reef, branching staghorn corals in the Saipan Lagoon. There was 35 - 70% mortality of staghorn corals, but there were only minor visual effects upon the fringing and barrier reefs, with no significant mortality on any long-term monitoring sites. Bleaching was noted to 16 m depth at Akino reef and on the eastern end of the western barrier reef in Saipan in 1994 and to a lesser extent in 1995 and 1997 at Unai Bapot in Lau Lau Bay in Saipan at the site of a vessel grounding in Pagan.

American Samoa

Summer bleaching now appears to be an annual event and bleaching was particularly widespread and prolonged (4 mo) in 1994, 2002 and 2003. Each of these events caused significant coral mortality, particularly among species of *Acropora* and *Millepora*. About half of the staghorn corals in the airport lagoon were probably killed by high temperature bleaching

in the summers of 2001 and 2002. A new program to monitor corals particularly susceptible to bleaching showed there was bleaching of *Acropora* corals in the Airport Lagoon on Tutuila in March 2004; no corals in the experimental sites died from this event. They also observed that formerly rare coral diseases were common, and coral tumours were observed. Mass coral bleaching and over-fishing may be the two most destructive threats to the local reefs.

Marshall Islands

The only documented bleaching event in the Marshall Islands was in September 2003 in the lagoons. Some shallow flat reefs on the lagoon side of Majuro Atoll bleached during particularly warm temperatures and no winds, coincident with a spring low tide. The local inhabitants reported similar bleaching on Jaluit Atoll. There are no reports of previous events in local knowledge.

Palau

It was realised after the 1998 El Niño bleaching event that Palauans had poor understanding of the consequences of bleaching and any potential management efforts due to limited data on their reefs. The massive bleaching event prompted the development of ecological monitoring programs in Palau, initially by local environmental and research NGOs, and then in 2001, the task was taken up by the Palau International Coral Reef Center. They developed a comprehensive long-term monitoring plan to gain data on the condition of Palau's coral reefs.

Current MPAs and Management Capacity

American Samoa

MPAs are increasingly being relied on as a precautionary form of protection. American Samoa is: developing an MPA/MMA Program to coordinate existing MPA programs and develop new ones; creating a territorial master plan for MPA management and development including proper management of community-based and territorial MPAs; coordinating between local and federal initiatives (i.e. National Park, National Marine Sanctuary); and expanding regional networks, primarily between American Samoa, Samoa, and Fiji.

Guam

Guam established 5 MPAs around the island accounting for 11.8% of the shoreline in 1997. They established monitoring sites in Piti Bomb Holes Preserve and Achange Reef Flat Preserve

These data on American Samoan MPAs were collected for the federal Marine Managed Areas Inventory. The table shows the coral reef area contained within these MPAs.

ISLAND	MPA	MPA SIZE (km^2)	CORAL REEF AREA (km^2)	
			0-50 m	0-100m
Tutuila	Fagatele Bay NMS	0.7	0.6	0.7
	National Park	6.6	6.1	6.6
	Community-based	1.0	1.0	1.0
Ofu	Vaoto Marine Park	0.4	0.4	0.4
	National Park	1.5	1.5	1.5
	Community-based	0.1	0.1	0.1
Ta'u	National Park	4.8	1.9	4.8
Rose Atoll	Rose Atoll NWR	158.1	9.9	11.6
TOTAL		173.2	21.5	26.7

TRANSFORMING CORAL REEF CONSERVATION IN PALAU

Palau has the most biologically and ecologically diverse coral reefs, lagoons, mangroves and seagrass beds in Micronesia; it is just off centre of the 'bulls-eye' for marine biodiversity in Southeast Asia. However, the coral reefs were significantly damaged by the 1998 La Niña coral bleaching event. Palau has become a major diving and tourism destination, which provide economic benefits as well as development challenges. There is increasing recognition by the communities that some marine resources are close to being over-exploited and that additional management is needed. Any action to conserve the coral reefs must address local threats and their underlying causes and focus on reefs that are resilient to unmanageable threats like global climate change. The Transforming Coral Reef Conservation (TCRC) program identified Palau as high priority to establish a national network of MPAs incorporating the concept of resilience (Box p 106). Palau was chosen because they have already established MPAs, there is strong political and community support, and there is a substantial research and conservation base. Two major scientific studies were initiated within TCRC:

1. developing hydrodynamic models of currents around Palau through the use of current meters, tide gauges, bathymetric maps, and satellite images. This is a collaboration between the National Oceanic and Atmospheric Administration of USA, the Australian Institute of Marine Science and the Nature Conservancy (TNC). The models will be used to predict patterns of hot and cool water during a bleaching event, and forecast which reefs may be more resistant to coral bleaching when the water is warm. The model will also assist studies of fish and coral larvae movements;
2. examining how physical and biological components control the transport of fish and coral larvae around Palau. The Coral Reef Research Foundation and TNC will focus on the known reef fish spawning aggregations, to identify those areas that are major sources of larvae for other areas.

The goal of the TCRC process is to assist Palau select sites for MPAs that will have the best chance of being resistant and resilient to major global threats.

and comparable non-preserve sites prior to full implementation in 2001. Two years later there were significant increases in fish density, diversity and the presence of larger fish within the preserves, with the majority of recruits smaller than 15cm. Fish density remained the same or decreased in adjacent non-managed areas. Studies by the local university supported these findings. The abundance of 4 species was significantly higher in protected areas than in adjacent control sites, especially the presence of larger parrotfish (*Chlorurus sordidus*) and the goatfish (*Mulloidichthys flavolineatus*) in the preserves; however, smaller sizes were more abundant in some of the non-managed sites. The weight of spawning fish was significantly higher in the marine preserves than outside, indicating that the marine preserves may function as 'egg banks' and provide higher production potential.

Continued monitoring will provide data to determine whether the marine preserves can restore some of Guam's inshore fisheries, however the effectiveness of these MPAs is limited because of

insufficient enforcement capacity. The number of Conservation Officers has dropped by almost 60% due to a lack of funding over the last 10 years. The effectiveness of law enforcement has improved through the purchase of vehicles and night vision scopes, however the lack of manpower is a serious concern.

Northern Marianas - CNMI

The CNMI Coastal Resource Management Office proposed MPAs in 1985 on the populated islands of Saipan, Tinian and Rota to promote tourism. But by the late 1990s, there were declining fish catches in Saipan, Tinian and Rota which strengthened calls for management. Local laws and regulations were declared for the sustainable management of coral reefs to enhance fish stock status throughout the CNMI. Spearfishing using scuba and hookah was prohibited in all the islands in 2003 when Saipan and the Northern Islands District agreed to the ban imposed by Rota and Tinian. There were similar regulations banning monofilament gill, surround and drag-nets to augment the existing CNMI Marine Sanctuaries Program. The program supports monitoring and assessment of coral reef fish resources in existing no-take MPAs, as well as continuing to support the development of additional MPAs. There was only one MPA when the program started. The Sasanhaya Bay Fish Reserve in Rota was designated in 1994 and provided with legal enforcement in 2000. The Tinian Marine Sanctuary and the Managaha Marine Conservation Area around Managaha Island in Saipan Lagoon were created soon after. All 3 MPAs were based on the 1985 study, with added 'no-take' provisions. Plans for the Tinian and Managaha MPAs will be completed soon, and regular monitoring will be included.

Marshall Islands

The preservation of Marshallese marine resources stems from a precautionary effort to conserve pristine reefs, and demands from local users who complain of reduced stocks of key target species. Lower abundance of clams, fish, lobsters and cowrie shells have been reported by local populations from different atolls (Likiep and Majuro). Marine reserves and other management measures are still in their infancy, but several atolls (Jaluit, Likiep, Arno, Mili and Rongelap) are spearheading this effort. Selection of conservation sites and practices is based on coral reef biodiversity, water current measurements, and conservation theories. Ecological observations through Natural Resources Assessment Surveys indicate which are the healthy and productive ecosystems for urgent conservation efforts. Emphasis is placed on sites that are important nursery grounds and spawning sites to assist in repopulating downstream sites with new recruits of target species. The process for MPA designation involves community consultations, expectations and requests, and incorporation of the research conducted by local and external scientists. Conservation will hopefully also help protect fishing grounds from illegal fishing. Likiep, Rongelap and Mili atolls have outstanding diversity and coral cover, and provide refuge for many marine organisms, however, illegal fisherman exploit the remote atolls of Ailinginae, Bikini and Jaluit.

Training of local personnel in management and monitoring is essential for community-based conservation and sustainable development. Capacity building in MPA management and monitoring has started at the College of the Marshall Islands, with assistance from external institutions. Local people are already showing an interest in being park rangers and are asking for training. A certificate Program on Marine Resource Management, including instruction on reef ecology and monitoring techniques, was offered at the College in 2004.

Federal States of Micronesia

The Conservation Society of Pohnpei has monitored reefs on Pohnpei since 2001 focusing on: monitoring grouper spawning aggregations; monitoring MPA effectiveness; and monitoring changes in benthic communities. The reefs in Kosrae are monitored annually to detect changes in benthic cover and fish abundance. Other reefs are protected by MPAs in the Trochus Sanctuaries Heritage Reserve and Kosrae Island Heritage Reserve, and more conservation areas are being negotiated in partnership with the FSM National Government. The chiefs and other traditional leaders usually control protection of specific areas. In Yap, the villages own the reefs, and have authority over resource use. Some islands have areas set aside for reef protection and limit resource extraction, but currently the FSM lacks the enforcement capacity to protect these MPAs.

Palau

MPAs in Palau are usually designated and managed by the local state governments for food security, recovery from perceived over-harvesting, and to protect biodiversity and significant habitats. MPA designation starts with the implementation of a traditional moratorium or *bul* on the area; all use is prohibited for a defined time (usually 1-3 years). The Palau Conservation Society and The Nature Conservancy are working in partnership with the state governments to implement community-based monitoring programs within the MPAs and to produce management plans, which go into effect after the moratorium period has expired.

MPAs have also been designated through legislation by the state governments to provide a legal basis for management. Palau passed the Marine Protection Act in 1994 to enable protection of important species of commercial reef fish through seasonal and export bans and the establishment of regulations controlling the exploitation of marine invertebrates and aquarium species. Minimum size restrictions were implemented for the humphead wrasse, bumphead parrotfish, rabbitfish and lobsters. The harvest of commercially important groupers was prohibited for 4 months during peak spawning times. In addition, the commercial export of certain reef fishes, crustaceans and other invertebrates was prohibited. Other important regulations were in place, such as a seasonal ban on the harvest of sea turtles during their nesting season and full protection for the dugong. Laws to regulate the export of other marine resources such as corals and sponges.

In 1994, there were only 2 MPAs in Palau; the Ngerukewid Islands Wildlife Preserve, established in 1956; and Ngerumekaol Channel. 'No-Take' designation prohibits fishing and extractive activities within each MPA. There are now 15 MPAs in Palau, and government and non-government agencies have carried out research and monitoring to support the management of state and nationally designated MPAs. Most of these MPAs are supported by local NGOs with funding from international donors.

Mooring buoys have been installed throughout the State of Koror to decrease damage to coral reefs by recreational divers, fishers and boaters. Fishing is regulated under very specific national regulations outside MPAs and other managed areas.

A NETWORK OF MARINE PROTECTED AREAS IN PALAU

Coral reefs are essential for the future social, cultural, economic, environmental stability and health of Palau, and there was a wake up call in 1998 when there was massive coral bleaching and mortality. In late 2003, the Palau National Congress (Olbiil Era Kelulau) passed major legislation for a Protected Areas Network. The Act provides a framework for national and state governments of Palau to collaborate to protect the terrestrial and marine biodiversity, and assist with local management of natural resources by establishing a network of protected areas. The goal is to protect areas of biodiversity significance, important habitats, and other valuable resources. The network of MPAs in Palau was planned through the cooperation of many partners, including national and state officials, traditional leaders, state protected area managers, NGOs, communities, and local and regional scientists. They have recommended a comprehensive set of activities over the next 3 years, including to:

- undertake a **marine ecoregional assessment** to identify habitats and conservation targets, threats to these resources, and the highest priority areas for conservation. Areas resistant and resilient to coral bleaching, and key reef fish spawning aggregation sites will be identified and incorporated into the plan;
- conduct **scientific studies** to understand current regimes and connectivity, spawning aggregation sites, ecological design principles, and coral bleaching mitigation factors and use these results to design the network;
- establish the **operational framework** for a nationwide MPA network within a system of marine and terrestrial protected areas under the Protected Areas Network Act 2003, and include selection criteria, regulations, policy framework, network operational procedures, financing mechanisms, training programs, and other administrative requirements;
- analyse existing MPAs to identify key gaps and priorities for future protection;
- build the network through engaging all partners, especially the states, in preliminary **site selection and designation of protected areas**, applying the selection criteria and the marine ecoregional assessment results;
- support the states in preparing **management plans** for sites in the network, and support **staff, skills, resources and infrastructure** development to manage the MPA network effectively in the long-term;
- identify, test and refine mechanisms to support long-term **financial sustainability** of the network through social and economic analysis, applying long-term financial and business planning, identifying and implementing appropriate finance mechanisms and cost effective management approaches.

The Ministry of Resources and Development signed an MOU in early 2004 with The Nature Conservancy to implement the network program under the Act along with other partners including: other agencies and departments of the National Government; state governments and the Association of Governors; communities and traditional leaders; NGOs (Palau Conservation Society and Community Centered Conservation) and research and educational institutions (Palau International Coral Reef Center, the Coral Reef Research Foundation, and Palau Community College). From: Andrew Smith, TNC Palau.

Government Policies and Legislation

American Samoa

The American Samoa Government coordinates coral reef management via the Coral Reef Advisory Group (CRAG) comprised of territorial and federal agencies and the American Samoa Community College. Each agency develops specific programs to enhance the quality of marine habitats, regulate activities on coral reefs, promote awareness, or facilitate coral reef research. American Samoa has recently adopted a threat-based approach to identify key coral ecosystem problems and CRAG has created 3-year action strategies to address over-fishing, global climate change, land-based sources of pollution, and population pressure.

The United States Coral Reef Initiative has supported the territory with coral reef conservation. The annual Coral Conservation Grant Program has provided managers and scientists in American Samoa with tools, staff, funds, and equipment to conduct key research and management projects. Two positions to develop and coordinate a comprehensive long-term monitoring program were added in 2003. The Government is also planning a new marine laboratory to be shared among all the agencies interested in marine conservation; the local community college, other Pacific Island groups, and visiting scientists.

Northern Marianas - CNMI

The protection of coral reefs and associated species and habitats is the responsibility of different government agencies, including: Coastal Resources Management Office for management, permitting and enforcement of coastal resources; Division of Fish and Wildlife for conservation, protection, and management of fish and wildlife, including MPAs; and Division of Environmental Quality for protection of water quality, including associated benthic communities. Governor Juan Babauta signed an Executive Order #235 in 2003 for the 'Establishment of an Interagency Structure to Coordinate on Coral Reef Issues' (Coral EO), which establishes a Coral Reef Point of Contact/Facilitator in the Governor's Office and 3 interagency committees including: a Coral Reef Policy Committee; a Coral Reef Coordinating Committee; and a Coral Reef Science Advisory Committee. Each has representatives from the 3 resource agencies above. The agencies have programs and there are now many laws, regulations, permits, policies, plans and education programs to manage human impacts on CNMI's reefs.

CNMI completed a 3-year Coral Reef Protection Local Action Strategy in 2003, which contains 49 projects in 5 focus areas requiring more than US$7 million to implement. The Strategy is a product of significant collaboration between public agencies, non-profit groups, business owners, interested members of the community, and federal agency partners. It was created to secure additional support for a short-term prioritised action plan for coral-reef management throughout the islands.

Guam

Guam recognizes the important benefits provided by coral reefs, and has developed a range of laws, regulations, permits, policies, plans and education programs for the management of human activities that damage coral reefs. Many of these were not created specifically to protect coral reefs, but now serve that purpose e.g. the Seashore Reserve Act created the Guam Seashore Protection Commission, which has review and approval authority over construction proposed from 10 m inland of the mean high tide mark out to a depth of 20 m (an area defined in law as the 'seashore reserve'). Two laws specifically address coral reefs: Public Law 24-21 restricts the relocation or transplant of corals and live rock anywhere within the waters of Guam and

protects coral reef habitats within the marine preserves; and Public Law 27-87 also protects coral reef habitats by regulating all non-fishing activities within the marine preserves. Mooring Buoys were installed in 1999 at popular sites on the western side of the island to reduce anchor damage from recreational boaters and fishermen, and these are maintained in partnership with the Guam Marine Awareness Foundation. Current plans are to install 24 buoys by late 2004.

Many positive steps have been taken in the last two years. In 2003, the Guam Coral Reef Initiative Coordinating Committee drafted local action strategies to address land-based sources of pollution, fisheries management, outreach and education, recreational misuse and overuse, climate change and coral bleaching. The process has served to broaden the network of stakeholder groups working to include agencies involved with watershed restoration and the tourism industry. Executive Order 2004-04 strengthened the Guam Watershed Planning Committee and instituted a comprehensive planning process to address negative impacts in each watershed. Other advances have included increased awareness of the economic value of coral reef resources, which has created a sense of stewardship in the tourism industry, and a shift towards management driven research at the University of Guam Marine Laboratory and Water and Environmental Research Institute.

Federal States of Micronesia

FSM is increasing coral reef monitoring with the focus on coral cover, commercially important fish species, and reef fish spawning aggregations. The capacity to monitor coral reefs has improved since the 2002 report as all state marine resource agencies have received training in monitoring reef fish spawning aggregations and they are identifying and monitoring existing large aggregations of commercially important fish. Kosrae State is continuing its annual coral reef monitoring program on benthic cover and fish populations. Private and government environment organisations are developing a state-wide coral reef monitoring program in Pohnpei focused on 4 permanent sites and is scheduled to begin in 2004.

Marshall Islands

The primary agencies involved in protecting coral reefs are the Marshall Islands Marine Resources Agency and the Environmental Protection Authority. In 2003, they established a Working Group with the Ministry of Internal Affairs, Marshall Islands Visitor Authority and the College of the Marshall Islands to monitor and manage marine resources. The National Biodiversity Strategy and Action Plan (NBSAP) and the National Biodiversity Report were approved by Cabinet in 2000 to address the need for conservation and management of natural resources. The NBSAP recommends strengthening the concept of 'mo', a traditional system of taboo that identified certain areas as 'pantries' that could be harvested only periodically. The NBSAP also addressed the need for sustainable fishing practices and a retention of local knowledge.

The Marine Science Program at the College of the Marshall Islands is strengthening local capacity and studying marine resource status to help each atoll manage their resources and plan fishing and other activities in a sustainable manner, to assist in the conservation of particularly rich or threatened zones. The College and the Government are matching local marine survey expertise with outside scientists for surveys to assess the health of reefs and the fishing potential of the atolls. A 2001 pilot project in Likiep trained local students to gather data on the status of reefs and food fish resources in the atoll and issued recommendations on best sites for conservation. There was more monitoring in 2002 and 2003 on other atolls and Fishery Management Plans, including Ordinance for MPAs, are being drafted for the atolls of Likiep and Arno, and are ready for Majetto Island (Kwajalein atoll).

INVOLVING THE COMMUNITY IN WATERSHED MANAGEMENT ON GUAM

A collaborative partnership of communities, Guam and USA government agencies, scientists from the Universities of Guam and Hawaii, and NGOs has just developed a manual to assist in effective management of catchment areas to protect valuable downstream coastal resources, especially the coral reefs. The 'Collaborative Watershed Management in Micronesia: The Experience in Umatac, Guam' was developed after the indigenous Chamoru people of the Umatac village became concerned that fish catches were declining in size, quality and numbers of fishes. They asked for help from universities in Guam and Hawaii, and together they developed the manual with funding from an EPA Star Grant and NOAA USA. The partners identified the following steps:

1. To collect data on coastal waters (with a strong emphasis on collecting oral histories from the community on what the region was like in the distant past);
2. To determine the types of discharge that pose the greatest threat to the coral reef and near shore marine environment;
3. To assess the societal costs of environmental degradation;
4. To apply these data to watershed management regimes; and
5. To assess if coral restoration is practical if coupled with watershed restoration efforts, marine protected areas, and pollution abatement programs.

This attractive 22 page manual was published by the Social Science Research Institute of the University of Hawaii and is available as a PDF document. From: Robert Richmond, Pacific Biomedical Research Center, University of Hawaii, richmond@hawaii.edu

Palau

The Ministry of Resource and Development has overlapping jurisdictions with the 16 local state governments over all marine areas within 12 nm to the high tide mark. It is responsible for the management of all submerged lands from the high tide mark to 200 nm from shore, and each of the state governments has rights to territorial waters up to the high tide mark within 12 nm. The Palau legislature passed the Protected Areas Network Act in 2003 to support local government efforts to protect marine resources. This legislation created a nationally sanctioned framework to coordinate NGOs and local government initiatives to conserve marine resources in a system of protected areas to conserve marine biodiversity. It is hoped that this Act will encourage more MPAs by the state governments. A Protected Areas Network coordinator will be appointed to facilitate the implementation of this Act, with technical assistance from The Nature Conservancy. The state governments now have access to technical expertise and financial resources that are often lacking to develop effective MPAs.

The Palau International Coral Reef Center launched a nationwide coral reef monitoring program for Palau in 2001 to: establish permanent monitoring sites; determine the status of Palau's reefs; assess changes to the benthic and fish communities at each site over time; and examine the recovery process at each site. The program consists of a rapid assessment of reef habitats using a spot check method and a detailed monitoring survey of benthic organisms, fish and coral recruitment. Some monitoring sites are located within MPAs.

Conclusions

100 Years ago: The major pressures on coral reef ecosystems were tropical storms, and cyclones were the primary factor in shaping coral reef structure. Surveys in American Samoa in 1917 indicated high coral cover with an average of almost 7 colonies per square meter. Coral reefs throughout the region were probably dominated by apex-predators, and subsistence fishing was managed by traditional tribal regulations and within the recovery capacity of the reefs.

In 1994: Coral reefs near large populations showed clear signs of damage from sediment runoff, nutrient pollution, over-fishing and shoreline modification and dredging. Benthic community status in harbours and other poorly flushed areas exposed to land-based inputs were declining. The recovery from extreme events like cyclones and COTS outbreaks was variable and lower in areas under anthropogenic stress. Traditional and customary knowledge and management practices were being eroded. Baseline surveys of coral reef ecosystem condition had started in most of the region, with most monitoring efforts centred in the local universities and not supported by long-term funding. Awareness within governments and local populations of the need for coral reef management was low but growing.

In 2004: Many of the threats to coral reefs highlighted in the 2002 report remain as concerns on the islands. This region still has some of the most diverse and pristine reefs in the world, but the cumulative impacts of sedimentation, increasing population demands, commercial fisheries, coastal pollution, ship groundings, and recreational activities are apparent on many reefs. Human population growth, understandably a sensitive issue, remains a key factor behind the expanding levels of anthropogenic disturbance. While reefs in isolated areas are in good to excellent condition, many of those adjacent to population centres, particularly on the high islands, are declining towards fair and poor categories, with recorded decreases in coral cover, fish abundance and resilience to natural disturbances. Coral bleaching and disease were either rare or undocumented in 1994, but are now clearly evident and considered serious threats to many reefs in the region.

Predictions for 2014: Improved research and monitoring capacity should translate into informed coastal stewardship decisions that maximize society benefits and minimize threats to coral reefs. Damage from point-source pollution, fishing, and recreational overuse will be controlled by better enforcement of existing regulations. Management efforts in populated areas will continue to reduce non-point source inputs. Reef condition should stabilize or slightly improve unless the adverse predictions for global climate change or more cyclones and bleaching eventuate.

Recommendations

Management agencies and researchers can reduce threats to coral reef ecosystems by enforcing existing laws and passing new legislation to protect coral reefs, and by developing new partnerships and programs to monitor and study them. Each country/territory should continue advancing the objectives of the Marine Resources Pacific Consortium by:

1. Developing the capabilities of the regional resource agencies, institutions of higher education, and community-based organisations within Micronesia and American Samoa to deal with issues surrounding sustainable use of marine resources of cultural, economic and scientific value;
2. Fostering cooperation and collaboration among the local and federal resource agencies, research facilities, community-based organisations, educational institutions and the private sector to assist in meeting their mandates, goals and community needs; and
3. Collecting, synthesising and disseminating adequate and accurate information in support of sound policy development on marine resource use, addressing present needs as well as the concerns for future generations.

It is important that the monitoring programs established recently continue to provide feedback to managers and decision makers to assist in developing policies and implementing effective management. Without monitoring data, the status of benthic communities and associated organisms cannot be adequately understood and managed. Catch levels and trends for reef fisheries should be monitored closely and accurately so that effective management of coral reef fishery resources can be implemented. Other information such as type of fishing gear used and the number of hours spent fishing would help determine the level of exploitation. Most agencies now have adequate staff resources to conduct a long-term monitoring program, but additional training for existing staff would improve the quality of the data and also empower local staff in the protection of reef resources. Basic training in data collection, data analysis and quality control should be combined with specialised training in identification of marine organisms. Baseline surveys are still needed in some areas to guide MPA placement and the selection of long-term monitoring sites.

An under-educated public is a major impediment for marine conservation in these islands. Effective management of marine resources requires an informed and supportive public. Community education and stakeholder involvement programs need to be expanded. School curricula from elementary to secondary and post secondary should incorporate environmental issues and concerns. Communicating information to policy and decision makers in order to support coral reef conservation continues to be a problem, and programs are needed to raise environmental awareness among policy makers, traditional and political leaders and villagers.

Agencies and organisations with coral reef monitoring and management responsibilities need to coordinate strategic planning and priority setting, and jointly identify which problems are best addressed with collaborative work. With limited resources (time, money, human resources), the islands need to work together to avoid duplication of efforts and competition among the different groups.

Reviewers

The 24 contributing authors from the wider Micronesian region as well as USA and Australia reviewed this chapter.

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ICRAN

JALUIT ATOLL MARINE CONSERVATION AREA, MARSHALL ISLANDS

Jaluit Atoll lies in the southern end of the Ralik (western) island chain and includes 91 islets with a total land area of 11.4 km^2 and a resident population of about 2,500 people. Primary subsistence activities including harvesting of giant clams, trochus, finfish species, oysters, and turtles are unsustainable. In an effort to alleviate recent problems resulting from coastal development and pollution, the Jaluit Atoll Marine Conservation Area (JACA) was established in 1999 under the Marshall Islands Environmental Protection Agency (RMIEPA) and in partnership with the GEF and SPREP. The Atoll Wide Resource Management Plan, finalised at stakeholder workshops and endorsed by the Governor, builds on a comprehensive baseline assessment and participatory community engagement. There is strong support from all communities concerned and a desire for the Local Council to immediately endorse and implement conservation measures to protect the marine resources in the atoll and to strengthen enforcement.

The College of the Marshall Islands and RMIEPA have visited villages and schools to raise awareness of the conservation project and waste management issues, train people in coral reef monitoring, and hold management workshops to reactivate traditional conservation areas in the atoll, including the strongly supported 'Mos' (traditional closures). Fishermen are now more aware of destructive fishing methods and the biological aspects of the resources, thus helping to promote sustainable fishing and resource use methods. Neighbouring islands and communities are interested in establishing similar conservation programs.

Awareness activities have involved communities in mangrove surveys, women's groups (including the Handicraft Club) have attended workshops, and continue their community beautification activities. JACA staff have learned new skills by attending trainings on project management, coastal resources management, and community-established conservation areas in Japan. With the help of local hotels and dive agencies, Jaluit Atoll is promoted as an eco-tourism destination with fully equipped guesthouses complete with solar lights, toilets and freshwater. A colourful brochure promoting eco-tourism activities has been distributed to hotels and the airport lounge for incoming visitors.

Ecological Monitoring: A survey of Jaluit's marine resources in 2000 showed that trochus and sea cucumber stocks were low due to unregulated harvesting. A harvesting ban was recommended in 2000. For other marine resources, a long-term monitoring system is needed and seasonal harvesting introduced to prevent over-exploitation.

Socio-economic Monitoring: No information received.

Contact: John Bungitak, eparmi@ntamar.com

Coral reefs are **80%** of the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **unknown.**

ICRAN

SAMOA MPA PROJECT – ICRAN DEMONSTRATION SITE

The 2 major islands of Samoa, Savai'i and Upolu, and many tiny islands are circled by diverse fringing reefs, as well as mangroves and some seagrasses. Overfishing, destructive fishing and poor land management threaten the reefs and fish stocks, on which the Samoan people are heavily dependent. To counter these threats, the Districts of Aleipata (11 villages) and Safata (9 villages) established community-based, multi-use MPAs including Village Fisheries Reserves under a World Bank-IUCN initiative. Aleipata and Safata MPA District Committees are responsible for reviewing completed work, management plans, and developing workplans for future years. As the decision making body for each MPA, both District Committees consist of a senior matai representing and selected by each participating village. District Officers attended the Regional Locally-Managed Marine Area (LMMA) Network meeting in Fiji and joined the project to the network as an associate member.

Samoa's 2004 phone book cover features Aleipata MPA's logo and is a good example of growing private sector support for MPAs. The MPAs established a trust fund with a highly transparent operating system to support the operations and can not receive donations. The MPAs' Marine Education in Schools program has benefited from 80 sets of donated snorkel gear and from Peace Corps volunteers helping with the Secondary Schools program. There are plans to expand the program, broadening MPA initiatives and further raising awareness of the MPA no-take-zones. Tourist visits to the MPAs are growing and the related levies are paid to the MPA Trust Fund by a range of Samoa tour operators. Fees from USA university study tours resulted in a 75% profit for MPAs and the local communities, generating income and building pride for the villages.

Ecological monitoring: Community meetings and restoration activities are ongoing, with long-term sites monitored every 3 years providing performance indicators for management. Community-based monitoring provides more immediate feedback is under trial. Baseline data were gathered in all major reef habitats (lagoon, channels and outer slopes) showed the reefs were in good health, despite many natural and anthropogenic pressures. Damage caused by cyclones in the early 1990s, COTS outbreaks 20 to 30 years ago, erosion from sea urchins preventing new coral recruits from growing on reef rock, and dynamite fishing is still evident. There was low coral cover on the inner lagoons (10-20%), but very high cover on the outer slopes (80-100%) and outer lagoons (50–60%). Fish abundance was low, with small individuals, indicating strong fishing pressures. However, fish were more abundant and diverse in less frequented areas as were prized species such as giant clams, sea cucumbers and edible molluscs.

Socio-economic monitoring: Incorporation of socio-economic monitoring into the baseline assessment and community monitoring is being developed.

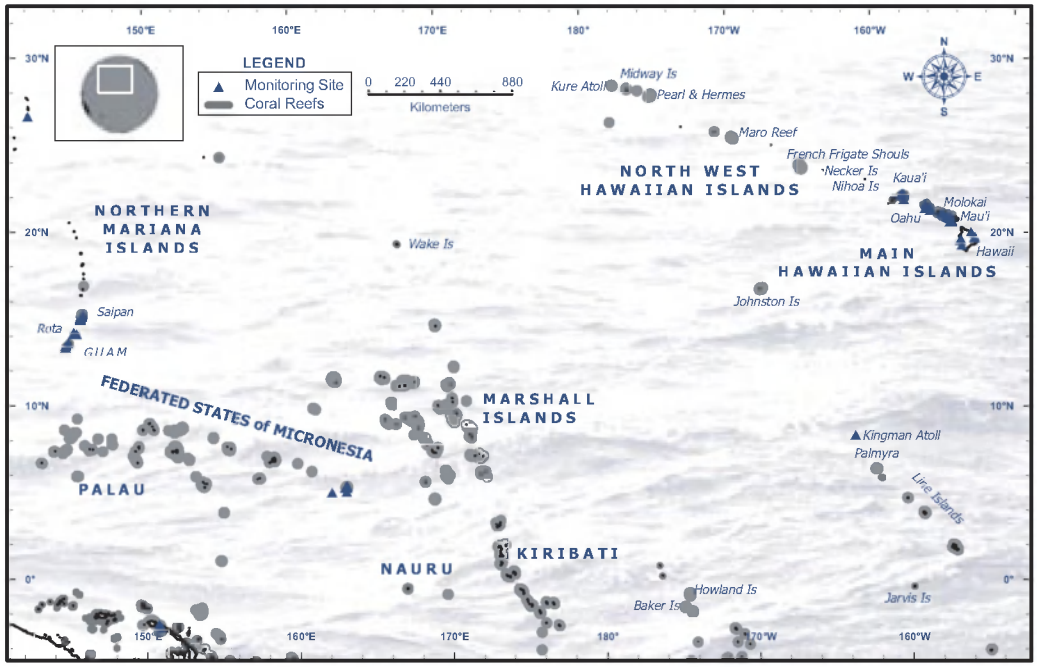
Contact: Sue Miller, Apia, Samoa (sue.miller@samoampa.com).
Coral reefs are **80%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **planned.**

15. Status of Coral Reefs in the Hawaiian Archipelago

Alan Friedlander, Greta Aeby, Russell Brainard, Eric Brown, Athline Clark, Steve Coles, Edward Demartini, Steve Dollar, Scott Godwin, Cindy Hunter, Paul Jokiel, Jean Kenyon, Randy Kosaki, Jim Maragos, Peter Vroom, Bill Walsh, Ivor Williams and Wendy Wiltse

Abstract

As one of the most isolated archipelagos in the world, Hawaii possesses some of the highest levels of marine endemic species in the world. This chain of islands stretches for more than 2,500 km from the island of Hawaii in the southeast to Kure Atoll (the world's highest latitude atoll) in the northwest. The archipelago consists of two regions: the main Hawaiian Islands (MHI) made up of populated, high volcanic islands; and the Northwestern Hawaiian Islands (NWHI) consisting of mostly uninhabited atolls and banks. Hawaii's coral reefs, which have recently been valued at US$10 billion, are under pressure from 1.2 million residents (more than70% live on Oahu) and nearly 7 million tourists each year. A number of urban areas and popular tourist destinations have suffered from land-based sources of pollution, overfishing, recreational overuse, and alien species. Despite these anthropogenic stressors, many of Hawaii's coral reefs, particularly the remote ones, are still in fair to good condition. The reefs of the NWHI represent almost undamaged coral reef ecosystems with abundant and large apex predators, due mostly to their isolation. The reefs also have an extremely high proportion of endemic species across many taxa, and virtually no impacts from alien species. The principal stresses to the reef ecosystems of the NWHI are coral bleaching and marine debris. In a major multi-agency effort to protect this region more efficiently, more than 470 metric tons of marine debris, primarily derelict fishing gear, have been removed from the reefs and beaches of the NWHI since 1996. The NWHI are an important nesting, and breeding site for many endangered and threatened species. In recent years, increased U.S. Federal funding and expanded partnerships among federal and state agencies, academia, and non-governmental organisations have greatly enhanced monitoring, mapping, and research efforts leading to a better understanding of the spatial and temporal dynamics of Hawaiian reefs. These partnerships have helped to guide management decisions.



Map courtesy of The WorldFish Center

Main Hawaiian Islands

100 years ago: The first Polynesian inhabitants collected reef resources for food and built fish traps and ponds on reef flats. They strictly enforced traditional management practices, and the reefs were healthy with good fish populations.

In 1994: There were clear signs of damage to coral reefs from pollution, development and dredging. Reef fish stocks had declined from over-fishing and there was inadequate enforcement of regulations to protect fish stocks. A need for Marine Protected Areas (MPAs) was recognised and many were established around the Hawaiian Islands.

In 2004: The reefs remain in relatively good condition, with some declines in coral cover and target fish stocks. The Hawaiian Government is improving management of reef resources to reduce over-fishing and pollution from the land. More MPAs have been added and monitoring is showing improvements in coral and fish populations. Coral bleaching and disease, and alien species now pose the most significant threats to the reefs.

Predictions for 2014: Reefs will continue to degrade as human pressures increase, but the rate of decline will be reduced if there is effective protection and management through adequate political and financial support.

Northwestern Hawaiian Islands

100 years ago: Coral reefs on the Northwestern Hawaiian Islands were in pristine condition with only limited harvesting of seals, turtles and fish.

In 1994: These remote reefs were still healthy except for some reef fishing and harvesting of lobsters. Monk seal and turtle populations were receiving strong management attention. There was minimal effective monitoring of the protected areas.

In 2004: Management, research and monitoring have increased dramatically since the designation of the reefs and islands as a Reserve in 2000. The lobster fishery is closed, reef fishing strictly controlled, and all activities require permission from management authorities. Coral bleaching was first observed in 2002 and 2004 and poses the greatest threat to the reefs.

Predictions for 2014: The coral reefs will remain healthy with strong collaboration between management agencies, but monitoring and surveillance will be necessary over these vast and remote reefs. Predictions of serious climate change and threats of increased coral bleaching remain the major potential cause for reef damage

Introduction

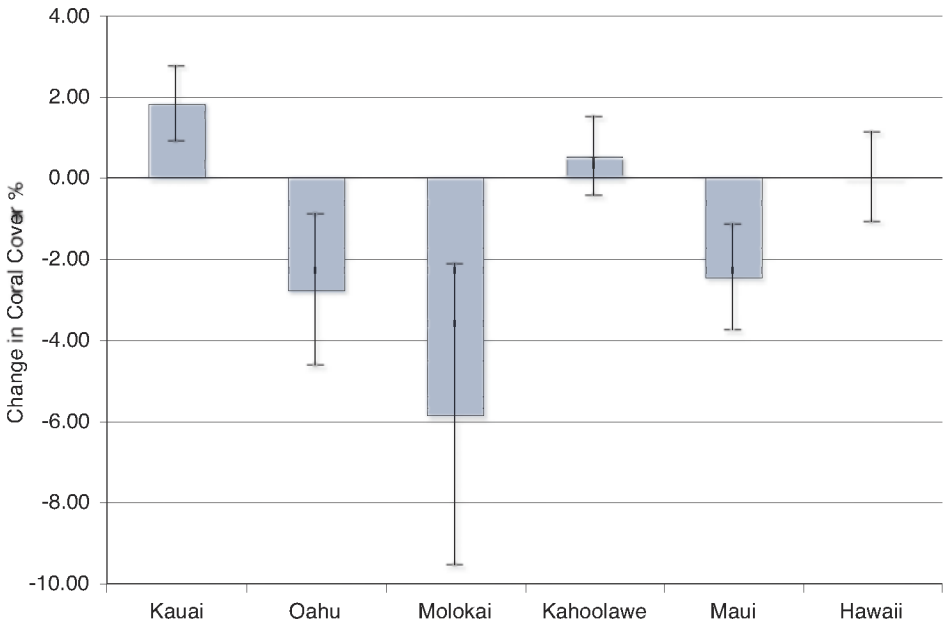
The Hawaiian Archipelago stretches from 19°N to 28°N latitude and includes the geologically younger and actively volcanic, main Hawaiian Islands (MHI) with fringing, patch and barrier reefs, and the older atolls and bank reef systems of the Northwestern Hawaiian Islands (NWHI).

MHI

The MHI consists of 8 high volcanic islands that range in age, from Hawaii which has active lava flows on the east side of the island to the 7 million years old Kauai. Coral reefs were important to the ancient Hawaiians for subsistence food, culture, and survival. Today these reefs provide commercial, recreational and subsistence fishing opportunities, create world famous surfing and diving locations, and are vital to the State's approximately $800 million per year marine tourism industry. In 2002, the economic value of Hawaii's coral reefs was estimated at US$10 billion with direct economic benefits of $360 million per year. Despite their economic significance, reefs near urbanized areas are coming under ever increasing population pressures from human and land-based pressures.

NWHI

The NWHI stretch for more than 2,000 km from Nihoa and Necker Islands (7 and 10 million years old respectively) to Midway and Kure Atolls (28 million years old) and represent the older portion of an emergent volcanic archipelago. The majority of the islets and shoals are uninhabited, although Midway, Kure, Laysan Island, and French Frigate Shoals have each been occupied for extended periods by various government agencies or commercial enterprises over portions of the last century. The NWHI provide important habitat for a number of threatened and endangered species. The Hawaiian monk seal is one of the most endangered marine mammals in the US (only about 1,400 individuals remain); it depends almost entirely on the islands of the NWHI for breeding and the surrounding reefs provide food. However, in recent years there has been an increase in the number of births of the monk seal in the MHI. More than 90% of all sub-adult and adult green sea turtles in Hawaii are hatched in the NWHI. One of the largest and most important assemblages of seabirds in the world occur as large colonies in the NWHI.



The average change in live coral cover between 1999 and 2002 at CRAMP sites among islands shows that the reefs off the large populated islands have decreased in coral cover, whereas those on the less populated islands have remained relatively stable in those 3 years.

Status of Coral Reefs

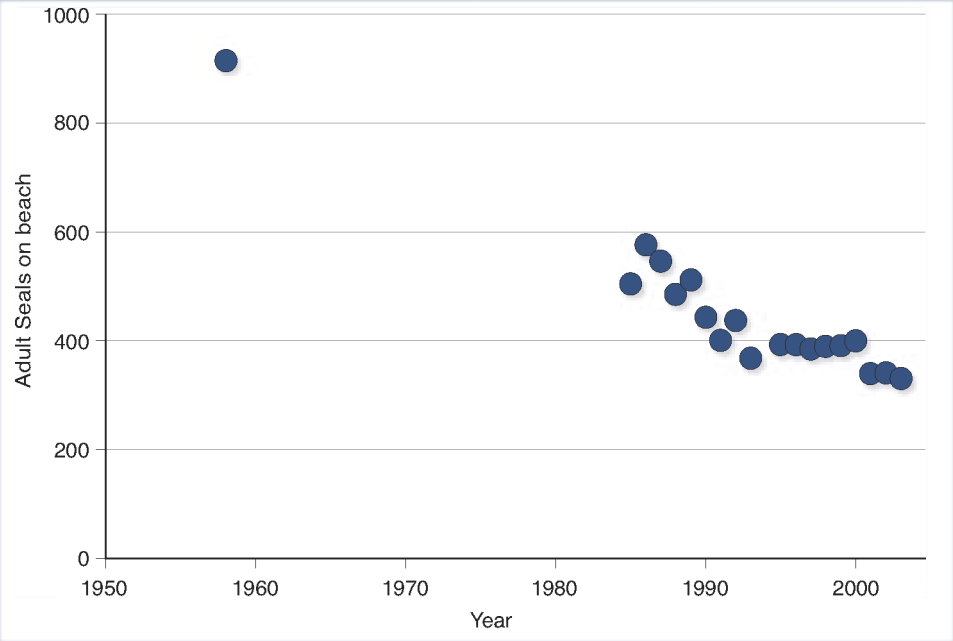
MHI

The Hawaii Coral Reef Assessment and Monitoring Program (CRAMP) has monitored benthic marine communities around the MHI since 1999. In 2004, coral cover at 60 sites around the state averaged 20.8% (range 0.5% to 86.0%), with 6 coral species accounting for 20.3% of the total cover (*Porites lobata*, 6.1%; *Porites compressa*, 4.5%; *Montipora capitata*, 3.9%; *M. patula*, 2.7%; *Pocillopora meandrina*, 2.4%; and *M. flabellata*, 0.7%). Coral cover, coral species richness, and coral diversity all showed a significant relationship with the physical factors of habitat complexity, sediment composition, mean wave direction and height, rainfall, and geological age of the islands. Sites exposed to the larger west and northwest swells on the older islands, such as Kauai and Oahu generally had lower coral cover, species richness and diversity.

Coral cover at most CRAMP stations changed less than 10% between 2000 and 2003; 16 of 60 stations showed a significant decline in coral cover with the greatest reduction being 19% on Molokai. In contrast, 13 stations increased in coral cover with the greatest increase on Maui of 14%. The downward trend was most evident in the central portion of the archipelago on the islands of Oahu, Molokai and Maui. Most Hawaiians live on Oahu (72%) and Maui (10%); Molokai has a lower population, but there is extreme erosion and sediment flow onto the reefs along the south shore due to inadequate watershed management. Oahu and Maui also have damaged watersheds and there are large population centres adjacent to major reef areas. The islands of Kauai and Hawaii, which have relatively low human populations, showed an increase in coral reef cover. Kahoolawe is a former military target island, and the condition of sediment-

STATUS AND CONSERVATION OF THE HAWAIIAN MONK SEAL AND GREEN TURTLE

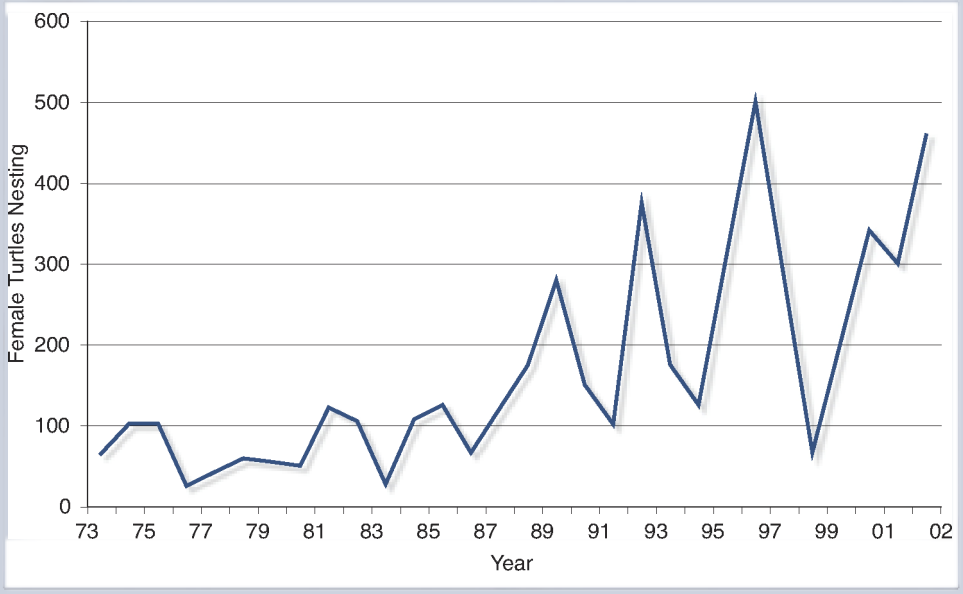
The Hawaiian monk seal *(Monachus schauinslandi)* is the only endangered pinniped in U.S. waters. Counts declined by about 5% per year from 1985 to 1993; remained relatively stable to 2000; and then declined again with record low beach counts recorded in 2001, 2002, and 2003. While Monk seals occur throughout the Hawaiian Archipelago, most are found in the NWHI with smaller numbers coming ashore in the MHI, where they rest,



The historical trend in beach counts of adult Hawaiian monk seals of the six main reproductive subpopulations shows a dramatic decline in populations of this endangered species.

molt, and nurse on isolated beaches. Beach counts estimate that the current population is 1,300 seals, which is a decrease of 60% from the 1950s. Population trends were variable at the 6 main reproductive sites in the NWHI but overall numbers of births and survival of juveniles have decreased at most sites. The largest declines were at French Frigate Shoals where adult counts have dropped by 60% since 1989. Most of the remaining individuals are older animals due to high juvenile mortality over the past decade. Future abundance trends will depend upon whether the predicted losses at French Frigate Shoals are balanced by gains at other locations. The main reasons for the losses were hunting during the 1880s, disturbance by military activities, entanglement of seals in marine debris, direct losses from fishing prior to the 1991 Protected Species Zone in the NWHI, predation by sharks, aggression by adult male monk seals, and reduction of habitat and prey due to environmental change.

The Hawaiian green turtle *(Chelonia mydas)* is a spatially distinct population with many feeding grounds within the Hawaiian Archipelago. The principal rookery is on French Frigate Shoals, where more than 90% of all nesting occurs. Monitoring of the population since 1973 has shown nesting females generally return to the same islands. Turtles have been protected under the US Endangered Species Act since 1978 and there has been a dramatic increase in abundance over 30 years. There are substantial fluctuations in the number of turtles nesting each year, which reflect regional variations in ocean-climate. Despite the recovery patterns after 25 years of protection, green sea turtles face a new threat from disease, particularly fibropapilloma tumours. Turtle tumours were rare prior to 1985, but are now common on turtles on Maui, Kauai, and Oahu. Up to 60% of the turtles in Kaneohe Bay, Oahu have tumours.



The number of female green turtles nesting at East Island (French Frigate Shoals, Northwestern Hawaiian Islands) from 1973 to 2002 has shown a steady increase, but with large variations that often correspond with changes in the ocean climate e.g. El Niño – La Niña events.

damaged reefs have remained stable following the removal of all grazing animals, cessation of bombing, and a massive program of revegetation.

Benthic cover has been monitored at a number of other sites around the MHI since the 1970s and 1980s. The long-term trends at these sites show that the majority of the stations (13 of 18) have declined since the first survey. Explanations for the declines greater than 10% include reef slumping (Kaneohe Bay, Oahu) and sedimentation (Honolua Bay, Maui). Other, less dramatic declines may be a result of natural variability or sampling frequency.

Coral populations in the Hawaiian Archipelago continue to be spared from epidemic diseases, unlike many other coral reefs around the world. Baseline surveys for coral disease showed that the average prevalence of disease (number of diseased colonies/total number of colonies) was 0.95% (range 0-4.4%) at 18 sites around Oahu.

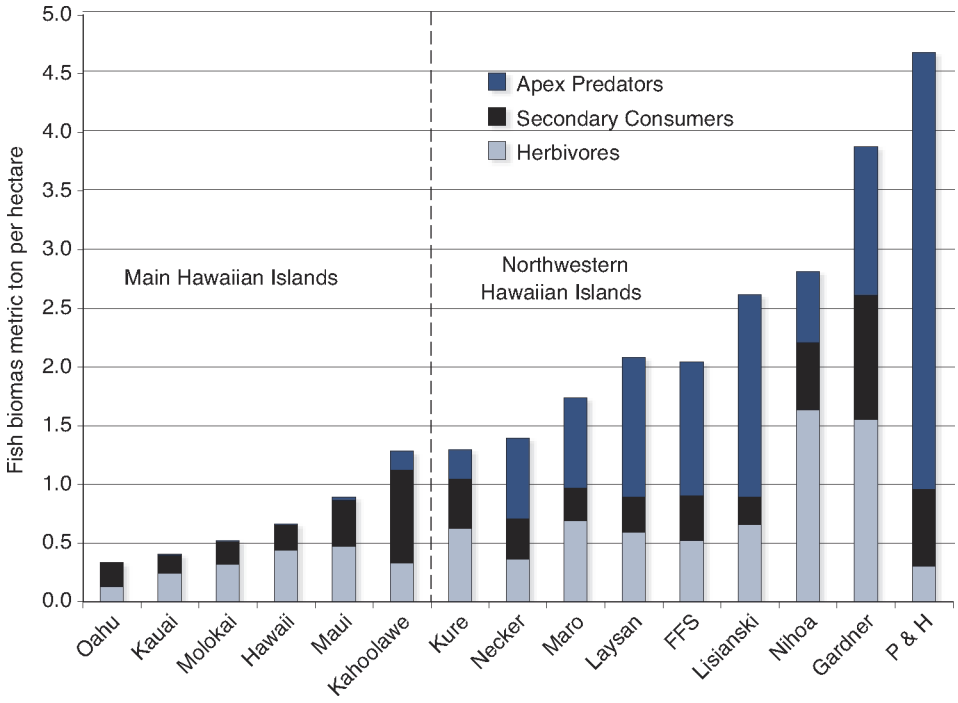
There are 557 species of reef and shore fishes in Hawaii, of which 24.3% are endemic species. Surveys of fishes at CRAMP sites provided the first broad spatial examination of reef fishes in the MHI. Surgeonfishes and parrotfishes were the dominant families (38% and 16% by weight, respectively) and herbivores were more than 65% of the total reef fish biomass, followed by invertebrate feeders (12%), planktivores (7%), and detritivores (7%). Predators were rare and accounted for only 4.7 % of reef fish biomass. Endemic species accounted for 28% of numerical abundance observed over all locations. The direction of wave exposure, amount of habitat complexity, and the level of protection from fishing were all important determinants of reef fish assemblage structure and standing stock.

NWHI

Between 2000 and 2003, investigations at 536 assessment sites recorded 57 stony coral species including 11 first records and 29 species range extensions. Rapid Ecological Assessment surveys showed: coral endemism is high with 17 endemic species (30%) accounting for 37-53% of the relative abundance of stony corals; 3 genera (*Montipora, Porites, Pocillopora*) account for 88% of the endemic species and most of the endemic abundance; and 7 *Acropora* species are now known from the central NWHI despite their near absence from the MHI. Coral cover was highest on Maro Reef (64%) and lowest on Necker Island (4%). Coral abundance and diversity were highest on the large open atolls of the central NWHI (French Frigate, Maro Reef, Lisianski/Neva Shoal) and declined gradually through the remaining atolls to the northwest (Pearl and Hermes, Midway and Kure). Stony corals were also less abundant and diverse off the exposed basalt islands to the southeast (Nihoa and Necker Islands, and La Perouse and Gardner Pinnacles), where soft corals (*Sinularia*, *Palythoa)* were more abundant. Exposure to severe wave action appears to limit coral development off these small islands and the surrounding deep platforms. There were fewer coral species and lower abundance on the northwestern end of the chain; most likely due to temperature extremes and the natural accumulation of lagoon sediments.

There are 366 known species of algae from the NWHI, and new endemic species have been described recently. The NWHI contain many Indo-Pacific algal species not found in the MHI, e.g. the common green calcareous alga *Halimeda velasquezii*. Algal-dominated reefs are normal for many healthy ecosystems of the NWHI with wide fore-reef and back-reef regions characterised by 15% macro-algal cover, while live coral cover was less than 8%. Oceanographic studies and monitoring suggest that water motion may be a major factor in defining algal assemblage structure.

Observations of NWHI reef fishes between two series of partially overlapping monitoring and assessment surveys in 1992-2000 and 2000-2004 showed that the average fish standing stock in the NWHI was more than 260% greater than in similar habitats of the MHI. The most striking difference was the abundance and size of large apex predators (primarily sharks and jacks) in the NWHI compared to the MHI. More than 54% of the total fish biomass on fore-reef habitats in the NWHI consisted of apex predators, compared to less than 3% in the MHI. Most of the dominant species by weight in the NWHI were either rare or absent in the MHI



There is a dramatic difference in coral reef fish biomass between the Main Hawaiian Islands and those of the Northwestern Hawaiian Islands. The difference is particularly noticeable with the 'apex predators', including the groupers, snappers and trevallies, which account for more than 50% of the biomass in the NWHI but less than 3% in the MHI. These differences are an indication of fishing pressure.

and any target species that were present in the MHI were nearly always much smaller than those in the NWHI. These differences represent almost local extinctions of the apex predators and heavy exploitation of lower trophic levels in the MHI, compared to the largely unfished NWHI. The level of endemic fish species is about 30%, and the proportion of endemics in the total numbers averaged 52%; emphasising the ecological importance of these endemic species. There is greater endemism towards Midway and Kure, which appears to be related to consistently higher rates of replenishment by new juveniles.

Status of Coral Reef Fisheries

MHI

The number of commercial fishers rose from 282 in 1966 to a peak of 1178 in 1996, with 925 in 2001. Excluding coastal pelagic fish which account for 80% of the nearshore commercial catch, there were 140,000 kg of coral reef fish landed in 2001 consisting mainly of surgeonfishes, goatfishes, soldierfishes, unicornfishes, parrotfishes, and octopus. Catch rates at the family level have been variable with no significant trends except for goatfishes, where there has been a downward trend since the 1960s. Total landings for a number of prized resource species like bonefish (*Albula* spp.) and Pacific Threadfin (*Polydactylus sexfilis*) have declined dramatically over the past few decades.

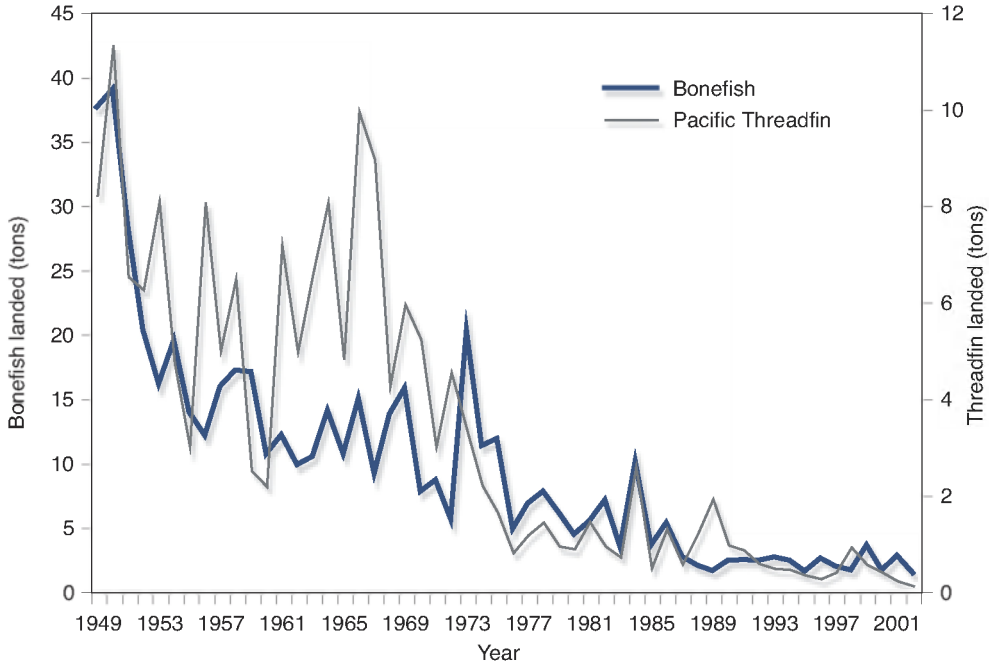
ALIEN SPECIES INVADE HAWAII

Due to the extreme isolation and consequent high numbers of endemic species, the invasion by alien species poses a significant threat to the native diversity in Hawaii. The estimated number of non-indigenous marine species (NIMS) includes 287 invertebrates, 20 algae, 20 fish, and 12 flowering plant species. Alien marine algae have proliferated on many nearshore Hawaiian reefs and out compete or smother coral reef species.

Gracilaria salicornia, Hypnea musciformis, and *Kappaphycus/Eucheuma* spp. were introduced to Hawaii for aquaculture in the 1960s and 1970s, and *Acanthophora spicifera* arrived on a ship hull in the 1950s. These 'superweeds' are now spreading rapidly and overgrowing and smothering corals on a number of Hawaiian reefs. While the majority of NIMS in Hawaii are invertebrates, many species are cryptic and/or have remained in highly disturbed harbour and other fouling environments. It is thus very difficult to determine the effects and interactions that the invaders may be having on native marine flora and fauna. The snowflake coral *(Carijoa riisei)* was first reported in Pearl Harbor in 1972. As it reproduces and grows rapidly, it is now found in high densities from the intertidal zone down to 100 m depth, especially where reduced light and moderate currents provide ideal growth conditions. It is overgrowing black coral beds between 75 and 100 m off Maui. The recently introduced orange keyhole sponge *Mycale armata* was observed at 5 of 41 sites, and in parts of Kaneohe Bay. It has become abundant and overgrows the dominant corals *Porites compressa* and *Montipora capitata.* Between 1951 and 1961, 11 bottom fish species (6 groupers, 4 snappers, and 1 emperor) were intentionally introduced into Hawaii. Of these, the blacktail snapper *(Lutjanus fulvus),* the bluestripe snapper *(Lutjanus kasmira)* and the peacock grouper *(Cephalopholis argus)* have established viable breeding populations and have spread throughout the state. The latter two species are particularly controversial because they have adapted well. They are now being blamed for declines in native fisheries species, although recent studies do not confirm this belief.

The nearshore recreational and subsistence catch is probably equal to or greater than the commercial fisheries catch, with these non-commercial fishers taking more species using a wider range of fishing gear. Intensive fishing on highly prized and vulnerable species has led to substantial declines in catch and size, raising concerns about the long-term sustainability of fish stocks. Pacific Threadfin, one of the premier recreational fish in Hawaii, has declined significantly in size since the 1960s, while the proportion of juveniles has increased from 6 to 40% of the catch. A recreational creel survey in Kauai in the 1990s found that 30% of the catch of bluefin trevally (*Caranx melampygus*) was below legal size and less than 3% had reached size at first sexual reproduction. Fishers frequently cite inadequate enforcement of fishing and marine resource laws as one of their major concerns. The lack of marine-focused enforcement and minimal fines for those few cases that have been prosecuted contribute to poor compliance with fisheries management regulations.

Most of the marine ornamental fish and invertebrates coming from U.S. waters are collected in Hawaii, which is known for valuable high quality and rare endemic species. This coastal fishery is the second most valuable after the scad fishery, with a reported value of $1.06 million in FY



The commercial landings of two important fish species, bonefish and Pacific threadfin, have clearly declined in the 50 years of record keeping in Hawaii.

2002. However, the true dollar value is thought to be $3 - 5 million per year, due to potential under-reporting and non-reporting. While the overall economic value of the aquarium fishery has been relatively stable over the last few decades, there have been local variations with the value of the Oahu aquarium fish catch declining by 76%, while the Hawaii catch increased by 282%. These trends are probably the result of overfishing, generalised damage to the habitat on Oahu, specific habitat destruction from two major hurricanes, and an expansion of the fishery on Hawaii. Surgeonfishes, butterflyfishes, and wrasses are the most commonly fished species, while feather duster worms, hermit crabs, and shrimp predominate among the invertebrates. The top 10 species constitute 73.3% of the catch with the Yellow tang (*Zebrasoma flavescens*) accounting for 37% of the total.

In 2002, the State began to gather recreational and subsistence fishery information through the Hawaii Marine Recreational Fisheries Survey (HMRFS), which is part of the nationwide Marine Recreational Fisheries Statistical Survey (MRFSS). This is being integrated into a national dataset, which will be available to all fisheries management personnel, and the public, via the MRFSS website. HMRFS surveyors perform intercept surveys at key fishing areas, in harbours, at boat ramps, and along the shoreline. The survey is designed to assess a number of parameters of recreational fishing, including the area fished, gear types, target species, and length/weight/species of fish caught.

NWHI

Fishing in the NWHI is mostly limited to two commercial fisheries: a bottomfish fishery; and a recently closed lobster trap fishery. The bottom-fish fishery targets snappers and groupers

on the deep-slopes (generally deeper than 100m). Only two species, the green jobfish (*Aprion virescens*) and the endemic Hawaiian grouper (*Epinephelus quernus*) occur in shallow reef habitats and contribute substantively to NWHI bottomfish landings, with far more jobfish being taken. Existing time series data suggest no obvious pattern of temporal change for jobfish, although there is a declining trend in catch per unit effort for Hawaiian grouper in the northern fishing zone. The lobster fishery targeted the endemic Hawaiian spiny lobster (*Panulirus marginatus*), as well as the non-endemic slipper lobster *Scyllarides squammosus* from 1998 to 2000, when it was closed because of growing uncertainty about the status of the stock.

A recreational catch-and-release fishery commenced in 1996 at Midway, after the Midway Naval Air Station was closed and the atoll became a USFWS National Wildlife Refuge. Giant trevally (*Caranx ignobilis*) and bluefin trevally, the main targets of the catch-and-release fishery, declined in abundance at Midway between 1996 and 2000, when sampling was discontinued. There are no other significant resource extraction activities in the NWHI.

Anthropogenic Threats to Coral Reef Biodiversity

MHI

The coastlines of Hawaii continue to be developed for a variety of land uses. Agricultural lands (primarily sugarcane and pineapple) are being converted for residential and resort use on all islands. Many of Hawaii's low-lying coastal areas were wetlands and flood plains before being cleared for agriculture and development. These areas acted as excellent filters, removing sediments and nutrients from streams before the water entered the ocean. More sediments are carried directly to the ocean because the coastal areas were cleared, flood plains filled, and streams channelled. Construction projects of more than 1 acre require State of Hawaii Department of Health authorisation and Counties (grading permits) to ensure the use of best management practices to control erosion. Recent major earthworks at development projects on Hawaii and Kauai have resulted in significant sediment discharges into the ocean. Lawsuits and enforcement actions delayed the work and cost the developer millions of dollars in remediation, penalties, legal fees, etc. One outcome of damage from these developments is that there is public pressure to preserve open space, coastal lands and beaches on all islands. The State and Counties, local land trusts and conservation organisations, have purchased, or are negotiating the purchase of major coastal land parcels for preservation.

Offshore water quality in Hawaii is generally good although there are few long-term data sets for waters near coral reefs. Contaminants in stormwater drains, streams and groundwater supplies from urban and agricultural lands enter the sea, but pollutant concentrations are rapidly diluted by the oceanic waters. The relocation of sewage outfalls into deep offshore areas has eliminated the direct effects of sewage on reefs, resulting in some recovery to previously stressed reefs. The total magnitude of these anthropogenic nutrient inputs into groundwater is unknown, however on West Maui, 61% of the total nitrogen entering the ocean from groundwaters came from pineapple and sugarcane agriculture, and 29.8% was from sewerage systems. Nuisance algal blooms are known along this coastline and these nutrient inputs are probably the cause of these blooms, although there are other natural or anthropogenic inputs.

The State of Hawaii estimates that more than 6.7 million visitors will arrive in 2004 and spend more than $11.4 billion; these are increases from 2003. Nearly 52% of all visitors participate

in diving or snorkeling activities, which outrank all other recreational activities of U.S and Japanese visitors to Hawaii, other than just visiting a beach. Hawaii's Marine Protected Areas (MPAs) and other calm water locations are the prime areas to dive and snorkel and are marketed as 'must see destinations' by the tourist industry. The potential damage to these natural resources are numerous at these high use sites. For example, extensive damage occurs in shallow, calm water sites when tourists trample on the more fragile corals, with considerable evidence of broken and dead coral in high coral cover areas. Education is a critical management tool in minimising such damage. A recent study has shown that tourists who are given a brief orientation and provided with floatation devices to use while snorkeling are much less likely to damage the corals than independent visitors entering the water from the shoreline without interpretive information or training.

Each year tons of marine debris wash onto Hawaii's shorelines, posing a threat to endangered Hawaiian monk seals, sea turtles and sea birds from entanglement or ingestion. The debris (especially derelict fishing gear from around the Pacific rim) is unsightly and also significantly damages the benthic substrate, especially coral and algae communities, as it washes over the reefs. In 2002, nearly 2,000 volunteers across the state collected more than14 tons of marine debris along 94 miles of shoreline in a one-day event. Of all the debris, cigarettes and plastic plates, utensils, caps and lids were the most common accounting for more than half the debris collected. Fishing line and net debris are the most common form of debris that becomes entangled on the reefs and can be removed only by divers.

NWHI

Most of the marine debris is derelict fishing gear from distant fisheries around the Pacific rim, the debris poses one of the most significant anthropogenic threats to the reefs of the NWHI. To address this threat, a large-scale multi-agency effort funded by the NOAA Coral Reef Conservation Program has removed more than 480 metric tons of derelict fishing gear and other debris since 1996. Based on an estimate that 1000 tons of debris have accumulated in the NWHI over the past few decades, and accumulation rates are continuing at 25-40 tons per year, the removal program will have to continue, while attempts are made to reduce debris from the sources.

Current and Potential Climate Change Impacts

MHI

The trend over the past few decades is for temperatures to increase in Hawaiian waters; the first multi-location coral bleaching events were documented during the summer of 1996 around the MHI. Although bleaching events may have occurred in the past, there is no quantitative or qualitative record of previous events, and there has been no documented case of extensive bleaching across the chain. The bleaching events were triggered by a combination of: prolonged exposure to sea surface temperatures greater than 1°C above normal maxima of summer; high solar energy; and low winds which resulted in restricted water circulation in areas where eddies retained the warm water. Most bleaching occurred on the lee sides of the larger Hawaiian Islands, probably due to higher solar irradiance because of clear skies and reduced trade winds.

NWHI

Coral bleaching was observed in the NWHI for the first time during late summer 2002. Bleaching was most severe on the 3 northern atolls (Pearl and Hermes, Midway, and Kure), with less at Lisianski and farther south in the NWHI. Bleaching in the north was most severe

on back-reefs, moderate in the lagoons, and low on the cooler and deeper fore-reef slopes. The predominant corals, *Montipora* and *Pocillopora*, experienced the most extensive bleaching with minor bleaching in *Porites*. Sea surface temperature data from satellites and in situ buoys showed that elevated temperatures were the most likely cause of the bleaching due to prolonged periods of light winds. No significant bleaching was seen in July 2003, but mortality from the 2002 bleaching was noted. Recent reports also indicate that mild bleaching occurred during September 2004 at several sites in the NWHI, including Pearl and Hermes Atoll and Maro Reef, however, the magnitude and extent of the bleaching is unknown.

Current MPAs, Monitoring and Conservation Management Capacity

MHI

Hawaii has a wide variety of MPAs that vary in size and level of protection. These include Marine Life Conservation Districts (MLCD), Fisheries Management Areas (FMA), Fisheries Replenishment Areas (FRA), a Marine Laboratory Refuge (MLR), Natural Area Reserve (NAR), Kahoolawe Island Reserve (KIR), and National and State Wildlife Refuges. The Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DLNR/DAR) administers the state's MLCD, FMA, FRA, programs, which are designed to conserve and replenish marine resources state-wide. Hanauma Bay, Oahu was created in 1967 as the first MLCD; 10 more MLCDs have been established since then. The State is currently evaluating its existing system of MPAs and exploring options for the creation of a network of marine managed areas, to ensure coral reef sustainability, and rehabilitation and enhancement of fisheries.

The Hawaii DLNR/DAR has undertaken a number of measures to improve the management of fisheries resources including: increasing minimum size limits for certain resource species; initiating marine recreational fisheries surveys, evaluating and expanding Marine Protected Areas (MPAs); and changing commercial reporting forms. Other management measures have included the use of stock enhancement based on aquaculture for a few highly prized species, and artificial reefs to improve the catch of some coastal fisheries species at a few select locations. A tag and release program initiated by DAR has involved more than 850 volunteer anglers and has increased public awareness about fish biology and conservation.

Hawaii created a Local Action Strategy (LAS) to focus on management, research and monitoring needs of coral reef fisheries. This document outlines the Coral Reef Fishery Management LAS for the MHI, and is a collaborative effort between federal, state, and NGO partners. The LAS will be updated regularly, as new information is obtained and new priorities identified. The goal of this local action strategy is to work towards the development of an integrated fishery management plan over the next 3 years in order to promote sustainable harvest using an ecosystem-based approach.

A network of 9 Fisheries Replenishment Areas (FRAs) was established in West Hawaii in 2000 to conserve fish targeted by the aquarium trade. With the designation of these additional sites, more than 35% of 150 miles of coastline was excluded from harvesting aquarium species. The West Hawaii Aquarium Fish Project (WHAP) is a collaborative effort between DAR and researchers at several Universities. It was established in 1998 to evaluate the effectiveness of the marine reserve network in West Hawaii, which was created to ensure the sustainability of the aquarium fishery. The initial objectives of the program were to:

1. Estimate impacts of aquarium fish collecting in West Hawaii;
2. Evaluate effectiveness of protected areas in increasing stocks;
3. Document recruitment patterns of aquarium fishes; and
4. Characterise benthic habitat and determine fish-habitat associations.

WHAP has monitored 26 sites bimonthly for fish and key invertebrates in West Hawaii and 4 in East Hawai'i since 1998, and found an increase of 26% in the abundance of target fishes after 3 years of closure, with the dominant species (yellow tang) increasing by 86%. The abundance of aquarium fishes did not decline in open areas, which coupled with a consistent catch per unit effort, suggests that there has been no diversion of harvesting effort outside the FRAs.

The goal of long-term coral reef monitoring is to combine existing programs with new components to form a comprehensive long-term regional coral reef ecosystem monitoring program within the State. CRAMP, WHAP, and other long-term monitoring data will be included in this new program. The ultimate objective of the project is to develop the capacity for effective monitoring of coral reefs and associated communities using the most appropriate, comprehensive, powerful and scientifically valid methods. These programs must be compatible with other monitoring programs in the State of Hawaii and elsewhere.

Local communities are becoming more accountable for the health and long-term sustainability of their marine resources by revitalizing traditions and increasing their knowledge about resources. The State has encouraged community-based management programs such as reef monitoring and assessments and community watch programs resulting in more reporting of violations. More partnerships are planned in the future.

In 1998, the Hawaii Coral Reef Initiative Research Program (HCRI-RP) was established to support scientific research and monitoring to enhance the state's capacity to manage its coral reef resources. DAR and the University of Hawaii jointly administer this program with funding from NOAA. The program also supports public awareness efforts, briefings for legislators and decision-makers, internships, and fellowships.

The NOAA National Ocean Service and its partners are developing comprehensive digital benthic habitat maps of shallow (< 30 m) coral reefs. These maps are used to evaluate existing MPAs and guide the design of monitoring programs. NOAA Fisheries, the University of Hawaii, and other partners are developing comprehensive moderate depth (20- 300 m) habitat mapping products for the MHI using multibeam acoustic imagery.

Federal and state agencies have created a Local Action Strategy for Hawaii to address Pollution Threats to Coral Reefs. This program builds on existing land management efforts and coral reef monitoring to determine how land management affects coral reef health. Three watersheds on the islands of Maui, Molokai and Kauai were selected as pilot sites for this Local Action Strategy because significant community participation is already occurring at these focal sites. In addition to the Local Action Strategy, many upland watersheds in the forest reserves are being managed by partnerships between landowners and the federal, state and county agencies. Pollution control projects on land include cesspool upgrades and erosion control. Coral reef monitoring programs are being designed to assess the effects of pollution, e.g. the EPA has banned large-capacity cesspools serving 20 or more people per day as both a health and pollution control measure. Volunteer coral reef monitoring activities include REEF and Reef Check, with a focus on reef conservation education with residents and visitors participating in the surveys.

NWHI

The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve was created by Executive Order 13178 in December 2000 and amended by Executive Order 13196 in January of 2001 to include the marine waters and submerged lands extending 1200 nautical miles long and 100 nautical miles wide from Nihoa Island to Kure Atoll. With this designation, the Reserve became the second largest marine protected area in the world. These Executive Orders contain conservation measures that restrict some activities throughout the Reserve, and establish Reserve Preservation Areas around certain islands, atolls and banks where all exploitation is prohibited. NOAA is working with its partner agencies that have jurisdiction in the NWHI (State of Hawaii and the US Fish and Wildlife Service) to designate the area as a national marine sanctuary.

NOAA Fisheries and partner agencies and various research institutes have been involved in marine research in the NWHI over the past few decades. With support from recent Executive Orders, the Pacific Islands Fisheries Science Center, the NWHI Coral Reef Ecosystem Reserve, and partner agencies have started a comprehensive program to map, assess, monitor, and conduct research for a better understanding of the coral reefs of the NWHI. Collaborators include other federal and state agencies, and numerous academic and NGO and international partners. The Northwestern Hawaiian Islands Reef Assessment and Monitoring Program (NOWRAMP) is a multi-agency, multi-year effort that began in 2000 to assess, evaluate, map, and monitor the shallow water reef habitats in the NWHI. This monitoring program is supported by the NOAA Coral Reef Conservation Program (CRCP) and led by the Coral Reef Ecosystem Division of the Pacific Islands Fisheries Science Center.

Since 2001, NOAA CRCP has established a comprehensive Coral Reef Ecosystem Integrated Observing System (CREIOS) in the NWHI to observe, monitor, and understand key oceanographic processes influencing these reefs. Their observations have already improved our understanding of the processes responsible for significant reef events, such as the 2002 coral bleaching. The NOAA National Oceanic Service and Fisheries Service have led a collaboration to develop two draft NWHI atlases: Shallow Water Benthic Habitat Maps; and Bathymetric Atlas of the NWHI based on acoustic mapping

Government Policies, Laws, and Legislation

MHI

The State of Hawaii, Department of Land and Natural Resources has proposed several policy and regulatory changes. These included: assessment of the current system of marine managed areas; a proposal to consider a network of managed areas; a proposed ban on gill nets in some areas statewide; additional bag limits for some regulated species; addition of more species into the minimum size regulations; the development of a 'community watch' program to assist in reporting marine resource violations; and the creation of new civil penalties for violations.

NWHI

Eight of the 10 NWHI (except Kure and Midway Atolls) have been protected by the Hawaiian Islands National Wildlife Refuge (HINWR), established by President Theodore Roosevelt in 1909. The Refuge includes all emergent lands, while administrative boundaries were established for the reef areas to 20 fathoms off Necker Island and to 10 fathoms off the remaining 7 islands. The

State of Hawaii manages the Kure Atoll Wildlife Refuge and all waters around each of the islands and atolls from 0-3 miles, except for Midway Atoll. The State has recently proposed regulations that would create the Northwestern Hawaiian Islands Marine Refuge and designate most of these waters as non-extractive. With the exception of Midway Atoll, the NOAA Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve (NWHICRER) established in 2000 by President Clinton (Executive Order 13178 and amended with Executive Order 13196 in January 2001) extends protection and federal jurisdiction beyond the offshore boundaries of State and HINWR waters to a maximum distance of 50 nm. The Reserve is planning to designate the region as a national marine sanctuary and is developing an Environmental Impact Statement and a Management Plan with input from partner agencies and the public. Midway Atoll is outside both State of Hawaii and NWHICRER jurisdiction and since 1996 has been under USFWS administration as the Midway Atoll National Wildlife Refuge, affording protection to all reefs and islands at the atoll.

Gaps in Current Monitoring and Conservation Capacity

MHI

Monitoring gaps include:

- An integrated multi-agency program that incorporates an ecosystem approach for all marine components;
- The capacity within the State to effectively monitor coral reefs and associated communities under their jurisdiction utilizing appropriate, comprehensive, powerful and scientifically valid methods;
- Financial support for ongoing programs such as CRAMP and WHAP;
- Education and outreach campaigns to reduce the spread of invasive species;
- Continued funding to assess and monitor the spread of invasive species;
- Additional monitoring of human use patterns in the marine environment which is critical to understand anthropogenic threats;
- Other mechanisms to characterise the habitat in high use sites, map and assess the patterns of use and develop a systematic approach to defining and determining appropriate levels of use to achieve a balance between minimising the human-induced stress while maintaining healthy ecosystems; and
- A systematic oceanographic and water quality monitoring program to assess oceanographic influences and sediment and nutrient loading on coral reefs.

Conservation capacity gaps include:

- Additional enforcement capacity in the marine sector;
- The small number and area of existing MPAs; there are several islands with no MPAs;
- Effective land management, to avoid the disconnect between land-based activities and resulting damage to coral reefs. The Local Action Strategy on pollution and the watershed partnerships needs support to address this issue comprehensively; and
- Funding to understand and combat the spread of alien species.

NWHI

Regular monitoring programs of coral bleaching and disease are needed to improve understanding of their impacts and role in shaping community structure. Regular monitoring in this remote area is logistically challenging and expensive, and it is difficult to access the area and respond rapidly when a major anthropogenic or natural catastrophic event occurs. In addition, patrolling and enforcing regulations over more than 1600 km of the island chain to ensure compliance by fishing, research and ecotourism users presents a challenge for all jurisdictional authorities. Thus, there is a need to implement an automated Vessel Monitoring System and require all vessels to carry transmitters and notify authorities of their location in relation to protected areas. This program will require funding for vessels, and for the management agencies to monitor vessel movements. Management and monitoring remain fragmented among agencies with differing missions, but efforts are underway to develop a more coordinated approach. The reliance on some agencies to inform others about fisheries management has had limited success and Federal court action has been required previously to obtain NMFS compliance to fisheries management and endangered species laws. The establishment of the NWHI Coral Reef Ecosystem Reserve and the process to designate the region as a national marine sanctuary, provides an opportunity to develop more collaborative and coordinated management for the region. The additional funding and assets provided by NOAA have already increased access and profile in the region, but continued funding and support are needed.

Conclusions

Coral ecosystems in the Hawaiian Archipelago are in fair to excellent condition, but are threatened by continued population growth, urbanisation and development. Ocean outfalls and urban and recreational coastal developments (hotels, golf courses, etc.) are focal points for coral reef degradation. New technologies for extraction, offshore aquaculture, and bioprospecting are cause for concern about the ability of management agencies to keep ahead of real or potential damage to coral reef resources. There is clear evidence of over-exploitation of most target food fishes and invertebrates. Key marine aquarium species were also heavily exploited in the MHI until recently. Potential under-reporting of exploitation levels and insufficient enforcement is compounding problems for resource managers. Introduced alien species now threaten the structure and function of Hawaiian reefs and some may out-compete endemic species. Some alien species have already caused complete phase shifts on some reefs.

However, significant progress has been made in mapping, monitoring, researching, and managing Hawaii's reefs. Habitat maps of the MHI and NWHI provide a baseline for understanding the most critical areas for biodiversity and fisheries productivity. Research studies are improving our understanding of land-water interactions and the effect of natural and human-induced stresses on coral reefs. Monitoring programs are now documenting management effectiveness in catalysing improvements in ecosystem health and function. Improved socio-economic valuations of Hawaiian reef resources are fundamental to assist management determine compensation levels for detrimental land (e.g. sediment runoff) and ocean activities (e.g. ship groundings). Much of the data needed for decision making has only been available in recent years. Problems still remain with marine debris and grounded vessels, but the community is more aware and cooperative in removing debris, especially from the MHI. There has been tremendous success in the recent removal of a large portion (480 metric tons) of marine debris from the NWHI.

There is now evidence that MPAs can effectively promote recovery of heavily exploited fish stocks in Hawaii, without causing significant declines in areas outside the MPAs. Fish Replenishment Areas have successfully reduced conflicts between collectors and other resource users, promoted a sustainable fishery, and enhanced aquarium fish populations. The success of the Fish Replenishment Areas in West Hawaii is likely to increase as aquarium fishes grow and mature within these protected areas and further replenish nearby reefs.

A new outreach campaign called 'Hawaii's Living Reef Program' launched in 2004 is raising public awareness of the importance of healthy coral reefs. The partnerships between management agencies, academia, NGOs and user communities continue to develop. However these partnerships need ongoing financial and political support to continue progress within the complex pattern of different coral reef and human communities in the Hawaiian Archipelago.

Main Hawaiian Islands

100 years ago: The affects of humans on the environment began with the settlement of the Hawaiian Islands by the Polynesians. They relied heavily upon nearshore resources for food and altered shorelines and reef-flats to develop fishponds and traps. Traditional fishery management practices were in use by early Hawaiians, with strict enforcement of rules. The reefs were almost certainly healthy with adequate fish populations.

In 1994: There were clear signs of damage to coral reefs from land-based sources of pollution, increased sedimentation, shoreline modification and dredging near urban areas. Over-fishing had resulted in significant declines in nearshore fish stocks over the previous 30 years. The inadequate enforcement of marine resource regulations hampered efforts to maintain fish stocks. The Hawaiian Government and people had already recognised the need for MPAs and had established numerous protected areas around the islands.

In 2004: The Hawaiian Government has undertaken a number of measures to improve the management of the State's coral reef resources. Monitoring has increased and there are more MPAs that vary in size and level of protection. Over-fishing is still a major problem that is severely damaging the health of the ecosystem. Alien species now pose a significant threat to the native species. Coral bleaching and disease are starting to become an issue and plans are in place to include them in future monitoring efforts. Regardless, the reefs remain stable and in relatively good condition, although declines in coral cover are occurring. These reefs are healthier and better managed than those in other regions of the world.

Predictions for 2014: The reefs will continue to decline due to ever increasing human populations and their associated pressures. The rate of decline will depend directly on the degree of protection given to the coral reef resources. Increased support (political and financial) will be needed for existing and future efforts to effectively sustain Hawaii's coral reef resources.

Northwestern Hawaiian Islands

100 years ago: The Northwestern Hawaiian Islands were a pristine ecosystem with little influence from humans, except for limited harvesting of turtles and fish.

In 1994: The NWHI were still in a healthy state, predominantly due to the remoteness of the islands that prevented easy human access. Fishing efforts were primarily limited to bottom reef fishes and lobsters, with limited entry and seasonal closure conditions applied. Research efforts were aimed at maintaining bottom fish and lobster stocks.

In 2004: The designation of the NWHI as a Reserve in 2000 promoted an increase in support and involvement of various management agencies in the conservation of the NWHI coral reefs. There was an increase in research to understand the reefs, and in management to protect the reef resources. The lobster fishery was closed and bottom fishing was capped. All future activities in the NWHI will require permits and will only be allowed if they are consistent with the goals of long-term conservation of the ecosystem. A significant coral bleaching event was observed in the northern end of the NWHI for the first time in 2002 and another milder event occurred in 2004. This emphasised the need for future research and monitoring efforts in the NWHI.

Predictions for 2014: The ecosystem will be in a healthy state with management agencies working in cooperation to fully understand and protect the environment. However, predictions of global climate change and the recent observations of coral bleaching suggest that there may be a need to further understand and minimize any potential ecosystem impacts of future bleaching events. Due to its vast size and remote location, significant resources will be needed to fully investigate, properly manage and protect the unique ecosystems of the NWHI.

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16. Status of Coral Reefs in the U.S. Caribbean and Gulf of Mexico: Florida, Flower Garden Banks, Puerto Rico, U.S. Virgin Islands, Navassa

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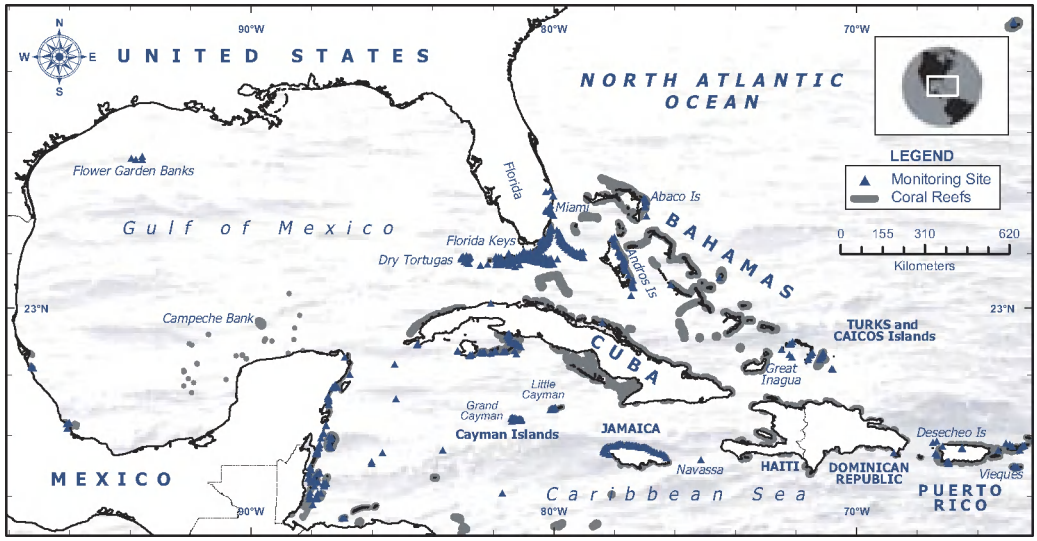
Abstract

Mapping, monitoring, and management of coral reefs of Florida, the Flower Garden Banks National Marine Sanctuary (FGBNMS) northwestern Gulf of Mexico, Puerto Rico, U.S. Virgin Islands and Navassa have all improved with increased awareness and funding from the Government of the USA. Quantitative baseline surveys of coral reef communities have been completed in Puerto Rico at three current or proposed Natural Reserves. Monitoring is demonstrating trends in reef community health and structure in other sensitive coastal areas. The Tres Palmas Marine Reserve has been designated recently, and existing MPAs and revisions to fishing laws were evaluated based on these results. In the U.S. Virgin Islands (USVI), the Buck Island Reef National Monument has been expanded and a new park, the St. Croix East End Marine Park established in 2003. The monitoring programs in the USVI are now detecting changes in fish and coral community structure in and around the managed



Map courtesy of The WorldFish Center

areas with a specific focus on elkhorn coral stands. Monitoring of water quality, reef diversity, growth, and populations of dominant fish and benthic organisms in Flower Garden Banks, Stetson Bank, and Navassa has assisted in evaluating impacts of climate change, tropical storms, fishing, and tourism pressures. An expanded Florida monitoring program is now completing the first integrated assessment of the reefs northwards from the Florida Keys. It is hoped that this increased attention to coral reef issues will continue, and that advances in the understanding of how coral reef ecosystems respond to anthropogenic stresses will result in better management plans that protect coastal resources by reducing those stresses. However, an improved understanding of the relative importance of how stresses contribute to or cause coral decline is needed. There is a need also to understand the linkages between water flows and the functioning of coral reef ecosystems. It is essential to strengthen cross-boundary and cross-jurisdictional agreements to facilitate ecosystem-based management and information and technology transfer.

100 Years ago: Virtually all coral reefs were healthy with normal fish populations. Clear, low-nutrient waters were the norm and reefs were dominated by healthy branching corals, urchins, large schools of game fish, sharks, and algal grazers.

In 1994: Coral reefs of the Caribbean had been heavily damaged by disease, coastal development, coral bleaching, and over-fishing. The scientific community was documenting the decline and public awareness was increasing. Management plans were being written for areas protected in National Marine Sanctuaries and Parks and universities, governments, and NGOs conducted research and monitoring. The more isolated reefs in the Western Atlantic were in better condition because they were not affected by land-based stresses.

In 2004: Reefs in the Caribbean and Western Atlantic range in condition from excellent to poor with reefs near population centres showing damage from land-based pollution, fishing, disease, bleaching, and ship groundings. In areas stressed by over-fishing and coastal development, recovery from the sea urchin die-off and coral bleaching events of the late 1980s and early

1990s is slow. However, the capacity to understand, monitor and manage coral reefs, and their use is expanding. More coral reefs are managed in protected areas and enforcement of existing regulations is improving in some of these areas.

Predictions for 2014: Reefs away from population centres will remain healthy, unless the adverse predictions for global climate change of more tropical storms and bleaching occur. Human stresses around populated islands will continue, but if governments maintain or build their capacity and commitment to improving reef ecosystem management, these stressors and resulting damage should be minimized.

Introduction

This report is a summary of the detailed reports in 'The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2004'; available at www.nccos.nos.noaa.gov in February 2005. Previous summary details are also contained in 'Status of Coral Reefs of the World: 2002' on www.reefbase.org.

Florida

The Florida Keys extend from Miami to the Dry Tortugas and are included in the Florida Keys National Marine Sanctuary (FKNMS), and the Biscayne and Dry Tortugas National Parks. The Sanctuary covers 9850 km^2 with 1400 km^2 of coral reef and hard bottom habitat. The reefs consist of almost continuous parallel banks, and include distinct habitats such as offshore patch reefs, seagrass beds, back reefs, reef flats, bank or transitional reefs, intermediate reefs, deep reefs, outlier reefs, and sand and soft bottom areas. The other major reefs are 3 parallel lines of reefs off southeast Florida. The first reef is shallow with a low cover of algae and small octocorals; channels and numerous octocorals dissect the second reef; and the third reef is deeper with the most diverse hard coral populations. It is evident that the banks of staghorn coral (*Acropora cervicornis*) are recovering from bleaching and disease damage, and many moderate sized colonies of *Montastraea annularis* now occur on the deeper reef; there are no *Acropora palmata* in this area.

Flower Garden Banks NMS – Northwestern Gulf of Mexico

The East and West Flower Garden Banks are the most northerly coral reefs of continental North America and some of the most isolated reefs in the Caribbean. These are 2 Jurassic salt domes that rise from 100 m depth to 17 m and contain 1.4 km^2 of luxurious bank reefs in the northwest Gulf of Mexico. There is relatively low coral diversity (21 species), but coral cover is more than 50% and consists of closely spaced, large (up to 3m in diameter) heads, many of which have been hollowed by eroding organisms.

Stetson Bank – the protected third site within the boundaries of the FGBNMS, harbours a small coral pinnacle, dominated by *Madracis decactis* and *Millepora alcicornis*. The coral cover on the pinnacle is close to 30%, and the remainder of the bank is dominated by sponges and algae.

Puerto Rico

Fringing coral reefs with a total area of 3,370 km^2 occur off the east, south and west coasts, around the 2 inhabited (Culebra and Vieques) and 3 uninhabited (Mona, Monito, Desecheo) small islands off Puerto Rico. Other areas of the shelf consist of hard ground and reef rock with scattered coral colonies and coral patches. The reefs have high hard coral diversity (125 species) along with 112 species of soft corals and gorgonians. The reefs have suffered major losses in coral cover through bleaching and disease, but stands of high coral cover (e.g. 70%) remain on some reefs which are remote from the land.

U.S. Virgin Islands

There are fringing, patch and deep reefs (wall and shelf-edge) around all the major islands (St. Croix, St. John, and St. Thomas) and some have prominent spur and groove formations. There are also offshore cays and a barrier reef on St. Croix, with the highest coral diversity on the deeper offshore reefs. Mapping of the area by NOAA showed 61% of the 485 km^2 area is covered by coral reefs and corals on hard-bottoms, 33% is predominantly seagrass beds, and 4% is sediment or rocky bottom. The jurisdiction over these coral resources is shared by several U.S. Departments (Interior and Commerce) and the Virgin Islands Government.

Navassa

This is a small, uninhabited raised island, 5 km^2 in area, which lies between Jamaica and Haiti and is managed by the U.S. Fish and Wildlife Service. This report adds considerably to the limited knowledge of these reefs and their resources.

Status of the Coral Reefs

Florida

The Florida Keys are probably the best documented reefs in the Wider Caribbean with 64 hard coral species, 2 fire corals, and 55 species of octocoral recorded. The dominant bottom cover in 2003 was hard bottom (~62%), followed by octocoral (13%), macro-algae (12%), stony coral (7% in the FKNMS, 13% in the Dry Tortugas), 2% sponges, 2% zooanthids, and 0.5% seagrass. This represents a 5% absolute decline in stony coral cover from 1996. Species richness also declined across all habitats between 1996 and 2003; 76 of the monitoring stations had lower species richness, 15 had increases, and 14 stations were unchanged. The offshore deep and patch reef habitats had the most stony coral species with 17 and 16 species, and 9 species on hard-bottom habitats. The number of diseased stony corals has increased alarmingly from 20 stations in 1996 to 95 stations in 2003, with more diseases being observed. A disease outbreak in 2003 affected staghorn corals and prompted Sanctuary management to close an area to divers. They support the quarantine to prevent the disease from spreading. Coral bleaching remains a problem, and has caused some of the dramatic declines in coral cover in the Sanctuary since 1997, but fortunately there has been no recent severe bleaching. Coral cover has not declined since the 1997 bleaching outbreak, but the corals have not shown any significant recovery.

There are also 90 species of marine macro-algae, 7 seagrasses, and 3 species of mangroves in Florida. Seagrasses cover approximately 12,800 km^2. The algal and invertebrate cover fluctuates widely between years, e.g. algal cover increased between 1996 and 2000, while sponge and soft coral cover decreased.

Poor water quality and pollution from fertilizers, sediments, and nutrients from Southeast Florida and the Keys pose considerable threats to the corals. In response, the Sanctuary has

increased water quality sampling to over 200 tri-monthly sampling stations in the Sanctuary and the Shelf, and 100 monthly stations in Florida Bay, Biscayne Bay, and the mangrove estuaries of southwest Florida. Such monitoring has identified the major nutrient sources, the differences in geographical water quality, and elucidated large-scale water transport pathways. Data from these water samples will provide a baseline to study how the 're-plumbing' of the Everglades has altered water flows and pollution levels in Florida Bay.

Flower Garden Banks National Marine Sanctuary

The overall health of the East and West Flower Garden Bank reefs is stable, with about 50% coral cover of mostly robust, massive species. Coral cover on the deep stations of the East Flower Garden Bank is about 69%, dominated by *Montastraea franksi, M. cavernosa, M. faveolata* and *Diploria strigosa.* Very little coral disease and bleaching mortality has been seen, and when there is minimal bleaching, recovery is usually 100%. Algae continue to play a balanced role in the reef habitat, and do not threaten the corals, while water quality continues to be good.

The corals on top of the East and West Banks of the Marine Sanctuary have been monitored annually since 1989 and continue to thrive with 54% coral cover reported during the 2002-2003 monitoring season. The dominant species on the crest of the reefs are *M. faveolata, M. franksi, Porites astreoides* and *Diploria strigosa*. The Sanctuary research team has observed the deeper regions with Remotely Operated Vehicles (ROVs) during the last 5 years. They report over 35 species of antipatharians (e.g. black corals) and gorgonians, and several species of non-photosynthetic corals, with indications that these deep coral reefs are important spawning areas for several species of grouper.

Puerto Rico

These reefs are the richest reefs in the US Caribbean with 237 coral-like species; 117 hard corals, 99 soft corals and gorgonians, 13 corallimorphs, and 8 hydrocorals. Assessments of 79 reefs around Puerto Rico between 1985 and 2003 show that reefs close to coastal developments have degraded, whereas the reefs near the offshore Descheo Island are probably the best-developed and healthiest in Puerto Rico. Most shallow reefs (1 - 5 m) were covered with 65% algae, with live coral cover ranging from 4 - 49% (mean 16%). The highest cover was on the southeast with 4 species contributing more than 50% of that cover (*Porites astreoides, P. porites, Siderastrea radians, S. siderea*). The encrusting octocoral, *Erythropodium caribbaeorum*, occurred at most sites with a maximum cover of 44%, and zoanthids, particularly the encrusting *Palythoa* sp., and sponges were the other main animals in shallow waters. Most inshore reefs at 6-12 m show advanced stages of degradation, with 0.6 - 49% live coral cover. Only one mainland reef on the northeast coast had live coral cover above 10%. Live coral cover increased with distance from shore in Mayaguez Bay. *Montastrea annularis* was the dominant stony coral on 19 of 22 reefs, but was virtually absent on reefs with low coral cover. Macro and turf algae were dominant on most intermediate depth reefs. Live coral cover on the deeper reefs (15 - 25 m) was highest at the shelf-edge reef off La Parguera (44%). Other reefs on the southwest coast had cover of 16 - 27%, dominated by *Montastrea annularis, M. cavernosa, Porites astreoides* and *Agaricia* spp. In most areas, stony coral cover was within 3% of previous baseline levels, indicating little recent change. The notable exceptions were at Cayo Coral in Guánica and at Cayo Caribes in Guayama where there was a decline in coral cover. These declines probably relate to local disturbances, as adjacent reefs showed no change. Similarly, an increase in coral cover at Tourmaline Reef was not matched on other reefs in Mayaguez Bay.

US Virgin Islands

The USVI has about 57 species of hard corals, 377 reef fish, 500 molluscs, 454 echinoderms, 737 crustaceans, 99 polychaetes, 3 seagrasses, 120 algae, and 75 species of tunicates. Although there were no good estimates or comprehensive data sets of coral abundance before the mid 1970s, dense stands of *A. palmata* were reported and photographed on reefs in St. Croix. In the 1980s and 1990s, hurricanes and diseases severely damaged these coral reefs. The average coral cover declined by 8-33%, with the cover of *A. palmata* falling by as much as 85%, and reefs becoming dominated by macro-algae.

Monitoring studies from 2000-2004 indicate that coral cover remains low, while macro-algal abundance remains high and the epidemic of coral diseases continues. AGRRA (1998-2000) and video (2001-2003) assessments indicate a range of live coral cover from 4-39%, with *Montastraea* spp. and *Siderastrea siderea* as the most common corals. Macro-algal cover was significantly lower on St. Croix than on the northern Virgin Island reefs. *Diadema* urchins were twice as abundant on the shallow reefs of St. John than on deeper reefs.

The US Geological Survey, National Park Service, and the University of the Virgin Islands are mapping elkhorn coral stands in the Virgin Islands National Park (St. John), Buck Island Reef National Monument (St. Croix) and Biscayne National Park (Florida). They are also examining threats that could prevent recovery of this coral, which was once the most important reef-building species in shallow water throughout the Caribbean. Elkhorn (*Acropora palmata*) and staghorn (*A. cervicornis*) coral are now being considered for listing under the Endangered Species Act because of extensive declines (more than 90% at some sites) from white band disease and storms in the last 15-25 years (Box 15). It is not yet known whether elkhorn coral populations will recover to the levels seen 30 years ago. Early evidence suggests that there has been an increase in the abundance and size within the 3 national parks, but disease, predation, and breakage from boats and snorkelers may delay or prevent recovery.

Navassa

An extensive survey of various reef habitats in 2002 showed that the highest live coral cover was 46% at 25 – 30 m. Cover ranged from 10 - 20% in shallower habitats (10 – 20 m). Macro-algae (predominantly *Lobophora variegata* and *Dictyota* spp.) were the dominant organisms in some reef habitats. Macro-algal cover doubled from 2000-2002 at one site (25 to 50%), but was similar at two other sites and there were no overall changes in benthic community structure. *Neofibrilaria nolitange* was the dominant sponge and 21 species of gorgonians were observed at low densities. The dominant corals are *Montastraea* spp., *Agaricia* spp. and *Porites porites*, and shallow species such as *Acropora palmata*. Some coralline algae and foraminifera are found at depths much greater than expected indicating very clear water around Navassa. *Acropora palmata* appears to be increasing in abundance with substantial populations at 3 shallow reef sites, with the increase probably due to continuing sexual reproduction and recruitment. In contrast, the staghorn coral *A. cervicornis* remains rare and in poor condition. Diseases were not observed on any shallow water coral colonies. The impacts of predators (4% of colonies), and competition by algae and sponges (14% of the colonies) were the major direct causes of damage to corals. However, an unknown disease, similar to white plague was observed on brain corals at deeper reef sites.

Status of Coral Reef Fishes and Invertebrates

Florida Keys

The Florida Keys has 389 reef fish among the total of 517 fish species. Fishing impacts are highest near Miami and lowest in the Dry Tortugas; in 2001, 6.7 million recreational fishers made 28.9 million marine fishing trips in Florida, and caught 171.6 million fish with half being released or discarded. The number of registered recreational boats in the 5 southern Florida counties increased by more than 500% between 1964 and 2002, while the commercial vessel numbers grew by 150%. Fish stock biomass was well below accepted standards for most of the key target species within the reef fish fishery, e.g. the average size of black grouper caught in Biscayne National Park was 40% of the size of those caught in 1940, fishing mortality is several times the level needed to achieve optimum yield, and the spawning stock is now less than 5% of the historical un-fished maximum. Fishing pressure was particularly high, resulting in 77% of the 35 stocks examined being over-fished according to federal standards. This included 13 of 16 grouper species, 11 of 13 snapper, the barracuda, and 2 of 5 grunt species.

In 2003, 6 Florida reef fishes (speckled hind, warsaw grouper, black grouper, red porgy, goliath grouper and Nassau grouper) were listed as either over-fished (i.e. depleted below minimum standards) or being fished at a rate that would lead to over-fishing; 4 species were not over-fished; and the status of 46 species was unknown. Recently, the hogfish (*Lachnoliamus maximus*) was listed as over-fished and undergoing over-fishing in the Florida Keys, although trends have improved following the establishment of minimum size regulations in 1993 and a fish trap prohibition in 1990. In the Gulf of Mexico in 2003, the goliath and Nassau grouper were over-fished or undergoing over-fishing, and 26 species were in unknown condition. Legal-sized spiny lobsters continue to be larger and more abundant in no-take zones than nearby fished areas, but Queen conch populations remain low, despite a ban on commercial and recreational fishing since the mid-1980s. Both are being monitored intensively, and attempts are underway to improve reproductive output. Populations of the long-spined sea urchin (*Diadema antillarum*) are recovering slowly since the massive die-off in 1983.

Flower Garden Banks National Marine Sanctuary

Fish diversity is lower (266 species) than on other Caribbean reefs, with plankton and invertebrate feeders being the most abundant species, and commercial species, like grunts and snappers being much less common. These reefs may be important spawning areas for grouper. There have been significant increases in queen and stoplight parrotfish (*Scarus vetula* and *Sparisoma viride*), possibly due to an increase in algal food following the disappearance of the long-spined sea urchins in 1983. Manta rays, whale sharks, tropical spotted dolphins, bottlenose dolphins, hammerhead and silky sharks, and spotted eagle rays can all be seen on the Banks. Only traditional hook and line fishing is allowed in the Sanctuary, however, illegal fishing by commercial long-liners and recreational spearfishers has been reported, but little is known about any resulting damage. Current legal fishing for snapper and grouper may be having a detrimental effect on populations. Lost and discarded fishing gear in the Sanctuary and on Stetson Banks is causing some damage to the coral reefs and loggerhead turtles have become entangled and injured. Stetson Bank is closer to shore, and is often targeted by recreational fishermen, and there appears to be more mechanical injury from fishing because of the relatively soft nature of the claystone and siltstone bottom.

Puerto Rico

There are 242 reef fish species, with the target fish under intense pressure from commercial and recreational fishers, and aquarium collectors. Reef fish catches have plummeted for two decades indicating classic symptoms of over-fishing: reduced total landings; declining catch per unit effort; shifts to smaller fish; and recruitment failures e.g. commercial fish landings fell by 69% between 1979 and 1990. Reef fish density (individuals per 30 m^2) ranged from 93.2 near Desecheo Island to 12.6 near Caja de Muertos, with both reef fish density and species richness correlated directly with coral cover and the bottom rugosity. The mean number of fish species per transect ranged from 16.8 near Desecheo Island to 7.0 at Cabo Rojo.

In 2003, there were 219,910 recreational anglers in Puerto Rico, with 34,905 being non-residents. Recreational anglers made 1,411,943 fishing trips in 2001, 1,098,420 in 2002 and 1,111,405 trips in 2003. The total number of fishers declined from 249,869 in 2001 to 219,910 in 2003, and commercial use of traps and nets also declined due to their high costs and relatively low yield. There was, however, an increase in the use of lines and scuba gear. Most recreational fishing (56 - 64%) was from the shoreline, 35 - 40% was from private boats, with the remainder being charter trips (1 - 3%). Most of the total recreational catch of 2.08 metric tons in 2000 and 1.09 tons in 2002 was caught by private boat anglers, with 16 - 29% being reef fish. The total catch decreased by 40% per year between 2000 and 2002. There were consistent declines in the catch of lane, mutton and silk snapper. There is an unwanted side effect of the decline in spiny lobster populations due to increasing fishing pressures. Coral-eating molluscs, which are a favourite food of the lobsters, increased and are causing more damage to the corals.

U.S. Virgin Islands

The composition of reef fish populations and landings has changed markedly in the USVI over the past 40 years. In the 1960s and 1970s, large grouper and snapper species were plentiful on reefs and common in fisheries landings. From the 1980s to the 1990s, there was a shift in fish species composition in catches and on the reefs to more herbivores. Fewer grouper and snapper species were seen or caught, and the average size of fishes decreased. The Nassau grouper fishery crashed, followed by a crash in the replacement redhind fishery. Monitoring studies from 2000-2004 indicate that herbivorous fish species remain abundant on reefs and in fishery landings. Populations of large snappers and groupers remain low, but their numbers may be increasing. The size and numbers of fishes spawning within some enforced protected areas also appear to be increasing.

Navassa

Surveys in 2002 found 35 new fish species records to make the total 272 for Navassa. They counted 20,901 fishes in 110 species from 45 families at 110 stationary samples, with plankton feeders dominating (71%), including blue chromis, creole wrasse, bluehead wrasse, and bicolor damselfish as the most abundant species (59.1% of the total). Most importantly, large fish were virtually absent from the population, with the average total length being 4.6 cm and only 11 of 1227 individual fish were longer than 24 cm. This is in stark contrast to findings in 2000, when in a less extensive survey, 92% of snapper and 23% of parrotfishes were longer than 40cm. This indicates that fishing is having a major impact on Navassa reefs.

Diadema antillarum were present at mid-depths (0.16 ± 0.24 m^{-2}) but much rarer on the shallow reefs (0.02 ± 0.02 m^{-2}). Coral eating molluscs, *Coralliophila abbreviata*, were found infesting *Agaricia* spp., *Montastraea* spp., *Diploria* spp. and *Acropora palmata* in the shallower

sites (<20 m). Although no quantitative data on queen conch (*Strombas gigas*) were collected, intense harvesting of mature conch populations was observed. This will be a high priority monitoring theme for the future.

Anthopogenic Threats to Coral Reefs

Florida

A combination of geography, multiple stressors acting synergistically, and natural factors explain the condition of the Florida reefs. Because coral reefs in Florida represent the northern extension of a rich Caribbean flora and fauna they are negatively affected by winter cold fronts which have previously killed substantial amounts of coral as far as the Dry Tortugas. Reefs in Florida suffer from many of the same problems that have caused coral decline throughout the Caribbean, especially white band disease (affecting the branching corals *Acropora palmata* and *A. cervicornis*) and an urchin disease. In combination, these events have considerably altered the condition of the offshore reefs in the Keys.

Over-fishing is a well-documented problem in the Keys (65% of the 35 species analyzed were over-fished). Between 1995 and 2000, the commercial fishing fleet grew by 26%, and the recreational fleet by 465%. In addition, 400-600 vessels have run aground each year in the FKNMS, with 15% of these damaging the corals. Large-vessel groundings cause more immediate damage, but the cumulative effects of small-vessel groundings have long-lasting impacts. Damage also occurs from anchors and chains. Fibre optic cables and gas pipelines have recently been installed off Miami-Dade, Broward, and Palm Beach Counties. The drilling and trenching has released sediments and raised turbidity, further adding to reef degradation. The State of Florida has directed cable companies to install cables where there are gaps in the reefs to reduce damage. The growing South Florida population has added to fishing pressures and increased problems associated with coastal development.

Nutrient enrichment is a problem close to shore, but the relative importance and effects of different nutrient sources is unclear. Harmful macro-algal blooms have increased off Palm Beach County during the past decade, and the cyanobacterium, *Lyngbya confervoides*, has covered extensive areas of the middle reef tract off Broward County over the past 2 years. Such algal blooms smother and kill coral, and reduce larval settlement. Water pollution has increased bioerosion rates and may be linked to coral diseases. The primary nitrogen source for these blooms is land-based, i.e. sewage, followed by surface water run-off, stormwater discharge, and groundwater seeps. Nutrient loading of nitrogen and phosphorus from inland agriculture is evident in the coastal waters offshore from Palm Beach County due to surface water discharge was 2,473 and 197 metric tons per year, respectively, and 5,727 and 414 metric tons per year via submarine groundwater discharge. The water quality monitoring program that started in1995 has shown elevated nitrogen levels in the nearshore areas of the keys, but not in the Tortugas region, indicating that the source is from the land.

Flower Garden Banks National Marine Sanctuary

These reefs are in the middle of one of the largest oil and gas fields in the world; 6,500 oil production platforms have been installed, 43,300 wells drilled, and 168,474 km of pipeline laid in the Gulf of Mexico. Within the Minerals Management Service 4 mile regulatory zone of the East and West Flower Garden Banks, there are 14 production platforms and 178 km of pipeline, and Sanctuary staff review many requests to lay pipelines or install platforms in this regulatory

zone each year. In addition, many scuba divers, and recreational and commercial fishers visit the Banks. The main physical damage is from vessel anchors, minor water pollution, fishing activities, and oil and gas exploration and development. The managers of the Sanctuary consider that there is a need for a public awareness program targeting the potential for divers to spread coral diseases, and to encourage visiting divers to adequately wash out their dive gear, particularly wetsuits, prior to traveling to new dive sites.

Puerto Rico

The coral reefs are deteriorating due to accelerated urban and industrial development on the coast, and a lack of effective resource management. There has been massive clearing of mangroves, dredging of rivers for sand and harbours, runoff from large-scale agricultural developments, deforestation in large watersheds, raw sewage disposal and building of power plants all resulting in coral reef damage. Other major anthropogenic activities include oil spills, anchoring of large cargo vessels, over-fishing, uncontrolled recreational activities, eutrophication, and military bombing activities (at Vieques and Culebra Islands).

The 2002 commercial fishery census reported 1,163 active commercial fishers using 956 fishing vessels, 10,372 fish traps, 2,774 lobster pots, 147 beach seine nets, 993 gill nets, 391 trammel nets, 1,267 cast nets and 12,310 fishing lines of different types. These fishers caught 1.6 million tons of fish per year from 1995-2002, with 87% of them targeting reef fish, as well as conch and lobster. Recreational fishers and ornamental collectors also target reef fish, consequently reef fisheries have plummeted during the last 20 years and commercial fish landings have fallen by 69% between 1979 and 1990. Over 200 species of ornamental fish and invertebrates have been exported from Puerto Rico as an unregulated industry. New State fisheries regulations approved in 2004 limit the species allowed for export, and establish annual export quotas.

US Virgin Islands

Water quality around the USVI is generally good but it is declining with increased point and non-point source pollution. Overloaded municipal sewerage systems are responsible for much of the point source pollution. Increased tourism and the accompanying increase in solid waste have exacerbated the problem. Other impacts from tourism include physical damage to habitats, groundwater depletion and contamination, increased sediment loads, and the displacement of traditional resource users. Sediments running off coastal developments are reducing water quality in St. Thomas and St. John where 80% of the slopes exceed a 30% gradient with increased runoff from unpaved roads.

Navassa

Despite its status as a National Wildlife Refuge, fisheries at Navassa are poorly managed as the regulations are not well publicised or enforced, due to remoteness and other challenges. In 2002, most fishing boats were 6-9 m wooden vessels manned by 3 to 6 fishers using either hook-and-line, nets or Antillean Z-traps. The extent of larger commercial fishing vessels operating in Navassa waters is not known. Finfish catch appeared unselective and included predominantly small (<30 cm) fishes such as trunkfish, ocean triggerfish, surgeonfish, and bar jack. The catches also included queen conch (*Strombus gigas)* and Hawksbill sea turtles (*Eretmochelys imbricata).* In addition, the artisanal fishers have installed a system of makeshift moorings and rock anchors at Lulu Bay in the middle of an extensive stand of *Acropora palmata.*

Current and Potential Climate Change Impacts

Florida
Coral bleaching has affected the Keys many times in the past 15 years. In 1997 and 1998, significant bleaching was observed for the first time in successive years. Large numbers of corals are presumed to have been killed by the bleaching, but this was not well documented because there were no appropriate monitoring programs. There has been no repeat of severe of bleaching since 1998.

Flower Garden Banks National Marine Sanctuary
The location and depth of these coral reefs buffer them from the short-term effects of global warming and climate change, and 2002-2003 data indicate negligible bleaching, except when the water temperature approached 30°C, which caused 4% bleaching but negligible mortality. It is predicted that the incidence and severity of bleaching events will increase with rises in global ocean temperatures.

Puerto Rico
Current levels of 'natural' events (hurricanes, coral bleaching, coral diseases) together with anthropogenic pressures are causing considerable coral reef degradation, which may mask any signals from climate change.

U.S. Virgin Islands
Coral bleaching was recorded at all AGRRA sites in 1998 - 2000, with the most frequent around St. Croix and the least frequent around St. Thomas. The1998 bleaching coincided with the highest seawater temperatures. Bleaching in 1999 was associated with milder temperatures (28.8°C) but did not result in extensive coral colony mortality with most colonies recovering within 6 months. Recent data suggest that climate change remains a threat to the coral reefs in the USVI.

Navassa
Virtually no historic observations or data exist for the physical parameters or condition of Navassa reef resources. There are no records of coral bleaching because no regular observations have been made. However, most of the high coral-cover habitat around Navassa is relatively deep (18-30m), and the exposed oceanic location ensures that strong currents and surges may provide some level of protection from bleaching.

Current MPAs and Management Capacity

Florida
An ecosystem-based plan to conserve, protect and manage the natural and cultural resources of the Florida Keys now prohibits oil exploration, mining, large shipping traffic, anchoring on or touching corals, and collecting coral or 'live rock' in the Sanctuary. The sources of pollution from outside the Sanctuary are being identified and abatement measures are being adopted. In 2002, a 'no discharge zone' for vessels within state waters of the Sanctuary was implemented. With the designation of 23 no-take zones in 1997 covering less than 1% of the Sanctuary, it was possible to protect 65% of shallow coral reef habitats. Three years later in 2000, densities of economically important yellowtail snapper and grouper species in these no-take areas had increased significantly compared to reefs outside, and one year later, gray snapper had also increased significantly. In comparison, average densities of non-exploited striped and stoplight parrotfish were unchanged compared to baseline data. The 518 km^2 Tortugas Ecological Reserve (far west Florida Keys) was implemented in 2001 increasing the amount of coral reef in no-take zones within the Sanctuary to 10%.

Biscayne National Park encompasses an additional 291 km^2 of the northern reef tract. The decision to declare the Park was prompted by concerns about coastal development, intense use by recreational boaters, and growing fishing pressure. Protection of Park resources includes Natural Resource Reserve areas where fish nurseries and spawning habits are protected from fishing. Wildlife management zones in the Key West and Great White Heron National Wildlife Refuges direct human activities away from the 1,610 km^2 of sensitive coral reef habitat.

Goliath grouper fishing was closed in Florida and Atlantic waters in 1990 and in the Gulf of Mexico in 1992. The Madison-Swanson and Steamboat Lumps Spawning Sites (off the West Florida shelf) were established in June 2000 to protect spawning aggregations of gag (*Mycteroperca microlepis*), as well as other reef and pelagic fish. There was evidence in 2003 that the stock was recovering and had a 50% chance of returning to historical levels in the core habitat of southern Florida. Similarly, signs of recovery of adult queen conch are evident after the fishery was closed in 1986.

Flower Garden Banks National Marine Sanctuary

The Sanctuary was designated in 1992, and Stetson Bank added in 1996. The regulations are designed to protect sensitive coral reef features by prohibiting: anchoring of vessels within the Sanctuary; mooring of any vessel longer than 30 m on a Sanctuary mooring buoy; oil and gas exploration and development within a designated no activity zone (almost the entire sanctuary); injuring or taking coral and other marine organisms; using fishing gear other than traditional hook and line; discharging or depositing any substances or materials; altering the seabed; building or abandoning any structures; and using explosives or electrical charges. The Banks were designated by the International Maritime Organization in 2001 as the world's first international no-anchor zone, with the location and regulations listed on international charts.

Puerto Rico

The island Government (Department of Natural and Environmental Resources) and the Caribbean Fisheries Management Council share responsibility for managing 24 MPAs, with most sites having some year-round protection, while 3 red hind Spawning Aggregation Sites are under a temporary fishing ban from December to February. Recent legislation has strengthened coral reef management, and Puerto Rico designated Tres Palmas Marine Reserve in Rincón as a natural reserve in 2004 with funds allocated for a management plan. New State fishing regulations, compatible with USA Federal regulations were signed in 2004, and recreational use of 6 coral reef keys within 5 Natural Reserves is now regulated via an administrative order. State regulations designate 1/2 mile around Mona, Monito and Desecheo Islands as MPAs, and the red hind closed season has been extended to the entire territorial sea. Large-scale assessment of fish and benthic communities is being used to determine the size and location of other proposed MPAs, with an emphasis on protecting essential fish habitats and populations and also assessing the socioeconomic impacts of MPA designation.

U.S. Virgin Islands

The St. Croix East End Marine Park was designated by the USVI Legislature in 2003 as the first territorial marine park. This opened the way for the establishment of a territorial network of Marine Parks. Buck Island Reef National Monument was expanded by 7,700 ha of submerged land in 2003 with a marine park advisory committee of community stakeholders developing a management plan. A Marine Managed Area (MMA) inventory is accessible online at www.mpa.gov. The Department of Planning and Natural Resources has deployed fish aggregating devices (FADs) in territorial waters to reduce fishing on the reefs and promote a shift to

pelagic fishes. Six FADS are deployed around St. Croix, three around St. Thomas, and more are planned. Mooring buoys have been installed to decrease damage by dive operators, recreational fishermen and boaters on the coral reefs. More buoys are being added, especially within the St. Croix East End Marine Park. Outside the managed areas, fishing is regulated by federal and territorial regulations with size restrictions for whelks, conch, and lobster. The harvest of goliath grouper and the commercial harvest of billfish are prohibited.

Navassa

In 1999, the island and a 12-mile radius of marine habitat became the 517th National Wildlife Refuge administered by the U.S. Fish and Wildlife Service. Comprehensive conservation planning began in 2004 with development of a 15-year management plan, which will soon be open to the public for comment. Bi-annual marine expeditions have produced substantial biological information, which will assist in developing the management plan.

Government Policies and Legislation

Florida

The FKNMS is a federal/state partnership between NOAA and the State of Florida Department of Environmental Protection (FDEP). The Sanctuary implements various management programs including: scientific research; education and outreach; damage assessment and restoration; and mooring buoys. In 2004, a Draft Revised Management Plan was released for public comment.

FDEP, as a member of the US Coral Reef Task Force, has begun the Southeast Florida Coral Reef Initiative, which is focused on improving coral reef conservation for the reef tracts off southeast Florida from Miami-Dade County to Hobe Sound. The Initiative has 4 focus areas

- Land-Based Sources of Pollution;
- Fishing, Diving and Other Uses;
- Awareness and Appreciation; and
- Maritime Industry and Coastal Construction Impacts.

Water quality standards are being re-evaluated to reduce damage to reef systems e.g. the National Pollution Discharge Elimination System regulates point sources that discharge pollutants into State waters. Industrial, municipal and other facilities must obtain permits to discharge directly into surface waters, and discharged storm water must meet appropriate treatment criteria and not violate water quality standards. The program has been effective in requiring many private small wastewater package plants to eliminate raw sewage discharges, and all municipal treatment plants must achieve minimum levels of effluent quality to secondary treatment level, even for ocean outfalls. Wastewater in the Florida Keys is handled by approximately 200 treatment plants and septic tanks, however these leach nutrient-rich water through the porous limestone into the coastal waters. The Monroe County is studying the effects of septic tanks and will consolidate wastewater plants into regional facilities to decrease this nutrient loading.

Fishing in state waters is managed by the Florida Fish and Wildlife Conservation Commission (www.myFWC.com) and in federal waters by the South Atlantic (www.safmc.net/fishid) and Gulf of Mexico Fishery Management Councils (www.gulfcouncil.org). Actions include: prohibiting destructive or wasteful fishing gear (e.g. roller trawls, explosives, wire fish traps); requirements

to reduce bycatch death (e.g. vessel holding requirements and limits on number of short lobster used as live bait in lobster traps, escape gaps and release hatches for lobster traps); establishing minimum size and bag limits on a number of reef species landed; establishing seasonal and spatial closures for certain fishing gears (e.g. spears, power heads, lobster diving) and breeding seasons (e.g. amberjack, black grouper); limiting or restricting fishing for some species; and limiting entry to certain fisheries. Some areas in the Sanctuary restrict fishing and diving. Fisheries for Nassau grouper (*Epinephelus striatus*), goliath grouper (*E. itajara* – formerly jewfish), queen conch (*Strombus gigas*), and stony corals remain closed.

Installation of mooring buoys on highly visited reefs in Monroe, Dade, and Broward Counties is reducing chronic effects from small boat anchors. To reduce groundings, the State and the FKNMS are educating boaters about navigating in coral reef areas, and large vessel avoidance areas are marked with radar sensitive beacons installed on lighthouses between Dry Tortugas and Key Largo. Future efforts will include extending vessel avoidance zones, prohibiting the use of the Port Everglades anchorage when the wind speed exceeds 25 knots, and enhancing management of the Port Everglades anchorage.

Flower Garden Banks National Marine Sanctuary
Regulations governing the Sanctuary under the National Marine Sanctuaries Act (16 U.S.C. 1431), including the International Maritime Organization designated no-anchor zone, are contained within the Code of Federal Regulations and can be viewed on the web at: http://www.sanctuaries.nos.noaa.gov/oms/pdfs/FlowerGardensRegs.pdf.

Puerto Rico
In an effort to convert a collapsing fishery into a sustainable one, the Government of Puerto Rico has enacted new fishing regulations that: require recreational fishing licences; prohibit recreational spearfishing with scuba; will eliminate beach seine nets within 3 years; establish size limits and daily quotas on several species; require species-specific permits for high-value and sensitive species (i.e. spiny lobsters, queen conch and land crabs); and create MPAs around Mona and Monito Islands, Desecheo Island and the Condado lagoon. Compatibility with USA federal fisheries management measures has largely been achieved. Puerto Rico is developing a Local Action Strategy to address land-based pollution by reducing urban sprawl, concentrating industrial development, and developing agricultural practices to protect soils and avoid erosion into waterways. The coastal zone is managed by the DNER, the Environmental Quality Board monitors water quality, and the Regulations and Permits Administration administers land-use regulations. A Coastal Non-Point Sources of Pollution Control Plan was approved by NOAA and the USEPA in 2000.

U.S. Virgin Islands
The U.S. Departments of the Interior and Commerce, and the Virgin Islands Territorial Government have overlapping jurisdiction over the submerged lands within the USVI. These agencies supervise research and monitoring to assist management of the coral reefs. They employ a variety of management tools to reduce the effects of fishing, recreational use, and land-based sources of pollution.

Navassa
A 12-mile fringe of marine habitat around Navassa (estimated at 134,000ha) is under U.S. Fish and Wildlife Service management. A comprehensive Conservation Plan is being developed.

Gaps in Current Monitoring and Conservation Capacity

Florida

A comprehensive coastal water quality monitoring program is needed for southeast Florida, especially as extensive macro-algal blooms have recently covered the adjacent reefs. Research on the response of reef communities to changing water quality is also required. Reef monitoring in southeastern Florida is limited by a lack of comprehensive information about marine communities, and effective baseline assessments are needed for all monitoring sites in the region. These should include a functional classification of all reef habitats, and instigation of regular monitoring on the Florida Middle Grounds. All data collected should be consistent with state, national, and international programs, and should be rapidly disseminated to the public. Reef fish monitoring should be expanded to detect cryptic species, and fish below 30 m which are poorly characterised, but are exploited by recreational fishers. Likewise, data are needed on the reef fish communities in seagrass and mangrove habitats of Port Everglades and coastal waterways, as these have high potential to be nursery grounds, but are subjected to high levels of human activity. Only 50% of Florida's coral reef and associated habitats have been mapped, therefore it is difficult to determine which areas should be considered for protection by no-take provisions. Major mapping gaps include the reefs on the southeast coast, the Middle Grounds banks and deeper regions of the Tortugas.

Flower Garden Banks National Marine Sanctuary

These Banks are approximately 100 miles from shore, which hampers research and enforcement. Thus, the Sanctuary lacks on-site enforcement, observation and management of human activities. A remote camera/radar system may provide the answer to this management need. The Banks may serve as important spawning areas for several grouper species with the larvae probably traveling to other reefs and banks in the northwestern Gulf of Mexico and further afield, although data on larval flow in and out of the system are limited. An example of this unique system has been the discovery of an endemic wrasse on the Banks and nearby reefs. These highlight the importance of protecting the biodiversity and confirming the size and extent of spawning observations. Research is needed on effects of the expansion of oil and gas activities on water quality around the coral reefs. Currently the management authorities are unable to determine the carrying capacity of recreational divers and fishers on the Banks. To date, data from long-term monitoring of nearby Stetson Bank have not been analysed. Oceanographic data buoys are located in the proximity of the Sanctuary, but no analysis has been conducted on the archived data.

Puerto Rico

New research and monitoring programs in Puerto Rico are filling gaps and providing information to managers on status and trends of the coral reefs. The 5-year Coral Reef Ecosystem Study by researchers at the University of Puerto Rico and NOAA commenced in 2002 to investigate natural and human stresses and processes, socioeconomic factors, and the use of MPAs in management planning. The study aims to integrate all data into a unified GIS visualization tool to help managers predict the outcomes of management actions.

U.S. Virgin Islands

A lack of adequate staffing in State and Federal agencies limits the enforcement of existing rules and regulations and should be addressed before considering additional or stricter regulations. Management agencies lack information on the impacts of resource use, e.g. recreational fishers do not obtain fishing permits so there is no record of their activities.

Another complication is that 'recreational fishing' is used to describe all non-commercial fishing including occasional and frequent fishers, subsistence-level and 'commercial' fishers. Some of these unlicenced fishers sell their catch, although it is illegal; thus they are probably responsible for a substantial impact on coral reef fish resources. Another problem, which often results from similar capacity needs, is a gap between research and management. Data have not been analysed such that the effectiveness of MPAs cannot be evaluated. Research is often donor driven because of inadequate funding, whereas it should address territory issues and support innovative management. Management plans are needed for all designated Areas of Particular Concern, because at the moment these exist only on paper and are used to support coastal development decisions.

Navassa

The Island is remote and highly susceptible to episodic disturbance or recruitment events. The current information consists of a series of 'snapshots' of reef condition, and cannot be used to draw conclusions about possible trends in reef condition or used to develop management plans. Recent depletion of large fish around the island indicates major information gaps on catch statistics and fishing effort.

Conclusions

Florida

Citizens, stakeholders, elected officials, and resource managers must work together to improve water quality, minimise physical damage to corals and seagrasses, reduce non-point pollution, and raise awareness to introduce a stronger sense of stewardship for coral reef conservation. Immediate action is needed to curtail alarming declines in coral reef condition throughout Florida. Local communities, which are culturally and economically supported by the reefs are working to implement management strategies and focus attention on the need for more reef protection. They aim to control adverse human pressures such as the environmental impacts of fisheries, dredging, vessel anchorages, freshwater management, and nutrient flows into southeastern Florida. Communities in the Florida Keys are continuing to seek solutions to reduce wastewater and stormwater problems, and limit habitat degradation and over-fishing.

Flower Garden Banks National Marine Sanctuary

While long-term monitoring shows that the Banks are virtually pristine, these coral reefs are potentially susceptible to the same decline as other systems. It is therefore crucial that the resources be maintained as standards of coral reef health for the Caribbean, where there is almost universal decline. The reefs of the Sanctuary may contain the parent stock to assist recovery in other areas through the transfer of juvenile fishes, e.g. recent data indicate that the Banks may be major sources of grouper larvae for other reefs, highlighting the benefits of no-take status in protecting biodiversity.

Puerto Rico

Many of the nearshore reefs are degraded from decades of accelerated urban and industrial coastal development, and poor implementation of policies, which are designed to protect them. Scientists and the Government continue to try to understand, protect, and manage the reefs, but the failure of existing regulations and the lack of enforcement continue to undermine these efforts. Unfortunately, full compliance with existing regulations may not be sufficient to reverse the decline in fisheries stocks, but recent legislation may help. The Tres Palmas Marine Reserve in Rincón was designated in 2004. New State fishing regulations and an administrative

order regulating recreational use in 6 coral reef keys within 5 Natural Reserves were all approved, and new coral reef regulations are nearing completion. A strategy to address land-based pollution is being developed.

U.S. Virgin Islands

The importance of MPAs has been recognized and the Buck Island Reef National Monument in St. Croix was expanded in 2003 and the St. Croix East End Marine Park was established. However, a lack of enforcement may undermine their effectiveness. Management plans are still required for some designated Areas of Particular Concern, and existing plans need to be implemented. However, a Nassau grouper spawning population is re-establishing itself and the biomass of spawning red hind at the Marine Conservation District south of St Thomas is increasing. Continued coral reef ecosystem monitoring is recommended to track changes in reef health, biodiversity, and coral disease. Management could be improved with stronger coordination and collaboration among Federal, Territorial, and non-governmental agencies, increased public education and outreach, and enforcement of existing marine protected areas and laws governing resource extraction. An increased research and analytical capacity in management agencies is also needed. Efforts to reduce threats to coral reefs should focus on reducing land-based sources of pollution from coastal development and runoff, the effects of fishing and ship groundings, and improving or maintaining water quality in densely populated areas.

Navassa

Declining coral reef habitat conditions throughout the Caribbean underscore the conservation importance of this National Wildlife Refuge's 290,000 acres of marine habitat in the heart of the Caribbean. Multinational fishing pressure within this largely marine refuge remains unquantified, but it is certainly damaging the coral reefs. Systematic monitoring, including quantitative fishery data, is needed to document ongoing changes. Monitoring should also include catch data of the critically endangered Hawksbill turtles. This will require a regular source of funding for the Navassa National Wildlife Refuge.

The 'island biogeographic theory' predicts that small isolated islands like Navassa will have reduced species diversity in the future. This is clearly born out in the fish populations, as there is not enough habitat variation to contain all the common Caribbean fish groups. Now strong fishing pressures are clearly damaging the Navassa reefs, such that there is a real chance for population crashes because the island is small and subject to high physical disturbance, and the reefs around Navassa are poorly buffered.

100 Years ago: The major pressures on coral reef ecosystems were tropical storms, and cyclone damage was a primary factor in shaping coral reef structure. Anecdotal reports were of flourishing reefs with high coral cover and large populations of fishes. The coral reefs were probably dominated by apex-predators. Subsistence fishing was generally small-scale and was managed by traditional tribal regulations.

In 1994: Coral reefs in close proximity to large human populations showed clear signs of damage from sediment runoff, nutrient pollution, over-fishing, and coastal development. Many fisheries in the region: were experiencing declines in the average size of fish; were under pressure from an increase in fishing effort with no significant increase in landings; and showed that pre-spawning juveniles made up most of the catch. In some cases, the combined impacts of over-fishing and nutrient pollution resulted in a phase shift from coral to algal dominated

systems. Concern was growing about coral bleaching and disease, and coral reef management was becoming stronger.

In 2004: The cumulative impacts of sedimentation, coastal development, commercial and recreational fisheries, land-based pollution, ship groundings, and recreational activities are apparent on many reefs. Warmer temperatures have increased coral and fish vulnerability to diseases; this is further exacerbated by man-made pollutants that nourish bacteria and fungi running off the land into the sea. Many reef ecosystems adjacent to population centres are declining towards fair and poor categories, with recorded decreases in coral cover, fish abundance, and resilience to natural disturbances. However, reefs in isolated areas, like the Flower Garden Banks and Dry Tortugas remain in good to excellent condition.

Predictions for 2014: Improved research and monitoring capacity should translate to informed coastal stewardship decisions that minimize damage to coral reef ecosystems, while maximizing social and economic benefits. Better enforcement of existing fishing, pollution, and MPA regulations should slow the downward trend in reef condition. Management efforts will continue to focus on improving water quality and reducing fishing pressure. Reef conditions should stabilize or slightly improve, but climate change and the associated increases in the incidence and severity of diseases and bleaching may restrict recovery in susceptible areas.

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	WHS	MAB	RAMSAR

EVERGLADES AND DRY TORTUGAS, USA – MAN AND THE BIOSPHERE RESERVE

Everglades National Park is on the southern tip of the Florida Peninsula, bounded by the Gulf of Mexico to the west and the Florida Keys to the south and south-east. The biosphere reserve includes the Dry Tortugas National Park, a group of 7 coral reefs and surrounding shoals, coral reefs and waters in the Florida Keys. The Dry Tortugas is primarily a marine park and Everglades National Park is both terrestrial and marine, containing a vast marine area in Florida Bay. The total area of the biosphere reserve is 636,411 ha and the environment is characterised by saltmarshes, mangrove forests, beach and dune complexes, brackish water estuaries, cypress swamps, and marine systems including coral reefs. The 2 parks were accepted together as a biosphere reserve in 1976 and the Everglades National Park was inscribed on the World Heritage List in 1979, and was designated a Ramsar site in 1987.

The Reserve is under the administration of the US National Park Service and both parks have Strategic Management Plans. The government and conservation organizations work to protect and enhance the marine areas of the biosphere reserve by finding innovative new ways to manage activities in the parks to avoid harm to coral reefs, seagrass beds, sunken archaeological treasures, and marine flora and fauna. Strategies include creating no-take zones where only research is allowed and limiting the traffic of motorized boats.

Ecological Monitoring: The National Oceanic and Atmospheric Administration (NOAA) conducts long-term coral reef monitoring studies in the reserve and other institutions are examining issues such as surface hydrology, water quality, vertebrate ecology and restoration ecology. The monitoring was enhanced when significant areas of the Dry Tortugas were declared no-take zones to conserve dwindling fish stocks. Early results show improving fish stocks in these no-take areas. The baseline data assessing the resources of the Dry Tortugas was instrumental in the designation of different zones and was used in consultation with fishers and other users to gain agreement on reserve boundaries. Now monitoring data are instrumental as performance evaluation measures of the effectiveness of resource management, especially for fish and lobster populations.

Socio-economic Monitoring: NOAA is also conducting socio-assessments of the key stakeholder groups, especially fishers.

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Coral reefs are **30%** of the natural resources.
Ecological Monitoring is **substantial**.
Socio-economic Monitoring is **substantial**.

MAB

VIRGIN ISLANDS, USA – MAN AND THE BIOSPHERE RESERVE

The U.S. Virgin Islands (USVI) is a group of 3 islands, St. Thomas, St. John, and St. Croix, in the Eastern Caribbean. The Virgin Islands National Park includes 3 individual areas, whereas the Biosphere Reserve, established in 1976, incorporates the entire area, including rocky shores, coral and sand beaches, numerous bays, fringing coral reefs, canyons of coral ledges, coral gardens, mangrove swamps and natural salt ponds. About 900,000 visitors per year visit the area for diving and snorkeling, boating, fishing, and hiking. The Cruz Bay Visitor Centre provides orientation talks, guided snorkel trips and cultural demonstrations. The islands now face serious environmental problems from increasing tourism and residential development, including destruction of wildlife habitats, reef destruction, commercial fishing activities, land erosion and related sedimentation on coral reefs. The aim of the biosphere reserve is to protect natural systems while enhancing the quality of life for the local community.

In 1999 a marine conservation district was declared southwest of St. Thomas, as a cooperative effort amongst fishers, divers and the local government. The area is closed to all fishing and anchoring, and represents an important step towards cooperative fisheries management. The effects of hurricanes and coral disease have seriously damaged the coral reefs in the USVI with coral cover dropping from 85% in 1976 in the Buck Island special reserve to 5% in 1988 following storms and disease. Damage to reefs is also comes from tourism, and especially fishing, with significant harm being caused by anchoring and ship groundings. Within the last 15 to 20 years, the amount of live coral cover has declined, while the abundance of algae has increased. Overfishing is also widespread throughout the islands.

Ecological Monitoring: U.S. Park Service and U.S. Geological Service initiated a long-term reef monitoring program around St. John and Buck Island in 1989. In cooperation with other local institutions and agencies, the Virgin Islands Resource Management Co-operative (VIRMC) has completed a variety of studies within the reserve including characterization of local fisheries, analysis of the cultural role of fishing, mapping of nearshore marine communities, as well as descriptions of the bays.

Socio-economic Monitoring: This is not as detailed as the ecological monitoring; however there are plans to implement more substantial monitoring.

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Coral reefs are **60%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **occasional.**

17. Status of Coral Reefs in the Northern Caribbean and Western Atlantic Node of the GCRMN

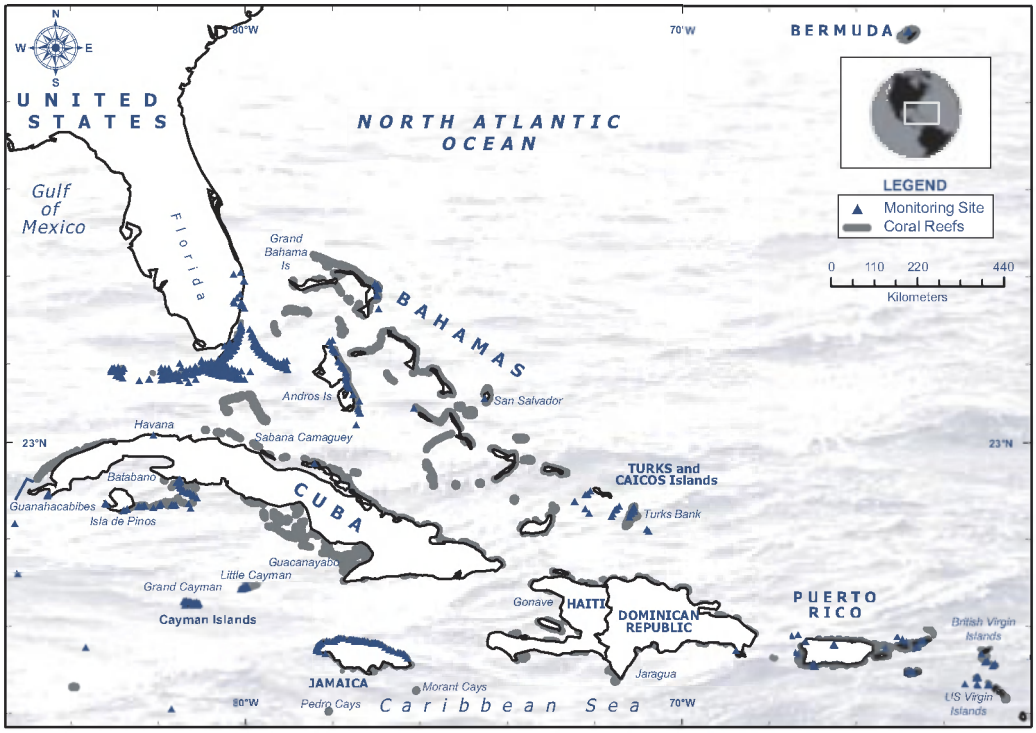
Loureene Jones, George Warner, Dulcie Linton, Pedro Alcolado, Rodolfo Claro-madruga, Wesley Clerveaux, Reynaldo Estrada, Tatum Fisher, Kathy Lockhart, Marsha Pardee, Joanna Pitt, Chris Schelten, and Rob Wild

Abstract

The percentage of coral cover over the Northern Caribbean remains generally low in comparison to pre-1960s status, with an average of approximately 20%. Some sites in most countries of the node have high coral cover of 30-50%, whereas other sites are much lower, 3-10%. There has been little change in Bermuda since 2002, while Jamaica reports modest improvement and Cayman shows some decline since 1997. In other countries there is no evidence of either a decline or improvement since 2002. Data were obtained from Haiti for the first time. The causes of coral mortality in the region include disease (Bahamas, Cuba), bleaching (Cayman), pollution (near Havana, Cuba) and overgrowth by algae (Cuba). All countries continue to report significant threats to coral reefs including: local impacts such as over-fishing and land-based sources of pollution; and regional or global factors such as coral bleaching and disease. Over-fishing is considered to be the major cause of the high cover of macro-algae on these reefs because of the removal of herbivorous fishes such as parrotfish and doctorfish. Fishing intensity, however, varies considerably over the region, with the lowest in Bermuda and Cayman, and highest in Jamaica and Haiti. National capacity to implement and enforce fisheries regulations appears inversely proportional to fishing intensity. Most countries have adequate legislation (with significant exceptions) but enforcement is inadequate or lacking. Many MPAs lack adequate management. Although progress in coastal management is being made in most countries, poor financial resources often impede the implementation of laws and policies.

100 Years ago: Healthy reefs were dominated in shallow water by species of *Acropora*. Corals were the dominant organisms and provided a three-dimensional habitat with numerous hiding places. Plentiful herbivorous fishes and the sea urchin, *Diadema* controlled the fleshy algae. Predatory reef fishes such as snappers and groupers were numerous.

In 1994: Reefs were variable across the region with *Acropora* spp. often greatly reduced. Dominance had shifted away from corals to macro-algae and *Diadema* were scarce. Several new coral diseases had appeared, coral bleaching had occurred and land based pollution was



Map courtesy of The WorldFish Center

evident in many places. Over-fishing was occurring in some countries, with herbivorous fishes often targeted.

In 2004: Reefs continue to lack abundant *Acropora* coral cover, and diseases, bleaching and pollution are still occurring. Patchy recovery of *Diadema* is occurring but algae still dominate many reefs. Fishing is still intense; some grouper populations are virtually extinct, and in some countries few large fishes of any species can be found.

Predictions for 2014: Corals will not recover their dominance on most reefs due to diseases, bleaching and land-based pollution. There will be some recovery where integrated coastal management is implemented. Populations of fast-growing fish will recover in MPAs with effective no-take zones, but groupers will still be scarce.

Introduction

Reports of the state of Caribbean reefs from the 1940s to the 1970s suggest a period of relative stability, with coral cover generally above 50% and with the shallow reefs dominated by two species of *Acropora* – *A. palmata* around the reef crest and *A. cervicornis* on the shallow fore-reef slopes. Both species are abundant in coral sediments and as fossils, suggesting that they had dominated the reefs for a considerable length of time. Reef algae were mainly in the form of 'turfs' and calcareous algae like *Halimeda* spp. and encrusting red algae; the sea urchin *Diadema antillarum* was an important grazer. While some countries showed signs of over-fishing, groupers and large parrotfish could be found on most reefs.

Caribbean reefs suffered significant decline during the 1980s due to a range of damaging stresses. These included apparently new coral diseases (especially the rapidly lethal white-band disease of the *Acropora* spp.), mass mortality of *Diadema* (1983-4), which reduced grazing pressure on the benthic algae, and over-fishing, especially of herbivorous fishes. The massive reduction in grazing pressure on the macro-algae meant that they were able to proliferate and overgrow reefs. Macro-algae (fleshy and calcareous) became the most important space occupiers on reefs, reaching a cover of 50 to 80%. Sporadic coral bleaching events from the 1980s onwards have caused additional stress, which may have led to increases in coral mortality. A further decline in the health of the coral reefs was due to nutrient and sediment pollution from land-based sources and destruction of habitats due to increasing human populations and economic pressures on the coastal zone. This suite of negative factors has meant that Caribbean reefs have often failed to recover significantly after being damaged by hurricanes.

These degraded reefs are unable to provide important services such as fisheries, tourism and coastal protection. Subsistence fishing is still the mainstay of the low-income coastal populations. The growth in the tourism industry has provided some alternative employment opportunities, but this has not been enough to reduce fishing pressure in the face of rapid population growth. The populations in many countries increased by more than 50% between 1980 and 2000. Tourism also has unwanted environmental and social impacts, such as the depletion of natural resources, increased pollution levels, and physical damage due to unwise coastal developments and urban migration into areas around tourist resorts in the search for employment.

These Caribbean countries (Bahamas, Bermuda, Cayman Islands, Cuba, Dominican Republic, Haiti, Jamaica, Turks and Caicos) all face the challenge of generating foreign exchange and increasing economic activity, while maintaining the integrity of their ecosystems (wetlands, forests, marine reserves). Carefully considered policies on the use of these resources is required. Tourism is a major Caribbean industry, which is expected to expand, but it depends largely on the health of the coasts and particularly coral reefs. Therefore conservation and any necessary restoration of the reefs should be a high priority in policy development in the region. Many of these countries will need assistance to achieve these goals.

This report follows earlier status reports and we have attempted to give updates and new information rather than to repeat already published material. Where no new information was received from a particular country, no report is given.

Geographic Reef Coverage and Extent

Bahamas

The Bahamas with a total surface area of 13,880 km^2, comprise 13 major islands and 700 smaller islands and cays on 2 large, shallow banks. The islands are aligned northwest to southeast covering more than 1,400 km from near Florida to southeast Cuba. The area covered is approximately the distance between Puerto Rico and Trinidad and Tobago. Coral reefs fringe most of the north and east windward coasts and bank edges.

Bermuda

This is an isolated island chain and the most northerly coral reef system in the Atlantic. The islands and reefs surround a central shallow lagoon, which contains a complex of shallow, highly diverse patch reefs interspersed with seagrass beds and isolated pockets of mangroves.

Cayman Islands
These islands on the Cayman Ridge extend from southeast Cuba to the Bay of Honduras and are flanked by the 6,000 m deep Cayman Trench to the south. Grand Cayman is the largest island, followed by Little Cayman and Cayman Brac. These are low-lying limestone platforms with narrow island shelves that support prolific coral reefs.

Cuba
Reefs surround virtually the entire border of the Cuban marine shelf (>98% = approx. 3200 km) and extend inshore across broad areas. Reef crests in Cuba tend to be more abundant at the edge of the 4 broad sections of the Cuban shelf: the Golfo de Guanahacabibes (Northwest Cuba); Archipiélago Sabana-Camagüey (central north); Golfo de Ana María-Guacanayabo (southeast); and Golfo de Batabanó (southwest). The narrow shelf of the Northeast also has well developed reef crests. Inshore patch reefs are dispersed on the northwest (Golfo of Guanahacabibes), southwest (Golfo de Batabanó) and southeast (Golfo de Ana María-Guacanayabo) where there are unique reefs on muddy substrates. There are 2 barrier reefs: Archipiélago Los Colorados (NW Cuba); and Archipiélago Jardines de la Reina.

Dominican Republic
The land area of 48,484 km^2 on the east end of Hispañiola has a coastline of 1,389 km, with 377 km (27%) of mangroves, and 166 km (11%) of coral reefs. The main coastal features are emerged reef terraces and cliffs.

Haiti
The western third of the island of Hispaniola is Haiti with 1,535 km of coastline and a narrow continental shelf totaling approximately 5,000 km^2. Well-developed coral reefs fringe long stretches of coastline, and there are offshore barrier and atoll-like reefs, and 'walls' of coral along the shelf edge. The highly productive and spectacular reefs are largely unexplored.

Jamaica
The island is in the centre of the Caribbean and the third largest island after Cuba and Hispaniola. The marine area of Jamaica is 251,000 km^2 with a reef area of 1,240 km^2. Well-developed fringing reefs occur along most of the north and east coasts, while patchy fringing reefs grow sporadically on the broader shelf of the south coast. Reefs and corals also grow on the neighbouring banks of the Pedro Cays, 70 km to the south, and the Morant Cays, 50 km to the southwest.

Turks and Caicos Islands (TCI)
These consist of low-lying limestone islands that are an extension of the southeastern Bahamas Platform. The banks of the TCI are fringed by narrow, discontinuous, shelf-edge reefs dominated by corals, algae and gorgonians growing on hard substrate. There are scattered patch reefs, sparse seagrass beds, algal plains, coral rubble and bare sand on the centre of the bank. The land area is 492 km^2 while the marine area is 6,564 km^2, with 25% consisting of reefs (1,736 km^2). Water depth ranges from a few centimetres on the coasts to 20 – 40 m at the reef drop-off.

Status of the Coral Reefs

Bahamas
AGRRA surveys off Andros in 1997-8 found mean hard coral cover of 36%, while off Abaco in 1999 it was 14%. These data are probably more typical of the Bahamas than the CARICOMP site of Fernandez Bay Reef, San Salvador which showed a decline in coral cover from 9.6%

in 1994 to 4.2% in 2001, then a small increase to 4.7% in 2003. Coral disease was probably the cause of the decline. The Bahamas have been hit hard by the loss of *Diadema*, as there is widespread overgrowth by algae as well as frequent disease outbreaks. Air pollution drifting from the Southeastern USA may be contributing increased nutrients.

Bermuda

The reefs remain relatively healthy and stable with no apparent change over the past 10 years. Coral cover has remained stable at around 20% at the rim reef sites since 1993. Cover in other reef zones may be higher (45-50% on terrace reefs) or lower (10-15% on lagoon patch reefs) and is dependent on depth, wave action and turbidity. The CARICOMP site shows a small increase from 18% in 2001 to 21% cover in 2002.

Bermuda retains healthy herbivorous fish populations, which prevent major algal overgrowth, despite the *Diadema* die-off. The island has also escaped most serious coral bleaching impacts as temperatures generally return quickly to normal allowing most species, except *Millepora*, to recover. Widespread bleaching in 2003 affected many species and reduced photosynthesis and calcification. The fire coral, *Millepora alcicornis*, showed high mortality, but other mortality was low and corals recovered when Hurricane Fabian brought cooler seawater.

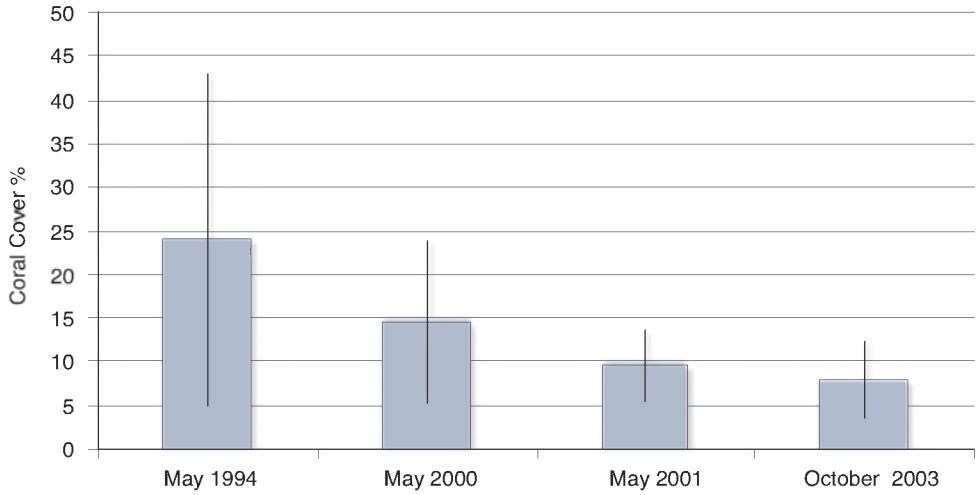
Cayman Islands

Mean coral cover on Grand Cayman was 25.7% in 1997, but dropped to 15.4% in 2001. The decline is probably a result of past bleaching events but coral diseases as well as algal overgrowth may also have been important factors. Pollution by nutrients leaching from resorts and residential areas may be stimulating algal overgrowth in the coastal waters near the more populated parts of the islands.

Cuba

The coral reefs off Havana Bay have been damaged by organic and chemical pollution delivered by the Almendares and Quibú rivers, and the underwater sewage out-fall east of the Havana Bay entrance. The nutrient enrichment from this pollution favours fleshy and filamentous algae on the reefs near Havana Bay, Río Quibú, Playa El Chivo and near the entrance of Mariel Bay (north-west end of Havana Province). The diversity of corals, sponges and gorgonians has decreased to very low levels on the reefs close to Havana Bay, with the dominant coral being *Siderastraea radians*. The remaining species and low species diversity are indicators of organic pollution. Fish diversity and abundance has dropped as a consequence of reduced shelter and available food. This situation is made worse by intense pressure from subsistence and recreational fishers. A slight recovery was observed recently due to management by the Integrated Coastal Management Authority, and reduced port activitiy due to the economic decline.

Extensive AGRRA assessments around Cuba from 1997 to 2003 found that the main causes of coral reef decline are diseases and the *Diadema antillarum* die-off. Cuban coral reefs in the Archipiélago Sabana-Camagüey have suffered a gradual decline from disease and competition with algae, but the rate has slowed since 1999, with little recent mortality. There has been no repeat of the massive mortality of *Acropora palmata* of 1987 to1992, and there is considerable recovery all around Cuba. White plague disease killed the coral *Dichocoenia stokesi* at the Archipiélago Sabana-Camagüey and Havana City coast in the spring of 2001. Average live coral cover on Cuban reef crests and shallow reefs is 21% (median = 19%, range = 3 - 71% at 90 AGRRA sites) and 18% on fore-reefs (median = 17%, range = 3 - 40% at 108 AGRRA sites).



There has been a dramatic decline in coral cover on the coral reefs of Archipiélago Sabana-Camagüey, north central Cuba over the last 10 years due to coral disease, bleaching and algal overgrowth.

Dominican Republic

CARICOMP data show that coral cover increased from 8.2% in 2000 to 11.5% in 2001. Reef Check surveys in 2004 at Bayahibe showed mean coral cover of 19.4%.

Haiti

The first data from Western Haiti were collected in 2003 during Reef Check surveys at sites 60 km northwest of Port-au-Prince. The reefs appeared to be in reasonable condition, especially at shallower sites, with a mean overall percentage hard coral cover of 21.8%. Some sites had relatively high algal cover and *Diadema* densities were generally low, the highest (0.12 per m^2) being at 5m depth at the island sites. Coral cover ranged from approximately 7% to 50%, with the highest being 47% at shallow (4 m) and 52% at the deeper (6 m) sites of Bo wout Montrois. Another near shore site, Trou Forban, had coral cover of 21.2% and 15.2% at the shallow and deep sites respectively, with high algal cover (26.3% at shallow and 51.8% at deep sites). Three Les Arcadins offshore island sites were surveyed: Ti' Teal had coral cover of 28.1% in the shallow and 27.6% in the deep; Ilé Fa had 25.1% (shallow) and 6.0% (deep) with high algal cover (32.8% shallow, 74% deep). Large mats of the alga *Lobophora variegata* occurred at the deeper site. Ilé Sud was the most affected of the Les Arcadins, but only one survey was completed at 4 m, with 12.8% coral cover and 39.6% algal cover. Coral disease and bleaching were relatively scarce, even though elevated seawater temperatures of 30°C were recorded.

Jamaica

The estimated live hard coral cover of more than 50% in the 1970s had declined to less than 5% in some places by the early 1990s. However, cover had increased to 10 to 15% at 5-15m depths at several sites near Discovery Bay by the late 1990s, and reached a mean of 12.5% in 2000 at 60 AGRRA sites at 10m depth on the north coast. Increases in coral cover coincided with increases in *Diadema* abundance near Discovery Bay and elsewhere, but the recovery of *Diadema* is patchy and restricted to shallow water.

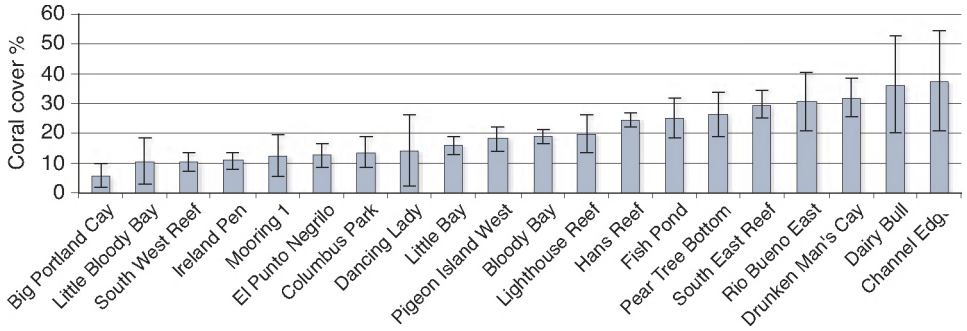
CORAL REEF MONITORING IN HAITI

The first coordinated monitoring and training exercise in Haiti was conducted at Les Arcadins in September 2003- just 12 months before the massive Hurricane Jeanne swept over the island. These surveys provided a brief snapshot over 4 days, but may prove invaluable as a baseline of data before a major disturbance. The surveys were part of a program of the UNEP Caribbean Environment Program and the International Coral Reef Action Network to improve coral reef monitoring in countries of the Northern Caribbean node of the GCRMN. A Jamaican team from the Jamaica Coral Reef Monitoring Network (JCRMN) led by the Centre for Marine Sciences, University of the West Indies, visited Haiti and was hosted by the only NGO in Haiti concerned about the reefs, the Foundation pour la Protection de la Biodiversite Marine (FoProBIM). They found that the reefs were in reasonably good condition, with the exception of some sites that were covered in algae, suggesting nutrient pollution. The team also conducted training in Reef Check methods at Les Arcadins and along the nearby coastline. Reefs in the western end of Haiti and on small offshore islands had coral cover ranging from 7 to 50%, with the Bo wout Montrouis being the best with 47% at 4 m depth, and 52% at 6 m. There is evidence that the populations of the sea urchin *Diadema antillarum* may be recovering, with 14.5 per 100 sq m at Ilé Fa and 9 per 100 sq m at Ti' Teal. Intensive over-fishing was indicated by the scarcity of snappers, groupers and large parrotfish at all sites. The poor economic and security situation in Haiti makes it unlikely that there will be regular coral reef monitoring without considerable assistance. There are very few trained divers in the country and equipment like scuba dive gear and air compressors are not readily available. Moreover there is no tertiary institution in Haiti that focuses on marine science education, therefore there is no pool of marine scientists to maintain a program - even if funding could be found. It may be some time before the effects of Hurricane Jeanne and the massive amounts of sediment washed off the deforested hillsides are known on the coral reefs of Haiti. From Dulcie Linton, dulc2001@yahoo.com

Since 2002, Reef Check has established monitoring sites at several locations around the island including Negril, Westmoreland; Boscobel, St. Mary; Drunkenman's Cay, Port Royal; and on several cays of the Portland Bight Protected Area. An overall improvement in coral cover has been observed; e.g. at the Channel Edge Reef in Boscobel, on the north coast coral cover was 34% at 3 m and 42% at 10 m. Coral cover on the south coast ranged from 5 – 33% in the Portland Bight Protected Area and up to 46% at Drunkenman's Cay near Port Royal.

Turks and Caicos Islands

Reef condition across the Islands is quite similar, although there are variations in human pressures, with the most evident being fishing, boat grounding, diving/snorkeling damage and sediments and nutrient outflow from coastal development. Live coral cover on Providenciales ranges from 6 – 36%, with extremely low macro-algal cover. The near shore patch reefs have many isolated coral heads of *Montastrea* sp. and *Diploria* sp. and a high cover of gorgonians. Similarly the dominant corals at South Caicos include *Montastrea* sp., *Siderastrea* sp. and *Porites* sp., and macroalgal cover was generally higher than Providenciales. This is probably related to greater fishing activity in South Caicos and localised eutrophication. Grand Turk



These data show a wide variation in the amount of live coral cover on reefs around Jamaica. These baseline data were gathered during Reef Check monitoring by the Jamaica Coral Reef Monitoring Network.

reefs are in good condition, with average coral cover of 24% (range17 - 33%) and high coral species diversity, however, the coral cover at 5 major dive sites has decreased from 32.4% in 1995 to 21.9% now. The dominant coral species are *Montastrea annularis*, *M. cavernosa*, *Siderastrea siderea* and *Agaricia agaricites,* with many gorgonians and relatively low algal cover (1- 20%).

Status of Coral Reef Fisheries

Bahamas

Over-fishing, particularly of spawning aggregations, continues to be a problem throughout the Bahamas. Groupers and snappers were rare on San Salvador reefs and wrasses and surgeonfishes dominated. However, AGRRA data showed that large grouper species were present off Andros Island. There has been major recovery of Queen conch populations in areas protected from fishing, demonstrating the value of MPAs in protecting breeding stocks.

Bermuda

Fish populations showed clear effects of over-fishing when the preferred target species were rare in fish trap catches. Trap fishing was banned in 1990 and populations of critical herbivores, such as parrotfish increased. However, the ban shifted many commercial fishermen into the pelagic fishery. Now populations of smaller reef predators are increasing, as is the larger black grouper, *Mycteroperca bonaci*. The absence of recovery of other larger predators may be related to diminished brood stock and a destruction of coastal nursery habitats (seagrasses and especially mangroves) since 1900. Destructive fishing practices are not evident in Bermuda, and subsistence fishing was not a significant source of fish mortality prior to 1984, when fish traps were restricted to commercial fishers.

Cayman Islands

The reefs continue to support relatively diverse and abundant fish assemblages. Previous conservation regulations did not prevent over-fishing of high-value species such as conch, lobster and grouper, and there was little protection of grouper spawning grounds and turtle nesting sites from coastal development. The relevant regulations have been recently amended.

Cuba

Better coral reef fish populations have been reported from Cuba than from other Caribbean islands such as Martinique, Guadeloupe and Jamaica. There is higher biomass, species richness and average size. Most of the fishing damage has been caused by large-scale and low-selective fishing gear (e.g. set nets and trawls), and heavy fishing on spawning aggregations. Predator and herbivore fishes, and invertebrates such as lobster, conch and octopus all show some declines due to commercial, subsistence and recreational over-fishing and large fish are quite scarce. Fishing pressure is moving from target coral reef fish (lane snappers, groupers, etc.), to other species such as rays (*Dasyatis* sp.), gray snappers (*L. griseus*), jacks (Carangidae), and grunts (Haemulidae). Shark fishing has also decreased because stocks have been reduced due to a long period of sustained over-fishing. Small-scale collection for aquaria is officially supervised. Commercial catches of the Nassau grouper (*Epinephelus striatus*) have declined over the last 20-30 years, with much of the annual catch taken from spawning aggregations, resulting in rapid stock depletion. Moreover urban, industrial and tourist developments have reduced suitable habitats for juveniles and adults.

Haiti

Densities of indicator fishes were low ranging from 0.5 to 5 per 100 m^2 (at all Reef Check sites). There were higher fish counts at Les Arcadins: 5 per 100m^2 at Ilé Fa; 3.6 per 100 m^2 at Ilé Sud; and 1 per 100m^2 at Ti' Teal. The more easily accessible near shore sites of Trou Forban and Bo wout Montrois had fish counts of 0.5 and 0.7 per 100m^2 respectively. Grunts were observed more often than snappers; few large parrotfish and no large groupers were seen. There were many small fishing boats at all sites, indicating very high fishing pressure.

Jamaica

Intense over-fishing of reef fish continues around Jamaica with small-mesh traps, nets, lines and spearguns used in an unregulated and unrecorded fishery. Only the queen conch and lobster fisheries are regulated. There are low population densities of the Reef Check indicator groups and these are mostly small and immature fish. Very few snappers, groupers or large parrotfish are evident. The coastal waters, particularly the narrow northern shelf, can only support subsistence fishers, whereas the only catches of medium and large sized fish are made on the offshore banks. The most commercially important fishery is queen conch on the offshore Pedro Bank, but this fishery has declined and is plagued by poaching from foreign fishing vessels. The Fisheries Division of the Ministry of Agriculture is developing a new Fisheries Policy and Fisheries Act for Jamaica, to progressively limit access to the reef fish fishery. It will also stipulate minimum mesh sizes for traps and nets.

Turks and Caicos Islands

These reefs support active fisheries for export and the local market, with the main commercial species being the queen conch (*Strombus gigas*) and the spiny lobster (*Panulirus argus*). Most full-time fishermen use hand lines and few are involved in trap fishing. The main target species include grouper, hogfish and snappers, whereas herbivores such as parrotfish and surgeonfish are usually thrown back. Most reef fish are sold in local markets. Fishing pressure is relatively low and reef fish communities appear to be relatively intact on both the Turks and Caicos Banks. In 1999, AGRRA identified 46 reef fish, including 7 grouper and 7 parrotfish species. A potential reef fish yield of 70 – 140 kg per km^2 has been estimated on TCI Banks, and AGGRA report that the average fish density ranges from less than 2 to more than 14 individual fish per100 m^2 for selected families (Pomacanthidae, Cheatodontidae, Balistidae, Acanthuridae, Haemulidae, Lutjanidae, Serranidae and Scaridae). Fishermen report that this figure has probably not changed in the past 5 years.

REEFS AT RISK IN THE CARIBBEAN 2004

The Reefs at Risk in the Caribbean project by the World Resources Institute provides decision-makers and the public with information and tools to manage coastal habitats more effectively. These reefs are vital natural resources providing fish and invertebrate food, and protecting shorelines from storms. Most importantly they support the largest economic sector of the region -tourism. The project compiles, integrates, and disseminates critical information on these precious resources over the entire Caribbean region to assist regional and national organizations set priorities for conservation and natural resource management. The first task was to map 26,000 square kilometres of coral reefs and assess the extent of human activities that stress and damage reefs, and determine where reef degradation is expected to occur, or has occurred. The process involved forming partnerships with over 20 organizations and many scientists working in the region under the ICRAN and the UNEP Caribbean Environment Program.

Reefs at Risk (R@R) compiled data from many different sources with an emphasis on indicators of coral reef condition. Using a geographic information system to help arrange the information and identify problems, the threats were divided into 4 broad categories: coastal development; watershed-based sediment and pollution; marine-based pollution and damage; and over-fishing. These threats were further categorised into levels of high, medium, or low, and calibrated against available data and observed impacts on reefs. The results from the 4 indicators are combined to form a single, integrated index of human pressure on Caribbean reefs. The key findings from the Caribbean-wide analysis are:

- The R@R Threat Index indicates that about two thirds (64%) of Caribbean coral reefs are threatened by human activities, with the highest threats in the Eastern Caribbean, most of the Southern Caribbean, Greater Antilles, Florida Keys, Yucatan, and the near-shore parts of the Mesoamerican Barrier Reef in the Southwest Caribbean. In these areas, degradation of coral reefs with reduced live coral cover, increased algal cover, or reduced species diversity has already occurred, or is likely to occur within the next 5 to 10 years. About one third (33%) of Caribbean coral reefs are threatened by coastal development, especially along the coastlines of most of the Lesser and Greater Antilles, the Bay Islands in Honduras, along the Florida Keys, the Yucatan, and the Southern Caribbean.
- Sediments and pollution from land-based sources threaten over one-third (35%) of Caribbean coral reefs. The major areas at risk from increased delivery of sediments and pollution from agricultural lands were assessed in more than 3,000 watersheds. Areas with a large proportion of reefs threatened by these sediments and pollution were off Jamaica, Hispaniola, Puerto Rico, the high islands of the Lesser Antilles, Belize, Costa Rica, and Panama. Marine-based pollution and direct damage from ships threaten 15% of coral reefs across the region, with the highest threats in many of the Eastern Caribbean islands, Bermuda, Puerto Rico, Jamaica, Panama, Aruba, and the Netherlands Antilles.
- Over-fishing threatens over 60% of Caribbean coral reefs. Fishing above sustainable levels affects coral reefs by altering the ecological balance of the reef by removing breeding stock. The threat was high on almost all narrow coastal shelves close to human population centres.

- Diseases and rising sea temperatures threaten to damage coral reefs across the Caribbean region. Diseases and warming sea surface temperatures present further and growing region-wide threats to Caribbean coral reefs, although this has not been assessed in detail in this R@R project.
- Ineffective management of protected areas further threatens Caribbean coral reefs. With the growth of tourism, fisheries, and other development in coral reef areas, MPAs should be important tools to conserve coral reefs. However, the level of protection in the 285 declared MPAs varies considerably across the Caribbean. Only 6% of MPAs are managed effectively, and 13% have partially effective management. Only 20% of coral reefs are located inside MPAs, and only 4% of reefs are in effectively-managed MPAs.
- The coastal communities and national economies of the Caribbean region are poised to sustain substantial economic losses if current trends in coral reef degradation continue. The valuable goods and services that coral reefs provide local and national economies are threatened. Coral reef degradation will lead to significant economic losses, particularly in the coastal areas of developing countries, through loss of fishing livelihoods, malnutrition due to lack of protein, loss of tourism revenues, and increased coastal erosion. The R@R analysis indicates that Caribbean coral reefs provided an annual net economic value of US$3,100 million to $4,600 million from fisheries, dive tourism, and shoreline protection services in 2000:
- Coral reef-associated fisheries provide net annual revenues of US$310 million. Coral reef degradation could reduce these annual revenues by an estimated 30-45%, or US$95 million to $140 million per year by 2015;
- Net benefits from dive tourism were US$2,100 million per year in 2000. Coral reef degradation could result in reduced net benefits from dive tourism of US$100 million to $300 million by 2015;
- The value of shoreline protection services provided by Caribbean coral reefs is estimated at US$700-$2,200 million per year. Coral degradation and death within the next 50 years could result in losses of US$140-$420 million annually.

Conclusions and Recommendations: Actions are required at local, national and international scales to: implement better management practices; make fisheries more sustainable and improve yields by protecting breeding stocks; protect reefs from direct damage; and integrate conflicting approaches to management in the watersheds and adjacent waters around coral reefs. A wider involvement of the public and stakeholders in the management process is essential as is an improved understanding of the importance of coral reefs - especially the economic value of coastal ecosystems. Understanding the links between human activities and changes in coral reefs is critical to implement the necessary changes in management, and strengthen political will and community support for these changes. From Lauretta Burke *(lauretta@wri.org)*, Jon Maidens *(jmaidens@wri.org)* World Resources Institute, Washington, DC 20002; details on www.reefsatrisk.wri.org

Anthropogenic Threats to Coral Reef Biodiversity

Bahamas

Dredging for marinas and canals is poorly regulated and poses a significant problem in the Bahamas. Existing regulations are enforced by the *Town Planning Act, 1961* because permission for the development of land is required, and harbour dredging requires permits from the Ministry of Transport. Proposals for gas pipelines crossing the Straits of Florida suggest the possibility for future dredging activities.

Bermuda

The most significant impacts on the reefs were prior to the 1980s, e.g. there were 13 groundings from 1940 to 1984, with 4 of these destroying significant reef areas. Ship groundings were eliminated when a 12-mile shipping exclusion zone was introduced for the northern platform. The most significant impact on Bermuda's reefs was the dredge/fill operation in 1942 to create a military airport, which destroyed large areas of seagrasses and mangroves. Bermuda is the third most densely populated place on earth (64,500 people on 56 km^2) with annual visitor numbers exceeding 8 times the resident population. These large numbers of people together with those on cruise ships generate the major pollution threat to the reefs. Household waste is incinerated with the resulting ash being disposed of in an inner lagoon; another long-term point source of pollution. There is limited sewage treatment and most buildings have single septic tanks which discharge through the porous coral rock. Town sewage is discharged through submarine outfalls, which are often close to the reefs. Antifouling paint on the 6,500 registered vessels poses an additional threat to coral reef animals.

Cayman Islands

Land-based sources of pollution may be enhancing coral decline through increased resident populations and increased tourism. Both of these result in increased sewage and wastes as well as additional development. Port development for cruise ships, which currently anchor in the coastal zone, will risk sediment deposition on nearby reefs.

Cuba

The main human activities that damage Cuban coral reefs are: land-based organic pollution and sedimentation; coral damage from fishing and development; coral disease; and fish stock reduction from commercial, subsistence and recreational fishing of key predators and herbivore fishes, which result in algal proliferation. These have exacerbated the effects of the *Diadema* sea urchin die-off in 1983, coral bleaching due to increased temperatures during El Niño events, several pathogenic coral diseases and a probable slow nutrification process of oceanic waters in the Caribbean and the Gulf of Mexico. These regional/global factors are probably the main causes of coral reef decline in Cuba. About half of the Cuban shelf edge (54%) is separated from the mainland by broad areas of shallow water and groups of coral islands that prevent local anthropogenic influences from reaching the reefs. Moreover, much of the mainland coast is only slightly urbanised or industrialised, however, watersheds have been extensively deforested resulting in increased sediment runoff to the sea. Thus extreme pollution only affects coral reefs at a few locations, while some degree of sedimentation seems to be more common. The sedimentation from deforestation affects approximately 20% of the reefs fringing the Cuban Archipelago, especially where the marine shelf is narrow and nearby watersheds are mountainous. Large sediment plumes occur during heavy rains on the east of Havana City and east of the entrance to Cienfuegos Bay.

Haiti
The coastal resources are heavily exploited and inadequately managed. Over-fishing, urban and domestic pollution and sediment washed from deforested land during heavy rains are the main impacts (recently spectacularly evident during Hurricane Jeanne). The effects of anchor damage, trash and destructive fishing practices in 2003 were generally low.

Jamaica
In addition to over-fishing, Jamaican reefs are stressed by sedimentation from soil erosion and coastal developments including road building, nutrient loading from agricultural run-off, industrial and domestic effluent and improperly treated sewage. Damage to coral reefs from development activities has been both direct and indirect. Mangroves have been removed for housing, hotels and roads, while seagrass beds and coral reefs have been removed to widen shipping lanes and improve recreational swimming.

Turks and Caicos Islands
These reefs are threatened by human activities, including destructive fishing practices, mechanical damage to corals from marine vessels, sedimentation from coastal development and various forms of pollution. The use of noxious substances such as household bleach and liquid detergent to drive lobsters from their caves has caused extensive damage to the reefs. The Fisheries Division of the Department of Environment and Coastal Resources recently increased their enforcement capabilities in an effort to curtail such illegal fishing. 'Ghost fishing', spear fishing, dropping fish traps on reefs, and fishers damaging coral while free diving, are other fisheries-related issues of concern.

Potential Climate Change Impacts and Responses
Many of the low-lying island states are highly vulnerable to climate change and the associated sea-level rise. This is particularly true for the Bahamas as much of the land area rarely exceeds 3 to 4 metres above the present mean sea level. Hurricane Ivan (2004) drove storm surges and waves right across Grand Cayman. Coastal areas of high islands are also susceptible to flooding associated with the combination of sea level rise, heavy rains and storm surge. Some models of climate change predict more frequent and more intense hurricanes in the Caribbean region. Concurrent weakening of protective coral reefs increases the threat of damage to coastal communities from sea level rise and extreme weather events.

Elevated seawater temperatures can cause coral bleaching leading to impaired reproductive function and sometimes mortality. The reefs of the Cayman Islands have been most affected by coral mortality from bleaching, with coral bleaching also affecting the south coast of Jamaica in December 2003, with low mortality. Bermuda also experienced coral bleaching in 2003, with minimal mortality.

Marine Protected Areas (MPAs) and Management Capacity

Bahamas
Many of the existing MPAs have no staff, so there is often some poaching. However, there are reports that local fishers assist in the protection of MPAs since they understand the benefits of protecting fish stocks. Several new MPAs have been proposed for Andros and at least two are in the process of being implemented.

Bermuda
In addition to the MPAs reported in 2002, 29 new small no-take MPAs have been designated -primarily to protect the reefs from anchor damage and prevent conflicts between tourism operators and fishermen. Seasonal closures of grouper spawning grounds are particularly important. The main spawning aggregation sites have been protected since the 1970s, and awareness-raising activities with the fishing communities are focussed on ensuring that any new aggregations discovered are protected. Juvenile fishes of the common species are recruiting well, but juveniles of depleted species are still rare. The no-take MPAs have not made a significant contribution to the enhancement of fish stocks. Antifouling paints with Igarol as the active ingredient were banned after it was shown that the compound decreased photosynthesis by the algal symbionts of corals.

Cayman Islands
The area from mean low water to 30 m depth on Grand Cayman is closed to all fishing. This regulation appears to be respected by both locals and visitors.

Cuba
There were virtually no MPAs in Cuba in 2000. By 2004 there were 30 officially-declared MPAs, which cover 198,934 ha or 3.5% of the Cuban shelf. These are part of a National System of Protected Areas planned to cover 22% of the marine shelf. The 4 reef areas of the shelf have significant, but as yet, not totally effective management. Agreements are being developed between the fishery, conservation and tourism sectors to convert diving sites to 'no-take areas'. Illegal fishing is poorly controlled but may be decreasing. The effectively-managed National Park of the Archipiélago Jardines de la Reina now has the best coral reef fish communities of Cuba, with greater fish biomass, sizes and diversity. More than one third (1100 km long; 198 sites) of coral reefs bordering the Cuban shelf were assessed by AGRRA between 1999 and 2003, with repeat assessment at Archipiélago Sabana-Camagüey. Cuban CARICOMP reef sites have not been monitored since 1997 because of critical logistical constraints. However, a network of Reef Check monitoring sites are being developed in protected areas, and the Archipiélago Sabana-Camagüey area will be systematically monitored under a UNDP/GEF Project.

Dominican Republic
The established MPAs have no protection or management, because the existing laws that govern environmental activities are not enforced due to funding and enforcement limitations.

Haiti
There are no MPAs and only the Foundation pour la Protection de la Biodiversite Marine, which is under-funded and under-staffed, attempts to monitor and protect the environment. Their efforts were encouraged by visiting scientists from Jamaica using UNEP funds aimed at building capacity in Haiti. This resulted in Reef Check training and monitoring at 5 sites.

Jamaica
The Government has attempted to prevent the degradation of the marine and terrestrial environment by establishing natural areas for special protection under the Natural Resources Conservation Authority Act. It aims to create 14 terrestrial, marine and integrated protected areas covering 25% of the island and 50% of the shallow shelf to 20 m. This vision has not yet been realized. Capacity in coral reef monitoring has increased since 2002, with more enthusiasm from Jamaican divers. Funding for training was obtained from UNEP, using the GCRMN and Reef Check as leverage and the Jamaica Coral Reef Monitoring Network started in 2003. They monitored reefs in MPAs, especially the Portland Bight Protected Area and on the

south coasts where few surveys had been conducted previously. Funding from ICRI in 2004 will stimulate more monitoring of fish, invertebrates and corals of the Portland Bight Protected Area, and will strengthen the capacity of the local NGO responsible for managing the area.

Turks and Caicos Islands

There are 34 Protected Areas in the Islands (11 National Parks, 11 Nature Reserves, 6 Historical Sites, 4 Sanctuaries, and 1 Fisheries Reserve), with 19 having marine or coral reef resources. However, these provide protection for less than 10% of the coral reefs. Protected area management has increased from about 2% in 1992 to 20 to 30% in 2003, and the Fisheries Division of the Department of Environment and Coastal Resources intends expanding management to all 34 Protected Areas. Reef monitoring capacity has been limited and activities were mostly conducted by visiting researchers. In 2001, the Department hired a consultant to monitor near-shore patch reefs that were being damaged by snorkelers, and monitoring capacity has increased with 24 monitoring sites established. Training in Reef Check has also been offered to park wardens, fisheries officers, local dive operators and other volunteers.

Government Legislation and Policy on Reef Conservation

Bahamas

Development and implementation of coastal policies and regulation have been ad hoc in the Bahamas. National policies, regulations, and enforcement of coastal activities do not adequately protect the environmental, social, and economic significance of the resources for the society. But these coastal resources are recognised as critical for the country, so improvements to legislation, regulation, and institutional arrangements are in progress. District councils and town councils, under the Local Government Act, 1996, decide on the upkeep and maintenance of coastal assets. The Town Planning Act, 1961, authorises coastal development while the Coast Protection Act, 1968, is tasked with the protection of the coast against erosion and encroachment by the sea. Bahamian fisheries are governed by the Fisheries Resources (Jurisdiction and Conservation) Act 1977, which is under revision. There are other acts covering coastal resources and conservation, thus there is no single agency or legislation with responsibility for coastal management.

Bermuda

Legislation to promote reef conservation is under the Fisheries Acts of 1972 and 1990 and the Protected Species Act of 2003. These promote the protection of species and their habitats from harvesting. Fishery Act management measures include gear restrictions, minimum sizes and bag limits, and protection against harvesting of corals, various molluscs, all parrotfish, 6 large grouper species and all marine mammals and turtles. A ban on trap fishing was introduced in 1990.

Cuba

In 1996 the first specific laws for the protection of coral reefs were developed with regulations on Fisheries, Black Coral, and Biological Diversity. These regulations prohibited collecting, anchoring, dredging, pouring sediments, pollutants and solid wastes, and using explosives in the vicinity of coral reefs, with fines imposed for violations. Recent environmental laws will pave the way for protection and sustainable use of reefs. The ongoing bans by the Ministry of Fishery Industry on the use of set nets ('tranques') and bottom trawl ('chinchorro') and other changes are expected to contribute to the recovery of coral reef fish communities. The Environmental Agency and relevant research institutions are preparing guidelines for protecting and sustainably using coral reefs, seagrass beds and mangrove forests. Another area

of concern is the damage caused by organic pollution, as there is now raised awareness of the damage caused to coral reef health, fisheries and for tourism. Integrated coastal management is being implemented in several provinces and municipalities, under the UNDP/GEF Sabana-Camagüey Project.

Dominican Republic

Environmental management remains inadequate, in spite of new environmental laws. The major limiting factor is a lack of ongoing funding. Similar to other countries, the implementation and enforcement of existing policies and laws is more critical than developing new policies when there are no financial resources for their implementation.

Haiti

The environmental laws are not enforced, due to the instability of the political system. There are also no financial resources for environmental protection. Marine resource protection is the responsibility of the Direction de Peche des Resources Naturelles, Service de Peche et Pisciculture (Fisheries Office of the Natural Resources Department). Over-fishing and the use of damaging fishing practices continue. Haiti has signed the relevant international conventions, namely Biodiversity, Climate Change, Desertification, Law of the Sea, Marine Dumping and Marine Life Conservation, but they have not ratified the treaties on Hazardous Wastes and Nuclear Test Bans.

Jamaica

There are many laws, regulations, and guidelines relevant to the management of ocean and coastal resources: the *Endangered Species (Conservation and Regulation of Trade) Act (2000)* protects corals, dolphins and sea turtles; the *Beach Control Act* (1956); the *Fisheries Act (1975);* and the *Wildlife Protection Act (1945)* all deal with fisheries management and prohibit the use of dynamite, and poisons to kill or injure fish. Jamaica has signed the Cartegena Convention, the Law of the Sea Convention and CITES, with a specific purpose to protect species such as the queen conch (*Strombus gigas*) and black corals (Antipatharia). New marine policy initiatives in the last 3 years include *Towards an Ocean and Coastal Zone Management Policy in Jamaica* and the *Biodiversity Policy and Action Plan*. However, inadequate funding and manpower for monitoring, regulation and enforcement limit the implementation of these laws and policies.

Turks and Caicos Islands

Significant steps have been taken to build capacity within the Government to enhance the implementation and enforcement of Fisheries and National Parks legislation, and to strengthen environmental provisions and improve management of MPAs. In 2003, a strategy and action plan (TCI Environment Charter) was approved and Revisions to the Fisheries Ordinance were completed, and National Parks Ordinance amendments are in progress. Endangered Species Protection legislation is being prepared to allow the CITES provisions to apply in TCI. The Government also intends to approve the Special Protected Areas and Wildlife (SPAW) and the Convention on Biodiversity (CBD) protocols. Coral reef issues were accentuated in late 2003, when the islands hosted the ICRI Coordination and Planning Committee meeting, which involved many government officials.

Gaps in Current Monitoring and Conservation Capacity

Most countries in the node have similar problems with monitoring and conservation capacity. The exceptions are Bermuda and Cayman where capacity, funding and awareness are higher. Monitoring is limited by available funds and operational equipment such as boats, but especially

by limited human resources. Staff turnover is high because of insufficent remuneration and this prevents continuity and sustained data collection. However, awareness has been increased by the international concern for coral reefs expressed through ICRI, the GCRMN and the United Nations, resulting in more widespread and increased monitoring and conservation.

Outdated laws and inadequate or absent implementation hinder resource conservation. Thus the implementation and enforcement of laws and improvement of legislation to prevent over-harvesting of reef organisms is a priority requirement. Some governments are ignoring immediate environmental concerns in an attempt to achieve economic growth, thus they are not implementing integrated land use and coastal management policies to control developments that damage coastal resources. Co-management and increased environmental education are important to ensure that communities are involved in saving their environments and enhancing their livelihoods. In this regard, the function of MPAs in managing over-fishing needs to be understood and implemented by ensuring the presence and enforcement of no-take zones in MPAs. More formal training in marine sciences and coastal management is needed. Progress is evident throughout the region, but is highly variable between countries and reflects economic prosperity: e.g. Bermuda is in the lead and Haiti is trailing behind.

Conclusions

Bahamas
Management strategies such as seasonal closures of the grouper fishery are essential for the maintenance of sustainable fish populations.

Bermuda
Coral health and cover have been relatively stable at about 20% for 10 years, and the island's fisheries have benefited from the enforcement of the ban on trap fishing.

Cayman Islands
The coral reefs and the fish populations are reasonably healthy, however continued protection from anthropogenic impacts is required.

Cuba
Regional and global scale stressors are the main causes of coral reef decline in Cuba e.g. *Diadema* mortality, coral diseases, temperature-associated coral bleaching, and probable nutrification of Caribbean waters. Direct anthropogenic effects are more local; e.g. over-fishing on specific reefs such as the Archipelago Sabana-Camagüey and northeastern Cuba and the damage caused to reefs off Havana by pollution. A lack of financial resources is the main reason for inadequate monitoring, enforcement and conservation of Cuban coral reefs.

Dominican Republic
Enforcement of the existing legislation and an improvement in management capacity are required for the reefs to recover.

Haiti
The near shore reefs are severely over-fished and show excessive algal growth, however there have been no comprehensive surveys. Stable governance and funding will greatly improve the environmental outlook for Haiti.

Jamaica
Jamaica has become more environmentally aware, but more policy initiatives on integrated

coastal management are needed. Unfortunately, the reefs around Jamaica continue to suffer from ineffective management and most declared and proposed MPAs remain as 'paper parks'. Over-fishing continues to be the major problem and it is essential to implement and enforce the new Acts. However, this is dependent on additional financial resources. Increased monitoring of the reefs on the south coast is required to assist in the formulation of relevant management plans.

Turks and Caicos Islands

Recent monitoring has revealed that the reefs across the islands are quite similar and in relatively good condition. However, data from Grand Turk show that coral cover appears to have declined over the past decade. There is little evidence of over-fishing, and management is being implemented to deal with current problems and prevent future degradation.

Predictions for the Future of the Coral Reefs

Pessimistic

The pessimistic prediction is that these coral reefs will continue to be damaged by factors outside the control of these countries. It is likely that continued global warming will result in more frequent and severe bleaching episodes with consequent coral mortality and reduction of fitness. New diseases will continue to arise and cause mortality in weakened corals. *Diadema* may suffer a repeat mass mortality while new strains of white band disease continue to prevent the recovery of the *Acropora* spp.

The coral reefs in countries with high GDP and well-educated populations, will have low (10-20%) levels of coral cover and an altered species composition. They will probably stop growing and protection of the coastline from sea level rise will be reduced. Fish populations will recover following implementation of fisheries management, but will be less diverse because of loss of coral habitats. However, some commercial species will not recover because of past destruction of spawning aggregations and continued unregulated fishing of upstream breeding stocks.

In countries with lower GDP, where much of the population is poorly educated, and there are insufficient employment opportunities, the reefs will experience continued over-fishing, sedimentation from poor land use management, and pollution from domestic and other sources. Algae, sponges and other heterotrophic filter-feeding organisms including borers will increasingly populate these coral reefs. Coral and fish communities will be sparse, have low diversity, and the fish will be small and of low commercial value. These reefs will suffer bio-erosion and experience negative growth. The protection of the coastline by the reefs will decrease leading to serious coastal erosion during storms. The problems will get worse as sea levels rise.

Optimistic

The optimistic prediction is that, despite continued global warming and introduction of new diseases, corals will adapt both phenotypically and through evolution, with some species surviving better than others. Thus in countries with higher GDP and well-managed coastal zones, mortality from bleaching and disease will decrease and corals on the reefs will increase to at least 50% cover. Reef growth will keep pace with sea level rise, thus continuing to provide shoreline protection. Coral species composition may still change, as better adapted corals become dominant on the reefs. Fish populations will recover in countries where strong fisheries management policies are implemented, and fisheries yields from well-managed stocks will be high and stable.

Countries with lower GDP will not see much change initially, but in the optimistic scenario they will progressively diversify and expand their economies and educate and train their populations resulting in higher per capita GDP, and better implementation of integrated coastal management. The reefs and reef fish populations in these countries will therefore progressively show improvement resulting from improved management and greater environmental awareness. Fisheries yields will improve as stocks are better-managed and spawning aggregations reform.

General Conclusions

- Funding remains the major hindrance to coral reef monitoring and conservation in the region.
- Legislation dealing with coastal environmental management requires both revision and effective implementation in most countries of the node. Enforcement of existing legislation is critical as over-fishing remains a major problem with poaching a growing concern.
- Better land use policies are required to curtail anthropogenic impacts and reduce pollution from sediments and nutrients.
- Greater political commitment is needed for forceful policy intervention as well as improved planning and management systems.
- The coral cover on selected reefs appears to be recovering, but increased monitoring is required to track these changes.

Recommendations to Improve Conservation of Coral Reef Resources

- Integrated, multi-disciplinary and multi-sectoral approaches in planning and land use are needed to alleviate and pre-empt coastal problems.
- Economic incentives and alternative sources of employment are required before artisanal fishers will respect no-take zones and closed seasons.
- Increasing the involvement of fishermen in conservation and research efforts may improve compliance.
- Designated MPAs need to be actively managed to effectively protect both the renewable and non-renewable natural resources. No-take zones and fish sanctuaries are required and must be enforced.
- Increased and ongoing environmental education, including economic valuation of coastal resources, is essential at all levels of society. This will facilitate more responsible use of the marine and coastal resources and foster more appreciation for the benefits of integrated coastal area management.

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WHS

DESEMBARCO DEL GRANMA, CUBA - WORLD HERITAGE SITE

The Desembarco del Granma National Park, in south-eastern Cuba, was designated a World Heritage site in 1999. The site contains most of the key habitats found in the region, including seagrass beds, mangroves, and the coral reefs of Cabo Cruz. There is a series of sub-marine terraces up to 30 m deep to the west of the park. The level of endemism in the park is globally important, with several species within the park boundaries being of conservation concern, including the Caribbean manatee, queen conch, and a number of species of marine turtles (loggerhead, green, olive, ridley and hawksbill). The major threats to this site are earthquakes and hurricanes.

There is very little tourism in Desembarco del Granma National Park with fewer than 1,000 tourists (both foreign and national) visiting each year. The first management plan for Desembarco del Granma National Park was approved in 1986, and the plan is regularly updated to maintain the conservation status of landscapes and species, restore degraded ecosystems, and to promote the recreational use by the public. The updated plan will include all marine ecosystems within the boundaries of the National Park and will provide an acceptable level of detail for management activities. There are already established environmental education and outreach programs within the local rural populations.

Ecological monitoring: No detailed scientific research has been conducted. Monitoring is needed to determine the effects on coral reefs of traditional fisheries and effluent from nearby towns.

Socio-economic monitoring: At least 900 people live within Desembarco del Granma National Park with most of them concentrated in the fishing village of Cabo Cruz. However, no monitoring has occurred.

Contact: Centre National des Aires Protégées, Reinaldo Estrada, Calle 18 A n°4114e/41 y 47, Playa C., Habana, Cuba (website: http://www.medioambiente.cu).

Coral reefs are **40%** of the natural resources:
Ecological Monitoring is **unknown.**
Socio-economic Monitoring: is **unknown.**

MAB RAMSAR

CIENAGA DE ZAPATA, CUBA - MAN AND THE BIOSPHERE RESERVE

Cienaga de Zapata is one of the largest and best-preserved wetlands in the Caribbean. The entire area has been declared a National Multi-use Protected Area, a Provincial Park and a UNESCO Man and Biosphere Reserve. Its core consists of 5 strictly protected areas, including Cienaga de Zapata National Park, and 4 other areas have been declared Refugios de Fauna or Reserva Florística. There is no management plan, but in the future the area is going to be monitored. The site harbours a large number of endemic species including the endangered crocodile *Crocodylus rhombifer.* Several species of endemic fishes are found, some of which live in the cave ecosystems of the area. The coastal mangroves of the site serve as a nursery for large numbers of juvenile fish and invertebrate species.

The site is completely owned by the government, as is almost all of the surrounding area. There are some private properties outside the site. Of the approximately 9,000 inhabitants, approximately 40% live in urban areas. Government land is being loaned to farmers for subsistence agriculture. Areas around the settlements are being grazed on a small scale and there are also state progammes for cultivating rice, citrus fruits and other crops. The extraction of wood and the production of charcoal are the main sources of employment and income. A small fishing port caters to local needs and bee-keeping is an important activity. Tourism has recently expanded, creating employment for a small part of the population. Annually, 800,000 domestic and 100,000 international tourists visit the site. Preparation of handicrafts is a relatively new activity and there is some sport fishing and hunting.

Ecological Monitoring: Water quality, ecology and fish production are being studied and monitored by the ecological station of the Ministry for Science, Technology and the Environment. Environmental education courses for several target groups are being taught.

Socio-economic Monitoring: Socio-economic, historical and cultural studies have been carried out by different institutes. Tourism and its impacts have also been studied.

Contact: OrganoCITMA, Carretera Playa Larga, Kilomatre 25, Cienaga de Zapata, Prov. de Matanzas (Phone: 53-59-5539)

Coral reefs are **20%** of the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **occasional.**

18. Status of Coral Reefs of the Mesoamerican Barrier Reef Systems Project Region, and Reefs of El Salvador, Nicaragua and the Pacific Coasts of Mesoamerica

Alejandro Arrivillaga and Miguel Angel Garcia

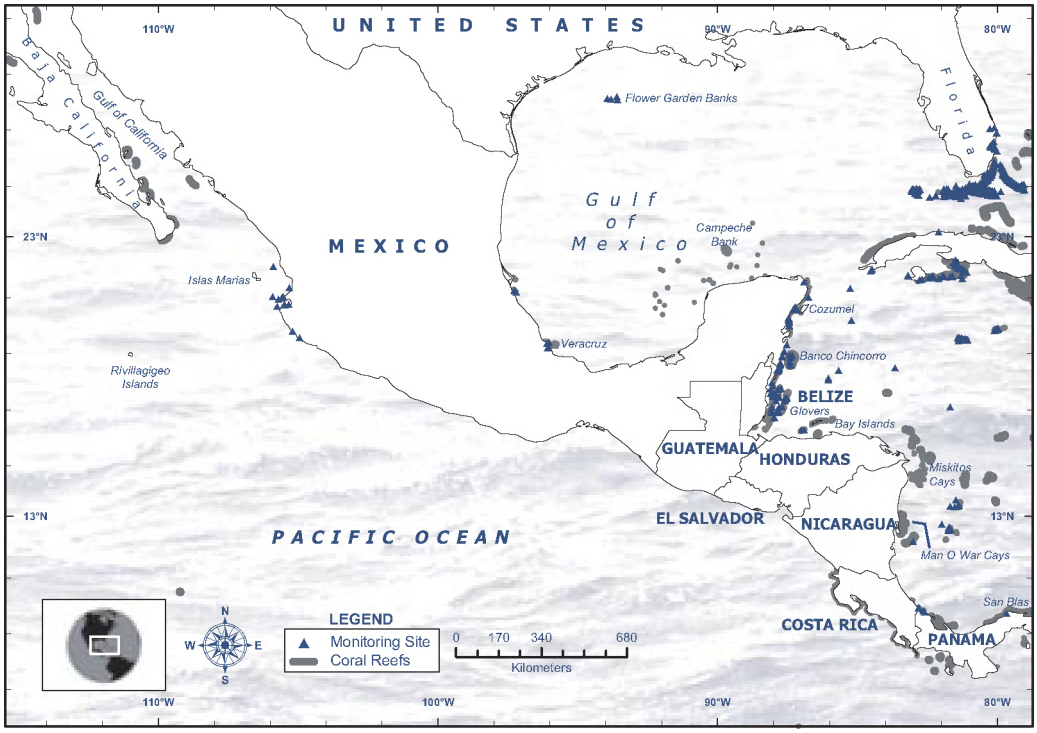
Abstract

The Mesoamerican Barrier Reef System (MBRS) region is the second longest barrier reef system in the world, extending over 1000 km from Yucatan, Mexico, to the Bay Islands in Honduras. Offshore atoll-like reefs, numerous patch reefs, faro formations, and fringing reefs are found throughout the region. Reefs in the Pacific of Mesoamerica are well developed in Mexico but less abundant in Guatemala, El Salvador, and Honduras. Natural disturbances, such as hurricanes, coral diseases, *Diadema* (sea urchin) mortality, and coral bleaching, and anthropogenic stresses, such as nutrient enrichment, sedimentation, over-fishing, direct damage, and maritime activities threaten the MBRS reefs. The MBRS Initiative, a regional cooperation program between Belize, Guatemala, Honduras and Mexico, has gathered considerable support for public and private conservation efforts.

The MBRS Synoptic Monitoring Program (SMP) ensures that environmental monitoring of coral reefs and associated ecosystems in the MBRS region is conducted in an organised and coordinated way. Data collection initiated in 2003, and all of the priority locations were monitored during 2004, including Mexico (Banco Chinchorro, Xcalac, and Chetumal Bay), Belize (Bacalar Chico, Caye Chapel, Gallows Point, Goff's Caye, and Sapodilla Cayes), Guatemala (Sarstun River, Puerto Barrios, and Punta de Manabique), and Honduras (Omoa, Puerto Cortés, Utila, and Cayos Cochinos). Corals, reef fishes, seagrasses, mangroves, and pollution are currently monitored through standardised methods.

100 years ago: Reefs were in pristine condition, mainly as a result of limited coastal development and minimal fishing pressures. While some fishing did occur, there were no destructive fishing practices and the reefs were generally exposed to minimal anthropogenic impacts.

In 1994: A build up of coastal and inland development associated with increased deforestation and resulted in an increase in sediment flow. Agricultural expansion and increased reliance on pesticides and fertilizer adversely affected reef health, especially near-shore systems. Over-fishing effects were first witnessed when fish catches were smaller and more difficult to achieve.



Map courtesy of The WorldFish Center

In 2004: The reefs are under significant threats from river runoff and over-fishing, as well as hurricanes and coral disease. Fishing pressures are increasing for conch, lobster, and grouper. Fishery regulations are not enforced, and management is fragmented. Many MPAs lack financial sustainability and trained staff. Monitoring and research capacity has improved because of the MBRS Initiative and there is considerable training, including on alternatives to fishing. The initiative is seeking solutions to regional and trans-boundary problems.

In 2014 - Optimistic: The regional monitoring and research capacity will have improved due to the MBRS Initiative and an environmental information system will be in place to assist conservation efforts. Increased funding for research and enforcement activities will have increased community awareness and scientific knowledge of the MBRS. Sustainably managed fisheries will be common and eco-tourism will have increased dramatically, to provide alternative livelihoods.

In 2014 - Pessimistic: There are many MPAs, but most lack financial sustainability and trained personnel to be effective. Government funding and community awareness will be minimal. Explosive coastal development will lead to widespread depletion of marine fisheries, and eventually to a decline in tourism and revenue for the region. Fisheries will continue to expand unsustainably to the point of stock collapses. A continuation of poor watershed management will completely destroy nearshore reefs close to rivers.

Introduction

This is a summary report of the coral reefs of the Mesoamerican Barrier Reef System (MBRS), regarded as probably the second longest barrier reef system in the world. The Barrier Reef starts in northern Yucatan, Mexico, and extends over 1000 km passing Belize where it is particularly well developed and ending in the Bay Islands in Honduras. These reefs are particularly well developed and contain some of the richest biodiversity in the wider Caribbean. The reefs also support major fisheries, and one of the fastest growing tourism industries in the world. However, these reefs are also subject to major stresses from human activities such as river runoff carrying excess sediments and nutrients from poor land use practices, major over-fishing and other marine activities. Natural disasters are also problems for these reefs, ie hurricanes, and severe bouts of coral bleaching and disease. These recent stresses have changed the appearance and structure of the reefs considerably in the last 2 decades.

The coral reefs in the Pacific have lower diversity and the best-developed reefs are in Mexico. The reefs are less abundant and more ephemeral in Guatemala, El Salvador, and Honduras. However, reefs in the Caribbean grow in most of the typical formats with barrier reefs, and many patch, fringing, and atoll-like reefs (Banco Chinchorro, Turneffe Island, Lighthouse, and Glovers Reef) in Mexico and Belize. There are also small coral communities along the coast of Guatemala and Honduras. Extensive reef complexes also occur in Nicaragua and San Andres, Colombia.

A description of the MBRS region coral reefs was presented in the 2002 version of the Status of the Coral Reefs of the World report and this chapter is an update to include a summary of the information presented in the earlier version, with new information generated and published since. A detailed review book 'Latin American Coral Reefs' (2003) has recently been edited by Jorge Cortes, Universidad de Costa Rica. There is also considerable information on MBRS-Project activities on the website: www.mbrs.org.bz.

The MBRS project is a regional conservation program, involving Belize, Guatemala, Honduras, and Mexico, funded by the Global Environment Facility, and implemented by the World Bank. The MBRS project is run by the Comisión Centroamericana de Ambiente y Desarrollo, CCAD (Central American Commission on Environment and Development), with help from governments of the participating nations and currently is implementing a 15-year management plan. The project works in coordination with government agencies, universities and research centres, and local NGOs in the different countries and maintains headquarters for the MBRS Project Coordinating Unit in Belize City. Other MBRS region initiatives are lead by international NGOs such as the World Wildlife Fund, The Nature Conservancy, and the Wildlife Conservation Society. The capacity to monitor and eventually manage coral reefs varies enormously in the region, but the MBRS monitoring program and the Regional Environmental Information System are working to increase capacity.

Reef Descriptions

Mexico: All 3 Mexican seas (Pacific, the Gulf of Mexico and Caribbean) contain hard (scleractinian) corals, but well developed reefs appear only in the Caribbean region, with large reefs off the Yucatan, as well as smaller reefs in the Southeast Gulf and on the Campeche Bank. The Campeche Bank reefs follow the outer fringes of the extensive Yucatan shelf, 80 to 130 km offshore. In the SW Gulf of Mexico there are 4 reef groups, including Isla Lobos, Tuxpan, Veracruz, and Anton Lizardo. Fringing reefs border most of the continental and insular

RESEARCH ON GLOVERS REEF ATOLL, BELIZE

There is ongoing monitoring and research on Glovers reefs by the Wildlife Conservation Society on algal grazing and nutrients to determine possible restoration options for reefs dominated by macro-algae. Coral cover has declined as macro-algal cover has increased after the loss of the major grazing sea urchin, *Diadema antillarum*. Research is underway to determine the causes of these changes. They have also been documenting the distribution and abundance of the commercially valuable species over 7 years; spiny lobsters *Panulirus argus*, queen conch Strombus gigas, Nassau grouper *Epinephelus striatus*, black grouper *Mycteropercus bonaci*, hogfish *Lachnoliamus maximus*, mutton snapper *Lutjanus analis*, and queen triggerfish *Balistes vetula*. Significant changes have occurred in protected populations and these data are being used to assist management to predict potential cost - benefit outcomes of various management options.

Research using cages shows that herbivores significantly reduce the biomass of algae, whereas nutrient enrichment has only a slight positive effect on increasing algal biomass. A combination of fewer herbivores and more nutrients caused major increases in algal cover, and more species of algae were present. When there are more herbivores and more nutrients, the low turf algae proliferated, whereas when there are fewer herbivores, there were more macro-algae, which were inhibited by high concentrations of nutrients. So the research concluded that the reduction in herbivore populations, rather than nutrient pollution was responsible for the high cover of macro-algae. The higher concentrations of nutrients had few effects on corals in the cages. From: Tim McClanahan, Wildlife Conservation Society, Kenya, tmcclanahan@wcs.org.

shores of the Mexican Caribbean from Isla Contoy south to Xcalak, but true fringing reefs are infrequent and a wide shallow lagoon separates the reefs from the shoreline. The reef lagoon bottom is sandy and has extensive 'turtle' seagrass beds.

The northern reefs are dominated by extended fringing reefs, characterised by high coral cover on the crest and fore-reef zones. *Acropora palmata* dominate the shallow fore-reef, reef crest and protected environments, while *Montastrea annularis* dominate the rear reef zone. The central reef is characterised by a chain of shallow *A. palmata* reefs, which border the shallow bays of the Sian Ka'an Biosphere Reserve area (Box p 486). These reefs arise from a submerged crest that may correspond with an ancient shoreline. In the Southern section, the continental shelf extension is reduced and the continental reefs are mainly fringing reefs with a high bottom relief and the typical spur and groove morphology in shallow and deep fore-reefs. The major reef formation in the south is Banco Chinchorro, a large (46 km x 14 km) atoll-like structure, surrounded by well-developed reefs and protected as a Biosphere Reserve.

Belize: Belize is a relatively sparsely populated country and the coral reefs are important for commercial and artisanal fishing, and aquaculture. Tourism and the export of marine products are increasing rapidly. The Belize Barrier Reef complex is the largest (220 km long) continuous reef system in the western Atlantic and includes 3 offshore atolls (Turneffe Island, Lighthouse Reef and Glovers Reef), numerous patch reefs, faro formations (small annular-shaped reefs

resembling a small atoll), and fringing reefs. There is a 46 km stretch of almost continuous shallow water reefs along the Mexico-Belize border, ending at Gallows Point Reef. The well-developed, continuous reefs in the central region extend 90 km through its southern end to Gladden Spit. In the south of the country, reefs extend 10 km down to the Sapodilla Cayes in the Gulf of Honduras, where the barrier reef ends in a J-shaped hook. This region has sporadic and less developed reefs. The offshore atolls of Lighthouse, Turneffe and Glovers are separated from the barrier reef by water 360 to 1100 m deep.

The crest in the Belize barrier reef is several metres in width and is adjoined by a series of spurs and grooves. Between the mainland and the barrier reef lies a 20 to 40 km wide lagoon, only a few metres deep in the north, but 50 m in some places further south. Faro reefs are found at Pelican Cayes and Laughing Bird Caye, while fringing reefs are found between Placencia and the north Port Honduras area. These fringing reefs are dominated by hardy species that can tolerate varying levels of salinity and turbidity, characteristic of inshore waters.

Guatemala: Reef development in Guatemala is poor, with low live coral cover (8%) and high non-coralline macro-algae cover (65%). There are few coral reef and hard bottom habitats along the Guatemalan Pacific coastlines, but there is good reef development along the Caribbean coast of Guatemala, as well as extensive mangroves, seagrass beds and coastal lagoons. Coral reefs composition in Guatemala is not typical of most Caribbean reefs and is dominated by macro-algae and coral species resistant to sediments, such as *Siderastrea siderea*. Recent severe natural events such as hurricanes, flooding with high sediment loads, and temperature increases that have affected the Caribbean region, have contributed to the deterioration of Guatemalan reefs.

Coral reefs near Punta Manabique grow on continental carbonate banks, but hard bottoms and coralline algae are present on Punta Cocolí, Punta Herrería, and La Guaira, and from Punta Herrería to Tapon Creek. Other rocky and reef bottoms occur near the Sarstun River mouth and on Faro Blanco Shoal. Coral reefs at Punta Manabique are one of the most important resources of the coastal-marine territory of Guatemala. The economic activity of the Manabique Peninsula is focused on artisanal fishing, with high expectations for tourism development. Coastal communities depend on reef resources for food.

Because of the major rivers, reef development is isolated to coral communities and small patch reefs in the Gulf of Honduras. The biggest problem of coral reefs at Punta Manabique are sediments coming from deforested soil erosion, mainly from the Motagua, Sarstoon, and Polochic-Lago de Izabal-Rio Dulce river basins. High sediment loads are causing coral death and increased algal overgrowth. The current populations of herbivores are insufficient to control the macro-algae.

Honduras: There are no reefs on the Pacific coast of Honduras. Coral reefs on the Caribbean coast are restricted by river runoff. Here the indigenous communities rely on subsistence fishing and more increasingly on tourism in the Bay Islands. Because of high levels of runoff, there are only scattered, poorly developed coral communities around Puerto Cortés, La Ceiba and Trujillo, while the reefs of the Swan Islands and the Mosquitia Cays and banks are poorly known because of their limited accessibility. They have been visited only occasionally by research teams, and the information is mainly unpublished. There are numerous poorly studied

ACROPORA CERVICORNIS RESTORATION PLAN FOR THE CARIBBEAN

The recent Caribbean-wide decline of the staghorn coral *Acropora cervicornis* has potentially serious consequences for the structure and biodiversity of the coral reefs, and the fisheries and tourism economies of countries in the Caribbean. Although there have been major losses, some corals still survive and presumably these are now more resistant to disease and bleaching. Attempts have been made to remove the causes of coral reef decline in some areas and fish are returning to no-take areas, however, *A. cervicornis* does not seem to be recovering, despite a general increase in reef health. This poor recovery may be due to a lack of sexually generated coral larvae that would normally re-colonize the reefs. Each surviving *A. cervicornis* population is predominantly composed of multiple branches of a single clone, and self-fertilization is inhibited during spawning. A single surviving patch of *A. cervicornis* has been found on Barbados, and three surviving populations were found around Discovery Bay, Jamaica, but they are separated by many kilometres. The long-term survival of remnant staghorn coral populations is threatened unless they can increase and re-establish successful sexual reproduction.

Attempts to restore breeding populations of *A. cervicornis* started in January 2004 as a partnership between Counterpart International, Counterpart Caribbean, the Discovery Bay Marine Laboratory, and the Honduras Ministry of Tourism. The strategy involves training volunteers to reduce stresses around surviving corals; cleaning off excess macro-algae, removing coral predators, supporting no-take MPAs to re-establish large groupers to keep algal farming damselfish *Stegastes* in check, and potentially reintroducing sea urchins to control algal overgrowth. Small (10-20cm) coral branches are taken from surviving coral populations and grown on wire frames at coral restoration sites, several clones per site, in the hope that breeding populations will be re-established.

The first *A. cervicornis* restoration workshops were held at Discovery Bay Jamaica and on the Honduran Islands of Roatan, Utila, and Guanaja, establishing experimental restoration sites after seed funds and government permits were obtained. Participants were trained in coral ecology, methods of planting and growing *A. cervicornis,* and a multi-stakeholder approach to coral reef management to ensure long-term solutions. The hands-on coral planting work helped develop a sense of cooperation within sometimes antagonistic groups. MPA managers, conservationists, fishermen, and tourist operators all worked together on this task. Trainees returned to their own areas to survey the reefs and to look for surviving A. cervicornis populations. The program will be expanded to new sites and new countries if the results from Jamaica and Honduras prove encouraging, seeking new partners and funds. From Austin Bowden-Kerby, Counterpart International bowdenkerby@connect.com.fj

seamounts, which have relatively high coral cover and fish populations. These seamounts are also important targets for local fishermen and may be important fish spawning areas.

Some of the best-developed reefs in Honduras occur around the offshore Bay Island groups: Roatan, Utila, Guanaja, and Cayos Cochinos. These reefs grow in 9-12 m depth, before a deep

wall drops to 75 m. The dominant coral is *M. annularis*, with some *Acropora palmata* and *Agaricia tenuifolia* on the shallow fringing reefs. The Bay Islands are surrounded by fringing reefs, and the north coast of Roatán is dominated by a nearly continuous barrier and fringing reef. The southern coast of Roatán supports a discontinuous fringing reef, broken up by channels that were formed by erosion during past glacial events. Reefs on both coasts have relatively narrow landward lagoons, dominated by seagrass beds. Reef zonation on Utila is much more pronounced on the north of the island. The reefs of the leeward side of Utila grow on a narrow shelf with a poorly developed reef crest, and there is little reef development beyond 25 m. Hurricanes and bleaching events have resulted in low live coral cover, with values rarely exceeding 30% on Utila and only reaching 50% at the west end of Roatán.

The Cayos Cochinos Archipelago is located in the Honduran Caribbean and is among the important reefs in the southeast MBRS. The Cayos Cochinos Reserve is 489 km^2, and covers the entire archipelago and surrounding area to 5 nautical miles. It is an important fishing area, and has been designated a Marine Protected Area and a Marine Natural Monument for its ecological and cultural importance. Fringing reefs in Cayos Cochinos are located along the continental shelf. The reefs extend down to 25 m and are better developed on the north side of the islands. The most common scleractinean corals are *Montastrea annularis*, *Diploria* sp., and *Colphophylla* spp. but coral diversity is greater on the leeward side of the islands and is dominated by *Agaricia tenifolia*.

Nicaragua: Coral cover is generally low, around 25%, with 5% soft corals. Corals are found on both Nicaraguan coasts, but reef-building corals have only been reported on the extensive Nicaragua Shelf. Nicaragua's coral reef formations occur in 3 zones: the near shore shelf; the central shelf; and the self edge. Most of the information available is on the central shelf around Corn Island, where live coral cover is between 5% and 55%. Reef formations in Corn Island include inner patch reefs in the back reef lagoon, near shore fringing reefs, outer patch reefs, and rock reefs on the south side of the island.

El Salvador: The most important coral assemblages in this Pacific coast country are 11 km south of Acajutla, Sonsonate, at Los Cobanos. These are not true reefs, but groups of isolated colonies growing on rocky substrata. The area at Los Cobanos is extremely turbid (less than 2 m visibility), however, 15 species of stony corals occur there. *Pocillopora damicornis* is dominant in shallow water, and *Cladopsammia eguchii* is most abundant in deeper areas down to 20 m.

Threats to the Coral Reefs

Mexico: Reefs on the Atlantic coast are under pressure from tropical storms and hurricanes as well as biological threats, such as the death of sea urchins, coral bleaching mortality and diseases, algal overgrowth, and fish mortality. Anthropogenic impacts mainly include over-fishing and coastal developments related to tourism (including boat groundings, alteration to the coastal fringe, loss of mangroves and the resulting loss of protection from storms). Due to the limestone nature of the Yucatan Peninsula, there are no surface rivers and sediments have little effect on the coral reefs. There are 7 MPAs in the Mexican Caribbean (Costa Occidental de Isla Mujeres, Punta Cancun, Punta Nizuc, Arrecife de Puerto Morelos, Arrecifes de Cozumel, Isla Contoy, and Arrecifes de Xcalac), 4 National Parks and 2 Biosphere Reserves (Banco Chinchorro and Sian Ka'an).

Fishing pressure on Caribbean reefs has intensified recently, with more effort on catching commercially valuable species such as spiny lobster, conch and several species of groupers and snappers. Most have suffered major reductions in mean fish size and catches, however, the Mexican Caribbean coast has become a very successful resort area with almost 4 million visitors per year. Major tourism developments on the coast have resulted in direct damage and pressures from tourist divers. Broken corals have been glued back to the reef with about 80% success.

Belize: The most important threats to the reefs in Belize arise from natural disturbances, such as hurricanes, coral diseases, *Diadema* (sea urchin) mortality, coral bleaching, and sea level rise, as well as from anthropogenic threats like nutrient enrichment, sedimentation, over-fishing, direct damage (from boat and diving activities), and oil spills. Protection and management of coral reefs in Belize is achieved through a network of MPAs that include areas within the offshore atolls, areas in the Northern Province (Bacalar Chico, Cay Caulker), the central province (South Water Cay), and the southern province (Sapodilla Cays). Faro reef types such as Laughing Bird Cay and inshore reef at Port Honduras are also protected.

Guatemala: The high-water turbidity from the chronic influx of terrestrial sediments from rivers is the biggest problem at Punta de Manabique. Many major rivers empty into the Atlantic coast of Guatemala, including Motagua, Sarstun and the Rio Polochic – Lago de Izabal – Rio Dulce system, and carry with them agricultural runoff, with large sediment and nutrient loads and pesticides. Commercial shrimp trawling also has a negative effect on the reefs. Reef banks on the Caribbean coast of Guatemala are within the Punta de Manabique Wildlife Refuge. Other hard bottoms are included in the Rio Sartun Wildlife Refuge and therefore subject to some degree of protection.

Honduras: Although the coral reefs of Honduras are of vital national and international importance, both ecologically and economically, they are threatened because of rapid economic and population growth. The Honduras coral reefs are being damaged by a range of anthropogenic activities, including over-fishing, sedimentation and pollution, which have resulted in decreased coral cover. Increased coastal tourism has stressed the marine resources, such that recent coral bleaching events and storm damage have further exacerbated these effects by combining to reduce reef health and resilience. These events represent substantial long- and short-term threats to the ecological balance and health of reef ecosystems, and may ultimately lead to reduced income for coastal communities and other coastal zone stakeholders.

Reefs in the Bay Islands are threatened by rapid development of coastal areas, which results in sedimentation and other watershed management problems. As in many other countries, deforestation threatens the health of marine resources via increased sediment loads. Mangrove deforestation, in particular, has resulted in a loss of important nesting habitats for birds and other important species and will affect breeding and nursery grounds for commercially important marine species such as conch and lobster. Increased effluent and waste runoff nutrient levels, especially close to large towns and cities, are also regarded as a significant reef stress throughout the MBRS. Most buildings in the Bay Islands use septic tanks, but improper installation and maintenance of these septic systems is polluting the ground water and leaching nutrients into the reef areas. Physical damage from inexperienced divers and boat anchors results from the extremely high level of diver activity around the Bay Islands. Coral bleaching and diseases also have a severe impact on the reefs. Industrial shipping is one of the largest and

LOOKING FOR THE BIG MAMMAS IN THE MESOAMERICAN REEF

When was the last time you saw really big fish? We've seen a few and mostly these are inside fully protected MPAs. WWF, NOAA and local partners developed a campaign to raise awareness about the fisheries benefits of fully protected MPAs and to support a regional network of MPAs including fully protected zones.

The 'Big Mamma' campaign included a colorful big mamma logo, a lively song (radio advertisement), and a 3- minute video (TV advertisement), which were aired in March 2004, coinciding with fishing community meetings in Belize, Mexico and Honduras. The fishers listened to the science behind MPA design, connectivity, and fisheries benefits. Increased egg production of larger fish is a largely unrecognised component of these benefits and was the focus of the campaign. Fishers quickly understood the significance of the increased egg production, or as the song says: *"Bigger fish mean more eggs… more eggs mean more fish… more fish mean more money… fisherman can't you see?"* They were also very interested in the latest findings on current patterns, connectivity and the existing MPAs. Statistics compiled before the campaign showed substantial mis-information and a large over-estimation of the area under protection e.g. Belize has a system of MPAs covering about 22% of the shelf but only 2% is fully protected. The fishers participated in lively discussions, listened and even danced to the big mamma calypso beat, went home feeling better about the MPAs, and were given colorful big mamma T-shirts to reinforce the message.

Post meeting opinion surveys in Belize found that 75% of participants supported fully protected MPAs as a fisheries management tool. This compares to a 2002 survey that found that 45% of fishers believed MPAs actually had a negative impact on fisheries resources. Fishers did express concern over the need for better definition, demarcation and enforcement of the existing fully-protected zones and any planned new ones. They also requested training in alternative livelihoods and for exchange programs to discuss management implementation and fishing practices in other parts of the region. WWF will conduct both activities in 2004-2006 through the ICRAN - USAID Mesoamerican Reef Alliance Project. Overall this campaign has been highly successful, mainly due to the popularity of the 'Big Mamma' icon and the simplicity of the message. Such efforts that involve and inform fishers about the fisheries benefits of MPAs are a critical component of any effort to develop functional MPA networks. The tourism benefits of fully-protected MPAs are clear, well-recognised and supported by the tourism industry, however, the fishing industry requires better engagement and explanation of how fully-protected MPAs function within framework of ecosystem-based fisheries management. The value of saving Big Mamma is just being realised in the wider fishing community in the Mesoamerican Reef and being transferred around the world. For a copy in English or Spanish contact Melanie McField, WWF Mexico, mcfield@wwfca.org.

potentially most environmentally damaging industries in the Gulf of Honduras. Puerto Cortés, on the western coast of mainland Honduras, is one of the largest ports in the region, resulting in potential threats from petroleum or chemical vessels. This combination of threats to reef

health underscores the need to control land-based sources of stress through better land-use planning and environmental management.

Nicaragua: The Caribbean coastline has suffered considerable deforestation, which has resulted in increased sediment loads that have degraded the coastal reefs. There are also problems with excessive and damaging fishing practices as well as pollution from untreated sewage. Little is reported on the status of the more extensive reef of Pearl Cays, or of the extent of damage from Hurricane Mitch. However, damage is likely to have been substantial as the Hurricane passed over the Bay Islands and caused considerable flooding.

El Salvador: Human impacts are the main threat to reefs in El Salvador. Removal of carbonate rock and corals to produce cement, extraction of colonies to be sold as souvenirs, and increased fishing pressures have affected many reefs. Deforestation has also increased coastal sedimentation, and river runoff is responsible for transportation of pollutants to the coast and coral areas.

Status of Coral Reef Fishes and Fisheries

The increasing tourist industry in Honduras has resulted in tremendous pressure on the local fishing industry. For example, fishes, particularly groupers (Serranidae), snappers (Lutjanidae), grunts (Haemulidae) and jacks (Carangidae) are targeted by artisanal fishermen using a variety of traditional techniques. Although quantitative data are sparse, intensive fishing effort has clearly reduced populations and fishermen in the Bay Islands now target remote offshore banks, and put less effort in the heavily exploited fringing reefs. Furthermore, decreases of herbivore fish populations, in conjunction with the death of the sea urchins and decreasing water quality, also contribute to increasing algal cover, further deteriorating reef health.

Similarly, lobster and conch are a significant fishery resource on reefs around the islands and mainland. Both artisanal and commercial fishermen catch these species. Honduras maintains the largest lobster fleet of all Central American countries with 190 vessels in the early 1990s. Although detailed data are lacking, the lobster and conch fisheries are generally considered to be over-exploited.

The Synoptic Monitoring Program

Monitoring in Belize, Guatemala, Honduras and Mexico is now conducted in a coordinated way within the MBRS Project. The MBRS Synoptic Monitoring Program (SMP) has established a standardised, long-term environmental monitoring system, oriented towards the identification of local and regional problems. The collection of data through time has established a solid baseline to support integrated management proposals for conservation and sustainable use. Due to the complex biology, ecology and oceanographic nature of the MBRS, it is essential to generate information on these processes, including research and monitoring of the oceanographic currents and their influence on the status and processes of the critical ecosystems in the MBRS. Monitoring focuses on 3 core areas: coral reef ecology and associated ecosystems; marine pollution (from land-based and marine sources); and physical oceanography and models. The MBRS Initiative has developed a 3-D oceanographic model for the entire region to help management understand patterns in the region, interconnectivity between reefs, transport of eggs and larvae and dispersion of pollutants. The monitoring involves the active participation of many partners from government agencies, NGOs, academia and coastal communities. The data are included in the web based Regional Environmental Information System.

TOWARDS CO-MANAGEMENT OF NICARAGUA'S REEFS

Maps are particularly powerful tools to involve communities in the co-management of their areas and resources. Thus the 'reefmap' team has developed maps within a long-term, community based research, monitoring and management project on the Caribbean Corn Islands. These islands are in the south of the vast Nicaraguan continental shelf, where the communities rely heavily on seafood processing and supply 40% of national lobster exports. Recent declines in catches, despite an increased fishing effort, indicate that the fishery is over-exploited. The fisheries department implemented a 4 month closed season, although they lack the financial resources for fisheries monitoring and enforcement. The local government is developing an inshore municipal marine park to diversify the economy by promoting eco-tourism and reducing the pressures on fisheries resources. The 'reefmap' project supported the local community and the Nicaraguan government by working with local universities and NGOs to collect data for the co-management of the fisheries and the marine habitats. The fisheries studies indicated that traps were left offshore during the closed season, reducing the impact of fisheries enforcement. In addition, the closed season transferred fishing pressure to inshore reef fish populations, that are were not over-exploited. This artisanal fishery, however, is unregulated and there are no long-term catch data. There is a need for long-term monitoring and research to develop sustainable fisheries policies in close collaboration with the fishers to ensure local support. Development, pollution, and sea-level rise are stressing the coastal wetlands. There has been saltwater intrusion into the island's inshore waters, and the resulting exchanges will increase nutrient concentrations over the fringing reefs. Corrective measures are needed to reduce pressure on these critical habitats to prevent an ecological collapse. The coral reef surveys have shown that macro-algae dominated shallow reefs around the Corn Islands, indicating that nutrient enrichment may already be a problem. The deeper reefs still have well developed coral communities, but these have been affected by white plague disease. The 3-dimensional maps of the habitats out to 3 km of the islands will be used to develop policy and plan long-term monitoring in consultation with the community. From: Duncan Hume, info@reefmap.org.uk; www.reefmap.org.uk.

The vision of the SMP is to provide high quality information, and help improve the management and decision making for the reef system and its associated ecosystems. The SMP allows for the development of a baseline that provides timely information on the MBRS ecological health and provides an indicator of the effectiveness or impact of management and conservation measures implemented in the region.

The MBRS Project produced a Manual of Methods in English and Spanish, available on the Website (www.mbrs.org.bz). The project has also provided continuing training for monitoring personnel at both the regional and country levels, through courses in Belize; Guatemala; Honduras; and México. The Project has also provided equipment and instruments (scuba diving equipment, boats, water quality equipment, microscopes, GPS, etc.) to the National Monitoring Coordinators in the 4 countries.

Data collection started in 2003, and during 2004 all of the priority locations were monitored, including Mexico (Banco Chinchorro, Xcalac, and Chetumal Bay), Belize (Bacalar Chico, Caye Chapel, Gallows Point, Goff's Caye, and Sapodilla Cayes), Guatemala (Sarstun River, Puerto Barrios, and Punta de Manabique), and Honduras (Omoa, Puerto Cortés, Utila, and Cayos Cochinos). The SMP project has promoted collaboration with other institutions with a common interest in the MBRS region and the Caribbean. Some of these organisations include international agencies such as the Summit Foundation, World Bank Targeted Research Initiative, ICRAN – MAR, and national institutions like meteorology offices, universities and research centres. Plans have been developed to assess inland activities in the MBRS watersheds and underground waters in the Yucatan Peninsula. This watershed analysis will focus on river discharges, land use, sources of pollution, and sediment load.

Other Coral Reef Monitoring Initiatives

The capacity to monitor reefs varied considerably across the region until recently. Most monitoring and research was done by a combination of local NGOs, MPA biologists, GCRMN, AGRRA, REEF, Reef Keeper and Reef Check, CARICOMP and numerous local and national programs; many of the monitoring projects were short-lived. There had been poor coordination and data sharing among monitoring programs, with few successes in using the data for conservation or decision-making. Most government agencies lack the funds and capacity for extensive monitoring programs.

Conclusions and Recommendations

- The Mesoamerican Barrier Reef System is the second longest barrier reef system in the world and supports reefs, which are well developed, rich in diversity, and important to fishery and tourism industries.
- Reefs in the Pacific are well developed in Mexico, but less so in Guatemala, El Salvador, and Honduras.
- Reefs in the Mesoamerican area are subject to significant threats from human activities, such as river runoff and marine activities, and natural disasters such as hurricanes.
- Fishing pressures continue to increase for conch, lobster, and grouper. Fishery regulations are not well enforced, and management is fragmented. Initiatives such as the MBRS Project are providing training in alternatives to fishing. This initiative is also helping the countries seek regional and trans-boundary solutions.
- Monitoring and research capacity has improved via the MBRS Initiative and an environmental information system is in place to assist conservation efforts.
- There are many MPAs, but many lack financial sustainability and trained personnel to be effective. Some countries have effective legislation and some enforcement.
- A regional and comparable monitoring program has been implemented. It will help better identify, characterise, and monitor the extent and condition of coral reef habitats and associated organisms.
- The physical oceanography model has been developed by MBRS to gather information on coastal and oceanic currents and circulation patterns, and water temperature trends and patterns to track larval and pollutant flows.

- There is a need for improved understanding of the growth and reproductive parameters of target fish species (snapper, grouper, pelagic fishes, conch and lobster populations), particularly information to identify juvenile nursery areas, spawning aggregation sites, and larval transport pathways.
- Fishery statistics are inadequate for a regional resource management approach, although some countries do have statistics on key species. There is a need for uniform reporting standards and yearly updates on fishery statistics.

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SIAN KA'AN BIOSPHERE RESERVE, MEXICO – ICRAN DEMONSTRATION SITE

Sian Ka'an is located in Quintana Roo, Mexico and was declared a Man and the Biosphere reserve in 1986, and a World Heritage site in 1987. Around 1000 residents live in the buffer zone along the coast, with a further 500 living in communities within the reserve. Most live in settlements ('rancherias') scattered along the coast and in the forest. Fishing is the most important income-generation activity, but agriculture (maize and copra) is common. The Caribbean spiny lobster is the main catch (75%), with the majority exported to the United States and Japan. However, most of the young people study outside the community, and many do not want to return to lobster fishing because they can work in a less demanding and more lucrative environment elsewhere. Tourism has increased recently and provides a number of employment opportunities.

The ICRAN project at the Sian Ka'an Biosphere Reserve (SKBR) focuses on technical assistance and capacity building. This includes the implementation of an environmental monitoring program, integrated management of domestic waste, a socio-economic assessment of Javier Rojo Gomez community (Punta Allen), a fishers exchange program with Panama, a bibliography of the studies conducted at the SKBR, and a coastal/marine signage program. The signage program includes a system of mooring buoys for snorkeling and SCUBA diving as well as demarcation buoys for navigational purposes, and terrestrial signs. The Socioeconomic Assessment of Punta Allen provides information on the public's perspective on conservation, the efforts to secure the development of sustainable activities in the community, and the effect it has had on their lives. It also describes how the lobster fishery's use of gear limitations and allocation of fishing grounds has achieved sustainable management, proving to be a model organisation in Latin America. The report also highlights the important role that women play in income generating activities and community politics.

Ecological Monitoring: Long-term ecological monitoring of Sian Ka'an has contributed valuable scientific data which is crucial for decision making and the development of management measures, and has provided information on ecosystems and resource conservation status as well as on the trends related to human impacts.

Socio-economic Monitoring: The socio-economic assessment provided baseline data for the implementation of a long-term socio-economic monitoring program. Future monitoring is needed to determine whether increased visitation will decrease conflicts between providers, or increase threats to the community and the environment.

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Coral reefs are **30%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **effective.**

ICRAN

HOL CHAN MARINE RESERVE, BELIZE – ICRAN DEMONSTRATION SITE

The Hol Chan Marine Reserve (HCMR), established in 1987, is on Ambergris Caye 6 km south of San Pedro Town in northern Belize. The Reserve protects the reefs and commercially important species with a no-take zoning system, gear specifications, and exclusive recreational areas. HCMR is focused on Environmental Education Outreach and staff have participated in exchange programs with other sites; strengthening networking and collaboration among sites. Two members of HCMR staff have received Dive Instructor Training and a volunteer program has commenced with school children and community members currently being trained in marine life identification and coral reef monitoring (Reef Check Method, Box p 533). So far, HCMR has trained 13 individuals in SCUBA diving, coral reef ecology and marine life identification.

Educational programs have been established in 8 elementary schools and almost 200 students have received information on MPAs, and conservation issues. Local information has been gathered and an underwater photo bank has been successfully developed. A number of public education materials, including 3 brochures and 2 booklets, have been produced. HCMR organised "Reef Week" in 2004 which consisted of a night lecture with MPA Managers from other parts of the country and a day of educational fun on the beach with posters and other presentations for school children including glass bottom boat rides to the reef. A mangrove cleanup was also conducted, with 60 volunteers participating. Tourism has become the major income activity in Belize, but is associated with the over-fishing of lobster and conch, and developments involving dredging, cutting of mangroves, and pollution, damaging the very resources upon which it is dependent. Currently, courses which focus on HCMR rules and regulations and reef etiquette are being conducted for dive shops and tour operators.

Ecological Monitoring: Lobster and conch populations are monitored, and fish populations assessed using a visual census technique. Corals are monitored using CARICOMP methods (Box p 524). Data from the early 1990s showed coral cover was 20-40% in most areas, with a reduction in healthy patch reef due to bleaching in 1995. Since the establishment of HCMR, there has been an improvement in fish stocks, and monitoring enables management to demonstrate that the MPA is fulfilling its objectives when compared with adjacent areas. The current monitoring program aims to show fishers the spillover effect of increased fish, lobster and conch populations being available in nearby fishing areas, as well as to convince visitors and locals of the benefits of the MPA in hopes of stimulating plans to extend the reserve.

Socio-economic Monitoring: Visitor impacts are assessed by observing recreational divers for half an hour although this is not sufficient and more monitoring is needed.

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Coral reefs are **60%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **occasional.**

WHS

BELIZE BARRIER REEF RESERVE SYSTEM- WORLD HERITAGE SITE

The Belize Barrier Reef is the second largest reef in the world and the largest Atlantic reef system. The Belize Barrier Reef Reserve System (BBRRS) is a serial site comprised of 7 marine protected areas (Bacalar Chico National Park and Marine Reserve, and Laughing Bird Caye National Park, Half Moon Cay Natural Monument, Blue Hole Natural Monument, Glovers Reef Marine Reserve, South Water Cay Marine Reserve, Sapodilla Cayes Marine Reserve). The reef system includes fringing reefs along its mainland coast, the main barrier reef, 3 offshore atolls (Lighthouse Reef, Glovers Reef and Turneffe Atoll), and more than a thousand sandy and mangrove cayes. It contains a rich and diverse array of marine ecosystems with various habitats such as patch reefs, coastal lagoons, and estuaries.

The Belize Barrier Reef contributes approximately 30% of the country's Gross Domestic Product, through provision of commercial fisheries products such as conch and lobster, high quality eco-tourism, and private sector investments in coastal developments and aquaculture. The country's largest source of foreign exchange comes from tourism. The MPAs within the BBRRS all have management plans that include descriptions of permitted activities, monitoring and research programs, surveillance and enforcement plans, environmental education, and public awareness programs. The Fisheries and Forestry Departments are in charge of the day-to-day management of the sites but in some cases management is delegated to NGOs and local communities, with the government agencies providing support and assistance.

Despite its enormous economic value to Belize, the Barrier Reef is threatened by over-exploitation and degradation of reef resources by the fishing and tourist industries. The heavily visited reefs sites are showing signs of stress caused by over harvesting and damage from boat anchors. Other major disturbances are caused by hotel and marina construction, nutrient enrichment from agricultural plantation run-off, sewage pollution from expanding tourist resorts, residential and urban centres, and choking of corals by siltation from dredging for coastal fill and sand mining.

Ecological Monitoring: During the last 5 years regular monitoring of coral cover, algae, urchins and fish have been conducted.

Socio-economic Monitoring: Several training workshops have been conducted on socio-economic monitoring and management effectiveness of MPAs. Many MPAs have incorporated socioeconomic monitoring in their management plans and annual operational plans.

Contact: Leandra Cho-Ricketts, (lcricketts@btl.net)

Coral reefs are **40-50%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **planned.**

RAMSAR

CAYOS MISKITOS Y FRANJA COSTERA IMMEDIATA, NICARAGUA – RAMSAR SITE

This reserve is home to one of the largest seagrass beds in the Caribbean and supports several rare and endangered species including turtles, manatees, freshwater dolphins, otters, and sharks. The site is the only mangrove area of *Pelliciera rhizophora* on the Caribbean coast and many commercially important fish and crustacean species frequent the site. This reserve is located in the north-eastern part of Nicaragua and territorial jurisdiction resides with the Waspam Municipality, Puerto Cabezas y Prinzapolka. Over 85,000 hectares in area, this site consists of an offshore Caribbean island, shoals, and adjacent mainland coastal areas which support large coral formations and systems of small islands.

The 50,000 people living in the reserve are dependant on fishing and commercial forestry and use the site for firewood, timber, transportation and recreation. Erosion caused by logging and increased sedimentation has led to environmental degradation. An economic crisis and lack of alternative economic activities have lead to increased fishing, which further degrades the system. Tourism is commencing and the Association of Indigenous Women of the Costa Atlantica recently began a promising eco-tourism project focusing on training courses for local women.

Part of the site is communally owned, with the rest being owned by the state government. The site is a Marine Biological Reserve and has been declared a Protected Area by the President of Nicaragua. A management plan has been prepared but only small parts have been implemented. Bluefields Indian and Caribbean University is located within the site and promotes regional natural resource management.

Ecological Monitoring: Currently, no scientific research is taking place and no monitoring information was provided.

Socio-economic Monitoring: No information was provided.

Contact: Dirección General de Areas Protegidas del Marena, Km 12 Carretera Norte, Managua, Nicaragua (phone: 505 233 1278).

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **unknown.**
Socio-economic monitoring is **unknown.**

RAMSAR

PARQUE NACIONAL JEANNETTE KAWAS, HONDURAS – RAMSAR SITE

The park covers 78,150 hectares and is located in the Atlantida province near the city of Puerto de Tela. This site supports 374 species of marine plants and animals, including 51 coral and 151 mollusc species. Sea turtles, crocodiles, dolphins, and manatees are also found in the site along with many nationally and internationally rare or threatened fish species.

Anchors and fishing equipment damage the reefs although their effect is not as great as the increased sedimentation caused by commercial deforestation. Discharges of waste, chemical pollutants and a palm-oil extracting factory also jeopardize the reefs. Because the coral reefs of Honduras have suffered from natural disturbances as well as human impacts, they are in need of sound management. However, there are currently no government measures to alleviate the developments around the park. In 1996, a grant was awarded to strengthen capacity and to begin implementing a management plan. Training, awareness, and vigilance programs have begun, as well as other small community projects.

Ecological Monitoring: No information provided.

Socio-economic Monitoring: No information provided.

Contact: Secretaría de Estado en los Despachos de Recursos Naturales y Ambiente, Biodiversity Direction, Secretary of Minister, Tegucigalpa, Honduras (phone/fax: 504 235 4864).

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **unknown.**
Socio-economic monitoring is **unknown.**

REFUGIO DE VIDA SILVESTRE PUNTA IZOPO, HONDURAS – RAMSAR SITE

This site is located in the municipalities of Tela and Arizona in the department of Atlantida, east of Puerto de Tela. It covers an area of 11,200 hectares and contains remnants of the original humid tropical forest in unaltered pristine condition. Manatees and endangered turtle species are found in the reserve as well as crocodiles and 70 freshwater fish species, 2 of which are threatened with extinction.

Serious erosion problems exist in basins which drain the reserve. The resultant increase in sedimentation along with runoff of farming chemicals decreases water quality and threatens the coral reefs. In the surrounding area, the oil industry is another source of contamination and sedimentation in the reserve.

In 1994, a management plan was prepared as a first step in preserving the natural, cultural, historical and economic resources. An environmental impact assessment, ecotourism research, environmental education and community participation programs have been conducted. The increased awareness among local inhabitants about the benefits of these programs has led to more community participation in other activities. The management plan establishes specific steps for the development of the reserve, taking into account the national and regional context.

Ecological Monitoring: No information received.

Socio-economic Monitoring: No information received.

Contact: Secretaría de Estado en los Despachos de Recursos Naturales y Ambiente, Biodiversity Direction, Secretary of Minister, Tegucigalpa, Honduras (phone/fax: 504 235 4864).

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **unknown.**
Socio-economic monitoring is **unknown.**

19. Status of Coral Reefs in the French Caribbean Islands and other Islands of the Eastern Antilles

Claude Bouchon, Andre Miller, Yolande Bouchon-Navaro, Pedro Portillo and Max Louis

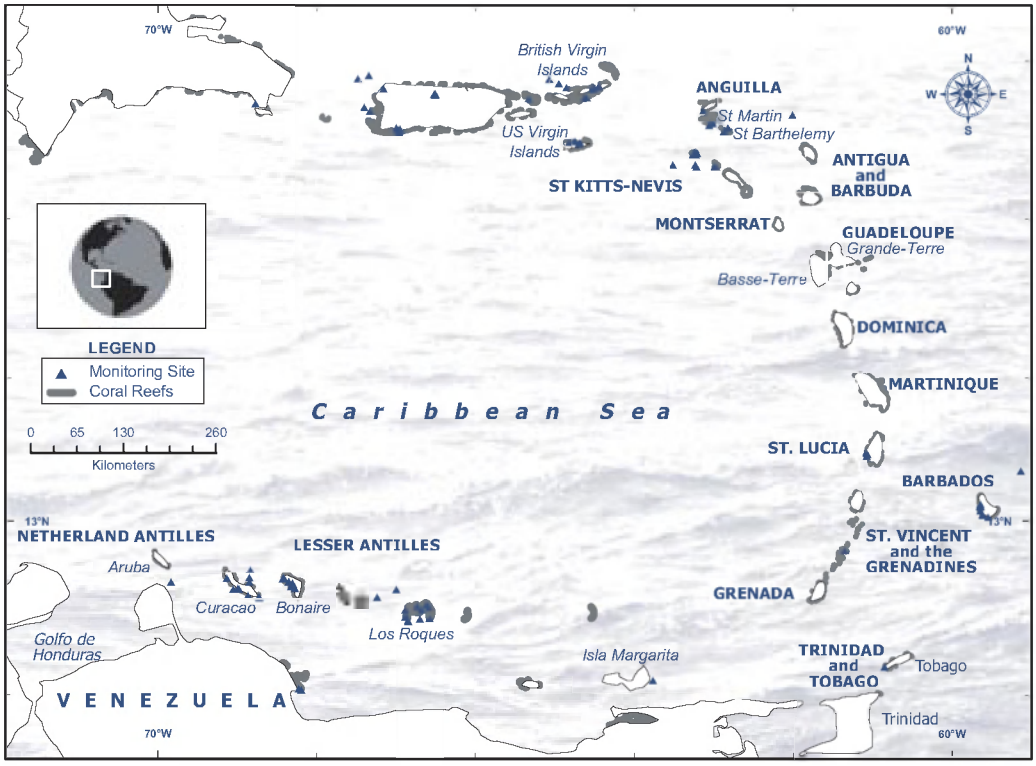
Abstract

The coral reefs surrounding the islands of the French West Indies and nearby islands have shown a slow, but progressive decline since the early 1980s. Recent surveys and mapping efforts of the coastal areas have confirmed that this phenomenon is applicable on most of the reefs of the area. This stimulated a long-term monitoring project at 10 sites in Guadeloupe in 1999 and Martinique in 2001. These sites are monitored twice a year in the dry and the rainy seasons, and 5 years of monitoring data of coral and fish communities do not show any obvious negative or positive trends. The reefs of these islands have faced a common set of threats: high rates of sedimentation due to deforestation and bad land management, which affect mainly the reefs in the enclosed bays; algal proliferation due to an overload of nutrients in the coastal waters from excessive use of fertilizers and poor wastewater treatment; and chronic over-fishing and harvesting of reef resources.

The UNEP Regional Coordinating Unit in Jamaica and the Barbados Coastal Zone Management Unit have supported the Reef Check Eastern Caribbean Project for fish and benthic monitoring on St Vincent, Grenada, Dominica, Antigua, St Kitts and Tobago. These were designed as rapid assessments of coral reefs, where there were no current data. The assessments were accompanied by considerable training of local fisheries and dive operator staff, along with the provision of basic monitoring equipment.

100 Years ago: Although there are no data, the reefs were presumably in a pristine state with healthy coral and fish populations. The small human populations were not exerting strong pressures on the resources, although some easy prey, like turtles, may have been depleted. The first scuba divers in the early 1950s, report that the reefs were pristine.

In 1994: The decline of the reefs that started in the 1980s continued on most islands, with increases in sediment and nutrient pollution on the reefs and clear examples of over-fishing taking out the key target species. Management was not particularly effective and most MPAs were not well managed.



Map courtesy of The WorldFish Center

In 2004: The situation is very similar to 1994, with a slow degradation in the areas of high sedimentation and nutrient input. Fortunately, the reefs of the French West Indies and nearby islands were not too severely impacted by coral bleaching in 1997 and 1998 and exhibited good recovery. There are more MPAs (4 marine reserves and 9 no-take zones) around the different French islands. Awareness is increasing in all sectors of the community, government and the tourist industry on the need for more coral reef management and monitoring.

Predictions for 2014: In spite of the existence of these protected areas, substantial efforts need to be made to control the main forms of pollution of the coastal waters. Without such efforts, the health of the reefs will continue to decline.

Note: This chapter contains reports on just some of the islands previously detailed in the Status of Coral Reefs of the World: 2002 report. No information was received from the other island states; readers are directed to the 2002 report for more information.

Introduction

The French West Indies

The French West Indies are in the Lesser Antilles between 14°20 and 18°00 N with: fringing coral reefs that border the coast; barrier reefs, separated from the coast by a lagoon; and non reef-building coral communities which are mainly on the Caribbean coasts and are often more diverse and flourishing than those of the Atlantic coast reef formations.

Martinique Island

Martinique is the most southern island of the French West Indies, and is approximately elliptical with a maximum elevation of 1,397 m. It is 65 km by 30 km and covers 1,075 km^2 with a 350 km coastline. **The Caribbean coast** of Martinique has rich coral communities, although on the northern end of the island, the particularly steep slopes and abundance of volcanic ash from the Montagne Pelée have inhibited coral growth on both Caribbean and **Atlantic coasts.** The 25 km Atlantic barrier reef is a mix of coralline algae and corals, and protects the shore where fringing reefs have developed on the rocky coasts, with mangroves in the bays. The **southern coast** of Martinique is very different from other parts of the island, as there is an almost continuous line of shoals between the Pointe du Diamant and Sainte-Luce growing on a wide 10 m deep platform, cut by valleys in front of the river mouths. The most active coral growth is on the outer edge of the platform to form reefs growing up to the surface or 'cayes', which resemble a barrier reef. There are extensive seagrass beds (4,000 ha) behind the barrier along with mangrove forests near the coast (1,850 ha).

Guadeloupe Archipelago

Guadeloupe is a large island approximately in the centre of the West Indies with 2 islands covering 1705 km^2: Basse Terre (848 km^2; 1,467 m highest point) and Grande Terre (590 km^2; 135 m highest point), separated by a narrow channel (La Rivière Salée). There is a barrier reef off the Grand Cul-de-Sac Marin 29 km long, which encloses an 11,000 ha lagoon with a maximum depth of 30 m. There are fringing reefs along the Atlantic coast of Basse-Terre, but only coral communities grow on the rocky seafloor on the Caribbean coast. However, these communities contain the highest biodiversity of the island, particularly around La Pointe Lézarde and Les îlets Pigeon. There is a discontinuous line of small fringing reefs on the southern coast of Grande-Terre, but there are almost no reefs on the northeast and northwest coasts, because the island ends as steep cliffs. There are also large areas of mangroves (3,000 ha) and seagrass beds (9,726 ha).

Marie-Galante (158 km^2) is 43 km south of Grande-Terre, and has a few poorly developed fringing reefs on the east, southeast and southern coasts of the island. Flourishing coral communities are found below 20 m on the west coast where seagrass beds are patchily distributed on sandy bottoms.

Les Iles des Saintes (13 km^2) has no coral reefs, but the rocky bottoms are colonized by corals and seagrasses on the sandy areas.

La Désirade (20 km^2) has some small fringing reefs in the south, and seagrasses grow but are limited by strong wave action.

Petite-Terre (1.7 km^2) has 2 islands surrounded by poorly developed fringing reefs.

Saint-Barthelemy and Saint-Martin Islands

The islands of Saint-Barthelemy and Saint-Martin are the most northern in the French West Indies. **Saint-Barthelemy** (21 km^2; 302 m highest point) is surrounded by numerous small islands. **Saint-Martin/Sint-Maarten** are respectively under French and Dutch control. The northern French part is 50 km^2 (highest point: 424 m). The fringing reef formations are poorly developed around these 2 islands, but the seagrass beds are very extensive on the shallow continental shelf, and mangroves are limited.

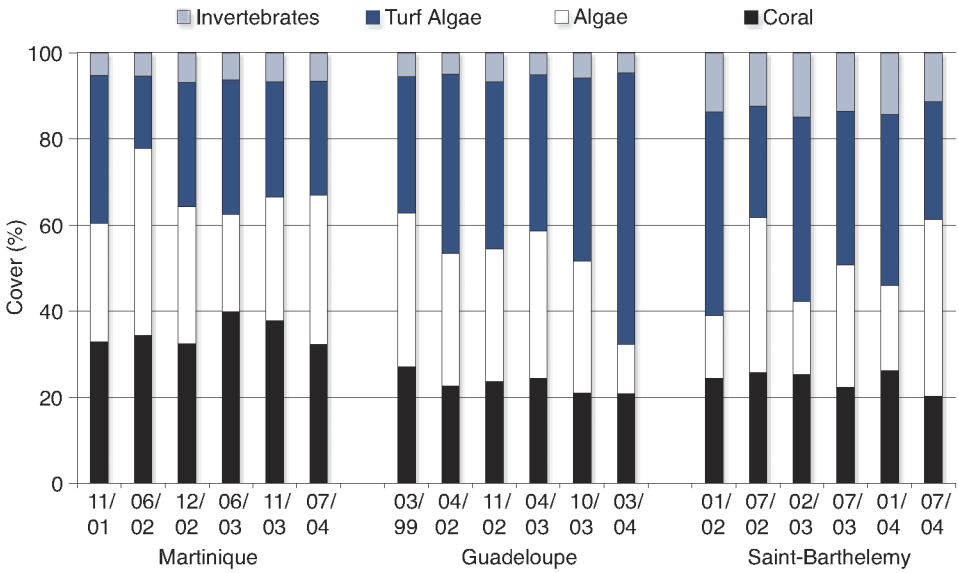
Status of Marine Ecosystems

The French West Indies

The consensus of many studies is that there has been a slow degradation of coral reef ecosystems in the West Indies, due largely to demographic and economic expansion on the islands. These small islands of the Antilles are particularly fragile, as most are mountainous with narrow shelves and often contain a high content of endemic marine flora and fauna.

There is very clear evidence of coastal ecosystem degradation throughout the French West Indies, not only of the coral reefs, but also of the seagrass beds and mangroves. Satellite mapping of Guadeloupe and Martinique show that only 15 to 20% of the reefs on both islands still have thriving coral growth. This has been confirmed by recent mapping, combined with underwater observations on Guadeloupe and Saint-Barthelemy. The live coral cover varied between 11 to 17 % on the reef flats, and 20 to 49 % on the outer slopes. At one site (îlets Pigeon) the cover declined from 46 % in 1995 to 26 % in 1999. Another alarming sign is that between 11% and 56 % of the coral colonies at one site had diseased tissues. The average rate of dead tissue fluctuates between 19% and 53% of the surface of the colonies. There have been similar observations on Martinique, with clear signals of reef decline since the 1980s.

Similar patterns of coral reef decline have been evident on the **Guadeloupe Archipelago** and on **Saint-Barthelemy** and **Saint-Martin** since the 1980s, with coral communities being progressively replaced by algal assemblages consisting mostly of *Sargassum* and *Turbinaria* on Atlantic coasts and *Dictyota* and *Lobophora* on Caribbean coasts. There are often short-lived algal blooms after Hurricanes have passed, due to a transient eutrophication of the coastal waters from massive



The cover of corals, macro-algae and other invertebrates has remained relatively stable in the 5 years of coral reef monitoring on the French islands. The monitoring, however, started after a series of destructive events (hurricanes, coral disease and some coral bleaching) reduced coral cover on many of these islands.

amounts of sediment and nutrients running off the land. The lagoons on the rainy Atlantic coast of Guadeloupe are particularly susceptible to heavy sedimentation pressures.

In **Martinique**, algal proliferation is a major factor contributing to the deterioration of the reefs. This was first evident on the Atlantic coast in the early 1980s, and spread to the Caribbean coast from 1984. Half of the land area of Martinique drains into Fort-de-France Bay that had the highest coral diversity on the island because it had a wide diversity of different habitats (reefs, seagrass beds, shoals, rocky shores). These communities in Fort-de-France Bay are polluted by urban wastes and high sediment loads such that the entire eastern part of the Bay is covered by silt and colonized only by seagrass beds. Industrial, urban and agricultural development continues with increasing levels of pollution. The prediction is that the coral communities in Fort-de-France Bay are doomed in the near future. A similar situation occurs in nearby Bay Du Marin. The same signals of algal proliferation in reef areas and high rates of sedimentation in lagoons and closed bays occur on other French Islands contributing to the degradation of the coral reefs.

Other Eastern Antilles Islands

Antigua: There are extensive shallow-reef systems on Antigua with some areas remote from the land between Long Island and Bird Island, where navigation is particularly difficult. Recent monitoring was a collaborative operation between the local dive operator, the Fisheries Division and the Reef Check team from Barbados. There are extensive *Acropora palmata* beds on top of most reef crests. During the last 6 years, 2 major hurricanes have passed over the island and these have detached many *A. palmata* colonies from the shallow areas and deposited some in the deeper areas, where there are many thriving colonies of the more robust corals *Diploria* sp, *Siderastrea siderea, M. annularis, P. asteroidea*. There were also many new coral recruits on the skeletons of the dead *A. palmata*. Macro-algal cover is relatively high, and probably linked more to a lack of adult algal grazers than to nutrient enrichment. The monitoring was insufficient to assess the condition of the reefs on Antigua and Barbuda, and there is a need to establish more monitoring sites; this will require a higher level of political will and more financial support.

There are no MPAs, but staff of the Fisheries Division are concerned about the lack of management and mechanisms to conserve the coral reef resources, especially the fisheries. The partnership between Dive Antigua and the Fisheries Division is effective in establishing some management. Dive tourism is increasing; however spearfishing is banned on the islands and is enforced by the coastguard and Fisheries staff. Antigua recently started a Reef Ball and coral transplantation project.

Dominica: Dominica has an impressive record in coral reef conservation for the region. Staff of the Soufriere-Scotts Head Marine Reserve and the Fisheries Division have been particularly active in conserving the reefs. The monitoring sites are in the MPA, where the Park staff negotiate carefully with fishers, requesting them to fish outside the park and use mooring buoys. Potential poachers know that they should not fish in the park, but the staff need more assistance to implement effective enforcement.

There are few well-defined offshore bank reefs, as the shelf can drop steeply within 30 m of the shore. The most productive coral reefs are within 250 m of the shore. The sites surveyed had high hard and soft coral abundance, very low algal cover, no observable diseases, no bleaching,

and no anchor damage because the mooring buoys are in place. These sites are typical of the Dominican reefs. Sediments from heavy rains have smothered some reefs on the southern coast nears Scotts Head. The low algal cover is probably linked to high populations of *Diadema* and parrotfish/doctorfish (algal grazers) and there are some large groupers, which is rare for the Caribbean. The commercial diver operators collaborate with the Fisheries Division and assist in patrols and monitoring.

Grenada: The monitoring sites are close to Grand Anse, which is the tourist capital. There is evidence of significant damage from Hurricane Lenny (and damage from recent Hurricane Ivan is suspected) at many shallow offshore bank and patch reefs, where large stands of *Acropora palmata* have fallen and are breaking up. This was also evident on the north of the island. Carriacou and Sandy Island lost a very high percentage of branching corals in last 5-7 years due to storms. Grenada has extensive shallow banks that are covered with large robust corals (*Siderastrea, Montastrea*). The deeper, low profile reefs are, however, quite healthy; algal cover appears to be very seasonal and not strongly linked to eutrophication as considerable growth of macro-algae was observed off uninhabited islands. Parrotfish abundance is quite healthy, however most fish are small, and *Diadema* are predominantly found in deeper areas.

The best reefs in Grenada are off the north coast with some healthy, large, dense stands of *A. palmata*; however these may not have survived Hurricane Ivan. Several offshore bank reefs have large populations of reef fish and lobsters; these do not appear to have been fished. A series of wrecks off Grenada diverts some of the diver damage away from the coral reefs. Most of the conservation work is done by private dive operations, with some involvement of St Georges University.

St Kitts and Nevis: St Kitts has fringing reefs, offshore bank reefs, like Ponds Bar, and near vertical walls similar to those on Dominica, but not as steep. Monitoring was restricted to the leeward side of island, where fish populations of both predatory and grazing species were relatively high. However *Diadema* populations were relatively low. The Kenneth Dive Centre has maintained observations of fish abundance for 30 years and report a significant decline, although the numbers are comparable with other Caribbean islands. Dive tourism is not well developed; however live aboard boat tourism from other islands visit the good diving sites off Brimstone Hill, where there are populations of large fish. Nevis Island has proportionally more dive sites, but was not monitored. The Chief Fisheries Officer is a dive master, which increases the awareness in the government of the status of the resources, however, there are limited budgets for coral monitoring. This is the case for many of the small island states, where monitoring is considered as a novelty. The Fisheries Department and the dive operator are cooperating on conservation projects, including installing artificial reefs.

St Vincent and Grenadines

The 'ole timers' readily confirm that fish populations, especially in the south of the island, have decreased dramatically since 1950s. Three monitoring sites were assessed within 8 km of the capital; 2 sites were reported by locals to be indicative of the other reefs. There was relatively high coral abundance, which ended at the sharp drop-off. There are large areas (100s of metres) dominated by the branching *Madracis mirabilis*. There are also healthy populations of *Diadema* sea urchins and the 'West Indian sea egg', which is not consumed locally. The high abundance of Diadema and parrotfish probably accounts for the low algal cover and high coral abundance at some sites. The west coast has numerous bays with extensive coral growth on the headlands.

Despite the perceived decrease in fish catches, large schooling predator fishes were observed in deeper water at the base of the reef. Coral diseases were minimal and restricted to black spot disease, and bleaching was absent at all sites monitored. The Fisheries Department and the Caribbean Regional Fisheries Mechanism Secretariat are active in fisheries management, and are continuously monitoring fish catches. Their staff took part in the Reef Check training, and it is anticipated that they will continue to monitor the reefs. The only MPA is on Tobago Keys (middle of the Grenadines), and is relative inaccessible to poachers; therefore it is anticipated to have healthy fish populations. The lobster fishery is tightly managed with closed seasons and good compliance, whereas fishing pressure is heavy in most other areas.

Marine Protected Areas

Guadeloupe

The **Grand Cul-de-Sac Marin Natural Reserve** in Guadeloupe was created in 1987 to enclose 2,115 ha of territorial waters and 1,622 ha of forested lands. In 1993, the reserve was designated as a Ramsar wetland site of international importance and was also declared as a Man and Biosphere reserve. This natural reserve includes coral reefs, seagrass beds and mangroves areas, and is managed by Guadeloupe's National Park.

Petite-Terre: the Natural Reserve of the Islands of Petite-Terre was created in September 1998, covering 990 ha of land and waters to 10 m depth. It is managed by the ONF (Office National des Forêts).

Les îlets Pigeon: this is currently a no-take zone, where both commercial and sport fishing are prohibited and more formal designation as a reserve is planned.

Saint-Barthelemy: a Natural Marine Reserve was created in 1996 to cover 1,200 ha of ocean, excluding the small islands. Management of the reserve is through a non-profit association, including the municipality, the public users and a few private individuals.

Saint-Martin: a marine and terrestrial reserve of 3,060 ha was created in September 1998 on the northeast of Saint-Martin. The area includes coastal reefs and lagoons and is also managed by a non-profit association.

Martinique

There are no permanent marine reserves in Martinique, but 8 temporary no-take zones exist where commercial and recreational fishing is prohibited. They were originally created for 5 years, but have not been reopened and management is by the Direction des Affaires Maritimes of Martinique.

Resource Use

The population in **Guadeloupe, Martinique, Saint-Barthelemy** and **Saint-Martin** was 830,000 people in 1999, with an average density of 290 inhabitants per km^2. Of these, there were 2,200 registered fishermen. Fishing on **Guadeloupe** is predominantly artisanal, with 1,200 registered fishermen using 947 boats (mostly small-scale fishing from 6 to 8 m open boats, with only 10 vessels equipped for offshore fishing). There are probably 1,000 unregistered fishermen. About 8,800 tons of fish and 650 tons of crustaceans and shellfish are caught annually by these fishermen. A small benthic fishery contributes about 5,200 tons annually and imports (from

The known biodiversity on the reefs in the French West Indies. The source of the information is in the 1999 reference of Bouchon et al. at the end of the chapter.

Major Group	# of Species	Location
Algae	90	Guadeloupe
Phanerogams	6	Martinique/Guadeloupe
Sponges	73	St-Barthelemy/St-Martin
	70	Martinique
	42	Guadeloupe
Gorgonians	35	Martinique
	66	Guadeloupe
Corals	52	Guadeloupe
	45	Martinique
	47	St-Barthelemy/St-Martin
Annelids	33	French West Indies
Molluscs	570	Guadeloupe
	370	Martinique
	179	St-Barthelemy
	166	St-Martin
Crustaceans	60	French West Indies
Ascidians	93	French West Indies
Fish	400	French West Indies
Turtles	5	French West Indies

Venezuela, Europe, French Guiana etc.) make up more than 40 % of the estimated demand of 15,800 tons.

Fishing on **Martinique** is traditionally artisanal. In 2002, there were 1,052 registered fishermen, including 949 involved in coastal fishing. More importantly there are many unregistered fishermen, who could bring the total fishing population to 2,500. The fishing fleet consists of 914 boats with 98% being open boats averaging 7 m. The total fish catch was about 5,500 tons between 1991 and 1993, with pelagic species contributing 3,500 tons. However, no fishery data have been collected since 1993, so recent trends are unknown. It is probable that pelagic fish catches have increased with the recent development of anchored fish aggregation devices. All fish products are sold fresh in Martinique, but are not sufficient to satisfy the great seafood demand, so 7,000 tons of seafood are imported.

Tourism is a major industry in Guadeloupe with 623,000 tourists visiting in 2000. Hotel capacity is over 8,500 rooms, supplemented by other forms of accommodation including rural cottages. There were 736,000 visitors to Martinique in 2002 making tourism 10 % of the GDP;

this is a growth of 3 times in 15 years. Hotel room capacity is 4,900 with an additional 335 rural cottages. The major marine tourist activities are: glass-bottomed boats, kayaks, water skiing, surfing, sailboat rentals, sport fishing and especially scuba diving. There are 40 scuba diving clubs in Guadeloupe and similar numbers in Martinique. Most diving is on the Caribbean coast e.g. there are 80,000 divers annually around Les îlets Pigeon.

There are 2 marine research centres in the French West Indies: the Station Marine du Robert de l'IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) in Martinique, specialising in aquaculture and fisheries research; and the Laboratory of Marine Biology, Université Antilles-Guyane in Guadeloupe, devoted to tropical marine ecology.

Long-term Monitoring Sites

Long-term quantitative monitoring of corals and fish fauna is undertaken twice a year, during the dry and the rainy season at 10 coral reef sites in Martinique, Guadeloupe and Saint-Barthelemy. These sites were chosen to include all major habitats and include marine reserves and areas where fishing is permitted. More sites will be added to develop a network of sites to include Saint-Martin and Petite-Terre.

Coral cover varies between 32 - 40% in Martinique, 21 - 24% in Guadeloupe and 20 - 26% in Saint-Barthelemy. Algal turf is the most important component of the benthic community, and there are also extensive areas covered by brown macro-algae, which can be an indicator of organic or nutrient pollution of the environment. These data show neither a negative nor a positive trend over these 5 years. The most important changes have been in the amount of brown macro-algae, which appear to be controlled by inputs of nutrients from the land as well as seasonal temperature changes and wave action. The cover of brown macro-algae on Saint-Barthelemy has regularly increased since the start of monitoring survey in parallel with increases in dead coral cover, which has varied between 17 % and 46 %. There is a direct correspondence between dead coral and proximity to and amount of pollution source; but there is no clear trend. The recruitment of juvenile corals fluctuates between 0.4 and 2 per m^2, and similarly there is no obvious trend seen in the 5 years of monitoring.

The average number of fish species in 600 m^2 areas varies from 45 species in Guadeloupe, to 46 in Martinique, and 48 in Saint-Barthelemy. The average fish biomass is also very similar in these sites: Saint-Barthelemy 751 kg ha^{-1}; Martinique, 788 kg ha^{-1}; Guadeloupe: 807 kg ha^{-1}. There appears to be no specific trends in the fish communities, although there are seasonal variations of fish biomass on Saint-Barthelemy.

Stress and Damage to Corals Reefs

Sediments and Nutrients

There are high levels of rainfall in the French West Indies, which result in considerable erosion of deforested lands on Guadeloupe and Martinique. This began in the 17th century for agriculture, and is now compounded by injudicious coastal development, which all add to the input of sediments and nutrients into the marine environment. In addition, there is inappropriate use of fertilizers and poor wastewater treatment. Mangrove forests were destroyed throughout the 20th century, thereby removing these mechanisms for natural filtration of sediments and nutrients for the coral reefs. This has resulted in a deterioration

of coastal water clarity and high rate of sediment accumulation inside the bays and lagoons. There has been a parallel deterioration of coral reef communities due to intense macro-algal competition linked to nutrient overload. There has been a progressive invasion of reefs by algae in Guadeloupe since the beginning of the 1980s, predominantly by *Sargassum* and *Turbinaria* on the exposed outer slopes on the Atlantic coasts, and by *Dictyota* on more sheltered areas in lagoons and reefs on the Caribbean coasts. The corals on the islands of Saint-Martin and Saint-Barthelemy have also been colonized by *Dictyota*, which compete actively for space with corals and other benthic animals. *Turbinaria* and *Sargassum* are very resistant to Hurricane wave action, whereas *Dictyota* are removed by each passing Hurricane. However, they recolonise the reefs rapidly after the storms, including the coral areas devastated by the waves.

Damaging Fishing Methods

Techniques used in commercial fisheries vary widely, with some being very destructive, both to habitats and to fish stocks. Caribbean trap nets are particularly damaging, as individual fisherman may have up to 150 traps. They also use gill nets, trammel nets and seine nets.

Coral Bleaching

Coral bleaching generally occurs in the West Indies when water temperatures exceed 30°C for long periods. Bleaching is observed on some corals almost every year during September. In 1984 and 1987, a long-term elevation in surface water temperature caused mortality among certain species on the French islands. This was linked to the El Niño phenomenon, which also affected Indo-Pacific reefs in those years. These bleaching events had minimal effects on the reefs in the French West Indies. The first significant bleaching episode occurred in September and October 1998, when the sea surface temperature exceeded 29°C over several weeks. There was large-scale bleaching of corals (Scleractinians and Hydrocorals) and also other symbiotic animals such as Actinarians, Zoantharians and some Gorgonians. In Martinique, 59% of coral colonies bleached, with an average of 69% of tissues being bleached. There was similar bleaching in Guadeloupe, with 56% of corals affected and 80% of tissue area bleached. However, there was little mortality compared to other regions in the Caribbean over the next year, with tissue death in 20 to 30% of coral colonies, with the exception being *Diploria labyrinthiformis,* where mortality reached 80%. In September 1999, there was another bleaching episode confined to reefs in the Guadeloupe Archipelago, which affected almost 50% of the corals, but the Hurricane Lenny which followed, cooled the waters and reversed the bleaching. There has been no significant coral bleaching in the French West Indies since 1999.

Hurricanes

The French West Indies are affected by major Hurricanes every 10 years on average, which cause serious damage to the coastal ecosystems. There have been 4 recent Hurricanes: Hugo (1989) hit Guadeloupe; and Hurricanes Luis and Marilyn (1995) and Lenny (1999) hit Saint-Barthelemy and Saint-Martin very hard and also caused damage in Guadeloupe. The coral reefs of Martinique suffered significant damage after the passing of Hurricanes David in 1978 and Allen in 1980. Tropical storms are usually accompanied by torrential rains, resulting in massive runoff of sediments and nutrients to the nearshore reefs. Hurricane waves are the principal factor limiting coral reef growth in the Eastern Antilles. Hurricane Hugo smashed branching corals on the outer reef slopes down to 15 m (*Acropora palmata, A. cervicornis, Madracis mirabilis*), and there was delayed coral mortality in all species during the following months. The *Acropora palmata* populations never re-established themselves. After Hugo however, *Madracis mirabilis* quickly recolonised the area. Hurricanes Luis, Marilyn and Lenny damaged Guadeloupe's coral reefs even more severely than Hugo, mainly through large waves

up to 13 m high, which destroyed corals, sponges and gorgonians to depths of 25 m on the reefs. This was compounded by torrential rains and major soil erosion. There have been a few signs of recolonisation of *Acropora palmata*, which was the most common coral species on the outer reef slopes. On Saint-Martin and Saint-Barthelemy, hurricane Luis caused direct damage to the coral reefs, but the most significant impact was the disturbance of sediments on the shallow continental shelf. Fine particles remained in suspension for several months and smothered many organisms. Hurricanes David and Allen also damaged the *Acropora palmata* and *A. cervicornis* populations on the upper reef flat of Martinique, especially in the Sainte-Luce region. These populations have never re-established themselves, even though there has been no major Hurricane damage on Martinique since then.

Potential Threats To Coral Reefs

The major natural and human factors threatening the coral reefs are summarised in the Table below. Two threats stand out: macro-algal proliferation in all the reef habitats; and high rates of sedimentation, especially in the bays and lagoons.

The summary of potential threats to the coral reefs of the French West Indies as assessed by local scientists and resource managers. These are probably the same level of threats applicable for other island states in the Eastern Caribbean. These show that the major threats are sediment and organic pollution from land-based activities, followed by over-fishing and coral bleaching.

Threat	Martinique	Guadeloupe	St-Barthelemy	St-Martin
Hurricanes	3	3	3	3
Coral bleaching	3	3	3	3
Algal proliferation	4	4	3	3
Organic pollution	4	4	4	4
Chemical pollution (pesticides)	4	4	1	1
Fertilisers	4	4	0	0
Hydrocarbon pollution	1	1	1	1
Sediment run-off	4	4	4	4
Land reclamation and dredging	3	3	1	4
Overfishing	4	4	1	3
Tourism impact	2	2	3	3

Risk : 0 = no threat; 1 = low; 2 = average; 3 = important; 4 = major threat.

Conclusions and Recommendations

Mapping surveys of the coral reefs in the French West Indies Islands have shown that anthropogenic pressures have affected most of them. These pressures have mainly developed since the 1980s, nevertheless the 5 years of monitoring were initiated after most of the damage and have not shown any subsequent decline in the composition of the corals and fish communities. The major steps for the reestablishment of healthy reef systems depend on creating suitable environmental conditions by effectively treating sewage and other wastewater and controlling land erosion.

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Significant Organisations in the French Caribbean

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ICRAN

BONAIRE NATIONAL MARINE PARK, NETHERLANDS ANTILLES – ICRAN DEMONSTRATION SITE

The Bonaire National Marine Park (BNMP), 100 km north of Venezuela, was established in 1979 and now has comprehensive legislation covering 27 km^2 of coral reefs, seagrass beds, and mangrove-lined bays. Over 390 fish species have been identified in the park. An annual fee for SCUBA divers (US$10 per annum) is used for park maintenance, to provide information and education, research and monitoring programs, and for law enforcement activities. Despite initial concerns from the dive industry, the admission-fee system has been successful and within a year the marine park was entirely self-supporting. Coral-friendly diving ethics have been promoted and dive operators support the park by collecting fees and providing compulsory orientations and check-out dives, leading to a high level of compliance with rules and regulations. Unfortunately, the marine park is currently financially challenged by expansion to include Klein Bonaire, requiring increases in staffing levels, as well as inflation and a general unwillingness to consider other funding options. These problems complicate the close partnership with the dive and tourism industry but recently progress has been made with alternative financing systems. There is a successful public-private partnership with the local marina to collect visitors mooring fees, and an annual fee for private boat moorings. Establishing a donor base and the promotion of souvenir sales have not proved viable, but plans for a fee for all visitors to Bonaire are underway.

Ecological Monitoring: Although still considered some of the best reefs in the Caribbean, monitoring has revealed a steady decline in coral cover and diversity related to competition from algae, repeated bleaching events, coral disease, and substantial increases in tourism and associated development within the coastal zone. Reef Check monitoring is conducted annually and mangrove and seagrass studies have been undertaken. Fish stocks are now facing collapse and plans are underway for no-take marine reserves.

Socio-economic Monitoring: Dive site visitation data are collected from the dive operators on a monthly basis. The number of yachts and dive operators and fishermen using the park is monitored. Studies have also been undertaken to assess the reasons for success of diver 'willingness to pay' and in particular the carrying capacity and economic impact of the MPA. Some dive sites were found to be at or beyond capacity in 1991. A full time Nature and Environment officer works to increase public awareness, and islanders are soon to be surveyed on perceptions of turtle conservation.

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Coral reefs are **85%** of the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **occasional.**

ICRAN

SOUFRIERE MARINE MANAGEMENT AREA, ST. LUCIA – ICRAN SITE

The Soufriere Marine Management Area (SMMA) extends along the Southwest coast of Saint Lucia, in the Eastern Caribbean. The site is managed by the Soufriere Marine Management Association, a non-profit stakeholder company. The SMMA is valuable for scientific study, improved the status of coral reefs and fish stocks in the marine reserves, and increased fishers catches. Initially however, a decline in fish catches, a lack of human and financial resources, inadequate legislation/enforcement and representational deficiencies resulted in misunderstandings and infringements of SMMA regulations. A Technical Advisory Committee comprising government organisations, NGOs, community members, and resource users was formed to address these concerns. An intense consultative and participatory review resulted in a more effective management structure with a stronger legal basis, clearly defined roles for all contractual parties and an evaluation process. As a result, conflicts have reduced among users, as their ownership and commitment to the initiative increased.

Under the new arrangement, the SMMA mission is 'to contribute to national and local development, particularly in the fisheries and tourism sectors, through the management of the Soufriere coastal zone, based on the principles of sustainable use, cooperation among resource users, institutional collaboration, active and enlightened local participation, and equitable sharing of benefits and responsibilities among stakeholders'. User fees have made the reserve effectively self-financed. Furthermore, the government of St Lucia and donor organisations have improved infrastructure and training for the fishers, and established an investment fund. School visits to the site are increasing as a result of presentations and a newsletter and documentary were produced to show the impacts of terrestrial activities on marine resources. Alongside 5 Public Service Announcements, beach clean ups are well attended, with less garbage documented than in previous years.

Ecological Monitoring: The SMMA and other organisations monitor coral reefs, fish landings and levels of salinity, turbidity and sedimentation. Monitoring is particularly important as storms have resulted in up to 50% coral death, a problem exacerbated by alteration of the river course. There are now attempts to manage the catchment areas to prevent rapid runoff of sediments. Studies have shown a spillover of larvae to areas outside of the reserve as well as increased fish densities inside the reserve. Fish catches outside the reserve have almost doubled, and the species richness has also increased.

Socio-economic Monitoring: The increased fish stocks benefit tourism, and the fishers, who lost prime fishing grounds during establishment of the SMMA.

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Coral reefs are **20%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **occasional.**

MAB RAMSAR

ARCHIPEL DE LA GUADELOUPE, FRANCE – MAN AND THE BIOSPHERE RESERVE

The French Archipel de la Guadeloupe in the eastern Caribbean, includes the islands of St. Barthélemy, St. Martin, Les Saintes, La Désirade, Marie-Galante and Guadeloupe itself. The archipelago contains three marine reserves, one located in Saint-Barthelemy, and two in Guadeloupe (Petite-Terre and Grand Cul-de-Sac Marin). Its coastal areas have rich mangrove forests, wetlands and coral reefs, while inland there are dense tropical forests. More than 52 coral species, 59 crustacean species, 157 species of molluscs and more than 250 species of fishes have been identified inside the reserve. This site is a tourist destination throughout the year; over 10,000 visitors annually come to the marine reserve, mostly on weekends and holidays. The Guadeloupe National Park Authority is responsible for managing the Grand Cul-de-Sac Marin marine reserve and it also initiates and funds various scientific studies. The management plan was inititated in 1998 and focuses on maintaining biodiversity and good water quality. The marine reserve is divided into different zones, each with its own specific objectives.

There are several unions for fishermen in Guadeloupe involved in solving problems related to the use and management of marine resources. Monitoring of coral and fish populations is carried out by the Université des Antilles et Guyane and a variety of other organizations conduct research in this area. Current research topics have focused on coral reef ecology, cyclone impacts on mangroves, and distinguishing human effects from natural fluctuations. Reintroduction of manatees is an additional challenge for the marine reserve. Educational booklets and movies are available and school visits can be organised. Hurricanes, water pollution, land runoff and damage (anchor, construction, deforestation) are the main threats.

Ecological Monitoring: Three coral reef sites are monitored in the Grand Cul-de-Sac Marin on a long-term basis by the Marine Laboratory of the University des Antilles et de la Guyane.

Socio-economic Monitoring: No monitoring takes place.

Coral reefs are **20%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **not planned.**

20. Southern Tropical America: Coral Reef Status and Consolidation as GCRMN Regional Node

Jaime Garzón-ferreira, Jorge Cortés, Aldo Croquer, Héctor Guzmán, Zelinda Leao and Alberto Rodríguez-Ramírez

Abstract

Since the end of 1999, 5 countries (Brazil, Colombia, Costa Rica, Panamá and Venezuela) have cooperated to develop coral reef monitoring in Southern Tropical America (STA) under the framework of the Global Coral Reef Monitoring Network (GCRMN) with the support of the Regional Coordinating Unit for the Caribbean of the United Nations Environment Program (UNEP-RCU/CAR) and the coordination of the Institute for Marine and Coastal Research (INVEMAR, Colombia). The STA region includes reefs in Pacific, Caribbean and Atlantic waters, with most being strongly influenced by continental runoff containing large amounts of sediments and high concentrations of nutrients flowing out of some of the largest rivers in the world; the Amazon, Orinoco and Magdalena rivers. Cold-water upwellings along the Pacific coasts of Panama and Colombia, and off eastern Venezuela also reduce reef growth. The reefs in Brazil are far removed from those in the Caribbean and hence contain a high proportion of endemic species. The coral reefs are less developed with fewer coral species on the Pacific side, with the best reefs on the Costa Rica-Panama coast.

Reef biodiversity in STA is comparable to that in many larger parts of the Caribbean to the north with the reefs being economically important for supplying food and as the basis of a strongly developing tourism industry. This summary report is focussed on the most relevant actions and agreements in the development of the STA-GCRMN regional node during the last 4 years, together with a short update of the status of the coral reefs in the region. The Node participants made an agreement to produce a detailed status report every 4 years, with the next one due in time for the global status report in 2006. Most of the information, conclusions and recommendations relating to the status and conservation of coral reefs in the STA region published in the Status of Coral Reefs of the World: 2002 report, are still valid.

Status of Coral Reefs in 2002-2003

Most coral reefs in the region have undergone major changes in the last 30 years, but particularly during the 1980s. There have been considerable losses of live coral cover in many

Map courtesy of The WorldFish Center

reef areas, while algae have become dominant. Nevertheless, high coral cover can still be found at numerous reef locations on both the Caribbean (means between 20-40%) and Pacific (means above 40%) coasts. Some of these negative changes have been caused by natural agents (El Niño Southern Oscillation events, bleaching, disease outbreaks, phytoplankton blooms), but others are clearly related to human pressures such as deforestation, increased sedimentation, coastal development, sewage pollution and overfishing. The 1997-98 El Niño coral bleaching event had little effect on reefs of the region.

Data on the status of reef fish populations are extremely scarce in the region, however the general consensus is that fish communities have been altered markedly and populations of important commercial species are severely depleted. Recent data from 2003 from some Caribbean localities of Colombia and Venezuela show that densities of target fishes such as snappers or groupers were very low at 0-3 fish per $60m^2$, while the damselfishes were very abundant at 10-49 fish per $60m^2$.

Monitoring data from the 5 countries suggest that reefs of the STA region have not undergone noticeable changes or damages between 2002 and 2003. In the Caribbean-Atlantic reef areas, average live coral cover ranged between 1.4 - 50.3%, while algal cover ranged from 31 - 75%. Pacific reefs showed coral cover between 0.2 - 74.3% and algal cover between 17.3 - 85.7%. In Colombia, the incidence of coral diseases has been monitored between 1998 and 2003 and continues to be below 5% in all areas, except in the Caribbean locality of San Andrés in 1999 (9.1%) and 2001 (6.3%). Dark spots and white plague continue as the most frequent coral diseases in the Caribbean region.

The live coral and algal cover measured during monitoring in 2002-2003 show wide ranges on Pacific and Caribbean/Atlantic reefs.

Region	Reef areas	Coral cover	Algal cover
Costa Rica - Caribbean	2	8-26%	62-75%
Colombia - Caribbean	7	9-43%	31-52%
Venezuela - Caribbean	3	1-50%	32-55%
Brazil - Atlantic	3	8-26%	-
Costa Rica - Pacific	2	0-37%	31-86%
Panama - Pacific	6	2-54%	7-98%
Colombia - Pacific	3	50-74%	17-36%

Actions to Consolidate the Node

Between 2000-2003 the following actions have contributed to significant progress in the consolidation of the STA-GCRMN Regional Node:

- A study of the capacity and needs for reef monitoring in the region;
- Establishment and signing of formal agreements between INVEMAR and participating institutions from the other countries (CIMAR from Costa Rica, STRI from Panamá, INTECMAR from Venezuela and CPGG/FUBA from Brazil);
- Support of monitoring activities during 2000, 2002 and 2003 in Colombia, Costa Rica, Panamá and Venezuela;
- Expansion of monitoring programs in all countries;
- Workshops of national coordinators in 2000 (Costa Rica) and 2002 (Colombia);
- Preparation of national and regional reef status reports as a contribution to the GCRMN global reports published in 2000 and 2002;
- Production of a strategic plan for the future development of the Node for the period 2004-2013;
- Production of a 5-year project proposal for sustaining the Node in the mid-term; and
- Strengthening the 'National Reef Monitoring System of Colombia' (SIMAC) as a model for other countries in the region.

Based on discussions during regional workshops, the following objectives have been agreed on guide the Node activities:

- Contribute to the organization and continuity of the Global Coral Reef Monitoring Network (GCRMN);
- Promote the development of coral reef monitoring in Southern Tropical America (STA);
- Develop cooperative research and monitoring activities among countries of STA, to standardise monitoring methodology, and integrate data analysis;
- Analyse all available information every 4 years and produce a diagnostic report on the status of coral reefs in STA as a contribution to coral reef management in the region and for the Status of Coral Reefs of the World reports; and
- Contribute data and information to ReefBase.

The following are the proposed objectives of the strategic plan for the STA Node development in the next ten years (2004-2013):

- Obtain and disseminate information about the status and changes in coral reefs from at least 4 reef areas of each STA country over a 10 year period;
- Enlarge the Node coverage by including all countries of the region with reefs and increase the number of monitoring localities in each country;
- Standardise the methodology and adjust monitoring programs in the region to assist in coral reef management and conservation, to include additions to the current protocols; and
- Contribute to the education of different community sectors so that they appreciate the value of their coral reefs and contribute to the conservation of reefs and associated ecosystems.

Acknowledgements

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ABROLHOS BANK, BRAZIL

The Abrolhos reefs are some of the most significant coral reefs of Brazil; therefore they have special conservation values. Three programs to promote the conservation of the Abrolhos reefs have started under leadership from Conservation International.

Management and Monitoring of the Corumbau Marine Extractive Reserve: A two-year project started in 2003 to strengthen participatory management by the fishing community of the Corumbau Marine Extractive Reserve with the following aims:

1. strengthen and organise traditional fishing communities to manage the Reserve;
2. implement a resource use plan and monitor the biodiversity and socio-economics of this reserve and adjacent areas; and
3. seek sustainable alternatives to the use of natural resources. Conservation International (CI) - Brazil and partners, with funding from the National Environmental Fund (Fundo Nacional do Meio Ambiente), hope to make the Corumbau reserve a model for other coastal and marine reserves in Brazil.

Exclusion of Oil and Gas Exploration: A campaign to exclude sensitive areas of the Abrolhos reefs from oil and gas exploration was successful in 2003. The National Oil Agency (Agência Nacional do Petróleo) opened bids for the 5th round of an international auction for natural gas and oil exploration in Brazil in 2002, offering 1,070 blocks (192,135 km^2) of coastline, including 243 blocks within Abrolhos Bank and Royal Charlotte Banks. The Center for Biodiversity Conservation of Conservation International - Brazil took up the challenge to conserve the Banks from oil industry damage. They reviewed the potential effects of the different phases of oil and gas exploration and production on the reefs and associated economic activities such as fishing and tourism. These data were added to the major findings of the 'Priority Setting Workshop for Marine and Coastal Areas' conducted by the Environmental Ministry and CI-Brazil. A map of environmental sensitivity to exploration was generated, illustrating the most sensitive areas potentially at risk from exploration. Specific areas for conservation were proposed in a document: 'Evaluation of Impact of Exploration and Production of Hydro-Carbons in Abrolhos Bank and Surrounding Areas'. This was supported by a major publicity campaign targeted at the relevant government ministries and the industry. In August 2003, the Federal Official Press published the National Oil Agency decision to exclude 162 of the 243 blocks considered to be environmentally sensitive and at risk of damage from oil industry activities. A federal judge subsequently declared that all remaining blocks within a 50 km radius of Abrolhos Bank were excluded from present and future plans for oil exploration.

Surveying the Twilight Zone of Abrolhos Reefs: The Abrolhos Banks include extensive offshore algal reefs of 30 to 80 m depth, as well as 'twilight zone reefs' between 80 and 110 m. However, these habitats are unrecognized and unprotected, mainly because they are poorly known. The CI-Brazil Marine Program and the Global Conservation Fund is working to expand the network of MPAs on Abrolhos Bank to include these biodiversity 'hotspots'. A group of scientists, deep diving specialists and photographers surveyed these deep habitats to 100 m. They recorded 7 fish species which were new

to the region, observed impressive coral growth at 63 m depth, and reported the first sighting of an ocean sunfish in Brazil. They also observed deep depressions surrounded by an outstanding abundance of marine life which they believed warranted further study. Contacts: Guilherme Dutra, g.dutra@conservation.org.br and Rodrigo Moura, r.moura@conservation.org.br

WHS RAMSAR

COCOS ISLAND NATIONAL PARK, COSTA RICA - WORLD HERITAGE SITE

Situated 550 km off the southwest coast of Costa Rica, Cocos Island provides critical habitat for marine wildlife, particularly large pelagic fish and sharks, and is one of the most diverse regions in the Eastern Pacific. The park includes the main island and 10 nearby offshore islets and occupies 24 km^2. The underwater habitat consists of a shallow fringing reef falling off abruptly to a submerged trench of several hundred metres. There are 32 coral species, with 9 in deep water, and over 260 fish species in the park. Cocos Island also plays an important role in the distribution of marine larvae, as well as hosting marine mammals such as the bottle-nosed dolphin and the Californian sea lion.

Cocos Island National Park was declared in 1978, but this status did not protect the marine resources. The area was inscribed on the World Heritage List in 1997 and due to the continued illegal fishing, conservation organizations rallied for an expansion of the boundaries of the marine reserve. The park was declared a Ramsar site in 1998, and in 2001 the marine reserve surrounding Cocos Island was officially extended from 15 km to 22.2 km (12 nautical miles) to increase protection of the marine resources. The Ministry of Culture declared the park a National Historic Site in 2002; and a partnership is being negotiated with the National Coast Guard Service and Mar Viva Association for patrolling the marine area and prosecution of illegal fishing boat owners. The area is also part of a regional project between Costa Rica, Colombia, Ecuador, and Panama, which focuses on sustainable conservation practices, including the MPAs: Galapagos, Cocos, Malpelo, Coiba and Gorgona, and the Tropical Pacific Eastern.

Ecological Monitoring: In 1992, live coral cover was only 3-4% but the reefs are now showing signs of recovery. In January 2005, el Centro de Investigación en Ciencias del Mar y Limnología (CIMAR) of Costa Rica University will assess the area and standardise monitoring procedures.

Socio-economic Monitoring: Cocos Island does not have permanent residents; however, permanent boats and fishermen are prohibited from entering the marine protected zone. Tourist operations are now restricted, with 3 boats operating with a daily limit of 60 people. In 2005, studies will define a fixed no-take boundary and explore how tourism and local fisheries threaten the area.

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Coral reefs are **40%** of the natural resources.
Ecological Monitoring is **planned.**
Socio-economic monitoring is **planned.**

WHS

AREA DE CONSERVACION GUANACASTE, COSTA RICA- WORLD HERITAGE SITE

The Area de Conservacion Guanacaste (ACG), northwest Costa Rica, is composed of 43,000 ha of coastal marine waters, including various near shore islands and islets, open ocean marine zones, beaches, rocky coasts, algal beds and approximately 20 km of sea turtle nesting beaches. The area is managed by the Sistema Nacional de Area de Conservación Ministerio del Ambiente y Energia, Costa Rica.

The region's marine biodiversity has long been harvested as traditional products (mostly snapper but also crabs, octopus, lobster, and other species) by local fisherman. Recent catch data shows decreases in animal size and increased effort to maintain catch levels. The ACG has established good relations with local fishermen and has started a program of applied research and participation with them to gradually stop them from the use of the area for any fishing. However, these are complex social-economic-ecological problems and trends, and managers estimate at least 5 years is needed before all fishing activities are stopped within the site.

The research projects that have been done in Sector Marino show the presence of many unique species of corals as well as a large amount of fishes, starfish, sea urchins, sea cucumbers, sharks, sponges, mollusks, turtles and many other organisms. The reserve is home to many creatures that were once commonly found throughout the Pacific coast of Central America, but have been severely depleted by over-fishing. Porpoises and dolphins are common and whales are seen occasionally.

Ecological Monitoring: During 2003-2004, the ACG has adopted a marine conservation strategy devoting full attention to restoration and permanent conservation of coastal marine biodiversity through its biodevelopment and non-damaging use. Monitoring sites have been established since 1994, and research is undertaken by the Universidad de Costa Rica.

Socio-economic Monitoring: Park rangers currently monitor the site although no socio-economic monitoring occurs.

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Coral reefs are an **unknown** percentage of natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **not planned.**

WHS

THE GALAPAGOS ISLANDS, EQUADOR - WORLD HERITAGE SITE

The Galapagos Islands are off the coast of Equador, in the eastern Pacific Ocean and were made famous by Charles Darwin, who visited these remote, inhospitable volcanic islands in 1835. The islands were granted World Heritage status in 1978 in recognition of their unique terrestrial wildlife but the marine biodiversity has only recently received attention. There are over a million sea birds among 19 different species, thousands of coastal birds, approximately 100,000 sea lions, hammerhead sharks, the flightless cormorant, green and hawksbill turtles, and nearly 300 fish species (with 23% being endemic).

Resource disputes cause problems for management as most of the 15,000 residents live on only 37% of the land and are either fishers, farmers or tourism operators. Over 70,000 tourists generate roughly US$55 million per year with minimal impacts due to the use large cruise ships or small boats. The local population expanded dramatically in the 1970s and 1980s due to tourism and increased exploitation of the fishing resources such as sea cucumber, shark, tuna and lobster. Biologists and conservationists agree that the Galapagos Islands are overfished and that marine biodiversity is under threat. The first management plan for the Galapagos Marine Reserve in 1992 was largely ignored due to increased social unrest caused by attempts to ban certain fishing practices. New legal, administrative and community participation structures are being designed to improve conservation of the marine ecosystems. The Charles Darwin Research Station was established in 1959 and advises the National Park Service on protection programs for the marine ecosystem, tourism policies and environmental education.

Ecological Monitoring: The first coral reef surveys in 1983 were after there was a 97% coral mortality during the severe El Niño of 1982/3. The event may have resulted in localised extinctions of *Pocillopora* species of hard coral. After recovery, the 1997/1998 bleaching event devastated *Porites* and *Pavona* species down to 30 m, with extensive bleaching in 10 to 15 m depth.

Socio-economic Monitoring: The Charles Darwin Research Station has participatory fisheries monitoring of catch, by-catch, consumption, and market prices to aid adaptive management of the Galapagos Islands.

Coral reefs are **5%** the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **occasional.**

WHS MAB

LA AMISTAD, PANAMA /COSTA RICA - MAN AND THE BIOSPHERE RESERVE

The La Amistad Biosphere Reserve and International Peace Park spans from southern Costa Rica into western Panama. UNESCO/MAB may propose a trans-border biosphere reserve consisting of the 2 coastal/marine elements on the Atlantic side, possibly together with adjacent terrestrial and/or marine areas. La Amistad includes tropical rainforest, cloud forest, and extensive coral reefs, seagrass beds, and mangroves. Coral reefs in La Amistad contain 25 species of soft corals and 54 species of hard corals. Habitat destruction is the greatest threat to the diverse aquatic flora and fauna in this biosphere reserve. Management plans for the reserve are currently being developed and updated in order to counter this threat. In collaboration with the Costa Rican government, and several local groups, Conservation International produced the official management strategy for La Amistad (adopted by the Costa Rican government in 1990). Since then, the Panamanian government and grassroots organizations have attempted a similar strategy for the portion of La Amistad that lies in Panama. There is a need to strengthen to facilitate cooperation between Costa Rican and Panamanian management authorities.

Ecological and Socio-economic Monitoring: No information was available.

Coral reefs are **20%** of the natural resources.
Ecological Monitoring is **unknown.**
Socio-economic Monitoring is **unknown.**

RAMSAR

ARCHIPIELAGO LOS ROQUES, VENEZUELA – RAMSAR SITE

Situated approximately 180 km off shore in the Caribbean Sea, north of Venezuela, the Los Roques system is an incomplete marine atoll still in the process of formation. It covers 213,220 hectares and rises sharply 850 m from the surrounding ocean floor. In the southern part, an area of shallow water (80 cm to 1 m deep) forms a lagoon, similar to the coral atolls of the Pacific. The archipelago is surrounded by 45 islands and more than 250 sand banks and reefs and harbours several severely threatened species, including sea turtles (hawksbill, green, loggerhead, and leatherback) and a protected species of sea snail. Among the commercially important fish are several species of shark and ray, which are sold either dried or salted. Lobsters are also commercially important species.

The land is government property, although there are private concessions as the site is currently used for tourism and research. The Dos Mosquises Marine Biology Station, one of the programs of the Fundación Científica Los Roques, is located on the Dos Mosquises Sur key. The station has conducted research on fish, shellfish, coral, echinoderms, sponges, plankton and sea turtles.

The Los Roques system was declared a National Park in 1972 and management and operational plans are being implemented. The administrative headquarters on Gran Roque are being improved and stations are being constructed for park rangers for the monitoring and management of activities in different areas. Staff is being hired in accordance with a contract signed in 1995 between Instituto Nacional De Parques and the World Bank. Gathering of sea snails has been prohibited since 1990 but fish, lobster, and turtle capture continues for tourist consumption and may threaten the survival of these species.

Ecological Monitoring: There has been no specific monitoring, however, zoning and strict protection measures regulate wetland activities. While small-scale fishing is regulated, overexploitation of fish, lobster, and turtle populations continues.

Socio-economic Monitoring: No information was provided.

Contact: Dirección General Sectorial de Fauna, MARNR, Centro Simón Bolivar, Torre Sur, Piso 6 C.S.B., Caracas, Venezuela 1010 (phone: 58 2408 1143, fax: 58 2484 6045).

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **unknown.**
Socio-economic monitoring is **unknown.**

MAB RAMSAR

SEAFLOWER. COLOMBIA - MAN AND THE BIOSPHERE RESERVE

The Seaflower Biosphere Reserve is in the Southwest Caribbean 1,000 km northwest of Colombia. It is a large reserve, covering about 300,000 square km. It contains the archipelagoes of San Andres, Providencia and Santa Catalina, with 3 small populated islands (with 60,000 inhabitants), several sand cays, atolls and complex coral reef areas. The reserve is principally oceanic but also includes more than 826 square km of coral reefs. The 3 major islands also have large mangrove forests and seagrass beds. The reserve contains high biodiversity; over 55 coral species, 40 gorgonian species, 118 sponge species and more than 270 fish species.

Ecological and Socio-economic Monitoring: There has been long-term coral reef monitoring programs since 1998 at San Andres Island (5 stations) and at Providencia Island (4 stations). There have been socio-economic studies of the interactions of fishing and other communities with the reserve.

Contact: June Marie Mow, Corporacion CORALINA (coralsai@coll.telecom.com.co)

Coral reefs are **60%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **effective.**

RAMSAR

PARQUE ESTADUAL MARINHO DO PARCEL MANOEL LUÍS , BRAZIL – RAMSAR SITE

This site consists of 3 separate coral banks (Manoel Luís, Tarol, and Álvaro) situated on the Maranhão Continental Shelf, off the northern Brazilian coast 180 km north of São Luís Island. It covers 34,556 hectares and has well-preserved ecosystems with banks supporting a considerable number of rare and endangered species. Almost all coral species recorded in the Brazilian northeast are found within the site, along with many endemic mollusc species and a large number of rare or endangered animal species, such as the green sea turtle. The area serves as a nursery and feeding ground for at least 132 species of fish from 52 different families, including several that are endemic and of commercial value.

The Federal Government of Brazil owns the site and has declared it a State Marine Park. With the support of the Ramsar Convention Small Grants Fund, the Ministry of Environment and scientists conduct research which provides the basis of the future management plan. This scheme will also include rules and procedures for visitors. The park is used for scientific research, fishing and recreation.

In the past, there have been shipping accidents because the area is very close to the navigation route to and from the São Marcos Bay. Future accidents must be prevented because they may introduce oil and/or cargo spills. Future tourism activity may pose a danger to the ecosystems too, although underwater fishing and the collection of fauna is prohibited except for scientific sampling.

Ecological Monitoring: Preliminary surveys have been undertaken by the Federal Universities of Maranhão, Rio de Janeiro, Pará and Rural de Pernambuco, and the National Museum of Rio de Janeiro. Collections of fishes, annelids, arthropods, molluscs, and cnidarians have also been made but no long-term monitoring is established.

Socio-economic Monitoring: No monitoring occurs. However, increased tourism may lead to overexploitation of reef resources and waste problems which should be monitored.

Contact: Ministerio do Meio Ambiente dos Recursos Hídricos e da Amazônia, Legal, Esplanado dos Ministérios, Bloco B-50, 70.068-900, Brasilia-DF, Brazil (phone: 55 61 317 1115).

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **occasional**.
Socio-economic monitoring is needed but **not planned.**

RAMSAR

GANDOCA-MANZANILLO, COSTA RICA – RAMSAR SITE

This wetlands site has well-developed and relatively undisturbed coral reefs. Species diversity is among the highest of Costa Rica's coral reefs and more than 35 coral species are present, including 2 which are endemic to Gandoca-Manzanillo. Almost 350 fish species (many of which are commercially fished), 150 mollusc species, and 25 species of crustacean have been identified in the site. The area is also an important nesting site for threatened loggerhead, green, leatherback, and hawksbill turtles.

The area is located in the province of Limón, 12 km from the town of Puerto Viejo, on the Caribbean coast adjacent to Panama. It covers 9,449 hectares and is composed of sandy beaches, mangroves, coral reefs, sea-grass beds and a coastal lagoon. Tourism is the most important activity, with more than 150,000 tourists per year visiting the region.

Gandoca-Manzanillo is managed by the Ministry for the Environment and Energy. Turtle egg harvesting is controlled (only 10% of total nests can be taken) by a local NGO (Asociacíon ANAI) and the Wildlife Section of the Ministry of the Environment and Energy as part of a Management and Conservation Project. Fishing and underwater hunting regulations have been proposed and a management plan is being prepared. The area is also part of the Talamanca-Caribe Biological Corridor and workshops have been held for fishermen to alert them to the effects of over-exploitation and the benefits of coastal resource management. Sedimentation and coral extraction are the 2 major environmental problems but banana plantations have also negatively affected water quality by leading to massive fish kills.

Ecological Monitoring: Studies on sea turtles, manatees, fish, and some invertebrates have been carried out but more consistent efforts are needed.

Socio-economic Monitoring: Increased tourism has put pressure on the reserve's marine resources yet to date no monitoring has been implemented.

Contact: Gandoca-Manzanillo, Puerto Vieja, Limon, Costa Rica (phone/fax: 506 754 2133).

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **occasional.**
Socio-economic monitoring is **not planned.**

21. Sponsoring Organisations, Coral Reef Programs and Monitoring Networks

AFD - Agence Française de Développement

This French government agency contributes to the economic and social development of more than 80 developing countries and the French overseas departments and territories. Total commitments in 2003 were EUR1393 million. It is both a public establishment and a specialised financial institution, and is responsible for France's official development assistance. AFD provides financial assistance for public and private projects in many sectors, including: water resources; finance; urban and rural development; and access to social services (health, education). AFD cooperates with other funding agencies e.g. European Investment Bank, the Asian Development Bank, the European Commission, and administers the French GEF Secretariat (French Fund for World Environment), which integrates environmental considerations within development programs. After the initial focus on terrestrial environmental programs (e.g. forestry, protected area management), AFD now includes marine ecosystems in its portfolio and launched the French Coral Reefs Initiative for the South Pacific (CRISP) in 2002. Contact: Dominique Rojat, AFD Paris; rojatd@afd.fr; www.afd.fr.

AGRRA – Atlantic and Gulf Rapid Reef Assessment

International scientists and managers collaborate via AGRRA to determine the regional condition of reefs in the Caribbean and Gulf of Mexico using a rapid assessment protocol. AGRRA seeks to provide baseline data on coral reef health by visual assessments of coral cover, coral mortality, coral recruitment, macro-algal index, sea urchin density, abundance and size of key fish families. Consistency between observers is ensured through training workshops. AGRRA surveys have been made at 720 reef sites throughout the Western Atlantic: Bahamas, Belize, Bonaire, Curacao, Cayman Islands, Costa Rica, Cuba, Jamaica, Mexico, Panama (Bocas and San Blax), Puerto Rico, St. Vincent, Turks and Caicos, US Virgin Islands, US Florida Reef Tract and Flower Gardens and Venezuela. All survey results are in a database to be released in 2005. Special issue #496 of the Atoll Research Bulletin contains the results of the first 20 areas assessed and a synthesis of these findings. Regional comparisons can be made by examining many reefs, but cause and effect relationships are pending further analysis. Contact: Robert Ginsburg, agrra@rsmas.miami.edu or by mail, 4600 Rickenbacker Cswy. Miami, FL 33149 or Judith Lang, JandL@rivnet.net; http://mgg.rsmas.miami.edu/agrra/index.html

AIMS - Australian Institute of Marine Science

AIMS is one of Australia's key research agencies and particularly committed to marine research in the tropics. AIMS undertakes research and development to generate new knowledge in marine science and technology, and to promote its application in industry, government and

environmental management. The research program involves medium- to long-term research that is geared towards improved understanding of marine systems and the development of a capability to predict the behaviour of complex tropical marine systems. In the past 25 years, the Institute has established a sound reputation for high quality research on coral reef and mangrove ecosystems, and on the water circulation around our coasts and continental shelf. Researchers have not only published extensively in scientific journals but have also written field guides, books and monographs for regional use. A major theme is developing and applying monitoring methods to assist in the sustainable management of tropical marine resources. AIMS supports a wide range of studies for effective coral reef management. Contact: AIMS, PMB #3, Townsville 4810 Australia; www.aims.gov.au

CARICOMP - Caribbean Coastal Marine Productivity Program

This is a 25 member regional network established in 1986 by a group of marine laboratories, parks and reserves with the support of IOC-UNESCO. CARICOMP monitors long-term variation in ecosystem structure and function in coral reefs, seagrasses, and mangroves according to standardised protocols in relatively undisturbed sites. The network also responds to regional events such as coral bleaching events and hurricanes. The Caribbean Coastal Data Centre at the University of the West Indies in Kingston, Jamaica archives the data and makes them available. CARICOMP contributes data to ReefBase and initiated the GCRMN in the Caribbean. In 2000, CARICOMP designed and initiated several sub-regional research projects, including studies of larval linkages and coral diseases, related to long-term management and restoration of Caribbean coastal ecosystems. These projects are being expanded. The CARICOMP program networks institutions in 18 countries: Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Colombia, Costa Rica, Cuba, Dominican Republic, Haiti, Jamaica, Mexico, Netherlands Antilles, Panama, Puerto Rico, Trinidad and Tobago, USA, and Venezuela. Contacts: John Ogden, jogden@seas.marine.usf.edu; Loureene Jones, Caribbean Coastal Data Centre, Jamaica, loureene.jones@uwimona.edu.jm; George Warner, Centre for Marine Sciences, UWI, Jamaica, gfwarner@uwimona.edu.jm; www.uwimona.edu.jm/centres/cms/caricomp/ ;

CBD - Convention on Biological Diversity

Biological diversity, the variability among living things and the ecosystems that support them, is the foundation upon which human civilizations have been built. Sustaining that biodiversity, in the face of considerable threats from human activities, constitutes one of the greatest challenges of the modern era. CBD arose from the Earth Summit in Rio de Janeiro in 1992 and has 188 Parties to this international legally binding treaty with virtually universal participation. The objectives of CBD are: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of the benefits arising out of the use of genetic resources. The Convention sets out broad commitments by governments to take action at the national level for the conservation and sustainable use of biological diversity. Since entering into force, the Parties have translated the Convention into work programs, including one on marine and coastal biological diversity, which addresses coral reef issues through work plans on coral bleaching and the physical degradation and destruction of coral reefs. Contact: Marjo Vierros, CBD Secretariat Montreal, Canada, marjo.vierros@biodiv.org or www.biodiv.org

CI - Conservation International

CI is a global, field-based environmental organisation that promotes the protection of biological diversity. Working in more than 30 countries over 4 continents, CI applies innovations in science, economics, policy and community participation to protect the Earth's richest regions of plant and animal diversity. The Marine Rapid Assessment Program (RAP) of the Center for Applied Biodiversity Science at CI organises scientific expeditions to document marine biodiversity as well as freshwater and terrestrial biodiversity hotspots, and tropical wilderness areas. Their conservation status and diversity are recorded using indicator groups (molluscs, corals and fish), and the results are combined with social, environmental and other ecosystem information to produce recommendations for protective measures to local communities and decision-makers. The main focus of Marine RAP surveys has been the 'coral triangle' in Southeast Asia, which contains the richest coastal and marine biodiversity in the world. Contact: Sheila McKenna, Conservation International, 1919 M St. NW, Washington, DC 20036 USA; www.biodiversityscience.org and www.conservation.org, s.mckenna@conservation.org

CORAL - The Coral Reef Alliance

CORAL is a member-supported, non-profit organisation based in California that is dedicated to protecting the health of coral reefs by integrating ecosystem management, sustainable tourism, and community partnerships. By targeting marine recreation providers, coral park managers, and other community stakeholders, CORAL's programs build cooperative solutions to the challenges facing coral reef destinations around the world. Training, technical assistance, and financial resources provide the basis for building cooperative management strategies, sustainable tourism, and community led conservation projects that improve the health of reefs and the sustainability of reef tourism. In addition, CORAL builds public awareness about coral reefs through various outreach programs, such as the highly acclaimed Dive In To Earth Day. Together, CORAL and its partners are working hard to keep coral reefs alive. Contact: Brian Huse, bhuse@coral.org; www.coral.org

CORDIO - Coral Reef Degradation in the Indian Ocean

This is a regional, multi-disciplinary program developed to investigate the ecological and socio-economic consequences of the mass coral bleaching in 1998 and subsequent degradation of coral reefs in the Central and Western Indian Ocean. CORDIO is an operational unit within ICRI, with objectives to determine the: biophysical impacts of the bleaching and mortality of corals and long-term prospects for recovery; socio-economic impacts of the coral mortality and options for mitigating these through management and development of alternative livelihoods for peoples dependent on coral reefs; and prospects for restoration and rehabilitation of reefs to accelerate their ecological and economic recovery. CORDIO assists and coordinates with the GCRMN in the Indian Ocean with monitoring and running the Node in East Africa, the Indian Ocean Islands and South Asia. The participating countries are: Kenya, Tanzania, Mozambique, Madagascar, Seychelles, India, Maldives, Sri Lanka, Reunion, Comores, Mauritius and Chagos. Program co-ordination contacts: Olof Lindén, World Maritime University, Malmo, Sweden, olof.linden@cordio.org; David Souter, University of Kalmar david.souter@cordio.org; South Asia: Jerker Tamelander, IUCN South Asia, 53 Horton Place, Colombo 7, Sri Lanka, jet@iucnsl.org: East Africa: David Obura, CORDIO East Africa, P.O. Box 10135, Bamburi, Kenya, dobura@africaonline.co.ke; Island States: Rolph Payet, Ministry of Environment, Seychelles, ps@env.gov.sc

CRC Reef - Cooperative Research Centre for the Great Barrier Reef

CRC Reef Research Centre is a knowledge-based partnership of coral reef managers, researchers and industry, which provides research solutions to protect, conserve and restore the world's coral reefs by ensuring industries and management are sustainable and ecosystem quality is maintained. The needs of end-users are incorporated into the design, instigation and progress of research. CRC Reef Research Centre is in Townsville, Australia and its partners have internationally-recognised expertise in coral reef science, technology and management, and provide education and training to tourism and fisheries industries, and coral reef managers. It is a collaborative venture with researchers (Australian Institute of Marine Science; James Cook University, Queensland Department of Primary Industries and Fisheries), the tourism industry (Association of Marine Park Tourism Operators), the commercial and recreational fishing industry (Sunfish Queensland, Queensland Seafood industry Association), managers (Great Barrier Reef Marine Park Authority), and non-government organisations (Great Barrier Reef Research Foundation). Contact: Russell Reichelt, CRC Reef Research Centre, PO Box 772, Townsville 4810 Australia; info@crcreef.com or www.reef.crc.org.au

GBRRF – Great Barrier Reef Research Foundation

The Foundation was established in 1999 to raise and aggregate funds for strategic research into coral reefs and foster a co-operative and integrated approach to that research amongst the universities, marine institutions and museums of Australia. The Directors and benefactors of the GBRRF are also concerned to develop opportunities to export, wherever possible, the scientific, management and humanitarian benefits of funded research to developing countries, many of which have economies heavily dependent on healthy reef systems. The GBRRF currently sources financial support and sponsorship from individuals, corporations, Trusts, Foundations and Government, and the Board of Directors is drawn from the foremost ranks of Australian business and philanthropy. The GBRRF is also supported by some of Australia's most eminent marine scientists who act as its International Scientific Advisory Committee (ISAC) and scrutinise all activities, projects and programs supported by the Foundation. Contact: Judith Stewart, Managing Director, Great Barrier Reef Research Foundation, Level 20, 307 Queen Street, Brisbane QLD 4000, Australia; judith.stewart@barrierreef.org or www.barrierreef.org

GCRMN - Global Coral Reef Monitoring Network

The GCRMN was formed in 1995 as an operational unit of ICRI. The GCRMN is in partnership with ReefBase, Reef Check, CORDIO and NOAA, which constitute the central direction. The GCRMN is sponsored by IOC-UNESCO, UNEP, IUCN, CBD, the World Bank, AIMS, WorldFish Center, the ICRI Secretariat, and central coordination is supported by the U.S. Department of State and the National Oceanic and Atmospheric Administration through contributions to UNEP. IUCN currently Chairs the Management Group of the GCRMN, and the Global Coordinator is hosted at AIMS and IMPAC and interacts closely with the WorldFish Center. The GCRMN seeks to encourage and coordinate three overlapping levels of monitoring:

- Community - monitoring by communities, fishers, schools, colleges, tourist operators and tourists over broad areas with less detail, to provide information on the reef status and causes of damage using Reef Check methodology and approaches;

- Management - monitoring by predominantly tertiary trained personnel in government environment or fisheries departments, and universities for moderate coverage of reefs at higher resolution and detail using methods developed in Southeast Asia or comparable methods;
- Research - high resolution monitoring over small scales by scientists and institutes currently monitoring reefs for research.

Equal emphasis is placed on monitoring to gather ecological and socio-economic data, with manuals available for both. A major objective is to produce 2 yearly national, regional and global Status of Coral Reefs Reports, such as those that form the basis for this report. The GCRMN functions as a network of independent Regional Nodes that coordinate training, monitoring and databases within participating countries, and institutes in regions based on the UNEP Regional Seas Program:

- Red Sea and Gulf of Aden - Middle East assisted by the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) Contact: Abdelelah Banajah, Abdelelah.Banajah@persga.org; or Abdullah Alsuhaibany, abdullah.alsuhaibany@persga.org;
- The Gulfs – the Persian/Arabian Gulf, Gulf of Oman and the Arabian Sea - assisted by Regional Organisation for the Protection of the Marine Environment (ROPME). Contact:Hassan Mohammadi, ropme@qualitynet.net; or Peyman Eghtesadi, eghtesadi@inco.ac.ir
- Eastern Africa – assisting Kenya, Mozambique, South Africa and Tanzania operating through the CORDIO network in Mombasa. Contact: David Obura in Mombasa, dobura@africaonline.co.ke;
- South Western Indian Ocean Island States - coordinating Comoros, Madagascar, Mauritius, Reunion and Seychelles with assistance from the Global Environment Facility and Indian Ocean Commission. Contact: Jude Bijoux, j.bijoux@scmrt-mpa.sc or Rolph Payet, rolph@seychelles.sc
- South Asia - for India, Maldives and Sri Lanka with support from the CORDIO program of SIDA and IUCN. Contact: the Regional Coordinator in Colombo, Jerker Tamelander, jet@iucnsl.org or Arjan Rajasuriya, Arjan@Nara.Ac.Lk
- South East Asia - for the ASEAN countries with assistance from the ICRAN project and the WorldFish Center, Penang Malaysia. Contact: Karenne Tun, Regional Coordinator, k.tun@cgiar.org or Chou Loke Ming, National University of Singapore, dbsclm@nus.edu.sg
- East and North Asia - Japan is assisting these countries via the Ishigaki International Coral Reef Research and Monitoring Center, and the Nature Conservation Bureau in Japan. Contact: Tadashi Kimura, tkimura@jwrc.or.jp or Keisuke Takahashi, KEISUKE_TAKAHASHI@env.go.jp
- Southwest Pacific and Melanesia, for Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu coordinated through the Institute of Marine Resources, University of the South Pacific and support from Canada. Contacts: Tim Pickering, pickering_t@usp.ac.fj, or Reuben Sulu sulu_r@usp.ac.fj, Ed Lovell for Reef Check (lovell@suva.is.com.fj);

- Southeast and Central Pacific, the 'Polynesia Mana Node' for the Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga and Wallis and Futuna coordinated in French Polynesia from the CRIOBE-EPHE Research Station on Moorea. Contact: Bernard Salvat bsalvat@uni-perp.fr, or Caroline Vieux, carolinevieux@hotmail.com
- Northwest Pacific and Micronesia, the 'MAREPAC Node' for American Samoa, the Marshall Islands, the Federated States of Micronesia (FSM), the Northern Mariana Islands (CNMI), Guam and Palau. Contact: the Palau International Coral Reef Center, Jason Kuartei, jkuartei@picrc.org
- Hawaiian Islands – for US islands in the Pacific. Contact: Ruth Kelty, Ruth.Kelty@noaa.gov, or Mark Monaco, mark.monaco@noaa.gov, or Athline Clark, Athline.M.Clark@hawaii.gov
- U.S. Caribbean – for U.S. territories and states of Florida, Flower Garden Banks, Navassa, Puerto Rico, and U.S. Virgin Islands. Contact Ruth Kelty, Ruth.Kelty@noaa.gov, or Mark Monaco, mark.monaco@noaa.gov or www.coralreef.gov/
- Northern Caribbean and Atlantic region coordinated through the Caribbean Coastal Data Centre, Centre for Marine Sciences, Jamaica for the Greater Antilles to Bermuda. Contact: Loureene Jones, loureene.jones@uwimona.edu.jm or George Warner, gfwarner@uwimona.edu.jm
- Mesoamerican Barrier Reef System for Mexico, Belize, Guatemala, Honduras. Contact: Alejandro Arrivillaga, MBRS Project office, Belize, aarrivillaga@mbrs.org.bz or Melanie WWF Mesoamerican Reef Program, mcfield@bt.,net
- Eastern Caribbean, for the Organisation of Eastern Caribbean States (OECS), Trinidad and Tobago, Barbados, and French and Netherlands Caribbean Islands, coordinated by CANARI, with support from UNEP-CAR/RCU from St Lucia. Contact: Allan Smith, ahsmith@candw.lc; Claude Bouchon, claude.bouchon@univ-ag.fr; Paul Hoetjes, milvomil@cura.net
- Southern Tropical America Node for Costa Rica, Panama, Colombia, Venezuela and Brazil via the 'Instituto de Investigaciones Marinas y Costeras' (INVEMAR) with support from UNEP-CAR/RCU. Contact: Jaime Garzón-Ferreira, jgarzon@invemar.org.co, and Alberto Rodríguez-Ramírez betorod@invemar.org.co.

Central Coordination contact: Clive Wilkinson Global Coordinator at the Australian Institute of Marine Science, in Townsville c.wilkinson@aims.gov.au; or Jamie Oliver at WorldFish Center in Penang Malaysia (j.oliver@cgiar.org); or Gregor Hodgson, University of California, Los Angeles, rcheck@ucla.edu, or Leah Bunce, NOAA Silver Springs Maryland USA, Leah.Bunce@noaa.gov; or Olof Linden, Olof.Linden@wmu.se; home page: www.gcrmn.org

ICRAN - International Coral Reef Action Network

ICRAN is a public/private partnership response to the International Coral Reef Initiative's (ICRI) Call to Action to conserve and manage coral reefs worldwide. Initiated with generous support from the United Nations Foundation, ICRAN's strategic alliance approach has been developed to ensure the future of coral reefs and related ecosystems and the future of the communities they sustain. This strategy includes alternative livelihoods, training, capacity-building, and the exchange and application of traditional knowledge, and current scientific, economic and social information. Examples of ICRAN activities are evident in many of the 'special sites' at the

end of regional chapters in this report. The ICRAN partners are: CORAL, GCRMN, ICRI, MAC, Reef Check, SPREP, UNEP, UNEP-WCMC, TNC, UNF, WorldFish Center, WRI and WWF. E-mail: Kristian Teleki, kteleki@icran.org; www.icran.org

ICRI - International Coral Reef Initiative

ICRI is a response to the global degradation of coral reefs and related ecosystems. It is a partnership of countries, international organisations, NGOs and regional seas programs created in 1994 following calls at the 1992 UNCED Rio Earth Summit and by Small Island Developing States. The initial partners were Australia, France, Jamaica, Japan, Philippines, Sweden, UK and USA, along with CORAL, IOC-UNESCO, IUCN, UNDP, UNEP, and the World Bank. The prime function of ICRI is to implement UNCED recommendations, and other international conventions and agreements, raise awareness of coral reef degradation and prompt action by governments and other stakeholders. ICRI functions through its members and operational networks, ICRAN, CORDIO and GCRMN to: advocate coral reef conservation in international fora; facilitate collaborative action and information exchange; increase funding for coral reefs; improve management practices; and increase capacity and political support. ICRI, with guidance from the Co-ordination and Planning Committee (a consensus grouping of partners) assists production of the Status of Coral Reef of the World reports and uses it to raise awareness. The ICRI 'Agenda' formulated in Dumaguete City, Philippines in 1995 as the ICRI 'Call to Action' and 'Framework for Action', was updated at International Tropical Marine Ecosystems Management Symposium (ITMEMS) in Townsville, Australia in 1998 (the ICRI Renewed Call to Action) and at ITMEMS2 in Manila in 2003 (Box P. &^% and P. &&*). The Secretariat implements the 'Agenda' through rotating hosts (Governments of USA, Australia, France, and jointly by Sweden and the Philippines). The Secretariat is currently co-hosted by the United Kingdom and the Seychelles; Japan and Palau will host the Secretariat from July 2005. Contact: Robert Baldi, robert.baldi@defra.gsi.gov.uk, www.ICRIForum.org

ICRIN - International Coral Reef Information Network

ICRIN is a coral reef outreach and awareness building program, which provides tools and resources to non-profit community groups, educators and coral park managers to support their local and regional outreach initiatives. ICRIN also provides general coral reef information to the public and policy makers via the Internet, targeted presentations and materials, and by sponsoring local events and activities. ICRIN is the outreach component of ICRAN and ICRI. Contact: icrin@coral.org; or www.coralreef.org

IFRECOR - French Coral Reefs Initiative

IFRECOR is the national program for coral reefs in French tropical overseas territories. IFRECOR, launched in 1999 by the Ministries of Environment and Overseas Territories, developed a National Coral Reef Action Plan to be coordinated by a secretariat in the two Ministries. A national steering committee contains members of parliament, other ministries, social and natural scientists, and NGOs to recommend tasks under the plan. The IFRECOR budget was Euro 2 million over the last 4 years for activities within the 7 French overseas territories with coral reefs. Each territory has a local committee of stakeholders to implement coral reef management. IFRECOR has been successful in raising public awareness of the importance of coral reefs, establishing a French coral reef monitoring network, exchanging coral reef experiences between overseas territories, promoting sustainable uses, involving local communities, and conserving coral reefs. IFRECOR promotes French scientific and technical

knowledge at international levels, encourages the participation of French coral reefs specialists in research, assists in developing and managing coral reefs in other countries, and participates in international coral reef monitoring. Since its establishment, IFRECOR, has catalysed an increasing the commitment by government and overseas territories to protect coral reefs and designate MPAs. Contact: Bernard Salvat, Ecole Pratique des Hautes Etudes, Université de Perpignan, France, bsalvat@univ-perp.fr

IMPAC - International Marine Project Activities Centre

IMPAC aims to further the sustainable development and conservation of critical coral reef, mangrove forest and seagrass bed habitats, and their fisheries. The specific focus is on providing training in oceans policy and governance of tropical coastal resources. IMPAC is a collaboration centre for international agencies focused on assisting people with sustainable livelihoods and in conserving resources of the tropical Indo-Pacific. The associates include: International Ocean Institute-Australia, the Regional Centre for Australia and the Western Pacific; The Nature Conservancy Science Coordinator for the Asia-Pacific & California Marine Protected Area program; and Global Coordination of the GCRMN, in association with the principal host, the Australian Institute of Marine Science. IMPAC is a non-profit subsidiary of the CRC Reef Research Centre Ltd. Contact: Clive Wilkinson, IMPAC Coordinator, c/o Australian Institute of Marine Science, P.O. Box 772, Townsville 4810, clive.wilkinson@impac.org.au; www.impac.org.au

IOC/UNESCO - Intergovernmental Oceanographic Commission

The IOC/UNESCO is the United Nation's focal point for marine science, research and observations to provide better knowledge about ocean resources, their nature and sustainability for marine management and policy development. Key priorities involve building national capacities to address the World Summit of Sustainable Development's Plan of Implementation, the role of Small Island Development States, and the Millennium Development Goals. IOC/UNESCO assists in the development of coral reef monitoring and data management, with equal emphasis on ecological and socio-economic information. A particular focus is understanding the role of reef-dependent poor coastal communities in conservation and development. IOC, with UNEP, IUCN and the World Meteorological Organisation formed the Global Task Team on Coral Reefs in 1991 to develop global coral reef monitoring, which was the precursor to the GCRMN, with IOC, UNEP, IUCN, World Bank and the CBD now as co-sponsors. The GCRMN contributes data on coral reef health and resources to the Global Ocean Observing System. Contact: Ole Vestergaard, IOC/UNESCO, 1 Rue Miollis, 75015 Paris, France.o.vestergaard@unesco.org; www.ioc.unesco.org,

IOI - International Ocean Institute

IOI is an independent, international non-governmental organisation with a network of 25 centres around the world, 10 of which are in developing countries with significant areas of coral reefs. The IOI mission is to promote education, training and research to enhance the peaceful use of ocean space and its resources, as well as the protection and conservation of the marine environment, guided by the principle of the Common Heritage of Mankind. IOI (Australia) is assisting countries, particularly Small Island Developing States, in the development of policies designed to conserve and sustainably manage coral reefs. IOI also encourages coastal communities to establish MPAs, and develop alternative livelihoods designed to reduce the pressure on scarce coastal resources. Contact: Robin South, IOI-Australia, robin.south@impac.org.au, www.impac.org.au/associates; www.ioi.org

ISRS - International Society For Reef Studies

ISRS (founded in 1980) is the leading organisation for professional scientists and students of coral reef studies, with a membership of more than 1000 from 60 countries. The Society promotes the production and dissemination of scientific knowledge and understanding of coral reefs, both living and fossil. This includes occasional and consensus discussion papers on emerging issues e.g. coral reef fisheries (Box p 29 and p 82). It prints and distributes the journal *Coral Reefs* and the magazine *Reef Encounter*, and offers major research awards and travel support for students. It also assists institutions in developing countries to develop their library resources. It grants the prestigious Darwin Medal for major contributions to coral reef studies, and coordinates and assists host countries with the four yearly International Coral Reef Symposia. E-mail: Peter Mumby, p.j.mumby@exeter.ac.uk; Web site: www.fit.edu/isrs/

IUCN - The World Conservation Union

Founded in 1948, IUCN brings 1035 States, government agencies and NGOs from 181 countries together in a unique global partnership to influence, encourage and assist societies conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. Its contributions include generating conservation knowledge, setting standards, developing and applying conservation tools, building capacity, and improving policies and global governance. The secretariat is located in Gland, Switzerland, and there are 42 regional and country offices and 10,000 volunteer experts within 6 Commissions, including the World Commission on Protected Areas (WCPA) and the Species Survival Commission (SSC), which focus on particular species, biodiversity conservation and the management of habitats and natural resources. The IUCN Global Marine Program links the members to all IUCN marine activities, including projects and initiatives of the regional offices and Commissions. The program is anchored in IUCN Headquarters, with most of the technical staff in regions with significant marine constituencies and issues. IUCN is a founding member of the GCRMN and the Head of the Marine Program chairs the Management Group. Contact: Carl Gustaf Lundin, Global Marine Program IUCN - The World Conservation Union, Rue Mauverney 28, CH-1196 Gland, Switzerland, Marine@iucn.org

Japan - Ministry of the Environment

The Ministry of the Environment is responsible for environmental policies ranging from waste management to nature conservation in Japan. The Nature Conservation Bureau of the Ministry is responsible for conservation of natural environments including coral reefs and related ecosystems. The Bureau has conducted a national survey of Japanese coral reefs and produced coral distribution maps. In addition, the Bureau has initiated coral reef rehabilitation projects since 2002. The International Coral Reef Research and Monitoring Center, established on Ishigaki Island, is the East Asia Seas Regional node of GCRMN to promote international and domestic coral reef monitoring. The Ministry of the Environment, on behalf of the Japanese Government, will host the next ICRI Secretariat (July 2005 to June 2007) in cooperation with the Republic of Palau. Contact: Biodiversity Planning Division, Nature Conservation Bureau, Ministry of the Environment, 1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-8975, Japan; coral@env.go.jp; www.env.go.jp/ and www.coremoc.go.jp/

MAC - Marine Aquarium Council

This is a multi-stakeholder, not-for-profit NGO created to ensure the global marine aquarium trade is sustainable by creating standards and certification for all those involved in the trade from reef to aquarium. MAC brings together the aquarium industry, hobbyists, conservation organisations, government agencies, public aquariums, and international organisations to ensure sustainability of the trade through a process of certification and market incentives. Reef conservation is enhanced because certified reef areas must be managed, include fish reserves, not use destructive methods, promote sustainable livelihoods and poverty alleviation, and support communities. MAC launched 3 Certification Standards in 2001 on: Ecosystem and Fishery Management Standard; Collection, Fishing and Holding Standard; Handling, Husbandry and Transport Standard; and Mariculture and Aquaculture Management is pending. Collectors, exporters, importers and retailers in the Philippines, Fiji, North America and Europe have been certified, and commitment indicated by 100 other companies in 20 countries. MAC has offices in USA, UK, Philippines, Fiji and Indonesia. Contact: Paul Holthus, Marine Aquarium Council, 923 Nu'uanu Ave, Honolulu, HI 96816, USA; www.aquariumcouncil.org, info@aquariumcouncil.org

NOAA - National Oceanic and Atmospheric Administration USA

NOAA is an agency of the Department of Commerce dedicated to enhancing public health and safety and promoting sound economic interests by researching and predicting weather and climate-related events and protecting the coastal and marine resources of the USA. NOAA is a steward of U.S. marine resources and co-chairs the U.S. Coral Reef Task Force, which is responsible for coordinating U.S. Government efforts to conserve coral reefs. The NOAA Coral Reef Conservation Program (CRCP) addresses priorities in the National Action Plan to Conserve Coral Reefs and the National Coral Reef Action Strategy such as mapping, monitoring, research, education and managing reef resources. The CRCP facilitates and supports partnerships with scientific, private, government and NGO groups at local, state, federal and international levels. The goal is to support effective management and sound science to preserve, sustain and restore valuable coral reef ecosystems. Contact: NOAA Coral Reef Conservation Program, 1305 East-West Highway, N/ORR, Silver Spring, MD, 20910 USA; coralreef@noaa.gov; www.coralreef.noaa.gov.

Norway - Ministries of Foreign Affairs and Environment

The Royal Ministry of Foreign Affairs, established in 1905, is responsible for Norway's Strategy for Environment in Development Cooperation, which promotes the integration of environmental considerations in multilateral programs through multilateral/bilateral support and co-financing. The main objective of Norway's environmental assistance is the sound management of the global environment and biological diversity. Norway supports the UNEP 'African Process on development and protection of the marine and coastal environment in Africa' and bilaterally supports activities in the Gulf of Guinea, Mozambique, Tanzania, Angola, Namibia, South Africa, Sri Lanka, Vietnam, Indonesia, and China, which include coastal zone management and the establishment of MPAs. Contact: Norwegian Ministry of Foreign Affairs, PO box 8114 Dep., N-0032 Oslo, Norway; post@mfa.no; www.mfa.no

The Royal Ministry of the Environment, established in 1972, has responsibility for the Norwegian biodiversity policy and action plan; the action plan includes cross-sectoral responsibilities and coordination within the Government. The national target is to halt the loss of biodiversity

by 2010. Basic elements of Government marine policy are sustainable management of the marine resources and implementation of an ecosystem approach. Protection of coral reefs is especially important both nationally and internationally due the vulnerability of coral reefs and their ecological and socio-economic importance. Norway has protected 6 cold-water coral reefs in national waters since 1999 and started preparation of a national network of MPAs, which will include coral reefs. Norway joined ICRI in 2004. Contact: Norwegian Ministry of the Environment, P.B. 8013 Dep., 0030 Oslo, Norway, postmottak@md.dep.no; www.odin.dep.no/md/engelsk/bn.html

Packard Foundation

The David and Lucile Packard Foundation is a private Foundation based in California. It established the Western Pacific Coastal Marine Conservation Program in 1998 with the goals of long-term conservation and responsible stewardship of critical coastal marine habitats and resources, especially coral reefs and seagrasses in 7 countries in the Western Pacific: Palau; Federated States of Micronesia; Philippines; Papua New Guinea; Solomon Islands; Fiji; and eastern Indonesia. The program's funding strategy focuses on: improving individual technical skills for effective conservation and resource management; supporting networks of marine protected areas; and developing a range of targeted, applied research and analysis initiatives to provide useful information for practitioners, policy-makers, and local community members. Contact: www.packard.org

Ramsar - Convention on Wetlands

The Ramsar Convention on Wetlands, was signed in Ramsar, Iran in 1971 and broadly defined 'wetlands' to include all 'areas of marine water the depth of which at low tide does not exceed six metres' (Article 1.1). It also explicitly allows the inclusion of 'coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands' (Article 2.1). Thus coral reefs figure prominently as Number 3 amongst the categories of marine and coastal wetlands, with some of the important international wetlands containing coral sites located in Australia, Brazil, Costa Rica, Cuba, Djibouti, Ecuador, France, Guinea, Honduras, Islamic Republic of Iran, Mexico, Nicaragua, Philippines, South Africa, Thailand, The Netherlands, United Kingdom and Venezuela. In several of these countries the sites go deeper than 6 m in accordance with Article 2.1. Contact: Margarita Astralaga, the marine focal point, Ramsar Secretariat, Rue Mauverney 28, CH-1196 Gland, Switzerland; astralaga@ramsar.org; www.ramsar.org/types_coral.htm

REEF CHECK Foundation

Reef Check is a global environmental group established to facilitate community education, monitoring and management of coral reefs. Reef Check is active in more than 70 coral reef countries and territories, where it seeks to: educate the public about the coral reef crisis and how to prevent it; create a global network of volunteer teams which regularly monitor and report on reef health under the supervision of scientists; scientifically investigate coral reef processes; facilitate collaboration among academics, NGOs, governments and the private sector to solve coral reef problems; and stimulate community action to protect remaining pristine reefs and rehabilitate damaged reefs worldwide using ecologically sound and economically sustainable solutions. Under the ICRI framework, Reef Check is a primary GCRMN partner and coordinates GCRMN training programs in ecological and socio-economic monitoring, and coral reef management throughout the world. Contact: Chris Knight, PO Box 8533, Calabasas, CA 91372; rcinfo@reefcheck.org; www.ReefCheck.org

SIDA & SAREC - Sweden

The Swedish International Development Cooperation Agency (Sida), and its Department for Research Cooperation (SAREC) assist developing countries alleviate poverty and achieve sustainable development. Environmental aspects are integrated in all development cooperation programs to ensure compliance with Agenda 21 and other environmental conventions. The Marine Science Program has actively promoted research cooperation and capacity building for Integrated Coastal Zone Management in eastern Africa, the western Indian Ocean and southeast Asia. National support for marine science is given to Vietnam, Sri Lanka, Mozambique and Tanzania. Many coastal projects and regional workshops are supported through the Marine Science for Management Program (MASMA), coordinated by the Western Indian Ocean Marine Science Association (WIOMSA) (www.wiomsa.org). MASMA allocates grants to researchers at national institutes on the western side of the Indian Ocean. The program's long-term objective is to improve the use of marine and coastal resources to combat poverty and environmental degradation. Sida is also the main supporter of the program Coral Degradation in the Indian Ocean (CORDIO). Contact: Håkan Berg, Sida – SAREC, SE-105 25 Stockholm; hakan.berg@sida.se

TNC - The Nature Conservancy

The mission of TNC is to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. TNC launched the Global Marine Initiative in 2002 to protect marine plant and animal life and safeguard the global benefits. The Conservancy operates 100 marine conservation projects in more than 21 countries and 22 U.S. states; they work with partners across seascapes and landscapes through transformative strategies and integrated planning and action. The focus is on: 1. setting priorities for marine conservation using ecoregional assessments and newly pioneered planning tools; 2. transforming coral reef conservation by establishing resilient networks of marine protected areas; 3. conserving and restoring estuarine and coastal ecosystems by utilizing innovative new methods; and 4. building support for marine conservation though strategic partnerships and working to shape global and national policies. TNC is committed to being a partner to find means to make the increasing use of the ocean compatible with marine conservation. Contact: Lynne Hale, Global Marine Initiative, The Nature Conservancy, URI Narragansett Bay Campus, Narragansett, USA: marine@tnc.org, www.nature.org/marine

Total Corporate Foundation

This marine biodiversity Foundation was established in 1992 following requests from Total employees for a visible commitment to the environment. The main focus is the preservation of marine and coastal species, specifically: *Biodiversity*, which recognises that human progress has occurred in parallel with damage to marine species, including some extinctions. Thus a conservation partnership was developed in 1992 with the Port-Cros National Park and the National Botanical Conservatory of Porquerolles; *The Sea*, as Total extracts significant energy resources from the sea and transports these by sea, a natural interest is the preservation of sensitive marine areas. Total's aim is to implement best practice during its marine industrial activities, improve understanding of marine ecosystems, and help restore damaged areas, including coral reefs, wetlands, protected areas, and control invasive species. The 'Coral Reef Biodiversity' program headed by Bernard Salvat, University of Perpignan from 2002-2003, had 8 components covering the biophysical, cultural, social and economic context of coral reefs in the Indian Ocean, Australasia and Pacific islands on: knowledge of biodiversity; cultural

perceptions of biodiversity; genetic diversity of coral species; economic valuation of biodiversity; role of protected areas in maintaining coral reef biodiversity; coral bleaching; coral reef monitoring and natural recovery; and monitoring with emphasis on climate change. Contact: Gina Sardella-Sadiki, gina.sardella-sadiki@total.com; Aurélien Vadier, aurelien.vadier@total.com; 2, place de la Coupole – La Défense 6, 92078 Paris La Défense Cedex, France; www.total.com; holding.fondation@total.com

UNEP - United Nations Environment Program

The mission of UNEP is to provide leadership and encourage partnerships in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations. UNEP makes a particular effort to nurture frameworks and initiatives at the local, national, regional and global level which enhance the participation of governments and civil society - the private sector, scientific community, NGOs and youth - in working together towards sustainable utilisation of natural resources. The challenge before UNEP is to implement an environmental agenda that is integrated strategically with the goals of economic development and social well-being; an agenda for sustainable development. Contact: UNEP, PO Box 30552, Nairobi, Kenya; cpiinfo@unep.org; www.unep.org

UNEP - Coral Reef Unit (CRU)

The CRU is the focal point within UNEP and the UN system to guide and mobilize policies and actions to support the conservation and sustainable use of coral reefs to safeguard their biological and biodiversity functions, which provide goods and services for the benefit of people and the sustainable development of dependant communities. Co-located with other coral reef resources at UNEP-WCMC, the CRU works closely with UNEP divisions/programs and international partners such as the International Coral Reef Initiative (ICRI) and Operational Networks. CRU activities include: supporting international collaboration to reverse coral reef degradation; cooperating to promote the political understanding of the importance of coral reefs; reviewing and integrating information on international policies related to coral reefs; and promoting innovative partnerships to address new and emerging coral reef issues, such as cold-water coral reefs. Contact: Stefan Hain, UNEP Coral Reef Unit, 219 Huntingdon Road, Cambridge, CB3 0DL, UK; stefan.hain@unep-wcmc.org; www.corals.unep.org and www.coral.unep.ch

UNEP - World Conservation Monitoring Centre

UNEP-WCMC is the biodiversity assessment centre of the UN Environment Program, with a major coral reef focus. This includes mapping, a global database on marine protected areas, monitoring trade in corals and marine ornamental species, and the global distribution of threats, including coral disease and bleaching. Reef associated ecosystems have been a major focus since the Status of Coral Reefs of the World: 2002 report. The World Atlas of Seagrasses (2003) was a major product, and work is underway to revise mangrove data into a new global atlas for publication in 2006. UNEP-WCMC, with support from the Marine Aquarium Council and members of the industry, completed an analysis of the global trade in live coral reef species in 2003. Future work at UNEP-WCMC will focus on a better understanding of ecosystem protection, especially coral reefs and associated ecosystems, in marine protected areas. Contact: Ed Green, UNEP-World Conservation Monitoring Centre, 219 Huntingdon Road, Cambridge, CB3 0DL, UK; ed.green@unep-wcmc.org; or www.unep-wcmc.org

UNESCO World Heritage Centre

The World Heritage Centre (WHC), based at the UNESCO headquarters in Paris, was established to assure the day-to-day management of the 1972 Convention concerning the protection of the World Cultural and Natural Heritage (World Heritage Convention). The activities include assisting member states prepare World Heritage nominations, following the state of conservation of inscribed properties as well as providing financial or technical support from the World Heritage Fund or from extra-budgetary sources for the conservation of the sites. The WHC is working towards a more integrated approach towards marine World Heritage sites. The recently established Marine Program aims: to increase awareness of the Convention as a legal tool for achieving conservation of marine and coastal ecosystems; to contribute to improving the state of conservation of existing marine World Heritage sites; to promote nominations of marine properties including serial and transboundary sites; and to establish partnerships to build a network of support for marine World Heritage. Contact: Marjaana Kokkonen, UNESCO World Heritage Centre, 7 place de Fontenoy, 75352 Paris 07 Sp, France; m.kokkonen@unesco.org

USCRTF - United States Coral Reef Task Force

The USCRTF was established by Presidential Executive Order in 1998 to lead U.S. efforts to preserve and protect coral reef ecosystems. The USCRTF, co-chaired by the Departments of Commerce and the Interior, includes 12 federal agencies responsible for coral reef conservation, 7 state and territory partners, and 3 freely associated states. The USCRTF adopted the U.S. National Action Plan to Conserve Coral Reefs in 2000, the first U.S. plan to comprehensively address the most pressing threats to coral reefs. The Action Plan identifies two fundamental themes for immediate and sustained action: understand coral reef ecosystems and the natural and anthropogenic processes that determine their health and viability; and reduce the adverse impacts of human activities on coral reefs and associated ecosystems. The USCRTF launched initiatives to help implement the Action Plan, including developing 3-year Local Action Strategies in each jurisdiction to address key threats to reefs. Contact: U.S. Coral Reef Task Force Secretariat, National Oceanic and Atmospheric Administration, Office of Response and Restoration, 1305 East-West Highway, N/ORR, Silver Spring, MD, 20910; www.coralreef.gov.

U.S. Department of State

The Department of State is the foreign policy arm of the United States Government. The Department is dedicated to creating a more secure, democratic and prosperous world for the benefit of the American people and the international community. Within the Department, the Bureau of Oceans and International Environmental and Scientific Affairs is responsible for advancing sustainable development and natural resource conservation, including aspects related to coral reefs and coral reef ecosystems, through a wide variety of international treaties, organizations, initiatives and public-private partnerships. Contact: Office of Ecology and Terrestrial Conservation, Bureau of Oceans and International Environmental Affairs, U.S. Department of State, Room 4333, 2201 C Street N.W., Washington D.C., 20520; www.sdp.gov/sdp/initiative/icri.

World Bank – Environment Department

The World Bank is an international financial institution dedicated to the alleviation of poverty. The Environment plays a crucial role in determining the physical and social well being of people. While poverty is exacerbated by deteriorating conditions in land, water and air quality, economic

growth and the well being of communities in much of the developing world, continues to depend on natural wealth and the production of environmental goods and services. As a result, the Bank is committed to integrating environmental sustainability into its programs, across sectors and regions and through its various financial instruments. Reducing vulnerability to environmental risk, improving people's health, and enhancing livelihoods through safeguarding the environment are the hallmarks of the Bank's Environment Strategy. Support for coral reef conservation and sustainable use is consistent with this theme, as it potentially affects millions of people around the world. The challenge for the Bank and its many partners in coral reef conservation, such as ICRI and GCRMN, will be to help communities capture the benefits from the sound management of coral reefs to meet immediate needs, while at the same time ensuring the sustainability of these vital systems for generations to come. For information on the Environment Department, contact: Marea Hatziolos, Environment Department, The World Bank, 1818 H St. NW, Washington, DC 20433 USA, Mhatziolos@worldbank.org; www.worldbank.org/icm; www.gefcoral.org

Worldfish Center

Formerly known as ICLARM, it is committed to contributing to food security and poverty eradication in developing countries. The efforts focus on benefiting poor people, and conserving aquatic resources and the environment. The organisation aims for poverty eradication, a healthier, better-nourished human family, reduced pressure on fragile natural resources, and people-centred policies for sustainable development. WorldFish Center is an autonomous, non-governmental, non-profit organisation, established as an international centre in 1977, with new headquarters in Penang, Malaysia and the focus for international efforts to tackle the major aquatic challenges affecting the developing world and to demonstrate solutions to resources managers worldwide. Contact: PO Box 500 GPO, 10670 Penang, Malaysia. Jamie Oliver, l.oliver@cgiar.org; www.cgiar.org/iclarm/

WRI - World Resources Institute

WRI is assisting coastal resource management and coral reef protection by providing comprehensive information on threats to coral reefs, economic value of the goods and services and losses that will result from reef degradation. The regional projects are implemented in close collaboration with partners, following the more-detailed global Reefs at Risk analysis from 1998. *Reefs at Risk in Southeast Asia* was released in 2002 and *Reefs at Risk in the Caribbean* in 2004, with the specific goals to: 1. improve the information base on threats to, status of, and protection of coral reefs in a region, by collecting, improving, and integrating information; 2. model threats to coral reefs based on population and development patterns, land use change, and the location and intensity of specific activities that degrade coral reefs; 3. develop a geographic information system (GIS)-based tool for local-level evaluation of development scenarios and related implications for coral reef health and economic value; 4. evaluate economic losses likely to result from coral reef degradation; and 5. raise awareness of human threats to coral reefs through wide dissemination of project results. All data (including GIS data sets) are on www.reefsatrisk.wri.org. Contact: Lauretta Burke, World Resources Institute, Washington, DC 20002, USA: lauretta@wri.org or Jon Maidens jmaidens@wri.org

WWF – World Wildlife Fund

WWF is the world's largest and most experienced independent conservation organisation, with more than 4.7 million members and a global network in 96 countries. The mission is to stop degradation of the world's natural environment and build a future in which humans

live in harmony with nature by conserving biological diversity. WWF leads efforts globally to safeguard marine ecosystems by: conserving cold water and tropical coral reefs; assisting coastal communities to manage MPAs effectively; and ending destructive fishing practices. There are activities in key regions throughout the tropics to establish networks of MPAs that safeguard the ecological integrity of larger reef systems. WWF has been instrumental in promoting innovative market incentives that reward responsible fishing methods. WWF also works to improve fisheries management, reduce bycatch fatalities of vulnerable species (such as whales and sea turtles), stop illegal trade in marine wildlife and reform government policies that undermine the ocean's web of life. Contact: Anita Van Breda, anita.vanbreda@wwfus.org; or Helen Fox, helen.fox@wwfus.org, WWF, 1250 Twenty-Fourth Street, NW, Washington, DC 20037; www.worldwildlife.org.

Appendix I. Suggested Reading

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Appendix II. List of Acronyms

AFD	French Development Agency
AGRRA	Atlantic and Gulf Rapid Reef Assessment
AIMS	Australian Institute of Marine Science
ASEAN	Association of South East Asian Nations
AUS AID	Australian Agency for International Development
BAPPEDA	Directory of Development Planning Board (in Indonesia)
CATIE	Centro Agronomico Tropical de Investigacion y Ensenanza
CABSMPD	Centre for Applied Biodiversity Science and the Marine Programs Division of CI)
CBD	Convention on Biological Diversity
CFC	Chlorofluorocarbon
CI	Conservation International
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of the Parties (to the Convention on Biological Diversity)
CORAL	The Coral Reef Alliance
CORDIO	Coral Reef Degradation in the Indian Ocean
COTS	Crown-of-Thorns Starfish *(Acanthaster planci)*
CPUE	Catch Per Unit Effort
CRC REEF	Cooperative Research Centre for the Great Barrier Reef (of Townsville, Australia)
CSD	Convention for Sustainable Development
DFID	Department for International Development (of UK)
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization (of the United Nations)
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRRF	Great Barrier Reef Research Foundation
GCC	Global Climate Change
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GIS	Global Information System
ICAM	Integrated Coastal Area Management
ICLARM	The International Centre for Living Aquatic Resources Management
ICM	Integrated Coastal Management
ICRAN	International Coral Reef Action Network
ICRI	International Coral Reef Initiative
ICRIN	International Coral Reef Information Network
ICRMN	Indian Global Coral Reef Monitoring Network
ICZM	Integrated Coastal Zone Management
IFRECOR	French Coral Reef Initiative
IMO	International Maritime Organisation
IMPAC	International Marine Project Activities Centre
IOC	Intergovernmental Oceanographic Commission (of UNESCO)

IOI	International Ocean Institute
IPCC	Intergovernmental Panel on Climate Change
ISRS	International Society for Reef Studies
ITMEMS	International Tropical Marine Ecosystems Management Symposium
IUCN	The World Conservation Union
LME	Large Marine Ecosystem
MAB	Man and the Biosphere Site (of UNESCO)
MAC	Marine Aquarium Council
MAQTRAC	Marine Aquarium Trade Coral Reef Monitoring Protocol
MARPOL	International Convention of the Prevention of Pollution from Ships
MCPA	Marine and Coastal Protected Areas
MDG	Millennium Development Goals
MEA	Multilateral Environmental Agreements
MPA	Marine Protected Area
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration (of USA)
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PERSGA	Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden
RAMSAR	International Convention on Wetlands
RAP	Rapid Assessment Protocol
RAP	Representative Areas Program (related to GBR rezoning)
REA	Rapid Ecological Assessments
ROPME	Regional Organisation for the Protection of the Marine Environment
SACEP	South Asia Cooperative Environment Program
SAREC	SIDA Department for Research Cooperation
SCUBA	Self-Contained Underwater Breathing Apparatus
SIDA	Swedish International Development Agency
SIDS	Small Island Developing States
SOI	Southern Oscillation Index
SPREP	South Pacific Regional Environment Program
SST	Sea Surface Temperature
TNC	The Nature Conservancy
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNF	United Nations Foundation
USAID	US Agency for International Development
UV	Ultraviolet Radiation
WB	World Bank
WCMC	World Conservation Monitoring Centre
WCS	Wildlife Conservation Society
WHS	World Heritage Site
WRAS	Web-based Reef Advisory System
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development
WWF	World Wildlife Fund (USA)
WWF	World Wide Fund for Nature (elsewhere)

Appendix III. Second International Tropical Marine Ecosystems Management Symposium Action Statement

Introduction

"Maintaining the biological diversity, condition, resources, and values of coral reefs and related ecosystems is a matter of global urgency." "Coral reef survival depends upon the world community acquiring and maintaining the knowledge and capacity to conserve and sustainably use coral reefs and related ecosystems. This requires that all uses and impacts be brought within and maintained at levels which do not exceed these systems' natural capacity for production and regeneration."

These statements, in the ICRI Framework for Action adopted in May 1995 at the International Coral Reef Initiative (ICRI) Workshop held at Silliman University in Dumaguete City, Philippines remain true today.

Drawing on the 1995 Call to Action and Framework for Action, the ICRI partnership has facilitated the leveraging and channeling of existing resources among all sectors for the benefit of coral reefs and related ecosystems. Many countries, agencies and individuals have implemented programs in response to the Call for Action. Yet the urgency remains. It has been heightened by widespread coral bleaching resulting from increased water temperatures, and by increased recognition of the crucial economic and social roles of coral reefs in the function and stability of many of the world's poorest coastal and island human communities.

The plight of coral reefs unites the developed and developing countries and is commanding the attention of governments and the international community. Most recently, The World Summit on Sustainable Development in 2002 called for the implementation of "the program of action called for by the International Coral Reef Initiative."

ITMEMS2 was held in Manila, Philippines on March 24 to 27, 2003. It brought together 200 people from 36 countries reflecting a broad range of experience of managers, scientists, private sector, non-governmental organizations, development and funding agencies to review progress to share and discuss lessons learned in implementing the ICRI Framework for Action. A specific objective of the Symposium was to identify gaps and priorities for implementation in the ICRI program of action to manage tropical marine ecosystems.

Like the 1995 ICRI Framework for Action and the Action Statement developed at ITMEMS1 in Townsville, Australia in 1998, this statement builds upon and reflects the principles and processes established in multilateral environment agreements and other relevant international programs[1]. It has been developed as a succinct statement which should be read and interpreted in light of these documents.

The principles and overarching actions identified in the 1995 Framework for Action continue to provide a valid strategic context.

Principles

The ICRI recognizes the following principles:

- Achieving the ICRI's purpose requires the full participation and commitment of governments, local communities, donors, NGOs, the private sector, resource users and scientists; therefore true partnerships, cooperation and collaboration exemplify the ICRI activities.
- The overriding priority is to support actions that will have tangible, positive and measurable effects on coral reefs and related ecosystems and on the well-being of the communities which depend upon them.
- Human activities are the major cause of coral reef degradation; therefore, managing coral reefs means managing those human activities. Individuals whose decisions and actions affect coral reefs–from boardrooms to beaches–need to become aware of and committed to the conservation and sustainable use of coral reefs and related ecosystems.
- The diversity of cultures, traditions and governance within nations and regions should be recognized and built upon in all the ICRI activities.
- Integrated coastal management, with special emphasis on community participation and benefit, provides a framework for effective coral reef and related ecosystem management.
- Developing national capacity to conserve and sustainably use coral reefs and related ecosystems requires a long-term (decadal) commitment. Improvement of coral reef management requires a permanent commitment and an adaptive approach.
- Strategic research and monitoring programs should be an integral part of the ICRI because management of coral reefs and related ecosystems should be based on the most relevant scientific information.
- Actions promoted under this framework should take account of, and fully use, the extensive body of international agreements and organizations that address issues related to coral reefs and related ecosystems. The ICRI will facilitate the leveraging and channeling of existing resources among all sectors for the benefit of coral reefs and related ecosystems.

Actions

- All those committed to supporting the ICRI and this Framework for Action are called upon to take account of and to act on the following at the international, regional and national levels.
- Support national and regional efforts to establish and coordinate strategies, priorities and programs to implement the ICRI Framework for Action, starting with regional workshops to be held by early 1996.
- Ensure that sustainable management of coral reefs and related ecosystems is considered at future relevant international meetings.
- Develop and/or strengthen national, regional and international mechanisms for gathering and sharing information and expertise on the sustainable management of coral reefs and related ecosystems.

[1] *WSSD, the U.N. Commission on Sustainable Development, the Convention on Biological Diversity, the U.N. Framework Convention on Climate Change, the Global Conference on Sustainable Development of Small Island Developing States, the U.N. Convention on the Law of the Sea, Convention on International Trade in Endangered Species of Wild Flora and Fauna, Global Program of Action to Protect the Marine Environment from Land-Based Activities, the Ramsar Convention, World Heritage Convention, FAO Code of Conduct for Responsible Fisheries, Regional Seas Conventions and Action Plans, the Convention on Migratory Species,*

- Promote improved access to financial and technological resources to enable institutions, regional centers and networks to assist and inform governments, industries and communities.
- Addressing conservation and sustainable use of coral reefs and related ecosystems requires activities in the following areas:
  - Integrated coastal management;
  - Public awareness, education and training;
  - Ratification of or accession to relevant international instruments;
  - Stakeholder participation at all levels; training policymakers and private sector decision-makers in the development and implementation of coral reef management;
  - Marine science and technology;
  - Environmental law, particularly environmental impact assessment regulations; and
  - Assessing the potential for micro-enterprise development and facilitating access to financing on a small to medium scale."

ITMEMS2 consisted of 20 workshops that considered priority issues or problems of management that had been identified through a questionnaire to managers from all coral reef regions of the world early in the Symposium planning process.

The report of the Symposium contains detailed recommendations of each workshop. This statement has been designed to focus on overarching priorities for action in the next 5 – 10 years to address the four elements of the ICRI Call to Action, which are:

- Integrated Coastal Management;
- Capacity Building;
- Research and Monitoring; and
- Review and Performance Evaluation.

The Proceedings of the Symposium contain the recommendations and detailed reports of the discussions of all workshops. This statement is intended to highlight the major issues and recommendations that arose through the discussions at the symposium.

Recommendations on Integrated Coastal Management (ICM)

Marine Protected Areas (MPAs)

Marine protected areas and networks of MPAs that implement large-scale and ecosystem-based management are essential for halting and reversing the decline in coral reefs and related ecosystems. Coordinated management of adjacent land areas is essential for effective ecosystem-based management of the marine environment.

Large scale and ecosystem-based coastal management provide a vital suite of tools to ensure sustainable use of coral reefs and related ecosystems. The following are inextricably linked components of such an approach:

- Mitigation of stresses that cause reef degradation;
- Protection of biodiversity and ecosystem processes at all levels;
- Recognition of the concept of "connectivity" and other ecological processes in the marine environment and the consequent importance of developing networks of MPAs that are ecologically connected;

- Incorporation of "no take" reserves to both protect biodiversity and to contribute towards ecologically sustainable fisheries;
- Recognition of the need to address the risk of bleaching impacts and resilience to bleaching effects in MPA and ICM design;
- Recognition of the important role community-managed MPAs play in conservation;
- Recognition that social, cultural and economic factors should drive MPA planning and management;
- Transparency of all processes in the development of MPAs;
- Partnerships and alliances in management including partnerships with community and private sector involvement for sustainable funding; and
- The use of multi-lateral agreements, conventions and similar arrangements to leverage cooperation across boundaries.

ITMEMS2 recommends that:

- Countries develop targets to significantly protect ecological processes, habitats and biodiversity through the establishment of MPA networks and integrated coastal and marine management.

Co-management

The social benefits (quality of life, education etc) to local communities of optimal tropical marine ecosystem management have not been fully recognized. Participatory planning and decision-making are recognized as critical elements for success in integrated coastal management. To be successful, management of tropical marine ecosystems should include full participation and involvement of local resource users giving due consideration to the needs of indigenous people.

A key element for successful community participation, information dissemination and education is understanding the local context, including the premise that community participation in management may work best in small, localised MPAs. Co-management relationships need to be flexible and can involve a variety of stakeholders (i.e. private sector, academe, government, non-government, community-based organisations, and others), but the interests of local subsistence resource users must be at the forefront.

ITMEMS2 recommends that:

- There should be formal recognition of traditional management practices and their institutionalisation into government policy;
- Participatory planning and decision making should incorporate clearly defined and accepted inter-agency, stakeholder, bilateral and multi-lateral partnerships and be part of a formal or informal agreement between the stakeholders;
- There be more recognition of the social values (both economic and non-economic) of wise practices for the management of tropical marine ecosystems;
- Programs emphasise poverty alleviation by promoting sustainable livelihood strategies in coastal communities dependent on coral reefs; and
- The local context be recognised as a key element for successful community participation, information dissemination and education.

Achieving Sustainable Fisheries

ITMEMS2 recognizes that management for ecologically sustainable fisheries is a critical issue in protection of coral reefs and related ecosystems and that: reef-associated fisheries are critically important for food security and livelihoods for coastal communities around the tropics.

ITMEMS2 further recognizes that many reef associated fisheries are already seriously overexploited and recommends:

- Urgent commitment to sustainable management of reef associated fisheries for long-term persistence including maintenance of biodiversity;
- Engaging those relevant international fishery instruments and regional fishery organizations charged with trade, enforcement, equity and management of reef-associated resources to comply actively with their mandates and to set and oversee long-term goals;
- Working towards the establishment and implementation of more no-take MPAs to contribute towards sustainable management; and
- Developing and applying a suite of tools to complement and enhance the effectiveness of no-take MPAs, including:
  - Conserving and managing fish spawning aggregations through robust strategies. Whenever possible, these should include complete or managed protection. A Call to Action on this issue is provided in attachment 1;
  - Encouraging sustainable mariculture, which avoids reliance on wild capture of juveniles for mariculture stock or of fish or other lower trophic level species for feed; and
  - Monitoring as an essential part of management to determine directions for action, provide feedback of information to local communities, to identify trends in catches, to provide a basis for adaptive management and evaluating management performance. This should include both fisheries dependent and independent data.

Coral Bleaching

Coral reefs of the world have been deteriorating from coral bleaching and mortality due to warming seas. Managers, scientists and policy-makers at ITMEMS have agreed that they can address these trends by adopting a number of risk minimising strategies.

ITMEMS2 recommends that:

- Resilience of coral reefs be supported through good MPA and ICM design, MPA networks, and by reducing threats within management control;
- Risk of bleaching impacts be factored into management by incorporating the principles of comprehensive representation and replication in the design of MPAs and MPA networks;
- Flexibility to respond to bleaching threats be incorporated into all coral reef management plans;
- Managers, scientists and policy-makers play an advocacy role towards influencing policy related to climate change;
- The extent and severity of bleaching events and degree of subsequent recovery be documented and reported on to raise the understanding and awareness of the public and policy makers of the environmental and socio-economic impacts of bleaching; and
- Documentation and mitigation of the negative effects of climate change on other tropical marine species and ecosystems (eg mangroves, turtle and seabird nesting, diseases, planktonic ecosystems) be promoted.

Restoration and Rehabilitation

It is clear from many reports of the condition of the world's coral reefs that efforts to restore or rehabilitate damaged ecosystems are an increasingly important management issue, particularly to those close to major cities and heavily populated coasts. While it is preferable and most cost-effective to prevent or minimise damage as far as possible, restoration and rehabilitation techniques are being developed.

ITMEMS2 recommends that:

- The focus of restoration and rehabilitation be on removing threats and applying methods to accelerate natural recovery processes in tropical marine ecosystems that otherwise have little potential for recovery to restore fisheries and protect tourism assets;
- A systematic review be made of restoration and rehabilitation methods and initiatives to evaluate effectiveness in recovering damaged ecosystems, overall cost, area coverage, and the contribution towards the effectiveness of MPAs and ICM. This review could also be used as an education tool; and
- A network of managers, scientists, practitioners and local communities be established to share information and develop guidelines on appropriate restoration and rehabilitation practice;

The Role of the Private Sector

Active engagement with the private sector is critical for long-term success in sustaining and conserving coral reefs and related ecosystems.

ITMEMS2 recommends that:

- The concept of the 'Private sector' be interpreted broadly to include all individuals, groups and enterprises of the formal and the informal economy, at local, national and international levels that use, impact, extract and exploit coral reef resources;
- Private sector involvement incorporate arrangements that maximize the flow of benefits for local stakeholders;
- Good practice examples of partnerships between the public and private sector in marine conservation (ecotourism, aquarium fish trade, pharmaceutical companies etc.) be identified and documented;
- Governments create a policy, legal, regulatory and institutional framework that creates incentives and removes disincentives for private investment in marine conservation and for ecologically sensitive resort construction, water & waste management, dive operations; and
- Effective international certification, labeling and awards for good practice partnerships in coral reef conservation and fisheries be promoted.

Enforcement

Without effective enforcement, MPAs and ICM programs will not provide their intended benefits to the marine ecosystems and the communities that depend upon them. There is an urgent need for greater recognition by government, funding agencies and NGOs that effective enforcement of marine resource use regulations is considered essential by both local communities and marine managers, and requires much greater financial and political support.
There is a widespread view from communities and managers across all tropical marine regions that the damage caused by and profitability of marine resource crimes are not recognized by the judicial system.

ITMEMS2 recommends that:

- Government, funding agencies and NGOs recognise that effective enforcement of marine resource use regulations is considered essential by both local communities and marine managers and requires much greater financial and political support;
- MPA and ICM planning explicitly incorporate consideration of compliance issues from the outset of the planning process;
- Fines and penalties for illegal acts be set at levels where they act as true deterrents rather than being considered by offenders as a cost of doing business;
- MPA and ICM planning explicitly recognise that local compliance can increase dramatically if communities are aware of and involved in MPA management and if they can invest in sustainable use; and
- MPA and ICM managers address the urgent need for greater communication, collaboration and sharing of lessons learned between countries on the issue of marine enforcement.

Recommendations on Capacity Building

Sustainable Financing

Lack of appropriate, sustainable funding mechanisms is a significant challenge to effective coral reef management. A fundamental issue is to address the local nature and the long time frames needed to address many management issues. Although many issues are national or regional in scale, much can be achieved through small amounts of funding that are effectively targeted.

ITMEMS2 recommends:

- Establishing Debt-for-Nature Swap initiatives aimed at marine biological diversity and coral reefs in particular;
- Establishing secure trust funds, endowments, and other financing mechanisms available over extended timeframes;
- Further exploring financing options that marry improvements in community well-being with improvements in ecosystem health, such as some MPA user fees, conservation concessions, and supplemental livelihood initiatives;
- Developing small grants programs to support local management in all coral reef regions;
- Continuing support for key priorities for monitoring and strategic research; and
- Developing strategic partnerships to more efficiently and sustainably fund and implement marine conservation.

Training/Awareness

Perhaps the greatest impediment to coral reef conservation is the lack of human capacity available for management and lack of awareness about coral reef values and threats.

ITMEMS2 recommends:

- Increasing efforts to build human capacity in critical areas, including MPA management, enforcement, and ICM;
- Developing targeted education/awareness programs for key audiences including legal institutions, government officials, and resource users;

- Continuing and strengthening efforts to raise public awareness on reef values and ecological complexity and the serious ecological, social, and economic losses caused by lack of stewardship;
- Recognising the role of NGOs and other partnerships as important catalysts for increasing capacity for management. Mechanisms to ensure accountability of all partners should be included in partnership agreements. There also needs to be planning for long-term continuity of introduced practices and management; and
- Enhancing community participation and providing training to stakeholders on sustainable resource management.

Networking/Partnerships
Partnerships and networks that increase the efficiency of information exchange are vital strategies in effective coastal management.

ITMEMS2 recommends:

- Increasing support for peer group exchanges;
- Developing and documenting good practice demonstration sites;
- Fostering partnerships across multiple boundaries, disciplinary, jurisdictional, cultural, etc;
- Promoting the development of networks at all levels for capacity building and exchange of experiences and good practices;
- Promoting partnerships so that donor funding in conservation does not compete with, but complements and supports private sector and community investment in marine conservation; and
- Recognising the role of NGOs and other partnerships as important catalysts for increasing capacity for management;

Recommendations on Research and Monitoring

Research And Monitoring Programs
Well-designed and targeted research and monitoring programs are essential components of tropical marine ecosystem management to maintain biological diversity, natural resources, ecosystem condition and the values of coral reefs and related ecosystems.

ITMEMS2 recommends:

- Continued commitment to high quality research and monitoring for tropical marine ecosystem management;
- That research and monitoring programs be highly targeted towards supporting decision makers on key issues;
- That all elements of research and monitoring should incorporate the full involvement of, and respect for the range of knowledge and skills available from the whole community, including scientists, resource users, indigenous people and members of the general community;
- Global evaluation and adoption of existing protocols for management related research and monitoring and development of new protocols where needed;
- Long-term monitoring of environmental and social conditions. This information is essential to provide early indications of emerging issues, measures of background

(natural) variation and long-term trends and impacts; and
- Encouraging multidisciplinary research in which socio-cultural-economic and biophysical components are integrated and complementary.

Information Coordination and Dissemination

A major obstacle to effective management and conservation of tropical marine ecosystems is the lack of awareness, and access to existing information and experiences of other managers. There is a wealth of information resources scattered among various organisations but much of it is inaccessible.

ITMEMS2 recommends that:

- Summary data and results including performance evaluation from all relevant projects should be made available on ReefBase, FishBase, and other widely accessible venues to promote information exchange, and transparency to and among stakeholders;
- A centrally coordinated certification and accreditation system should be established to ensure data quality standardisation and documentation. This should include guidelines for data storage safeguards, security, metadata, and the development of a core set of variables and formats;
- There should be a formal obligation (specified in permits, grant agreements etc.) for non-sensitive data to be made publicly available in a variety of formats as soon as possible;
- A code of conduct for data collectors and information managers be developed to ensure maximum free flow of data and proper regard to security for sensitive data;
- Information systems be client-oriented, able to provide for demand-driven requests for information in both digital and hard copy formats. Websites storing data in digital formats must be recognised as key data storage access facilities requiring similar levels of support as traditional libraries; and
- As a matter of priority, a global inventory of tropical marine ecosystem databases/ information systems should be created and made publicly available.

Communication

Awareness of management activity, the responsibilities and rights of resource and MPA users and the issues that management must address is essential for effective, planning, implementation and enforcement. Communication is essential to the success of every project and should start before and continue after it.

ITMEMS2 recommends that:

- All projects include a communication strategy that is carefully planned, feedback driven, adequately funded and involves outreach activities, and that this should be required by donors; and
- Communications are designed and presented in a culturally relevant form and focus on positive actions, which can be taken. Formal educational activities from pre-school to specialised professional courses are an important means of communicating specific information and promoting alternative practices.

Recommendations on Review and Performance Evaluation:

Methods

Maintaining and improving management depends upon good information on the implementation of management measures and their effectiveness in achieving the objectives of management.

ITMEMS2 recommends that:

- Management performance evaluation systems be based on clear performance targets and conform to the principles for management performance evaluation[2] including provision for stakeholder participation in establishment of performance targets and evaluation; and
- The quality of management performance evaluation systems be monitored to ensure acceptability, reliability, compatibility, and conformity to indicators, processes and other related evaluation protocols.

Resources and Allocation

Design of performance monitoring and evaluation systems must be done in the context of limited resources and competition with other elements of management.

ITMEMS2 recommends that:

- A specific financial resource (5-15%) of total budget be allocated for monitoring and management performance evaluation; and
- Funding agencies and governments use results of management performance evaluation;
  - as a basis for allocating further or continued management initiatives funding assistance;
  - as an incentive for high quality or disincentive for poor quality performance; and
  - in providing further capacity building assistance.

[2] The report of the ITMEMS2 performance evaluation workshop includes suggested principles for management performance evaluation.

Attachment 1: Call for Action

Reef Fish Spawning Aggregations Need Protection

A Threat to Sustainable Reef Fish Fisheries

Many commercially valuable reef fishes are particularly vulnerable to overexploitation because they form spawning aggregations that are highly predictable in time and location. These aggregations, and in some cases the migration routes to and spawning aggregation sites, are easy to find and target by fishers. The evidence is unequivocal that spawning aggregations can decimate rapidly by heavy fishing, resulting in serious declines in the fish populations they serve. Moreover, they are increasingly being targeted globally, particularly in the Pacific Ocean for commercial salted and chilled fish and for lucrative live fish export markets. Best known is the example of the Nassau grouper, *Epinephelus striatus:* a significant number of Nassau grouper aggregations are depleted in the western Atlantic, and some have possibly disappeared completely. The species is listed as endangered on the IUCN Red List of Threatened Species. Evidence is growing of aggregation depletions in SE Asia and the western Pacific.

Spawning aggregations are critically important for maintaining fish stocks and may thus underpin fisheries that contribute significantly to livelihoods in coastal communities, as well as to food supply. However, little management has been implemented to protect reef fishes when they spawn, despite the widely recognized need to protect spawning areas in marine protected areas. Unmanaged aggregation fishing is clearly non-precautionary. Management options include combinations of spatial and/r temporal controls, such as short-term, seasonal closures during the aggregation period, closures of aggregation sites, incorporation of aggregation sites into marine reserves, and various controls on catch and effort.

Specific recommendations

- Ideally, fishing of aggregations should be avoided unless part of important local traditional or subsistence fisheries;
- If spawning aggregations are fished for subsistence, they should be closely monitored and carefully managed;
- Fishing of spawning aggregations should not be permitted for export/commercial markets;
- Spawning aggregations should be included routinely in fishery management plans and marine protected areas design;
- The potential impacts and benefits of tourism on fish aggregations should be evaluated, especially to determine the possible disturbance caused by tourism activities;
- Education is needed to increase understanding of the biological and fishery importance of spawning aggregations and their vulnerability to fishing; and
- Extreme caution should be exercised not to make public information on the specific locations of aggregation sites that cannot be adequately protected from exploitation.

Key recommendation: fish spawning aggregations should be conserved, through robust management strategies. Whenever possible, this should include complete or managed protection, to ensure persistence of the populations that form aggregations, the integrity of reef ecosystems and the livelihoods and food supply of communities that depend on aggregating species.

This statement and other documents from the International Coral Reef Initiative are available from: http://www.icriforum.org/ or on ReefBase http://www.reefbase.org