GCRMN

GLOBAL CORAL REEF
MONITORING NETWORK

Status of Coral Reefs of the World: 2002

Edited by Clive Wilkinson

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

Dedication
This book is dedicated to all those people who are working to conserve the coral reefs of the world – we thank them for their efforts. It is also dedicated to the International Coral Reef Initiative and partners, one of which is the Government of the United States of America operating through the US Coral Reef Task Force. Of particular mention is the support to the GCRMN from the US Department of State and the US National Oceanographic and Atmospheric Administration.

I wish to make a special dedication to Robert (Bob) E. Johannes (1936-2002) who has spent over 40 years working on coral reefs, especially linking the scientists who research and monitor reefs with the millions of people who live on and beside these resources and often depend for their lives from them. Bob had a rare gift of understanding both sides and advocated a partnership of traditional and modern management for reef conservation. We will miss you Bob!

Front cover: Vanuatu - burning of branching *Acropora* corals in a coral rock oven to make lime for chewing betel nut (photo by Terry Done, AIMS, see page 190).
Back cover: Great Barrier Reef - diver measuring large crown-of-thorns starfish *(Acanthaster planci)* and freshly eaten *Acropora* corals (photo by Peter Moran, AIMS).

Office locations:

Townsville, Queensland
(main laboratories)
PMB No 3, Townsville MC Qld 4810
Telephone (07) 4753 4444
Facsimile (07) 4772 5852

Darwin, Northern Territory
PO Box 40197, Casuarina NT 0811
Telephone (08) 8946 6716
Facsimile (08) 8946 6847

Perth, Western Australia
PO Box 83, Fremantle WA 6959
Telephone (08) 9433 4440
Facsimile (08) 9433 4443

www.aims.gov.au

ISSN 1447-6185

Foreword

Our two governments have responded to the plight of coral reefs outlined since the United Nations Conference on Environment and Development in 1992, and reiterated in Johannesburg at the World Summit on Sustainable Development (WSSD) in 2002. The Philippines and Sweden have combined to guide the Secretariat of the International Coral Reef Initiative (ICRI) with the goal of bringing developing and developed countries together to conserve coral reefs. Our coral reefs are being damaged by both natural and human pressures and unless we act now, it is predicted that over half of the world's coral reefs could be severely degraded within a generation. Coral reefs can recover from natural threats, but recovery is slow from the direct and indirect damage that people are doing to reefs. Often that damage is inadvertent as people seek food or cultural items from the reefs, but unfortunately some of the damage is deliberate through constructing airports, ports and dredging channels. Damage is caused indirectly through poor land use practices that result in sediments and excess nutrients pouring over the reefs and through the release of sewage and industrial wastes that cause eutrophication. Even our excessive use of plastic bags ends up damaging coral reefs. The responses to these alarm calls have been the establishment of ICRI, the Global Coral Reef Monitoring Network, CORDIO (Coral Degradation in the Indian Ocean), Reef Check, ReefBase and the World Resources Institute *Reefs at Risk* project, to mention just some.

All people in the world are 'stakeholders' in coral reefs as we have inherited their wealth of biodiversity and natural beauty, therefore we all share the responsibility for conserving them. We now understand what damages coral reefs and the critical measures that users, local and national governments, international agencies and NGOs have to do in partnership to conserve reefs.

We are pleased to see that in the *Status of Coral Reefs of the World: 2002* report, there are many global and local initiatives being implemented to arrest the damage, conserve coral reefs and establish more protected areas. One example is Apo Island, in the Philippines, where the local university and the community have worked together to conserve their resources for the benefit of all. Another initiative is to ensure that the trade in live fish for restaurants and the aquarium trade is ecologically sustainable, and not damaging the reefs of Southeast Asia and the Pacific.

The Government of the Philippines, one of the founding countries of ICRI, hosted in 1995 the first ICRI international workshop in Dumaguete City, which outlined the pioneering global strategy for coral reefs through the ICRI *Call to Action* and *Framework for Action*. In March 2003, the Philippines will host the 2nd International Tropical Marine Ecosystem Management Symposium (ITMEMS 2) in Manila. It is expected to become another milestone conference to identify strategies on coral reef and associated ecosystems management when strong resolve is needed to respond to the WSSD Plan of Implementation. Then and now, the Philippines continues to be instrumental in bringing forth strategies and actions for implementation at global and national levels.

A significant Philippines national strategy is the devolution of ecological management responsibility to the municipality and 'barangay' level under the Local Government Code passed by Congress in 1991. The case studies on Pages 127, 143, 146 and 148 illustrate that when communities are given the responsibility for managing their own resources with help from government and scientists, the damage to the reefs can be reversed. In addition, the Philippine Government has been proud to declare the large Tubbataha National Marine Park as a World Heritage Site. It is jointly managed by the Palawan Council for Sustainable Development and the World Wide Fund for Nature (WWF) Philippines. In March 2002, as President of the Philippines, I had the wonderful opportunity to dive at Tubbataha, which enabled me to experience the natural beauty of Palawan. Even more rewarding is the genuine concern that the Filipinos have for conserving and managing these reefs.

The same tourism potential can be developed in other Philippine reef areas. We must start increasing the awareness of our people about how they can conserve and benefit from reef resources. We expect that the recommendations and assistance from the Symposium will greatly contribute to our efforts.

Sweden, also one of the founding countries of ICRI when it first met in 1994, has continued as an active member since then. In 2001 and 2002, Sweden together with the Philippines, served as Secretariat of ICRI. Sweden has also supported coral reef-related activities in the Indian Ocean region through the CORDIO Program (Coral Reef Degradation in the Indian Ocean; Page 363). The program was initiated when the major coral bleaching and mortality event of 1998 struck reefs in East Africa, the Maldives, the Seychelles, Comoros and Sri Lanka. As Prime Minister of Sweden, I am proud of the pro-active initiatives that our government has launched to assist countries with the sustainable development of coral reefs.

We are pleased to endorse this report and hope that it will stimulate international efforts to conserve coral reefs. We need action at all levels, from assisting local communities with co-management agreements, to truly global initiatives like managing the trade in coral reef products and reducing the release of greenhouse gases which apparently are linked to coral bleaching. We need to conserve coral reefs because of their magnificent resources of biodiversity, unparalleled beauty and enormous tourism potential, and particularly because sustainably managed reefs can provide food and shoreline protection for hundreds of millions of people around the world.

More power to ICRI!

Gloria Macapagal-Arroyo
President
Government of the Republic of the Philippines

Goeran Persson
Prime Minister
Government of Sweden

Contents

Countries, States and Territories

Acknowledgements

My role in editing this book is to condense large amounts of great material into a shorter format for a global audience. There would be no book without all the contributions from many people monitoring coral reefs, assembling data, writing reports, and running projects around the world. Most of these have contributed their information voluntarily as there are few people paid to undertake GCRMN activities. Many have given their data knowing that the Status reports do not recognise all contributions by citing the references or sources. Thank you. This is done deliberately to reduce the size of the book and focus on the messages, not the sources of messages. Where feasible, I have included an e-mail address or reference if the reader wants more information. Contacts for most of the national and regional authors are included at the end of the regional chapters. Special thanks go to those people (the Node Coordinators) who compiled the various national reports into regional reports that constitute the basis of the chapters. I also wish to thank Kristin Sherwood, Jos Hill, Madeleine Nowak, John Tyler and Robin South for their careful editorial contributions. I owe staff at AIMS special thanks. This book was prepared under an extremely tight schedule and would not have been realised without the always professional and friendly Science Communication team at AIMS, Steve Clarke, Wendy Ellery and Tim Simmonds – thank you.

The GCRMN has included two partners in the direction of the network: Gregor Hodgson brings his Reef Check network and volunteers; and Jamie Oliver provides the platform of ReefBase to ensure that data generated by the GCRMN has a means of reaching the world. The co-sponsors of the GCRMN have provided substantial assistance, advice and support: The Intergovernmental Oceanographic Commission of UNESCO; the United Nations Environment Programme (UNEP); IUCN – The World Conservation Union; the World Bank; the Convention on Biological Diversity; AIMS; WorldFish Center (formerly ICLARM); and the ICRI Secretariat. These meet voluntarily in association with ICRI meetings to provide guidance to the GCRMN. Direction for the GCRMN Management Group has been provided by Ned Cyr and Ole Vestergaard of IOC-UNESCO and Clarl Gustaf Lundin of IUCN – I with to thank them all.

Support for the GCRMN primarily comes from the US Department of State, the National Oceanographic and Atmospheric Administration and AIMS. Funds are channelled through UNEP in Nairobi and IOC-UNESCO in Paris. Without this support there would be no global coordination and no global status report – thank you. Many organisations support the monitoring in the regions and these are acknowledged in the chapters; thanks to them. Funds to print this book have come from the Government of the USA (Department of State and NOAA), SAREC/Sida of Sweden, the World Bank, the ICRAN project, the Great Barrier Reef Research Foundation, and IUCN-The World Conservation Union. Their assistance ensures that the book will be produced and provided at no production charge to people around the world who are working to conserve coral reefs, often voluntarily.

Introduction

We are pleased to endorse and support the 3rd report on the *Status of Coral Reefs of the World: 2002*. The two previous reports in 1998 and 2000 were particularly valuable in focusing the attention of decision makers, major donors and national and international agencies on the declining status of these invaluable resources, and the need to take action to assist the approximate 500 million people who depend on reefs, wholly or partially for their livelihoods. This report continues to show that reefs are declining, but it also illustrates major new initiatives that are being implemented to reverse their decline.

Coral reefs are not only major storehouses of incredible biodiversity (32 of the 34 recognised animal Phyla are found on coral reefs compared to 9 Phyla in tropical rainforests), but also provide food, cultural objects, building materials and shoreline protection for peoples living near them. Another benefit is coral reef tourism, which is one of the fastest growing industries in the world that now caters for people from the wealthier countries wanting to visit tropical coastal resorts. Tourism can be an effective pathway for the conservation of coral reef resources in developing countries.

The recent emphasis at the World Summit on Sustainable Development in 2002 in Johannesburg was on activities to improve the health and alleviate poverty amongst an estimated 500 million people who live in tropical developing countries and have some dependence on coral reefs. Such reefs have been estimated to provide the world with US$375 billion in goods and services. Per unit area, they are amongst our most valuable ecosystems. Yet we are witnessing an accelerating rate of their loss, with these losses directly impacting on poor people. For many of these people, coastal areas, and particularly coral reefs, are the last 'resort' where they turn to after agricultural lands have lost fertility or industries have collapsed. Displaced people can build a dwelling in the common lands bordering the sea and make a living with little expenditure by catching or gleaning food off coral reefs. This was particularly evident in Southeast Asia, the centre of coral reef biodiversity, when unemployment surged during the economic crisis of 1998. People returned to their home villages to make a living directly from the environment, often using damaging practices like bomb fishing. One of the most valuable actions that we can take is to implement mechanisms to conserve these valuable resources. If we succeed, we will have a greater chance of improving the nutrition and health of coastal populations. This 3rd report continues that trend of providing invaluable data and information to guide the world in coral reef conservation.

A specific theme of this 3rd edition of Status of Coral Reefs of the World is to document progress in conserving coral reefs in World Heritage Sites, Man and the Biospheres Sites, International Coral Reef Action Network (ICRAN) Demonstration sites, and other Marine Protected Areas (MPAs). Many of these sites arose from projects aimed at conserving the environment, but very few have implemented performance evaluation pertinent to the natural resources. For example, are the objectives of conserving the coral reef showing success? The critical first step in conservation is to assess the resources, then monitor trends in these resources, including how the human components are interacting with the resources. The types of monitoring encouraged by the Global Coral Reef Monitoring Network (GCRMN) aim to provide user communities and resource managers with the data needed to assess management strategies and adjust them to improve success. Another aspect that is frequently overlooked with monitoring is that the act of observing the system to gather data is a powerful awareness raising tool. When communities see the results of their activities, they are more likely to support management to conserve their resources. Decision makers are also alerted to the issues when they witness communities gathering data on coral reefs. This 3rd edition reports on the status of coral reef monitoring in these key conservation sites and provides a report card on the effectiveness of managing MPAs. This will be repeated in future editions as a check on progress at establishing and managing MPAs.

Since the last report, a series of major initiatives are starting to accelerate coral reef protection:

- the US Coral Reef Task Force and other governments have provided more funds and expertise to manage coral reefs across the globe, particularly in US dependent and associated territories;
- ICRAN, using funds from the United Nations Foundation, has started strengthening a series of key demonstration sites in 4 of the major coral reef areas of the world;
- the World Bank, IOC/UNESCO and other partners have launched a targeted research effort to bring the full force of science together to examine some of the major issues facing coral reefs (global climate change, coral bleaching, coral reef rehabilitation etc.);
- The Nature Conservancy, Conservation International and the World Wildlife Fund have launched a major project to create a linked series of MPAs that both exchange larvae and also are more resistant to climate change caused bleaching;
- The Packard Foundation has launched the Western Pacific Biodiversity Conservation Project, focussed largely on coral reefs of the Asia-Pacific region.

Some of the larger foundations in USA, Japan and Australia are emphasising coral reef projects and assisting NGOs in direct activities to establish large MPAs or link existing ones in order to arrest the degradation of coral reefs. For example, USAID and the UN Foundation announced a grant at WSSD of $3 million to ICRAN to tackle coral reef problems along the Caribbean coast of Central America.

An essential requirement for ocean management and sustainable development is an improved understanding of marine and coastal processes and resources. This must be founded on sound data and information gathered routinely from all parts of the world. The IOC (Intergovernmental Oceanographic Commission) of UNESCO, World Meteorological Organisation, UNEP with assistance from International Council for Science and the UN Food and Agriculture Organisation are establishing the Global Ocean Observing System (GOOS), in which coastal monitoring will be an important component. The GCRMN is a critical partner, particularly as it provides data on coral reef status and changes that are linked to global climate change. Coral bleaching is a key topic in this report, and it is conceivable that coral reefs may prove to be the first major marine ecosystem to be significantly impacted by global climate change. New data on coral reef dynamics and impacts of heat stress will be investigated under the developing targeted research effort on coral sustainability.

Accurate and accessible information on the state of coral reef ecosystems is essential for informed and effective management, but it is also recognised that there is a need for assessment of the social, cultural and economic values pertinent to reefs. UNEP (United Nations Environment Programme) and the Regional Seas Programme are collaborating with the GCRMN to promote monitoring of coral reefs and user communities to improve the flow of pertinent information. UNEP established the Coral Reef Unit in 2000 to coordinate activities within the organisation, as well as provide links to the wider community of researchers, multilateral environmental agreements, Governments, and NGOs. The goal is to assist in international efforts to save coral reefs and associated ecosystems worldwide. UNEP insists that efforts at the global and regional levels must result provide practical benefits for the well-being of local communities, their economies and for coral reefs. UNEP, and particularly the Regional Seas programs, works with ICRI and its operational networks like the GCRMN, to assist developing countries with reef conservation and monitoring. The new edition of the Status of Coral Reefs of the World makes extensive information on coral reefs readily available and accessible to a wide audience. Equally important, the collaborative process of putting together this report illustrates what can be achieved when people and organisations collaborate.

It is well recognised that NGOs (non-governmental organisations) play an effective role in conservation of coral reefs and, in particular, providing monitoring information for the GCRMN. The IUCN – The World Conservation Union assists the GCRMN by catalysing some of its 900 members in nearly 140 countries that are active in coral reef monitoring and conservation. The IUCN provides critical linkages to the GCRMN to broaden its influence and encourage and assist communities around the world in the conservation of coral reefs. The IUCN is currently strengthening its marine program, of which coral reefs and sponsorship of the GCRMN are major components. Other critical IUCN activities are developing marine protected areas in the tropics, and illustrating the links between global climate change and coral reefs, in collaboration with the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change. IUCN is also strengthening is collaboration with the Coral Reef Degradation in the Indian Ocean (CORDIO) program, and will soon be launching a number of joint activities.

The World Summit on Sustainable Development highlighted the importance of coastal resources, and coral reefs in particular, to the economic development of coastal nations and small island developing states in its Plan of Implementation (September 2002). It particularly noted the dependence of millions of people on reef resources for food, shelter, employment and foreign exchange. Targets were set by countries and the international community for the restoration of degraded fish stocks and the protection of marine biodiversity to ensure the continued productivity of essential environmental goods and services. The World Bank is committed to supporting these efforts through its membership of ICRI and via a growing portfolio of projects to support coral reef conservation and management. The GCRMN, through monitoring the status of coral reefs around the world and building capacity in countries, performs a vital task in helping nations assess their progress in conserving coral reefs and understanding the threats from climate change and unsustainable development. The World Bank aims to expand its ongoing partnership with the GCRMN to help guide conservation efforts to where they are most needed and to respond to the challenges of the WSSD 2002.

Coral reefs ecosystems are rich in biodiversity and their conservation and sustainable use are essential to the livelihood of many coastal populations in developing countries. Following the coral-bleaching events of 1998, the Conference of the Parties to the Convention on Biological Diversity decided to fully integrate coral reefs into its program of work on marine and coastal biodiversity and highlighted information-gathering as one of the priority areas for action on coral bleaching. Likewise, a comprehensive analysis of the status and trends of global coral reef ecosystems is one of the elements indicated by the Convention's Subsidiary Body on Scientific, Technical and Technological Advice for inclusion in the work plans on coral bleaching and on physical degradation and destruction of coral reefs. The new edition of the Status of Coral Reefs of the World is an important contribution to the implementation of the Convention's programme of work on marine and coastal biological diversity and provides a valuable tool for decision-makers and others concerned about the continuing health of these key ecosystems.

Coral reefs are coming under more and more pressures to provide fisheries resources as income and food for people in developing countries. The WorldFish Center has made coral reefs one of its focal areas in recognition of the importance of these roles and is working with other agencies to determine how MPAs can conserve fish stocks and increase productivity in adjacent areas. The WorldFish Center encourages regular monitoring and the dissemination of status reports by researchers, governments and communities and has developed ReefBase to ensure that coral reef data and information are widely disseminated. ReefBase serves as the global database for the GCRMN and other monitoring networks, as well as being a central repository of coral reef information.

Coral reef monitoring is fundamental in Australia for the sustainable management of the Great Barrier Reef, the largest World Heritage Site in the world, as well as the reefs off Western and northern Australia. It is recognised that these reefs are under much lower pressures than others in the region. The Australian Institute of Marine Science maintains a program of regular monitoring on the eastern and western side of Australia to ensure that there is an early warning system of reef degradation. A new centre for tropical resource research is now being established in northern Australia in association with the Australian National University. AIMS also plays a fundamental role in developing monitoring methods and in displaying results of monitoring on the Internet, and continues to support global coordination of the GCRMN.

This report brings together most of the major coral reef monitoring groups in the world: the GCRMN and Reef Check are linked in a strategic partnership, with ReefBase, the global coral reef database forming the foundation for collating and sharing the results of monitoring and research around the world. There are also contributions from CORDIO, CARICOMP, AGRRA and the Reefs at Risk projects (all described at the end of this report). These partnerships will expand in the future as all these organisations share common goals; gathering data and information for the conservation of coral reefs.

The Executive Summary and the Report demonstrate that major progress has been made during the last few years in establishing global monitoring networks and providing information for reef resource managers. But the Status 2002 report also demonstrates that data are insufficient from large regions of the world, and that our attempts at managing coral reefs to arrest their decline are still lagging behind the increasing rate of reef degradation. There is a need to tackle two parallel agendas: the losses in coral reefs at local scales around the world from the direct impacts of people (over-fishing, pollution, sedimentation and conversion of reefs to other uses); and the truly global threats posed by Global Climate Change. There was a wake up call in 1997-98 when the world's largest coral bleaching and mortality event 'temporarily destroyed' about 16% of the world's reefs. Some of these are now showing signs of recovery; but others are not. We must heed this call and the previous calls that human activities are destroying the coral reef resources that many poor people depend on. That is why we are combining our skills and resources in partnerships to tackle this global problem together. Our sponsorship of the GCRMN is a tangible example of international agencies acting in concert. We commend this report to you and urge you to assist with us in our attempts at coral reef conservation.

Patricio Bernal
Executive Secretary, Intergovernmental Oceanographic Commission of UNESCO

Klaus Toepfer
Executive Director, United Nations Environment Programme

Carl Gustaf Lundin, Head, Global Marine Programme, IUCN – The World Conservation Union & Chair, GCRMN Management Group

Robert Watson
Chief Scientist, The World Bank

Hamdallah Zedan
Executive Secretary, Convention on Biological Diversity

Stephen Hall
Director, Australian Institute of Marine Science

Meryl Williams
Director General, WorldFish Center

Executive Summary

Clive Wilkinson

Abstract

Two sets of counteracting human activities are affecting the destiny of the world's coral reefs:

- reefs are continuing to decline in many areas around the world due to steadily increasing threats from direct human pressures and indirect pressures of Global Climate Change; but
- there are many conservation and management projects being initiated at international, regional, national and local levels to arrest the declines in coral reef health in specific areas, and some of these initiatives are showing considerable success.

The 2002 report on the status of the world's coral reefs is a mix of bad news and good news, but there is strong evidence that the corner is being turned in our ability to stop reef decline, provided this continues to be supported by sufficient political will. We can predict gains in coral reef health at specific sites in many regions within the coming 2 decades. Many different projects are reducing the damaging human impacts on coral reefs and also setting more reefs aside for protection. Unfortunately, a large proportion of the world's reefs are outside protected areas, and much effort will be needed to replicate the small-scale successes at national and regional scales. In addition, many coral reef countries do not have national coral reef programs or monitoring plans, and are often unaware of the extent of damage to their reefs.

Many of the coral reefs that were severely damaged during the 1998 mass coral bleaching are showing encouraging signs of slow to moderate rates of recovery. However, there are also many reefs where recovery is barely evident. There has been more recovery on unstressed and protected reefs, whereas reefs being stressed by high levels of sediment and nutrient pollution and over-fishing are still largely bare of live corals.

There is one significant proviso for recovery. These improvements could be largely negated if the predicted threats posed by Global Climate Change of increasing sea surface temperatures and concentrations of CO_2 in seawater cause catastrophic bleaching and result in major reductions in the capacity of corals to calcify and grow.

This report brings together the assessment of reef status by 151 authors for more than 100 countries, which are assembled into 17 regions. For most countries, there is recent information, but for others no new data have been received since the last report in 2000.

The Positive Signs

Growing Awareness: There is a growing awareness of the need to conserve coral reefs by minimising the damaging human activities at local to global scales. This awareness is being translated into a wide range of pragmatic activities across a range of regions, scales, disciplines and themes. This awareness can be traced back to a sequence of wake-up calls on the increasing degradation of coral reefs:

- 1983 – the first regional-scale bleaching damage was reported during the 1982-83 El Niño;
- 1988 – the first reports on reef status were produced by Susan Wells and colleagues at UNEP and IUCN;
- 1992 – UNCED (United Nations Summit on Environment and Development) focused the world's attention on the need to include environmental considerations during development;
- 1992 – alarm calls were raised at the 7th International Coral Reef Symposium in Guam that 10% of the world's reefs were dead and another 60% were threatened if no remedial action were taken;
- 1993 – alarming case studies on the decline in coral reefs were reported at a meeting in Miami which stimulated calls for immediate monitoring;
- 1994 – the International Coral Reef Initiative (ICRI) was formed at the Small Islands Developing States conference in Barbados;
- 1995 – ICRI produced the global coral reef agenda as the Framework for, and Call to Action manifestos;
- 1997 – the International Year of the Reef focused attention on reefs and new activities started including launching Reef Check;
- 1998 – the Status of Coral Reefs of the World: 1998 report was released documenting serious reef decline in may parts of the world;
- 1998 – the Reefs at Risk analysis showed that 58% of the world's reefs were under moderate to severe threat;
- 1998 – the largest recorded coral bleaching and mortality event struck reefs around the world during to the 1997-98 El Niño event;
- 1998 – the 1st International Tropical Marine Ecosystems Management Symposium revised the Framework for, and Call to Action;
- 2000 – the 2nd Status of Coral Reefs of the World: 2000 report estimated that major climate change events of 1997-98 had devastated a further 16% of the world's remaining reefs with 32% more under threat;
- 2001 – the World Atlas of Coral Reefs was produced by UNEP- WCMC;
- 2001 – ReefBase, the global coral reef, database was launched as an interactive Internet resource;
- 2002 – the Reefs at Risk analysis for Southeast Asia reported that 88% of these reefs were at risk from human damage;
- 2002 – the World Summit on Sustainable Development in Johannesburg saw many 'Type 2' partnerships launched to conserve coral reefs and ICRI and ICRAN held side events; and
- 2002 – Reef Check produced a 5-year report that showed not only continued declines in coral reef health, but also many small conservation successes.

This report, however, includes information from the Marshall Islands and Trinidad and Tobago, which were not included in 2000.

New International Initiatives to Conserve Coral Reefs

Since the Status 2000 report, many major initiatives have started to have positive effects on coral reef conservation. Some of these are:

- the US Coral Reef Task Force and other government bodies have provided more funds and expertise to manage coral reefs across the globe, particularly in US dependent and associated territories;
- Governments and others partners in ICRI have established the priority needs of coral reefs as recognised priorities in the WSSD and in the work programs of the multilateral environmental agreements including the Conventions on Biological Diversity, Wetlands of International Significance (Ramsar) and World Heritage;
- the International Coral Reef Action Network (ICRAN), with initial funding from the United Nations Foundation, has started strengthening reef management at key demonstration sites in 4 of the major coral reef areas of the world;
- WWF (World Wildlife Fund), TNC (The Nature Conservancy) and CI (Conservation International) launched a partnership of initiatives on coral reefs in the centre of coral reef biodiversity in Southeast Asia;
- Private foundations, especially those in the USA and Australia (Great Barrier Reef Research Foundation) are increasingly targeting coral reefs in the Western Pacific, Southeast Asia and the USA as part of biodiversity conservation programs;

World Atlas of Coral Reefs

A major resource for all interested in coral reefs was published in 2001. *The World Atlas of Coral Reefs* was produced by the UNEP World Conservation Monitoring Centre (UNEP-WCMC) based on 20 years of information on the world's coral reefs. The Atlas is invaluable to scientists, researchers, resource managers, aid and development decision-makers, global travellers and students. It also caters to the needs of divers and boat owners. The Atlas includes considerable information on the natural history of coral reefs, their location, stresses and threats, and major protected areas gathered by UNEP-WCMC and its partners around the world. The World Atlas of Coral Reefs has: 424 pages, 302 colour illustrations as a hard-bound volume; 94 full colour maps, including maps of biodiversity and reef stresses; regional maps showing 3D bathymetry and high resolution maps showing reefs, mangroves, population centres, dive centres and protected areas; over 280 colour photographs of reefs, wildlife, people and places, including 84 photographs taken by Space Shuttle astronauts; introductory texts explaining the formation, structure and ecology of coral reefs; details of the various uses and abuses of coral reefs by humans; techniques used in coral reef mapping; detailed texts on the distribution and status of coral reefs in all countries; tables on biodiversity, human use, and protected areas; and statistics on coral reef area, biodiversity, fish consumption, and threats. The World Atlas of Coral Reefs can be ordered from the publisher www.ucpress.edu/books/pages/9635.html. Maps and text from the atlas can be down-loaded from www.ReefBase.org

- Other foundations in the USA, Japan, France and Australia are taking a greater interest in coral reefs and assisting ICRAN and the more active NGOs (WWF, The Nature Conservancy, Conservation International, CORAL, World Resources Institute, Marine Aquarium Council, Reef Check) establish large MPAs or link existing MPAs in order to arrest coral reef degradation; and
- At the WSSD, USAID and the UN Foundation announced a grant of US$3 million to the ICRAN partnership to tackle coral reef problems along the Caribbean coast of Mesoamerica.

Partnerships and Type 2 Initiatives at the WSSD in Johannesburg

While the Johannesburg meeting focused on activities to reduce poverty and improve human health, there was strong recognition that the maintenance of healthy environments was essential to these two goals. Coral reefs, sustainable fisheries and the International Coral Reef Initiative (ICRI) were mentioned in the final government agreed statement. A major feature of the meeting was the development of 'Type 2' partnerships between governments and development banks and agencies, especially NGOs, which can deliver results directly in the 'field'. Some of these partnerships were focused on coral reefs. For example, Australia promised to assist developing states of the Asia Pacific region with the management of tropical coastal fisheries, and also put special focus on the marine resources of the Arafura and Timor seas that are shared between Indonesia, Timor, Papua New Guinea and Australia. The USA and Japan pledged support to the UNEP and ICRAN initiative to strengthen the network of key demonstration sites and broaden the network to other coral reef regions.

Global NGO Partnership for Reefs

Three major global conservation groups, World Wildlife Fund, The Nature Conservancy and Conservation International, have formed a collaborative partnership to accelerate efforts to establish new coral reef marine protected areas. The WWF global coral reef work has 3 major categories: MPAs; fisheries; and ecoregion conservation. These are supported by a range of tools including community-based management, advocacy, communications, and innovative conservation finance. Adaptation to climate change, pollution, aquaculture, and trade in endangered species are key areas of activity. WWF is pioneering efforts to protect deepwater corals as well. The TNC has established a platform for marine conservation, the 'Southeast Asia Center for Marine Protected Areas', in Bali. This Center will fulfil a pivotal role in the strengthening of MPA networks throughout the region. CI has been instrumental in furthering conservation by developing a rapid appraisal methodology and then assisting in the conservation of biodiversity-rich areas by either purchasing the land or providing funds to divert damaging practices, like logging tropical rainforests. The partnership will seek to develop and manage a series of larger MPAs across the Western Pacific to ensure sustainability for the communities of users and also for biodiversity.

Global and Regional Initiatives to Conserve Coral Reefs

There is recognition that many problems are trans-boundary issues, thus there have been a series of international and regional partnerships developed between UN agencies, governments and NGOs. The ICRAN project operates through the UNEP regional seas offices in the Caribbean, the Southeast Asian and Southwest Indian Ocean area, and in partnership with SPREP (South Pacific Regional Environment Programme) in the Pacific.

The CORDIO project (Coral Reef Degradation in the Indian Ocean) was initiated by Sweden in partnership with the World Bank and Finland to assist countries devastated by coral bleaching in the Indian Ocean. An East African Coral Reef Task Force was established to coordinate coastal research, monitoring, education and management in 8 regional countries.

The USA, through their aid agency USAID, are strengthening coral reef activities in the Caribbean. The Japanese government developed coral reef facilities on the islands of Ishigaki and Palau, and has agreed to assist the countries of Southeast and East Asia in coral reef monitoring so that management effectiveness can be improved. A range of partners (NOAA, USAID, DFID, UNEP, GCRMN/Reef Check) are developing socio-economic assessment protocols to link the ecological monitoring to the activities of people on reefs. The French Government is supporting coral reef research and conservation in their territories in 3 oceans through their IFRECOR network.

Added to this, is a willingness by the major NGOs to pool resources to tackle major problems of coral reefs, particularly in the area of greatest biodiversity in the Western Pacific. Conservation International, The Nature Conservancy and the World Wildlife Fund are being supported by US foundations to tackle major coral reef conservation issues in the region where the reef biodiversity and value is highest. The Convention on Biological Diversity has a program to tackle the global issues of coral bleaching and human degradation of coral reefs that threatens biodiversity, and the IUCN is launching a major marine program with coral reefs as a key theme.

National Initiatives to Conserve Coral Reefs

ICRI is focusing the attention of developed and developing governments on the need to conserve coral reef resources for the benefit of user communities and also to conserve the global heritage of biodiversity. The USA has increased coral reef programs in US flagged and associated areas and is supporting international coral reef activities through a grants program. Australia continues to manage its own coral reefs and offers assistance to countries in the region with fisheries, oceans governance and training. The Indonesian government has assessed their reefs and reported that they are losing 3 to 6% of their resources each year; thus they are actively pursuing reef conservation and seeking assistance for this major task. India has formed national coral reef committees and is building a national research facility; all from a very low base of capacity a few years ago. Many other national initiatives are detailed in the Chapters that follow.

ReefBase: A Global Information System on Coral Reefs

ReefBase is a substantial database on coral reef information for managers and scientists. ReefBase covers global coral reef distribution, reef status, threats to coral reefs, and details of monitoring and management activities. It also provides national level information for all coral reef countries. ReefBase is an Internet database with access via a web-browser for searches by country and by topic, with information displayed as text, tables, graphs and maps; website http://www.reefbase.org. There is also access to many coral reef photos, and a library of relevant publications (many can be downloaded). A specific focus is gray literature and management related publications, which are often relevant but rarely accessible. A new feature is an online Geographic Information System (GIS) that allows users to view coral reef data on interactive maps. Datasets include: marine protected areas; monitoring sites; coral bleaching; and ICRAN demonstration sites. Users report that the online GIS can be used to produce maps for publications and presentations. ReefBase is the central repository for the GCRMN, and much information in ReefBase comes from the GCRMN national, regional and global status reports. Report extracts are fully integrated as text in tables within the database. Users can quickly access specific information for a country or region e.g. impacts of coastal development in Fiji, without downloading large documents. ReefBase collaborates with Reef Check (http://www.reefcheck.org), an organisation that uses sport divers for coral reef monitoring. Reef Check data from 1997 to 2001 are in ReefBase. The latest reports from GCRMN and other sources on the status and management of coral reefs are being added, and thematic multimedia CD-ROMs, based upon information in the database are planned. ReefBase is a WorldFish Center project, with support from the International Coral Reef Action Network (ICRAN). Contacts: Jamie Oliver, ReefBase Project Leader, j.oliver@cgiar.org; or Marco Noordeloos, ReefBase Manager, m.noordeloos@cgiar.org

Local Scale Initiatives to Conserve Coral Reefs

Throughout the world, many small to medium sized communities are managing their own coral reefs to reverse the damage from their activities. These communities are receiving major assistance from governments, and particularly from NGOs operating in the field. In Eastern Africa, communities in Comoros, Kenya, Tanzania and Mozambique with assistance from local and international NGOs are implementing community-based management (Pages 34, 77, 100). This is also happening in Sri Lanka and India and throughout Southeast Asia (Pages 124, 127, 130, 137, 143). Pacific Island communities have retained many of the traditional management practices to conserve their natural resources, and these are being applied in parallel with central government mechanisms (Pages 186, 199, 200, 201, 211). Throughout the Caribbean, where the problems facing coral reefs rank with those in Southeast Asia, there are positive examples of communities managing their own resources, when governments are prepared to devolve responsibility to these peoples (Pages 257, 315, 322, 340, 352). In Florida, there is now stronger community support for coral reef management including no-take zones; a partial reversal of the attitudes of fisheries lobby groups that previously resisted attempts to establish no-take areas (Page 268).

There is clear evidence that protecting some fish stocks from exploitation results in more fish reaching their full breeding potential. There is also indisputable evidence that exploiting fish stocks reduces the numbers and sizes of the larger breeding stocks of preferred target species. But there are still arguments about the value of establishing no-take zones. An interesting case study occurred in an estuary and coral community area in front of the Cape Canaveral space launch station in Florida. Merritts Reserve has been an unintended fisheries protected area for 40 years, and has resulted in sport fishing records for a number of species caught adjacent to the reserve.

One recurring theme is that communities will take the initiative to manage their own resources for their own and their children's future, if they are provided with information, support (usually via NGOs), and the responsibility. Few governments willingly devolve power to lower authorities but this has occurred in the Philippines, where local authorities (barangays) have been encouraged for years to manage their own coastal resources. This model is spreading to Indonesia, where decision making was previously concentrated in Jakarta. The government is progressively passing responsibility to the provinces and eventually to local governments. It will be a slow road, however, as these provincial authorities must develop the capacity for governance. These examples from Southeast Asia are promising in that these countries rank 1 and 3 in the global list of coral reef area.

The messages coming from these examples are:

- Communities must be given the necessary information in culturally and linguistically appropriate ways;
- Communities should be involved in all stages of resource management, especially in the initial assessment and mapping process to determine the extent and status of the resources;
- Communities should also be trained in coral reef monitoring of corals and the target fisheries species because this raises awareness of the problems;
- Often communities will require assistance to develop alternative livelihoods to enable them to shift away from over- and destructive-exploitation of coral reef resources;
- Community leaders, including religious leaders, should be targeted to lead the process;
- Governments should be prepared to devolve responsibility to local authorities and NGOs;
- Funding is necessary to seed projects and to employ community liaison officers;
- Successful community projects should be used to demonstrate success to neighbouring communities (and to other countries);
- Above all, patience is required and years of assistance and encouragement may be necessary.

Special MPAs and Other Sites

A special focus of the GCRMN is to facilitate coral reef monitoring as part of the performance evaluation in marine protected areas (MPAs) with reefs. Below are summary tables for three major 'categories' of protected areas. There is a poor representation of coral reef areas in World Heritage Sites of UNESCO, and this was a special theme of a meeting of experts in Hanoi in February 2002, to recommend priority sites for World Heritage recognition. The Man and the Biosphere sites were designated by UNESCO to promote research on natural environments, but there are few of these which have a large component of coral reefs. Finally, the ICRAN project has selected 17 sites around the world to serve as key demonstrations of best practice in coral reef conservation.

The summary tables below contain subjective assessments of coral reef areas as a proportion of the major natural resources listed as targets for conservation. More details on these sites are attached in the respective regional chapter. These illustrate that many of these sites have been established to conserve other natural resources with coral reefs being incidental (estimated proportion of coral reefs as % of natural resources). The tables also contain a subjective assessment of the level of ecological and socio-economic monitoring, with the implication that those sites with major components of coral reefs should have higher levels of monitoring. Obtaining information for some of the sites was not easy, thus the GCRMN would appreciate corrections to the assessments and the information. Our goal is to update these tables in future to show when more sites are declared for protection and measure any increases in monitoring.

The Role of the International Coral Reef Initiative in Conserving Coral Reefs

ICRI was a product of the rising concern over the status of coral reefs and dire predictions from 1992 and 1993, and the calls to action expressed at the Rio de Janeiro Environment Summit in 1992. ICRI aims to catalyse solutions to problems brought to the 'table', around which sit representatives of developing and developed governments, UN agencies, international NGOs, foundations and coral reef scientists. ICRI also acts through governments and international agencies to bring coral reef concerns to the attention of international forums such as UN Conventions, UN General Assembly etc.

The sharing of the Secretariat has succeeded in bringing new ideas and expertise to the table every 2 years, but it has been inefficient in that the learning experiences of each secretariat are dissipated after 2 years. The current arrangement of shared responsibility between the Philippines, a developing, and Sweden, a developed country was aimed at bringing the two perspectives together, with the Philippines providing a conduit for the views of the developing world, and Sweden channelling views of the European Union and other developed countries to members. However, the lack of dedicated funding for the ICRI Secretariat and the reliance on host country resources to support its operations, have meant that the views of the developing world have not received the emphasis necessary to arrest the problems faced by the coral reefs and their human populations. Thus there is a need for ICRI to establish a more stable network of coordinators, which will require sustainable funding. As in most situations, funding for coordination is more difficult to obtain than funds for on-the-ground activities (which will be more efficient if there is a system of coordination able to link similar activities elsewhere).

Key sites chosen by the International Coral Reef Action Network to demonstrate best practice in coral reef conservation and management to nearby countries; the page numbers of more detailed reports are listed. The assessments are subjective: substantial monitoring is when resource managers are provided with considerable information for decision making; effective refers to monitoring programs that can assist managers in their decisions; occasional monitoring usually refers to good assessments that have been conducted spasmodically or in response to a crisis or request; planned and not planned are self-explanatory.

	ICRAN Sites	Proportion of Coral Reefs	Coral Reef Monitoring	Socio-Economic Monitoring	Page
Kenya	Malindi & Watamu Marine National Park & Reserve	30%	Effective	Effective	74
Tanzania	Dar es Salaam Marine Reserve	30%	Occasional	Occasional	75
Madagascar	Nosy Atafana Marine Park	40%	Planned	Planned	97
Seychelles	The Cousin Island MPA	30%	Occasional	Occasional	96
	St. Anne Marine Park	50%	Effective	Occasional	95
Indonesia	Bunaken	60%	Occasional	Occasional	144
	Komodo	40%	Effective	Effective	145
Philippines	Apo Island	70%	Effective	Planned	146
Thailand	Mo Koh Surin	60%	Effective	Planned	147
Fiji	Management of Aquarium Harvesting	100%	Planned	Effective	199
	Coral Gardens Project	80%	Occasional	Planned	201
Samoa	Samoa MPA Project	80%	Effective	Planned	200
Marshall Islands	Jaluit Atoll Marine Conservation Area	80%	Planned	Not planned	236
Belize	Hol Chan Marine Reserve	60%	Effective	Effective	323
Mexico	Sian Ka'an Biosphere Reserve	30%	Effective	Effective	322
Bonaire	Bonaire Marine Park	85%	Effective	Occasional	338
St. Lucia	Soufriere Marine Management Area	20%	Effective	Occasional	340

Major World Heritage Sites of UNESCO that contain significant components of coral reefs and an assessment of the amount of monitoring.

	World Heritage Sites	Proportion of Coral Reefs	Coral Reef Monitoring	Socio-Economic Monitoring	Page
South Africa	Greater St. Lucia Wetlands	40%	Effective	Unknown	76
Seychelles	Aldabra Atoll	60%	Effective	Not Planned	98
Indonesia	Komodo National Park	40%	Effective	Effective	145
	Ujung Kulon National Park	10%	Unknown	Unknown	149
Philippines	Tubbataha Reef Marine Park	90%	Effective	Effective	148
Australia	Great Barrier Reef	90%	Substantial	Effective	179
	Lord Howe Island	10%	Planned	Planned	178
Solomon Islands	East Rennell Island	10%	Occasional	Occasional	194
United Kingdom	Henderson Island	80%	Occasional	Not planned	214
Cuba	Desembarco del Granma National Park	40%	Unknown	Unknown	302
Belize	Belize Barrier Reef Reserve System	70%	Occasional	Occasional	323
Mexico	Sian Ka'an Reserve	30%	Effective	Effective	322
Costa Rica	Cocos Island National Park	40%	Occasional	Not planned	357
Ecuador	Galapagos Islands	5%	Occasional	Occasional	358

World Heritage Sites and Coral Reefs

The Convention for World Heritage Sites provides for the protection of those cultural and natural properties deemed to be of outstanding universal value. The WHC (full title 'The Convention Concerning the Protection of World Cultural and Natural Heritage'; www.whc.unesco.org) was adopted in 1972, with more than 150 State Parties, and is an important instrument of international cooperation for environmental protection. The Convention is founded on the premise that the world's great cultural and natural sites constitute a common heritage for all humankind, and their destruction would be an irreparable loss. There are 690 WH sites, of which 529 are cultural sites, 138 are natural sites and 23 are mixed. The WH Committee decides on sites to add and assists State Parties to protect these sites, with advice from the IUCN on natural properties and by the International Council on Monuments and Sites on cultural ones. The major criterion for inclusion on the WH List is 'outstanding universal value', with 4 natural criteria to assist in selection. A natural site must: (i) exemplify major stages of the earth's history; (ii) represent ongoing ecological and biological processes; (iii) be of exceptional natural beauty; or (iv) contain the valued natural habitats, including those of endangered species. Sites must be virtually intact and protected and managed to the required standard. If a WH Site is seriously endangered, it may be entitled to special attention and international assistance.

Coastal, marine and small island biodiversity sites are under-represented, e.g. there are less than 10 inscribed for these values amongst 70 which feature biodiversity attributes of the 690 total. The UNESCO World Heritage Centre, the U.S. National Oceanic and Atmospheric Administration, UNEP-World Conservation Monitoring Centre and IUCN convened a workshop of experts in February 2002 that recommended the following 37 top priority sites that, if listed, would fill critical gaps to improve the representation of tropical, coastal, marine and small island ecosystems on the World Heritage List.

Middle East:

- Northeast Red Sea (Saudi Arabia, Egypt)
- Socotra Archipelago (Yemen)
- Southeast Oman
- Southern Red Sea Complex (Saudi Arabia, Yemen, Djibouti, Eritrea)
- Southern Gulf (United Arab Emirates)
- Hawar Islands (Bahrain)
- Jubail Wildlife Sanctuary (Saudi Arabia),
- Southern Gulf (Murawah Bu-Tini area)

East Africa:

- Astove-Cosmoledo, Extension of Aldabra World Heritage Site (Seychelles),
- Bazaruto Archipelago (Mozambique)
- Rufiji River Delta- Mafia-Songo Songo, (Tanzania),
- Maputo Bay – Ponto do Ouro, (Mozambique),
- Mnazi Bay-Ruvuma-Quirimbas, (Tanzania, Mozambique),

- Europa and Scattered islands (including Bassas de India, Juan de Nova, Glorieuses),
- NW Madagascar – Nosy Tanikely, Nosy Be

Southeast Asia:
- Raja Ampat Region (Indonesia)
- Spratlys Island Group (under dispute by 6 South China Sea nations)
- Tubbataha-Cagayan Ridge (Philippines)
- N. Borneo/ Balabac Strait/ Turtle Island Cluster (Philippines, Malaysia)
- Semporna/Tawi-tawi Chain (Malaysia)
- Berau Islands (Indonesia)
- Banda/Lucipara Cluster (Indonesia)

Pacific:
- New Caledonia (France)
- Milne Bay (Papua New Guinea)
- Rock Islands Cluster (Palau)
- New Hanover and Manus Cluster (Papua New Guinea)
- Marovo Lagoon and Arnavon Islands (Solomon Islands)
- Pohnpei-Kosrae Island Cluster (Federated States of Micronesia)
- Line Islands Cluster (Kiribati and US)

Latin America / Caribbean:
- Sea of Cortez – Gulf of California (Mexico)
- Mayan Coast Reefs – Sian Ka'an expansion – Banco Chinchorro
- Belize Barrier Reef System expansion to watersheds
- Revillagigedo and Clipperton Islands (France and Mexico)
- Cocos Island Extension: Cocos-Galapagos-Malpelo (Costa Rica, Ecuador and Colombia)
- Southern Cuba Coral Archipelago
- Southern Caribbean Island Group (The Netherlands and Venezuela)
- San Andres Archipelago (Colombia)

Phillips A (2002) The World Heritage Convention and its Application to Marine and Coastal Sites. Workshop on World Heritage and Biodiversity Conservation in Tropical Coastal, Marine and Small Island Ecosystems, February 25 – March 1, 2002 in Hanoi, Vietnam http://international.nos.noaa.gov/heritage/welcome.html

ICRI Operating Units – GCRMN

This is the 3rd global report from the network with clear evidence of progress in obtaining more authoritative reports from many countries. However, the report also contains much anecdotal information and assessments from experts, rather than sound monitoring data. A clear example was for many areas of the world seriously damaged by the 1998 global coral bleaching event, but the GCRMN and Reef Check had few before-bleaching data. Thus there was no way of assessing the true impact of 1998. The event however catalysed

Man and the Biosphere sites of UNESCO showing sites with coral reefs that have been set aside for major efforts in research for the benefit of the world.

	Man in the Biosphere Reserves	Proportion of Coral Reefs	Coral Reef Monitoring	Socio-Economic Monitoring	Page
Kenya	Kiunga	50%	Effective	Effective	77
	Malindi-Watamu	30%	Effective	Effective	74
Madagascar	Mananara Nord	20%	Effective	Effective	99
	Sahamalaza-Iles Radama	20%	Unknown	Unknown	100
India	Gulf of Mannar	50%	Effective	Unknown	121
Indonesia	Komodo	40%	Effective	Effective	145
	Siberut	30%	Occasional	Occasional	150
Philippines	Palawan	30%	Effective	Effective	151
	Puerto Galera	40%	Effective	Unknown	152
USA	Everglades & Dry Tortugas	30%	Substantial	Substantial	275
	Virgin Islands	60%	Substantial	Effective	276
Mexico	Sian Ka'an	30%	Effective	Effective	322
Cuba	Buenavista	30%	Unknown	Unknown	301
	Ciénaga de Zapata	20%	Unknown	Unknown	301
	Península de Guanahacabibes	40%	Unknown	Unknown	301
France	Archipel de la Guadeloupe	20%	Effective	Unknown	342
	Atoll de Taiaro	80%	Occasional	Not planned	215
Columbia	Seaflower	60%	Effective	Effective	359
Panama	La Amistad	20%	Effective	Unknown	360

major new efforts in monitoring with the constitution of the CORDIO project and the establishment of the Southwest Indian Ocean Node with significant funding from Sweden and GEF, respectively. Both of these projects have expanded the number of sites being monitored and future reports will carry even more data. Similarly there has been an increase in monitoring in Micronesia and the southwestern Pacific with funding from USA and Canada respectively. All USA associated areas with coral reefs have seen major expansions in coral reef assessment and monitoring, especially the remote areas of the Northern Pacific through both remote sensing imaging and direct field studies. Monitoring in Australia continues as the benchmark for broad-scale monitoring while Florida has the most intensively monitored reefs in the world.

The GCRMN continues as a network consisting of some people specifically funded to monitor coral reefs, however the majority conduct coral reef monitoring as part of other activities or totally voluntarily. To these people we owe gratitude, but we should also be seeking funds for regional coordination of monitoring training and field operations as well as encouraging donors and national governments to support more monitoring. Without the resulting data, sound management decisions on conserving coral reef resources will be based on anecdotal opinions –'decisions within a data vacuum'. The GCRMN welcomes input from any organisation monitoring coral reefs and the current structure recognises this. Direction of the network comes from the coordinators of ReefBase, Reef Check and the GCRMN and an 8 member Management Group.

Coral Reef Targeted Research and Capacity Building

A major initiative has been launched by the World Bank and IOC/UNESCO, with support from the Global Environment Facility, to provide coral reef resource managers with the best available scientific advice on coral reef responses to human disturbances and climate change. The initiative will stimulate targeted research and address the gaps in our knowledge of factors determining vulnerability and resilience of coral reef ecosystems to a range of stressors. The goal is to provide this knowledge to coral reef managers, who continue to struggle between the need for protection and providing for the needs of many direct and indirect users of coral reefs. This often means that complex tradeoffs are necessary, with decisions frequently made without access to sound scientific advice: 'Hard decisions require hard science, and successful long-term management without it is an illusion' (from Nancy Knowlton).

The GEF Targeted Research and Capacity Building Program is assembling more than 60 experienced scientists to answer critical questions concerning coral reef vulnerability to human stresses and the impacts of climate change. The program aims to:

- Address the gaps in scientific knowledge that prevent informed decision-making on coral reef management;
- Create the investigative framework and build human resource capacity to address these gaps.

This is a collaborative program between developed and developing country scientists to examine the issues on a global scale. It also aims to build capacity within coral reef countries to better manage reefs by furthering understanding of those factors conferring resilience or increasing vulnerability of reefs to major stress, and addressing the risks to reef sustainability. The program will be implemented by networks of researchers, and guided by a Synthesis Panel and 6 thematic coral reef working groups:

Synthesis Panel: Nancy Knowlton, Scripps Institute of Oceanography, USA; Robert Watson and John Dixon of The World Bank; Angel Alcala, Silliman University, Philippines; and the chairs of the 6 working groups.

Coral Bleaching and Local Ecological Responses, Chair: Ove Hoegh-Guldberg, University of Queensland, Australia. Goal: to develop molecular, cellular, physiological and community indicators for coral bleaching under a range of variables, and examine potential mechanisms of coral reefs for adaptation and acclimatization to environmental change. IOC/UNESCO convened the first meeting of the Bleaching working group in April, 2001, aiming to develop biological indicators and tools to predict environmental stress on coral reefs, and examine specific physiological mechanisms that lead to coral bleaching (as recommended by the Convention on Biological Diversity). With funding support from the Program, the group expanded its mandate to also consider local ecological factors; details on www.ico.unesco.org.

Complementing the investigations of this group, 5 additional working groups were formed under the Targeted Research Program to expand the scope of research. These groups encompass:

Coral Diseases, Chair: Drew Harvell, Cornell University, Ithaca, USA. Goal: to examine, prioritise and target investigations that are critical to the understanding of coral diseases, and how this information can assist managers in minimizing disease frequency and transmission;

Large-Scale Ecological Processes, Recruitment and Connectivity, Chair: Peter Sale, University of Windsor, Canada. Goal: to examine the role that larval transport, recruitment, post-recruitment survival, and connectivity play in networking coral reef environments, particularly as they relate to the siting and management of marine protected areas;

Coral Restoration and Remediation, Chair: Loke Ming Chou, University of Singapore. Goal: to examine the state of remediation techniques and efficacy of potential applications, with considerations on protocols to design and implement restoration strategies; gather baseline data for developing effective criteria; investigate the efficacy and feasibility of restoration and remediation techniques, and prospects for enhancing natural recovery;

Remote Sensing, Chair: Peter Mumby, University of Exeter, UK. Goal: to develop systems for holistic monitoring of the physical environment and stress on coral reefs; to develop tools to measure the status of reef ecosystems at various ecological, spatial and temporal scales; and integrate the above to provide a comprehensive perspective of how global, regional and local processes affect the health of coral reef ecosystems;

Modelling and Decision Support, Chair: John McManus, University of Miami, USA. Goal: to develop a coordinated information base that can improve the accuracy and reliability of forecasting and predictive modelling, and to develop modelling tools to handle data on aspects such as community dynamics, oceanography, climate, as well as socio-economic data on fisheries, tourism, and coastal development.

Each of the working groups has systematically identified what is known and unknown, and has begun ranking research priorities to benefit management. The 6 working groups will integrate their efforts and new findings, and will build new research capacities between developed and developing countries by integrating expertise and skills. Each group's reports, new findings and outputs will be available online.

Further information can be obtained from: Marea Hatziolos, Mhatziolos@worldbank.org; Andy Hooten, ahooten@worldbank.org; Ole Vestergaard, o.vestergaard@unesco.org; Jamie Oliver, j.oliver@cgiar.org.

ICRI OPERATING UNITS – ICRAN

The International Coral Reef Action Network has launched a major project to conserve coral reefs over regional scales with generous support from the United Nations Foundation. ICRAN comes under the umbrella of ICRI and seeks to implement one of the core mandates recommended; that of improving the capacity for coral reef management. Within the Network there are major partners active in coral reef matters that are collaborating to extend the lessons of demonstration sites as well as improve mapping, analysis and information sharing on coral reefs. The UN Foundation funds are being matched by a 'Type 2' initiative from the Government of the USA for increased activities in Mesoamerica. More funds are required to achieve the goal of having a stable funding base to tackle the problems of coral reefs at the site of many of the problems – in the user community.

ICRI OPERATING UNITS – ICRIN

The other unit under the ICRI umbrella is International Coral Reef Information Network, which has a goal of improving the information flow to all people interested in coral reefs, and especially decision-makers. ICRIN is targeting special themes and groups within the coral reef theatre, with the fishers and political decision makers being key targets. ICRIN is run out of CORAL – the Coral Reef Alliance, which has extensive databases of extension material in many languages and formats.

THE NEGATIVE SIGNS

Coral Bleaching and Global Climate Change

The Status 2000 report collated information from the regions and reported that corals on approximately 16% of the world's coral reefs were effectively destroyed during the major El Niño and La Niña climate change events of 1997-98. Most of the damaged reefs were in the central to northern Indian Ocean, in Southeast and East Asia and in the western Pacific. There was also some bleaching in the Caribbean and in the Western Atlantic including the coast of Brazil, however this bleaching resulted in minimal coral reef death e.g. of 386 totally bleached colonies in Puerto Rico, only 3 had died and 14 had suffered partial mortality when examined a year later.

Reports from the Nodes and coral reef scientists indicate that the recovery is only slow to moderate along the East African coastline and in the Comores, Seychelles and Maldives, particularly where the reefs are stressed by excess sediments and nutrients. Recovery is poor in Sri Lanka and parts of India with the reefs remaining effectively dead. There has been considerable recovery in the unstressed reefs of Southeast and East Asia and Palau, and also along the Great Barrier Reef of Australia, but it will take several decades before reefs return to pre-1998 status. There is broad concern that another Climate Change/El Niño event could arrest the recovery.

There has been a worrying repeat of some of these bleaching events in the Pacific with serious bleaching and mortality in Fiji and nearby countries in the southwestern Pacific in 2000 and 2002, with coral death in Fiji reaching 40% over large areas. There was also severe bleaching along the Great Barrier Reef in the southern summer of early 2002 with significant mortality (see Box). At the time of writing this report, a mild to moderate El Niño is developing in the Pacific, and there are concerns that the reefs will again suffer more bleaching.

There has been no field evidence of corals having reduced calcification and growth rates under the influence of increased concentrations of CO_2 in seawater, however, there has been confirmation of the potential for these effects during research conducted in Biosphere II in Arizona as well as in other mesocosm studies. This remains a strong potential threat that increasing atmospheric CO_2 will reduce the abilities of corals to grow and calcify their skeletons. Similarly the concentrations of CO_2 in the atmosphere continue to increase, and the Intergovernmental Panel on Climate Change is now stating definitively that global warming is occurring and that ecosystems will be altered as a result. There have been strong predictions from climate models that coral reefs will experience more regular and severe bouts of coral bleaching in the next decades.

It is clear that coral reefs will not become extinct, as some have predicted, but we will probably witness considerable reductions in coral cover and species diversity if these models are correct. Our current experience is that episodes of bleaching are becoming more severe and frequent, thus we should assume that coral reefs will be subject to more damage. A few reefs are demonstrating resistance and resilience (ability to recover) from climate change impacts, including bleaching and disease; but most are susceptible. This alone should be sufficient warning to governments to reduce greenhouse gas emissions into the atmosphere.

Diseases and Plagues

There is a growing plague of the crown-of-thorns starfish (COTS; more correctly seastar) on the Great Barrier Reef (GBR) of Australia, particularly concentrated in the Cairns section and central parts of the GBR. These have caused severe reductions in coral cover on affected reefs. There are also disturbing reports of larger than normal COTS populations in the northern Red Sea, Japan, Palau and Fiji. It is apparent that the COTS will remain a chronic problem for many reefs and a devastating problem for others in the Indo-Pacific. There is limited evidence that the outbreaks are triggered by a human-induced change to coral reef environments, but the nagging suspicion is that this is true and that the plagues are an inadvertent result of human activities.

Coral diseases have become a chronic and frequently catastrophic problem for coral reefs in the Caribbean and wider Atlantic region. Diseases stripped many of the branching corals from Caribbean reefs in the 1980s and 90s, with devastating effects on the major shallow water coral, the elkhorn (*Acropora palmata*). The extent of the problems has been recognised by the US Coral Reef Task Force, which convened a special task force to tackle the problem. A wide range of coral diseases has so far been reported and the causative agents for a few have been identified. Until recently it was considered that such major disease outbreaks were confined to the wider Caribbean, with few reported incidences on Indo-Pacific coral reefs. However, in early 2002 an outbreak of 'white syndrome' was reported to be killing significant patches of corals on the Great Barrier Reef of Australia. Thus wait to see whether coral diseases are another manifestation of human induced stress to coral reefs.

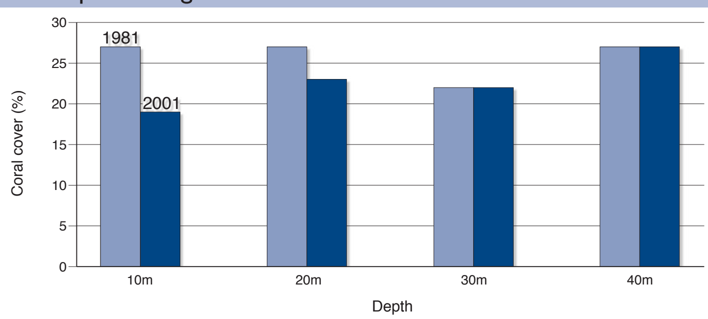
Collapse of Coral Settlement on Curaçao, Netherlands Antilles: An Indicator of Rising Stress for Caribbean Corals?

Results from a long tradition of coral reef research on Curaçao shows a dramatic lowering of coral recruitment. Rolf Bak assessed coral settlement and growth on permanent quadrats with photographs in the early 1970s. This was repeated and the results show that coral cover has changed little over the past 20 years (below), but the amount of coral settlement in 1999-2001 is now about one tenth that of 20 years ago. Also the amount of variation between years is 3.7 times smaller, meaning that the trend looks consistent.

Settlement rates of hard coral species as numbers per m^2 of photoquadrat at 15m depth over a 3 year settling period up to 1981 and 2001, showing an almost total collapse in the addition of new coral juveniles.

CORAL SPECIES	1981	2001
Agaricia humilis	6.07	0.09
Agaricia agaricites	0.52	0.00
Porites porites	0.26	0.00
Porites astreoides	1.13	0.04
Acropora spp.	2.08	0.00
Colpophillia natans	0.26	0.00
Madracis pharensis	3.73	2.34
Other hard corals	0.09	0.04
Non-photosynthetic corals	8.67	0.48
TOTAL ALL CORALS	**22.81**	**2.99**

The massive reductions are linked to a loss of crustose coralline algae, which is where many new coral larvae are attracted to settle, and large increases in macroalgae (mainly Lobophora and Dictyota) and sediment trapping turf algae. It is unlikely that the production of gametes and larvae by adult colonies has dropped as coral cover has hardly changed over the 20 years. These results show that determining coral reef health by observing coral cover is not enough for MPA management as it appears that other factors are preventing the arrival of new corals.



Changes in coral cover have been minimal at 4 depths during the same 20 year period. From: Mark Vermeij, NOAA Fisheries, Southeast Science Center, Miami, USA, Mark.Vermeij@noaa.gov, and Rolf Bak, University of Amsterdam, The Netherlands.

The Future Agenda to Conserve Coral Reefs

The Value of Coral Reefs to People and the World

The one global estimate in 1997 of the value of coral reefs to the world in goods and services was US$375 billion. The investment in research, monitoring and management is probably less than US$100 million per year i.e. less than 0.05% of the value. There are, however, larger values which are pertinent for coral reefs. We need to calculate the replacement value if approximately 500 million people start to obtain diminishing returns from damaged coral reefs, both in terms of the direct extractive products (food and building materials) and the indirect values of opportunities lost in tourism or the heritage values of reduced biodiversity. If reefs cease to calcify and sea levels rise, then whole cultures and nations could be displaced. It will cost much more to re-settle these displaced peoples.

Thus on financial considerations alone, there is a pressing argument to increase spending on coral reef research, monitoring and conservation in order to protect our 'investment' in these marine resources.

Where to now?

We are on a cusp with the rate of damage to coral reef resources increasing, counteracted by an increasing effort being undertaken to conserve reefs. If these succeed and countries increase their investment in conservation, we should witness large areas of the world's reefs recovering from the direct and indirect damage from human activities within the next 10 years. But, if the threatening clouds of global climate change cause major bleaching events and reduce the capacity of reefs to calcify, then many of our efforts will be negated.

The next Status of Coral Reefs of the World report due in 2004 will seek to examine what has happened to coral reefs in the 10 years since the formation of ICRI in 1994, and assess the prognosis for reefs in 2014 by gathering information from people in the regions to identify their needs for achieving sustainable use of coral reefs.

Continuing Human Damage to Coral Reefs

All regions of the world report that human factors are behind much of the losses of coral cover and declining health of coral reefs. The major contributing factors are increased sediments and pollution by nutrients and toxic compounds, or exploitation of reefs for fishes, invertebrates, algae, rock and sand, that damages reefs in the process. These threats have been dealt with in previous reports and the regional chapters. But a worrying concern is that, not only are the corals decreasing, but also there are more alarming reports of failures in coral recruitment e.g. on Guam and Curacao.

Prognosis for the future of the top 21 countries of the world that have 1% or more of the total area of coral on reefs. The list, area and proportion of the world total area are from the UNEP-WCMC World Atlas of Coral Reefs (2001) but the prognosis is a subjective assessment by the editor based on country reports and the level of political will for conservation.

Rank Country and locations	Coral Area km^2	World total %	Prognosis for the Future
1 Indonesia	51,020	17.95%	Mostly poor, some fair/good
2 Australia	48,960	17.22%	Good, bleaching only threat
3 Philippines	25,060	8.81%	Mostly poor, very few good
4 France (3 oceans)	14,280	5.02%	Good, bleaching threat
5 Papua New Guinea	13,840	4.87%	Good, many threats looming
6 Fiji	10,020	3.52%	Good/fair, bleaching threat
7 Maldives	8,920	3.14%	Good, bleaching big threat
8 Saudi Arabia	6,660	2.34%	Good, bleaching threat
9 Marshall Islands	6,110	2.15%	Good, bleaching threat
10 India	5,790	2.04%	Some good, many very poor
11 Solomon Islands	5,750	2.02%	Good, bleaching threat
12 United Kingdom (3 oceans)	5,510	1.94%	Good, bleaching threat
13 Micronesia, Fed. States of	4,340	1.53%	Good, bleaching threat
14 Vanuatu	4,110	1.45%	Good, bleaching threat
15 Egypt	3,800	1.34%	Good/Fair, bleaching threat
16 United States of America	3,770	1.33%	Good to poor, improving
17 Malaysia	3,600	1.27%	Fair to poor & threatened
18 Tanzania	3,580	1.26%	Fair to poor & threatened
19 Eritrea	3,260	1.15%	Good, bleaching threat
20 Bahamas	3,150	1.11%	Good to Fair, bleaching threat
21 Cuba	3,020	1.06%	Good, bleaching threat

Status of Coral Reefs of the World by Regions

Arabian Region

Reefs in the Red Sea remain in relatively good health with anthropogenic threats increasing slightly. There has only been minimal recovery of near-shore reefs in the Arabian/Persian Gulf, these were virtually destroyed by severe coral bleaching in 1996 and 1998. Offshore reefs still have some healthy corals. Tourism is the major force for conservation of reefs in the Red Sea. Monitoring and management capacity is developing through regional cooperation programs, but these countries still lag behind many others in the world for monitoring capacity and political will for conservation. There are very few effective protected areas.

Eastern Africa

The reefs continue to be threatened by many human disturbances from the African continent. Increasing levels of sediment runoff; nutrient pollution; and major over-exploitation of reef resources from growing populations threaten the reefs. There are encouraging signs that governments and communities are collaborating to develop sustainable practices for reef use including many small ecotourism ventures. Many efforts, however, were set back by massive coral bleaching and mortality during the El Niño event of 1998. Many reefs lost up to 80% of their live corals (especially Kenya and Tanzania). Coral recovery is occurring at a worryingly slow pace, particularly on reefs threatened by direct human pressures. More human and financial resources are required to build local and national capacity to manage reef resources.

South West Indian Ocean Islands

Coral reefs in the Comoros and the Seychelles are showing slow signs of recovery after the extensive damage from coral bleaching in 1998. However, human pressures are slowing the rate of recovery and there are insufficient protected areas to ensure coral reef sustainability. Reefs in countries to the south (Madagascar, Mauritius and La Reunion) remain relatively healthy away from human population centres, as they escaped most of the 1998 bleaching. Those reefs under more human pressures, especially on Madagascar, are declining. Monitoring has increased from 44 stations to 72 with 3 years of funding from the Global Environment Facility (GEF and World Bank) ensuring continued activities.

South Asia

Coral bleaching caused major damage to reefs around the oceanic islands of Lakshadweep, Maldives, and Chagos, and the mainland reefs of India (Gulf of Mannar and Gulf of Kutch) and Sri Lanka. Recovery of corals is poor, because natural and human disturbances are impeding successful new coral recruitment. However, some areas of the Maldives are recovering well. The high islands of Andaman and Nicobar remain healthy having escaped bleaching damage. Capacity for monitoring coral reefs continues to improve with donor assistance, however the monitoring data are largely ignored by resource managers, such that most MPAs in South Asia continue to be degraded. Several new protected areas have been declared (Maldives and Andaman-Nicobars) but will not succeed unless management and enforcement are improved and local communities are included in the process.

Southeast Asia

The Reefs at Risk analysis in 2002 reported that 88% of these reefs are at medium to very high threat from human impacts. By far the most serious threats are destructive and over-fishing, followed by coastal development, increased sedimentation and pollution. Monitoring capacity is relatively strong but not sufficient for a region that has the largest area of coral reefs in the world with the highest biodiversity. Management capacity continues to be weak in most countries with the drive for development taking priority over environmental conservation. There are, however, some excellent examples of effective management and successes in reef protection through community control.

East Asia

Most of the reefs damaged in 1998 are recovering in Japan and Taiwan, and possibly also in China, however, there was more bleaching in Japan in 2001, with some reefs experiencing about 50% mortality. There appears to be a crown-of-thorns starfish (COTS) outbreak in southern Japan, but sediment runoff from coastal development and damaging and over-fishing continue as the major threats. The Japanese government has established an international coral reef centre to facilitate coral reef monitoring for the GCRMN, and conservation in the region.

Australia and Papua New Guinea

There was major coral bleaching in early 2002 on the Great Barrier Reef of Australia with almost 60% of all reefs affected. Some inshore reefs suffered up to 90% coral death, and there was up to 95% mortality on the remote Flinders and Holmes Reefs in the Coral Sea. Otherwise the GBR reefs and those off Western Australia remain in predominantly good condition due to low human pressures and effective management. However, a major concern is an outbreak of the crown-of-thorns starfish and coral disease in the Central GBR. Management is supported by substantial research and monitoring. In contrast, there is little monitoring of the coral reefs of Papua New Guinea (PNG), although most are considered to be in relatively good condition. There are warning signs of increasing human pressures from fishing and deforestation and coral bleaching. Capacity within government is weak, but there has been a marked increase in involvement by large NGOs which are developing community-based management.

Southwest Pacific

Coral bleaching has emerged as the major threat to the coral reefs of these 7 countries, which also continue to be degraded as human pressures increase. These reefs escaped in 1998, but there has been serious coral bleaching and mortality in 2000 and 2002, especially in Fiji, and to a lesser extent in Tuvalu and Vanuatu. There has been an expansion of coral reef monitoring and capacity under the GCRMN and Reef Check frameworks. Similarly, many local and international NGOs have assisted communities to establish their own MPAs to monitor and conserve their coral reef resources, particularly in Samoa and Fiji, but ethnic tensions in the Solomon Islands have reversed much progress with communities.

Southeast Pacific

The coral reefs of these countries and states of Polynesia have changed little since 2000 and predominantly remain in good condition. However, there are few monitoring data from the region except for French Polynesia and to a lesser extent Wallis and Futuna. Tourism is the major industry, although these countries are relatively remote from the market. Black pearl culture is important in the Cook Islands and French Polynesia. Coral reef conservation is generally poorly developed, with poor enforcement and a lack of political will, although all countries have considerable legislation. Encouragement of the traditional management systems of the recent past would assist in raising public awareness and implementing conservation.

Micronesia

The coral reefs are comparatively healthy, although the reefs in Palau suffered extensive damage from coral bleaching in 1998. The levels of human pressures are also increasing. These countries and territories are now included in many of the coral reef initiatives of the USA, such as improved mapping, monitoring and training, and improved coral reef conservation. Reefs in American Samoa are recovering from crown-of-thorns starfish invasions, typhoons, and coral bleaching, but fish populations are not recovering well. The export of 'live rock' and scuba fishing were recently banned. There has been major progress in coral reef monitoring in the countries of Micronesia and several new MPAs have been established. These are beginning to show positive recovery of corals and fishes. The recently opened Palau International Coral Reef Center is coordinating coral reef monitoring in the region for the GCRMN.

Northeast (American) Pacific

There has been considerable monitoring and mapping of the reefs of the Hawaiian Archipelago and the Northwestern Hawaiian Islands after a major injection of funds and expertise. The Northwestern Islands are close to pristine and are protected in a newly created reserve, which includes large 'no-take' zones. In contrast, reefs on the Main

Hawaiian Islands continue to suffer from over-fishing, sediment pollution and tourism pressures from the islands. Fish populations are greater in reserves than heavily fished areas nearby, but efforts to create new no-take reserves are resisted. They are an urgent priority.

The American Caribbean

There has been a major increase in funding for the U.S. Caribbean, resulting in improved mapping, monitoring, and management of coral reefs. There is now more understanding of the status of these coral reefs, but many of the problems remain, with major losses of corals in Florida, US Virgin Islands and Puerto Rico. Monitoring in the Florida Keys shows that fishes in no-take reserves are larger and more abundant than in fished areas, which is improving public support for increases in management of the reefs. Despite the increases in conservation activities, much remains to be done to ensure the recovery of many of the coral reefs in this region.

Northern Caribbean and Western Atlantic

There is a continuing decline in coral reefs in easily accessible areas, although the rate of decline may have slowed. More isolated reefs of the Bahamas, Turks and Caicos, and Cuba are still relatively healthy, as are reefs of the Cayman Islands and Bermuda, although impacts are increasing. The reefs of the Dominican Republic, Haiti and Jamaica have low coral cover and few fish. The deterioration of these reefs is due to nutrient and sediment pollution, coral disease, over-fishing, anchor damage, destructive fishing and tourism pressures. Coral reef tourism, a critical component of the economies, is severely threatened by these losses. Many countries have MPAs but many remain as ‘paper parks’.

Central or Mesoamerica

The status of the coral reefs appears to be stabilising following considerable damage from coral bleaching, a series of hurricanes and human stresses. Prior to these events, reefs on the Caribbean side were considered in good condition, but hurricanes in 2000, 2001 and 2002 destroyed up to 75% of corals in some parts of Belize. There are intense fishing pressures and sediments and nutrients flowing onto the reefs because of poor land-use practices and unregulated coastal development. These threats are being addressed in a World Bank/GEF project to conserve the Mesoamerican Barrier Reef System in partnership with WWF Ecoregional Conservation Program in Belize, Guatemala, Honduras and Mexico, and other agencies. Efforts include ecosystem monitoring, environmental information systems, strengthening MPA management and raising national capacity and regional cooperation to tackle trans-boundary issues.

The Eastern Antilles

These islands face the same threats to their coral reefs as described in 2000: increased sedimentation and pollution from coastal development; anchor and tourism diver damage; overfishing due to increased demand; coral bleaching; and severe storms from climate change. Most shallow reefs in the eastern Caribbean have degraded, whereas deeper reefs are less affected. Some islands have established effective management and monitoring programs supported by funds gathered from tourists, however, others are hampered by inadequate legislation, poor enforcement, and insufficient human and financial resources. Reef Check methodology appears most appropriate for monitoring in many areas, and the values of monitoring and protecting areas should be demonstrated to national and local governments.

Southern Tropical America

The coral reefs in the 5 countries have changed radically since the 1980s, due mostly to anthropogenic stresses compounded by natural disturbances. Live coral cover continues to drop, and many reefs are now dominated by algae. However, some reefs retain coral cover of 20-40% in the Caribbean and above 40% in the Pacific. Brazil has reported monitoring data for the first time, as part of expanded reef monitoring over the last 3 years but this is not adequate for effective management. More government commitment and funds are required to reverse coral reef decline e.g. more MPAs, and better management and enforcement.

REVIEWERS

Stephen Colwell, Mark Eakin, Marea Hatziolos, Gregor Hodgson, Richard Kenchington, Russell Reichelt, Bernard Salvat, Kristin Sherwood, Robin South, Kristian Teleki.

THE REEF CHECK SUMMARY 1997 – 2001 THE GLOBAL CORAL REEF CRISIS

Summary: The Reef Check program based at the University of California Los Angeles has brought together hundreds of diverse groups from all sectors to work together as teams towards a common goal during its 6 years of operation. These teams have collected valuable data from reefs around the world, which constitute a synoptic assessment of global coral reef health using a standard method. The detailed results are presented in the Reef Check 5-year report, "The Global Coral Reef Crisis – Trends and Solutions" available on www.ReefCheck.org or www.ReefBase.org; this is an overview.

Monitoring was carried out from 1997 to 2001 by over 5,000 people at over 1,500 reefs in the Atlantic, Indo-Pacific and Red Sea. Following data quality assurance procedures, 1,107 sites were accepted for analysis. These analyses examined both spatial and temporal changes in indicator abundance as well as correlations between abundance and ratings of human impact provided by the teams. The key findings were:

- At the global scale, zero spiny lobster were recorded at 83% of shallow reefs indicating severe overfishing; there was a significant decline in lobster abundance in the Atlantic;
- The mean abundance of Diadema sea urchins decreased significantly in the Indo-Pacific from 1998 to 2000, approaching levels similar to those found in the Atlantic and possibly indicating ecological destabilization;
- A total of 101 triton were recorded indicating severe overfishing for the curio market;
- Globally, there was a significant decrease in the abundance of butterflyfish from 1997 to 2001;
- There were zero grouper larger than 30cm recorded at 48% of reefs surveyed indicating overfishing of these predators;
- Four species of fish are in critical condition: Nassau grouper were absent from 82% of shallow Caribbean reefs where only 8 reefs had more than one fish. Barramundi cod, humphead parrotfish and humphead wrasse were missing from 95%, 89% and 88% of Indo-Pacific reefs respectively;
- Moray eels were not recorded on 81% of reefs, and in the Indo-pacific, 55% of all reefs surveyed were devoid of parrotfish greater than 20cm;
- Globally, the mean hard coral cover was 32%. The percent hard coral cover was significantly higher on reefs having no anthropogenic impacts than on reefs with high levels of such impacts. Only 34 reefs had greater than 70% hard coral cover and none had higher than 85% cover.
- The 1997-98 bleaching event reduced live coral cover by 10% globally, indicating that coral reefs are a sensitive indicator of global warming;
- Algal cover was higher on reefs rated as having high sewage inputs;
- Natural differences between reefs in the two oceans are the relatively high abundance of fish of the families Haemulidae and Scaridae on Atlantic reefs and fish of the families Chaeodontidae and Lutjanidae on Indo-pacific reefs.

Achievements in Education and Management: A review of the first 5 years of Reef Check indicates that the basic program of education and monitoring works well. Dozens of Reef Check/GCRMN training workshops have been carried out at national and regional levels throughout the world. These workshops provide training in Reef Check and more taxonomically detailed protocols, as well as supplying information on sustainable financing and media relations. In 2001, a Southeast Asia Regional Training Center was established in Phuket, Thailand, which offers quarterly workshops. Ideally, new training centres can be set up in the Caribbean and East Africa. Reef Check supplies raw data to ReefBase and meta-data to GCRMN for status reports.

Reef Check has been particularly successful in attracting mainstream media attention to the plight of coral reefs. The public awareness campaign continues to build with the help of new private sector partners including Quiksilver and MacGillivray Freeman Films whose film and advertising capabilities offer mechanisms for delivering the message to the general public.

Reef Check also aims to design, test, and implement solutions to the problems facing coral reefs. As people learn more about coral reefs, they develop a sense of stewardship, and a desire to become involved in managing their local reefs. Participation in Reef Check has already led to the initiation of new coral reef management activities in some measurably successful marine parks.

The Next Steps: In the future, Reef Check will devote more effort to facilitating ecologically sound and economically sustainable coral reef management. The ingredients required for further success include:

- Expanding the global public awareness campaign to increase the level of knowledge among the general public about the coral reef crisis and solutions;
- Promoting the creation of a national legal framework for reef monitoring and management in every coral reef country;
- Fostering partnerships among governments, private sector, academia and environmental groups to carry out education, monitoring and management programs;
- Building up sufficient replication of monitoring to allow interpretation at the national and individual reef levels;
- Establishing a system to quickly return data analyses to each team so that they can be used by local managers;
- Channeling funding to national coordinators and training personnel willing to carry out the work.

From: Gregor Hodgson, University of California at Los Angeles, USA; gregorh@ucla.edu

1. Coral Bleaching and Mortality – the 1998 Event 4 Years Later and Bleaching to 2002

Clive Wilkinson

The two distinct themes in this Chapter are:

- how well have reefs recovered after the 1997-98 mass bleaching event and what lessons we have learned; and
- what has happened in coral bleaching since 1998 and where, and are there any patterns?

The major coral bleaching and mortality event of late 1997 and 1998 was by far the worst on record and also the most widespread. Reefs in the 3 Oceans were affected with severe bleaching stretching from the Arabian/Persian Gulf through the northern and central Indian Ocean, parts of Southeast Asia and the Great Barrier Reef of Australia, the far west Pacific, throughout the Caribbean and as far as Brazil in the Atlantic Ocean. By far the most severe bleaching in mortality terms was on reefs in the Indian Ocean north of Latitude 10°S; in southeast and east Asia; and around Palau in the West Pacific.

The levels of bleaching and mortality have been reported in the Status of Coral Reefs of the World reports in 1998 and 2000 and are also summarised in the Chapters following. The critical point for discussion in this chapter is: has there been coral recovery, and if so by how much; and if not, are there any reasons for this lack of recovery.

Summary of Recovery After the 1998 Bleaching

Middle East

Bleaching damage in the Red Sea in 1998 was relatively minor, however there were devastating bleaching impacts in the Arabian/Persian Gulf in 1996 and 1998 and virtually all shallow water corals on the Arabian side were destroyed. Recovery of these reefs will take many decades because breeding stocks have been lost and natural recruitment was already variable and low prior to 1998. There is some recovery of reefs damaged along the coast of Iran after moderate to slight losses in 1998.

Eastern Africa and Oman

Recovery of damaged reefs in Kenya and Tanzania has been poor to moderate, and very patchy. Reefs that previously had high coral diversity and cover have recovered to less than one quarter of their previous coral cover. Degraded reefs with low coral cover outside MPAs have generally recovered half to all of the pre-bleaching cover. The highest coral recruitment has been on protected reefs with reasonably healthy stocks of parent corals nearby. Recovery is higher on shallow reefs than in deeper water and reefs within MPAs have shown better recovery than those outside, especially on Chumbe Island off Zanzibar, and Mombasa Marine Park, Kenya. Most of the new recruits are *Pocillopora* species, with the largest numbers being more than 20 per m^2 at Mafia, Tanzania, and Kiunga, Kenya, whereas on most other reefs, the range is 1-3 new recruits per m^2.

South West Indian Ocean Islands

In the southern Indian Ocean islands of Madagascar, Mauritius and Reunion, most corals recovered immediately after the bleaching and mortality was minor. Recovery and new

Collaborative Management Helps Save Reefs in Tanga, Tanzania

Tanga in northern Tanzania has rich fringing and patch reefs, mangroves, seagrass meadows and estuaries. Local communities depend heavily on these resources, and the consequences of unsustainable use were apparent by 1990. Fish catches were declining, coral reef health was deteriorating, and mangrove and coastal forests were being reduced. Government and community responses to these problems were inadequate, leading villagers and local government authorities to seek control over resource access and exploitation. IUCN started technical assistance in 1994, using funds from Ireland Aid, to develop a long-term integrated conservation and development program, which has been running for 9 years in 3 Districts, with support from the Regional Administration. The resource users and District authorities have developed 6 collaborative fisheries management plans for the entire coastline, with several villages and their fishing areas in each plan. Each village environmental committee is represented on a Central Coordinating Committee to harmonise and coordinate action plans, by-laws, patrols etc. for the whole area. The health of the reefs has improved, the fish populations are larger, catch rates are up, and destructive fishing (dynamite fishing, beach seining) has declined due to collaborative enforcement by the villagers, District officers and the Navy. Some reefs have now been declared as no-take areas in the collaborative management plans. Village monitoring teams, with District Fisheries officers and IUCN, survey open and closed reefs annually using simple methods to record coral cover, invertebrates and fish (target and non-target species) at each reef. Coral bleaching in 1998 severely damaged the corals, but there has been rapid recovery, particularly in the managed areas where fish abundance is also increasing more on closed reefs than open reefs. From: Eric Verheij, Hassan Kalombo, Sue Wells, smw@iucnearo.org

Coral cover in two collaborative management areas is now higher than before bleaching in 1998 with the protected sites having even higher cover.

	Boze-Sange managed area		Mtang'ata managed area	
Reefs	**Open**	**Closed**	**Open**	**Closed**
Before El Niño (1998)	30%	30%	31%	31%
After El Niño (1998)	5%	20%	20%	20%
2002	35%	55%	48%	53%

coral growth on Madagascar is encouraging, but in many areas this is just balancing damage from anchors and pollution from the land. The major impacts were, however in the Comoros and Seychelles. Reefs in the Comoros appear to be recovering well, for example the corals in the Moheli MPA had recovered about half of their former coral cover to about 20% by early 2002, with even better prospects as recruitment was strong in 2002. The situation is less encouraging in the Seychelles with very low rates of natural recovery, even in the protected areas. Most recovery is in deeper water.

CORAL RECOVERY, AND FISH COMMUNITY RESPONSES AFTER 1998 BLEACHING AT ALDABRA, SEYCHELLES

The Aldabra Marine Programme (AMP) set up 11 permanent monitoring sites at Aldabra Atoll, southern Seychelles, to follow reef recovery after the 1998 El Niño bleaching. Aldabra is a World Heritage Site with virtually no anthropogenic impacts. AMP monitored changes in the coral communities using video transects, 1m^2 quadrats for coral recruits, and visual fish counts. In 1998, about 40% of the hard corals on the outer reef were recently bleached and 22% corals died in shallow water (10m). Few corals died in deeper water (20m) despite very severe bleaching. Coral mortality was at least 50% at St. Pierre Island, approximately 450km northeast of Aldabra. Many massive colonies bleached, but often had live polyps around the base. Now there is 3 -28% live coral cover in shallow water around Aldabra, and 0.2-36% in deep water. The highest coral cover is on the sheltered north western end and decreases steadily towards the more exposed south eastern end. Cover on islands east of Aldabra ranges between 12-32% in shallow water and 17-30% in deep water. Live coral cover at Aldabra did not increase significantly between 1999 and 2002, although the trend is rising from year to year suggesting recovery. Coral recruitment is high at Aldabra, ranging from 1-13 per m^2 in 2001 and 1-14 in 2002. St. Pierre and Assumption islands also have high recruitment, but it is low on Astove with only 1% in both shallow and deep water. Thus recovery is well underway on Aldabra and the nearby islands, and should accelerate, however, poor coral recruitment and an extensive bloom of *Caulerpa* algae, are delaying recovery at Astove. AMP counted 221 fish species from 38 families in February 2002 at Aldabra, which is higher than 211 species from 35 families in 1999 and 205 species from 40 families in 2001, but less than the 251 fish species identified in 1998. The combined count is 289 species, which indicates a healthy fish population. The degree of habitat complexity on Aldabra is important as there were more fish in very structured habitats, irrespective of whether the coral was live or dead. Fish numbers have fluctuated between 1,501 fish per 100m^2 in 2001 to approximately 3,000 fish per 100m^2 in 1999 and 2002; probably due to large passing schools of some species. AMP will continue monitoring the corals and fishes at Aldabra and other sites in the southern Seychelles, and is including sites under more anthropogenic pressures. From: Raymond Buckley, Ben Stobart, Nigel Downing, Kristian Teleki, Larry LeClair and Martin Callow; web site: www.aldabra.org

South Asia

Reefs in the Chagos Archipelago in the Indian Ocean suffered up to 95% coral mortality in many areas, and 2-4 years after 1998, there is some new recruitment in all reef areas, from reef flats to at least 30 m depth. This is encouraging, but most of the new corals have settled on dead *Acropora* tables, which are eroding and collapsing, thereby threatening their survival. Others have settled on reef slopes, which are being damaged by large quantities of mobile coral rubble that is abrading the new recruits. In addition, there will be a shift in the species composition of the reefs as more faviids are being recruited than before the 1998 mortality. The consensus is for slow recovery and a shift in the species make-up of the reefs.

Coral Recruitment After the Bleaching in the Maldives

The 1998 massive climate-related bleaching and death of corals in the Maldives occurred against a background of little baseline information on the condition of the reefs before the event. Several studies have followed to measure the rate and composition of new coral recruits on the bare substrate afterwards. The massive bleaching virtually eliminated all parent stock of the *Acropora* and *Pocillipora* corals (and many other susceptible species), with only a few resistant species left to constitute the 2 to 5% coral cover.

Within 10 months of the 1998 bleaching event in Maldives, Alasdair Edwards counted 202 live coral recruits on 150m^2 of artificial reef structures in North Malé atoll where 98% of adult branching corals *(Acropora, Pocillopora)* had died in 1998. Of these 67% were acroporids and pocilloporids, with the remaining 33% being recruits of massive species (poritids, faviids, agariciids and merulinids). On a nearby natural reef flat in March 1999 the mean density of recruits was 23.2 per m^2 with 22% of recruits being massive species and 78% being branching corals (comprising 47% acroporids, 31% pocilloporids). The relative numbers of branching as opposed to massive species recruits were similar on both reef structures. Similar recruit densities were reported by Tim McClanahan in April 1999 from 11 study sites in the eastern central atolls. Recruits averaged 29 per m^{-2}. Both of these studies showed that there were large numbers of *Acropora* and *Pocillipora* larvae arriving to settle on the reefs, despite the observations that virtually all the shallow water parent stock had died in 1998. This indicated that there were still populations of pocilloporid and acroporid corals alive after 1998, and reports indicate that the larvae were coming from corals in deeper water and in the passes from the ocean into the lagoon.

In early 2000, a group of German workers lead by Karen Loch counted 570 colonies in 130 per m^2 or 4.4 colonies per m^2, of reef flat at Komandoo, 140km North of Male, the capital island of the Maldives. These were observed 21 months after the coral bleaching and most were regarded as new recruits. This indicates that coral recruitment is continuing throughout the Maldives, possibly with year to year variations and provides encouragement for a healthy recovery of the coral reefs (provided that there are no repeats of the serious bleaching events).

Massive corals now dominate the reefs in the Gulf of Mannar, India as the branching forms (mostly *Acropora*) were lost in 1998. There was further bleaching in 2002 that killed many of the remaining non-massive corals. The massive corals also bleached, but most recovered rapidly. There was no serious bleaching in the Andaman and Nicobar Islands in 1998 and most remain healthy now. However, this is not the case for the Lakshadweep Islands, which suffered massive damage in 1998. Now there are clear signs of recovery with many small coral colonies settling on the bare reefs.

In the Maldives, the early reports were of almost total devastation across all the atolls, however more recent data show that some of the atolls in the far south escaped most of the major bleaching damage. Most of the other atolls were reduced to 0 to 5% coral cover, down from previous cover probably in the range of 40 to 60%. Most sites show some encouraging signs of recovery with the most susceptible species to bleaching showing strong levels of recruitment.

Recovery in Sri Lanka has been variable. Many small colonies of *Acropora* and *Pocillopora* are evident on the shallow parts of the Bar Reefs, where coral cover had been reduced to near zero from about 80% prior to 1998. About 14% coral cover has remained in deeper areas (8m depth) on these reefs and these are the probable parent stock for the shallow water recruitment. Coral cover in the Hikkaduwa MPA has increased from 7% in 1999 to 12% in 2002, but there is a long way to go before this recovers to be the tourist attraction that it was previously.

Southeast Asia

There is evidence of coral recovery in Cambodia, Indonesia, Philippines, Thailand and Vietnam after extensive coral bleaching mortality, mostly in the northern parts of Southeast Asia. In Indonesia, recovery has been slow in Sumatra and Lombok, but rapid in the Seribu Islands adjacent to Jakarta where coral cover is 40% on some reefs. Coral recruitment is low in the Gulf of Thailand indicating that recovery from the 1998 bleaching will be delayed. The coral reefs in the World Heritage Tubbataha reefs south of Palawan are showing rapid recovery after years of blast fishing and the 1998 bleaching event.

East and North Asia

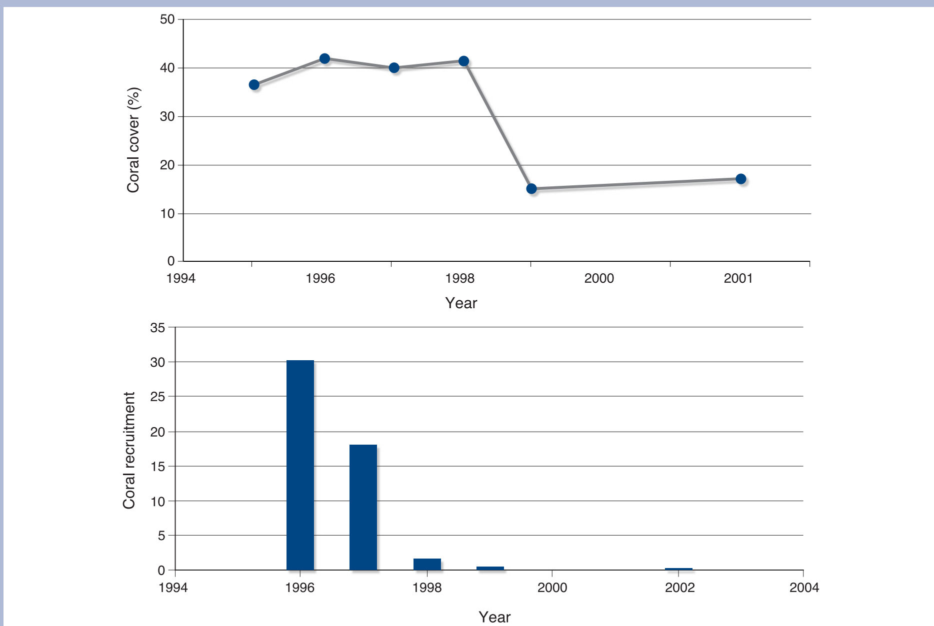
Most coral reefs that were severely damaged in southern Japan during 1998 are recovering rapidly. Throughout the Ryuku and Yaeyama Islands, there was 30 to 90% coral mortality from July to September 1998, with the large stands of *Acropora* and other branching corals lost. Now there are encouraging signs of recovery on most reefs although this was set back by a recurrence of bleaching in 2001. There has been reasonable recovery on Taiwan after extensive coral bleaching in 1998, when 20% of coral colonies died on Penghu Islands, Lutao, and Lanyu.

Australia and PNG

The reefs of the Great Barrier Reef have shown substantial recovery after the 1998 bleaching, assisted by the large scale of these reefs and the ready availability of coral larvae on reefs upstream. Some reefs that were severely bleached in 1998 still show dead standing corals, but most have healthy populations of new coral recruits. There has also been considerable recovery of reefs in the northern and central sections of the GBR after

Recovery After 1998 Bleaching Off Western Australia

Major coral mortality was detailed on Scott and Seringapatam reefs in the Status 2000 report. Both reefs are very isolated: Seringapatam (S 13°139' E 122°102') and Scott (S 14°11' E 121°148') and both suffered extreme levels of mortality in 1998 with reductions in hard coral cover from 41% to 15%, and soft coral cover from 10% to 3% on the outer slopes. There was almost 100% mortality of large *Acropora* beds with no survivors on most lagoon patch reefs, and corals on the reef crests were devastated, with few survivors. All animals with symbiotic algae at 9m depth were wholly or partially bleached, with variable recovery. Now many species are either extremely rare or locally extinct.



Coral cover (%) and recruitment (below) on Scott Reef before and after the major bleaching event in 1998. There is an indication of slight recovery, but it could take many years to reach the 40% level of pre-1998 because larval supply has collapsed.

Recovery has been slow since 1998 and coral cover has changed little from 16% in late 1998 to 18% in 2001. The extensive branching *Acropora* beds have failed to return. There are few juveniles, with small pocilloporids being the majority. There has been an almost complete failure of coral recruitment at Scott Reef since 1998. Recruitment has fallen from an average of 19 recruits per settlement plate in 1996 and 1997, to less than 1 per plate between 1998 and 2002. It is likely that Scott and Seringapatam coral reefs are self seeding because of the their extreme isolation. Consequently, recovery from the 1998 bleaching event at Scott and Seringapatam Reefs could take decades or longer, provided that there are no repeats of major bleaching events. From: Luke Smith, Australian Institute of Marine Science, l.smith@aims.gov.au major losses of corals due to the coral predator, the crown-of-thorns starfish. Similarly there has been substantial recovery on reefs damaged in 1998 off the Western Australian coastline. There are insufficient data to assess either the extent of coral bleaching or recovery in PNG, however the few data presented in Chapter 9 do indicate that there are concerns about coral bleaching damage to these reefs.

Southwest Pacific
There was virtually no bleaching in this region in 1998; however there has been major bleaching in 2000 and 2002.

Polynesia Mana – Southeast Pacific
There were no large impacts throughout Polynesia from bleaching in 1998, however there was severe bleaching on some parts of reefs e.g. coral mortality was over 90% on some outer reef slopes in Rangiroa. These reefs have shown rapid recovery, although there has been some repeat bleaching.

Micronesia
Some of the most significant bleaching in 1998 was on the coral reefs of Palau. Data in Chapter 12 show that some reefs have coral cover in the range of 50 - 70% suggesting that they escaped the major impacts of the 1998 bleaching, or recovered soon after. There are, however, reefs with 10 - 25% coral cover and with large amounts of dead standing coral indicating that these reefs were badly affected. There were reports from Palau immediately after the 1998 bleaching of up to 50% mortality on some reefs. *Acropora* corals were virtually wiped out on some offshore reefs, whereas reefs in more sheltered lagoon waters showed lower rates of loss. New coral recruitment has been very encouraging, including many of the *Acropora* species which were severely affected in 1998, however the major concern is that there are large numbers of crown-of-thorns starfish feeding on the newly settled colonies. The other countries of the Micronesian Node were not seriously affected in 1998.

Hawaiian Archipelago
Bleaching was not a problem in 1998; in fact there were colder than normal sea temperatures when the other side of the Pacific was unusually warm.

U.S. Caribbean
While there was major bleaching in 1998 on these coral reefs, mortality was generally low as large numbers of potentially susceptible corals had been killed off by previous bleaching events. Corals adjacent to the land in this region are being impacted by a range of other factors that have caused major declines in coral cover.

Northern Caribbean and Atlantic
There were similar low to moderate levels of coral bleaching in this region, but most corals recovered soon after and there are no major lasting effects.

Mesoamerica
The coral reefs from the Yucatan, Mexico to Honduras suffered severe damage from two major disturbances in 1998. First there was severe coral bleaching which was followed

soon after by the major hurricane 'Mitch'. This double impact destroyed many corals with losses up to 75% in Belize. Overall there has been a 50% reduction in live coral cover in Belize between 1997 and 1999, and cover has remained relatively stable at that level. Slow recovery is in progress.

Eastern Caribbean

Like other parts of the wider Caribbean region, there was moderate to severe coral bleaching in 1998, but generally there were low levels of mortality. At one site on Barbados, approximately 20% of bleached corals did not survive, but there were complicating pollution factors. Most reefs show signs of recovery from hurricanes, and sediment and bleaching damage from the previous 10 years.

Southern Tropical America

There was predominantly slight coral bleaching and minimal mortality during the major 1997-98 El Niño throughout the region. The exception was in the North Bahia and the Abrolhos region, Brazil where up to 80% of corals bleached, but nearly all the corals recovered after 6 months. The major damage to these reefs from bleaching occurred in the 1980s and early 90s. Recovery is slow as the reefs are under a wide range of anthropogenic pressures.

Coral Bleaching in 2000 to 2002

The summary of data below from ReefBase, shows that the big bleaching period after 1998 was in 2002, and the majority of these events were reported from the Great Barrier Reef of Australia (where there also are more people researching and monitoring coral reefs).

The major bleaching events since 1998 have been in the southwest to central Pacific in early 2000 and again in early 2002. There was also some bleaching in other areas, but the extent was much less than in 1998. So far there does not appear to be any pattern to these latest bleaching events.

2000

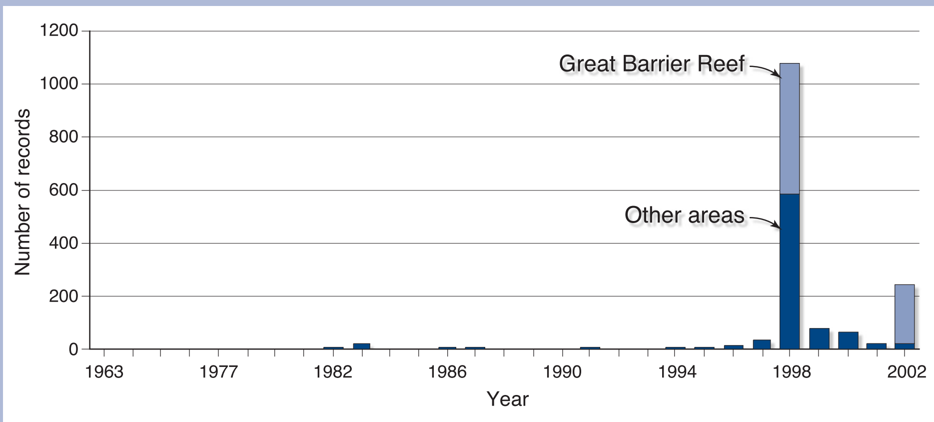
Mass bleaching of many coral reefs in Fiji occurred during the La Niña event in 2000, when water temperatures were above the normal maxima for 5 months. Temperatures peaked at 30.0 – 30.5°C during March and April. When 19 reef locations were surveyed during April – July over most parts of Fiji, 64% of colonies were bleached, except in northern Vanua Levu. The most intense bleaching (80% of colonies) was on the southern and east sides of the main islands of Viti Levu and Vanua Levu, and also on Kadavu and northern Lau group. An estimated 10 to 40% of corals had died when surveyed 4 four months later. The only areas that appeared to escape bleaching were in the far north. There was also similar, but less severe, coral bleaching at the same time in Samoa, Solomon Islands, Tuvalu and Vanuatu.

2001

There was minor coral bleaching in Reunion during February 2001, but these events were followed by relatively rapid recovery. There was also slight to moderate bleaching in the southern islands of Japan in mid-2001, but mortality was slight and most corals recovered

Coral Bleaching Records in ReefBase to 2002

Records of coral bleaching have been assembled into a comprehensive database accessible on ReefBase (www.reefbase.org). There are more than 3,800 records dating back to 1963, which can be queried online to generate maps and reports. There have been over 440 reports of bleaching from over 20 reef regions in 2002. This is the second highest number of records for any year after the massive bleaching events of 1998. A total of 23 reef regions were affected in 1998. The majority of the 2002 records are from the Great Barrier Reef, which is the worst bleaching year on record.



Between1998 and 2002, there were 70 bleaching records from 16 countries or territories each year. This either indicates increasing water temperatures and chronic bleaching between major events or more people are more conscious of bleaching. However, the reports from 1998 and 2002 far exceed any other year.

in most areas with the first storms in September. There was, however, mortality of up to 45% in parts of the Sekisei Lagoon and 70% on some reefs around Ishigaki Island. Other areas reported slight bleaching, but the corals generally recovered soon after. There was slight bleaching in Fiji in 2001, but much less then in either 2000 or 2002.

2002

There was moderate coral bleaching along the coast of Oman in July 2002 and the Straits of Hormuz in September 2002 when water temperatures were 2°C above normal summer maxima, however the level of mortality is unknown. There was a major coral mortality event on the island of Rodrigues (part of Mauritius) in March 2002 with losses of coral cover of between 10% and 75%, apparently associated with a relatively localised warm water event. There was also localised bleaching around the same time on parts of the Seychelles. There was a further reduction in the live coral cover in the Gulf of Mannar, India with more bleaching in early 2002 in shallow areas. Some susceptible branching corals died, and many of the massive corals bleached, but most of these have since recovered.

Coral bleaching and mortality rank as probably the major threat to the reefs in the Pacific as there are no major problems from runoff from large land masses. Over-exploitation and destructive fishing on reefs are the other major problems. There was severe bleaching again in Fiji in the summer of 2002; and the details are being assembled. Coral bleaching was also observed in parts of Vanuatu in 2002, but there are no monitoring data to estimate the extent.

Major Coral Bleaching on the Great Barrier Reef in 2002

North Queensland had unusually hot and still weather during the summer of 2001-02, which resulted in increased sea temperatures and stress to the Great Barrier Reef (GBR). A mass bleaching event followed in the Great Barrier Reef Marine Park, similar in scale to the 1998 event, but this one affected a much larger area than in 1998, and the inshore reefs were once again the most severely affected. When the first warning signals came in December 2001, the Great Barrier Reef Marine Park Authority (GBRMPA) implemented the 'Bleaching Response Strategy' in collaboration with the Australian Institute of Marine Science (AIMS), the CRC Reef Research Centre (CRC Reef) and the U.S. National Oceanic and Atmospheric Administration (NOAA). This Strategy had 4 components: monitoring of sea temperature and levels of stress on the reef; early warning of coral bleaching via a public reporting program; broad-scale aerial surveys of the extent and intensity of bleaching on the GBR; and detailed underwater surveys of the impacts of the bleaching. An important component was to provide regular reports of reef conditions and survey results to the community via Internet updates and press releases.

The first aerial surveys showed that the coral bleaching affected almost 60% of the total GBR reef area. The inshore reefs were more severely affected by bleaching (similar to 1998), however, many more offshore reefs were affected in 2002, than in 1998. The aerial surveys were followed by more detailed, underwater surveys that confirmed that few reefs had escaped the effects of the bleaching. There was extensive mortality on a few inshore reefs, with up to 90% of corals dead at the worst affected sites, however, it now appears that the majority of reefs will survive the bleaching event with only minimal coral mortality. A number of reefs in the Coral Sea adjacent to the GBR (e.g. Flinders and Holmes Reef) also suffered extensive bleaching mortality with up to 95% of corals dead at some sites. The overall pattern was complex and highly variable (from negligible to severe), even between reefs at similar distance from the shore. Bleaching was generally most severe in shallow water and strong patterns of species susceptibility were seen at all sites. The GBR was fortunate to escape with only a few reefs suffering extensive coral mortality in the 1998 and 2002 bleaching events. However, the extent of bleaching on the GBR in 2002 indicates that few reefs are immune from increased sea surface temperatures. The area affected by bleaching in 2002, combined with the potential for mass coral death at the worst affected sites, provides a vivid warning of the potential for widespread and severe ecological damage should warm water events increase in severity, duration or frequency in the future. From Paul Marshall, David Wachenfeld and Ray Berkelmans.

In the summer of early 2002, there was particularly damaging coral bleaching over considerable areas of the GBR of Australia (see box). Later in September 2002, there were reports of coral bleaching in the Marshall Islands with many of the *Acropora* species showing considerable mortality. Similarly, in October 2002, there were reports of bleaching in the North West Hawaiian Islands, but no details were available on the extent or consequences. In December 2001 to January 2002 corals bleached on many of the Society Islands, French Polynesia barrier reefs and lagoons. The bleaching was most serious on outer reef slopes in March and corals remained bleached until July, by which time about 10% had died.

Prognosis for the Future

The 1998 global-scale bleaching and the 2002 bleaching on the GBR and southwest Pacific are alarm calls for the future of the coral reefs as we know them. Models of climate change and their effects on warming of sea surface temperatures indicate that there are likely to be more bleaching events like those two in the future. As the southern hemisphere heads into summer in late 2002 with an apparently strengthening El Niño event, it is a strong possibility that there will be repeats of severe bleaching in January to April 2003 in the Indian and Pacific Oceans.

The increasing evidence is that coral reefs are bearing the brunt of Global Climate Change in the marine environment and the prognosis for reefs that we have been studying for the last 50 years is grim. It is predicted that we will see reductions in coral cover and localised extinctions of some coral species. These localised extinctions could result in total extinctions of corals with narrow distribution ranges. Thus, in 50 years time there will still be coral reefs but these could have lower amounts of coral cover and fewer species; the species that have special resilience to warmer waters. The major concern is that we may be in a period of accelerating ocean warming and more frequent coral bleaching events that could cause serious damage to reefs, not in decade scales but in the next few years. This is of obvious concern for people who rely on coral reefs for their livelihoods and who live on low-lying coral islands. There is a need for remediation strategies: introduce mechanisms to assist communities likely to be affected by global warming, sea level rise and potentially more damaging tropical storms; and implement urgent measures to reduce the releases of greenhouse gases that are the driving force behind global climate change. This is now the consensus position of most coral reef scientists and managers around the world.

Scientific Concensus Includes Global Warming as a Major Threat to Coral Reefs

A group of 15 world-leading researchers from Australia, Europe and USA met in Townsville in October 2002, to assess threats to coral reefs and a prognosis for the future. There was expertise in ecology, geology, palaeontology, oceanography, climatology and economics. They listed the threats to coral reefs worldwide as: 1. over-fishing; 2. pollution; and 3. climate change. There is reasonable understanding of the problems and solutions for 1 and 2; however, the damaging effects of climate change on coral reefs are not well understood. This presents scientists and managers with a huge intellectual challenge to integrate scientific knowledge and expertise from many disciplines to offer effective management solutions to deal with this threat. The experts concluded that: coral reefs will no doubt change with global warming; an ecosystem perspective must be used to manage coral reefs with an aim to re-build ecosystems that are more resilient to stress; and international, national and inter-agency collaboration with management efforts is essential.

The 'resilience' of a reef to withstand 'natural' stress from cyclones or bleaching, has decreased over the past 200 years under the negative impacts of overfishing and pollution. If these trends continue, coral reefs will decline further leading to accelerating losses of biodiversity and economic value. It is necessary to re-build the resilience of reefs in the face of increasing global climate change and the accompanying oceanic warming. This can be achieved by better protecting the food webs and key groups, such as, the herbivores that control algal blooms. In addition, projected increases in carbon dioxide over the next 50 years exceed the conditions experienced by coral reefs for more than half a million years. It is apparent that changes are already underway and some corals are more susceptible than others. This suggests that there will be changes to coral reef community structure in the future. Ocean chemistry is also changing due to higher atmospheric carbon dioxide, which may cause dissolution or weakening of coral skeletons. Emissions of carbon dioxide must be reduced to avoid this threat. Recent modelling indicates that to achieve the goal of re-building coral reef resilience and to have some insurance against losses due to changes in ocean chemistry, 30-50% of reefs should be set aside as MPAs.

The forum urged national leaders and international bodies to make a long-term commitment to conserve tropical marine ecosystems. They suggested that Australia, as the only developed country with significant coral reefs, has an obligation to lead this effort, and should lead the world's efforts to quickly reduce greenhouse gas emissions. Full text on www.seaweb.org/pdf/jcu_release.pdf Contact: Terry Hughes James Cook University, Townsville, Australia terry.hughes@jcu.edu.au

2. Status of Coral Reefs in the Red Sea-Gulf of Aden

Moshira Hassan, Mohammed M. A. Kotb
and Abdulmohsin A. Al-Sofyani

Abstract

The status of coral reefs bordering the Red Sea and Gulf of Aden is generally good, with live hard coral cover averaging 20-50%. There are predominantly fringing reefs bordering the coasts of Djibouti, Egypt, Saudi Arabia, Sudan, and Yemen. Atolls and pinnacle reefs occur mainly in the Central and Southern Red Sea. However, technical reports, personal observations and comparative data show recent decreases in live coral cover. Fish populations are also declining and there have been several small outbreaks of the crown-of-thorns starfish (COTS), some local bleaching events and an increase in bioeroding organisms such as the urchin *Diadema setosum* and the coral eating gastropods *Drupella* and *Coralliophila*. Threats to coral reefs differ within the region, and are continuously increasing with the increasing rate of coastal development. The major threats are land filling, dredging, sedimentation, sewage discharge and effluents from desalination plants. In major tourism areas, there is physical damage by tourists and boat anchors. Fishing pressure is constantly increasing throughout the region to satisfy demands of growing and more affluent populations.

Most countries have legislation for reef conservation and additional national laws and multinational agreements have been adopted by the countries with assistance of the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA). However, the implementation of these laws is difficult and completely lacking in remote areas. There is a need for enforcement of national and international laws, development of public awareness programs and the adoption of sustainable management strategies to reverse the current trend in deterioration of the environment.

Introduction

This report is the result of the first standardised survey of the coral reefs of countries (Djibouti, Egypt, Saudi Arabia, Sudan, and Yemen) bordering the Red Sea and Gulf of Aden, organised and funded by the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) and focused on the members of the Arab League. The Reef Check methods and protocols were used in April/May 2002 to:

- to obtain an initial picture of the health of the coral reefs using a standard and rapid method throughout the region; and
- to train local teams to conduct these surveys using standard techniques.

Geographical Setting and Reef Coverage

The Red Sea extends 2270km from 30°N in the Gulf of Suez to 13°N at Bab-el-Mandeb in the southeast. It is a narrow (maximum 350km wide) and deep (maximum 2920m) desert enclosed sea. The shallow 130m deep sill at the Bab-el-Mandeb Straight restricts water exchange between the Red Sea and the Gulf of Aden. The land surrounding the Red Sea is mostly hot and dry with minimal freshwater inflows and high evaporation. Therefore surface waters enter the Red Sea from the Gulf of Aden to compensate for evaporation losses, but even so the salinity varies along the length of the Red Sea from 36.5ppt (normal seawater) at the southern entrance to more than 41ppt in the northern Gulf of Aqaba in summer. Water temperatures and nutrient concentrations decrease in surface waters towards the northern end, where the water is generally clearer. Coral reefs are well developed along the Red Sea, with fringing reefs lining most of both shores and into the Gulf of Aqaba. Towards the south around latitudes 18-20°N there are fringing reefs around islands away from the shore. The only breaks in the fringing reefs are in front of wadis (dry river beds), which can carry large amounts of water and sediment.

Pinnacle reefs and atolls are mainly found in the Central Red Sea, and the coastal reefs are greatly reduced further south, but there are still healthy reefs with high coral cover further from the shore in cleaner water. The Red Sea has high biodiversity, with at least 266 coral species in Saudi Arabian waters, and 160 species in the Gulf of Aqaba.

Reef distribution is patchy and not well developed in the Gulf of Aden, except for the Socotra Archipelago, which is fringed by extensive reefs. Further details on the extent and development of coral reefs in several countries of the Red Sea are summarised in the Chapter 2 in 'Status of the Coral Reefs of the World: 2000' and the 'World Atlas of Coral Reefs'.

Status of Coral Reefs – Benthos and Fish

This report focuses on recent Reef Check surveys throughout the region. Other surveys were reported previously in the 'Status 2000' report.

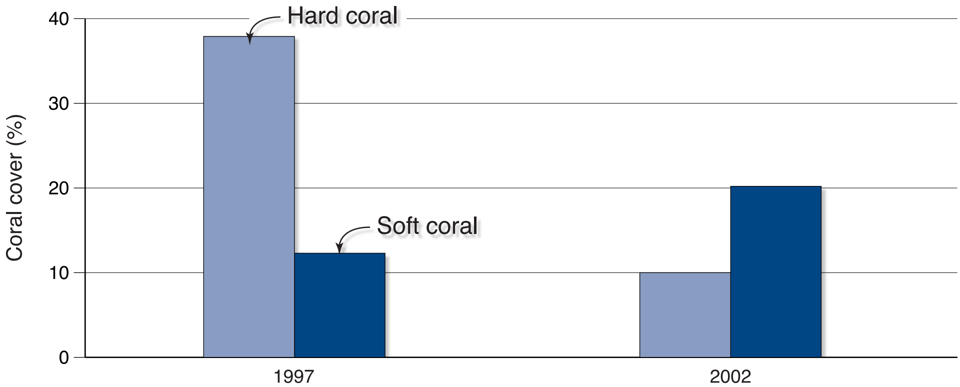
Djibouti

The cover of live hard corals in the Gulf of Tadjoura ranged from 12% in south Maskali to over 60% off Sable Blanc with an overall average of 36%. This is virtually unchanged since the previous report by PERSGA in 2000. However, several sites off Maskali Island were deteriorating, with previously healthy coral reefs being largely covered with algae. There were also reef-flats covered in rubble from eroding table corals around Maskali, and the mortality has been attributed to the 1998 bleaching event, and large numbers of the crown-of-thorns starfish (COTS) seen in 2000. These damaged sites were not included in the above average coral cover. In addition, increased numbers of the coral-eating gastropods (*Drupella* and *Coralliophila*) were seen at most sites, and the bioeroding urchin *Diadema* averaged 12 individuals per $100m^2$. Human pressures include increasing coastal construction, dredging and land filling, and shipping impacts around the port of Djibouti (the major harbour for Ethiopia). Anchor damage and tourism impacts are increasing in Djibouti with little increase in environmental awareness in the population.

Egypt

Living hard coral cover was significantly higher in the Red Sea than in the Gulf of Aqaba. Cover ranged from 16-67% at 5m depth, with an average of 45% in the Red Sea, and 35% in the Gulf of Aqaba. There was an average of 10% soft coral cover. The coral cover was significantly lower at 10m depth, with an average of 26% (Red Sea 33%; Gulf of Aqaba 20%). A comparison of two sites surveyed in 1997 and 2002 in the Gulf of Aqaba show that coral cover decreased from 37% to 13%, probably due to repeated outbreaks of COTS during 1998. There have also been major decreases in giant clam populations between 1997 and 2002, with many of the small clams seen in 1997 not surviving through to 2002. This is attributed to sediment from major constructions in South Sinai over the last 5 years.

Butterflyfish have decreased in the Gulf of Aqaba and the Red Sea proper, with an average of 9.7 butterflyfish per $100m^2$ in 1997, and only 5.2 per $100m^2$ in 2002, and sweetlip populations dropped by 69%. Abundance of groupers and parrotfish remained stable in the Gulf of Aqaba, but decreased in the Red Sea. There is better enforcement of no-take zones and fishing regulations in South Sinai and Gulf of Aqaba than in the Red Sea, where fish poaching is evident. Some solid wastes were seen, but there was little anchor damage.



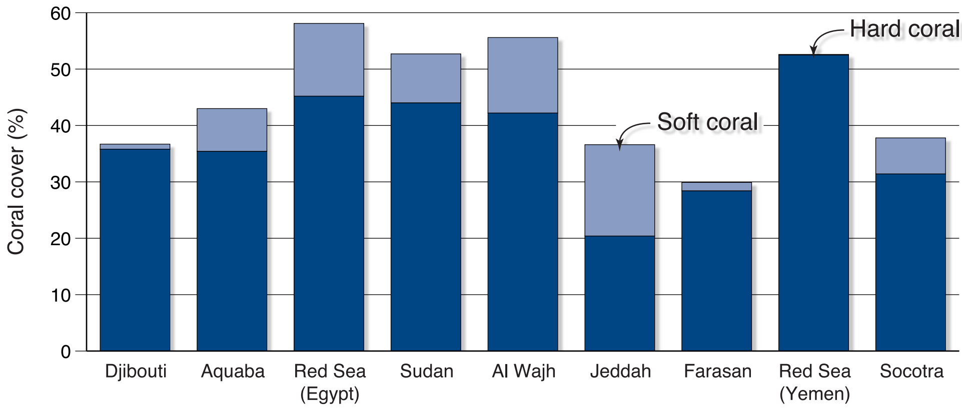
There has been a significant decrease in hard coral, but an increase in soft corals along the Sinai coast of the Gulf of Aqaba between 1997 and 2002.

Environmental awareness has increased in Egypt, due to activities of the Egyptian Environmental Affairs Agency and several NGOs, especially the Hurghada Environmental Protection and Conservation Agency, and increased interest from the Governor of the Red Sea. The installation of hundreds of mooring buoys and support from dive boat skippers at dive sites on Sinai and in the Red Sea has markedly reduced anchor damage. However, tourism development is increasing along much of the coast and this is adding to the difficulties in enforcing reef conservation laws. These developments are affecting the Egyptian coral reefs through damaging construction, sedimentation, and pollution, as well as the physical impacts of divers and snorkellers (more than 50,000 per year visit some sites), and increasing demand for seafood and illegal curios. There are attempts to improve the quality of tourism developments, encourage ecotourism, and to increase public awareness. The legal framework for the protection of coral reefs is excellent and is implemented in several areas, however, improved legal enforcement is needed over the whole tourism sector.

Saudi Arabia

The highest coral cover of the 3 sites surveyed in Saudi Arabia was on the Wajh Bank in the north, with an average of 40% cover at 5m. On the Jeddah reefs in the centre, there was 20% average cover at 5m and 28% cover on the reefs off Farasan Island in the south. Wajh Bank also had the highest cover at 10m, but the decrease in living coral between 5m and 10m was much higher than in the other regions, probably due to higher turbidity. Soft corals averaged 15% cover in the northern parts, but were low on Farasan Island. Fish counts were high for parrotfish, snappers and groupers, with the highest numbers of parrotfish seen at Wajh Bank (29 fish per $100m^2$ compared to 2 per $100m^2$ in the other regions), whereas the highest numbers of snappers were at Farasan Island (83 per $100m^2$ vs. 3 per $100m^2$ elsewhere).

Human disturbance to reefs in Saudi Arabia is generally low, but higher around several large cities. The reefs off Jeddah are influenced by the growing city which now has 2



Cover of hard and soft corals at 5m depth in 9 sites along the length of the Red Sea. At each site there were 4 replicate transects each 20m long and assessed using the Reef Check protocols. This shows relatively healthy coral populations in most sites.

million people along with increases in pollution, domestic and industrial sewage, construction, dredging for the construction of marinas, sedimentation and effluent from desalination plants. Local and foreign tourism is increasing with the accompanying boating and diving which results in direct impacts to the coral reefs. The Al Wajh and Farasan Islands regions have few human pressures, although there is increasing fishing pressure in more remote waters away from the of the Coast Guard patrols. Some destructive fishing has been reported e.g. bashing corals to drive the fish into nets. Despite this fishing pressure, snappers, groupers and parrotfish were observed in relatively high numbers.

Sudan

The average live coral cover was 44% at 5m water depth and 34% at 10m (ranges between 15% and 57%). There was also abundant cover of dead standing coral that indicated significant recent coral mortality. There was, however, less than 1% of recently killed coral indicating that there has been no new mortality events. Anchor damage and solid wastes were minimal. The abundance of several target fish species was average to low in Sudan compared to the other countries (groupers and snappers each less than 1 per 100m^2, parrotfish about 2 per 100m^2), however, the fish seen were generally larger. Several humphead wrasse (*Cheilinus undulatus*) were seen, but only one humphead parrotfish (*Bolbometopon muricatum*) was seen at Tala Tala, Southern Sudan compared to all the surveys of the Red Sea. The coral reefs near the ports of Port Sudan and Suakin suffer some shipping, construction and dredging damage, and tourism related threats are mainly from anchors and breakage by divers. Tourism is not highly developed in Sudan, but is a growing industry. There is low public awareness about coral reef conservation and the legal framework for coral reef protection is minimal.

Yemen

Live coral cover averaged 53% with a maximum of 69% on the Red Sea coast of Yemen. Cover on Socotra Island had an average of 31%, with the average cover being 27% at 5m depth and 36% at 10m. Hard coral cover on reefs off the Yemeni coast ranges from 15% cover in Mukalla to 69% in Belhaf at 2m depth where there was 2% of recently killed coral at several sites. Despite this apparent high coral cover, the surveyed reefs seem to have declined recently.

The reefs around Kamaran Island are severely degraded. Collecting of aquarium fish is increasing in Yemen, especially near Kamaran and there are reports of destructive fishing at some sites. Despite the increasing local and foreign fishing pressure, the abundance of indicator fish was among the highest in the Red Sea. Butterflyfish averaged 9 per 100m^2 (maximum 20), snappers were abundant averaging 100 per 100m^2 (range 24-2,000) and large schools of snappers were seen on many reefs. Socotra Island also had high numbers of snappers, butterflyfish and groupers.

Most of the reefs surveyed in the Red Sea and on Socotra were in relatively good condition, despite increasing human impacts. However, there are increasing signs of deterioration on the coral reefs. High numbers of coral–eating gastropods were found and COTS were seen consistently. There are also large populations of bioeroding sea urchins (average 29 per 100m^2 on Red Sea sites; 18 per 100m^2 on Socotra). Such sightings should cause alarm as these urchins can rapidly undermine corals and cause them to collapse. Public awareness about coral reef conservation is low in Yemen and the legal framework for reef protection is weak. The exception is Socotra Island, which is a National Park and receives international funding and research attention.

Regional Summary

The first obvious comparison is that the water is clearer in the north compared to the south: water visibility in the Gulf of Aqaba and Egypt is 40-50m; on the Wajh Bank, Saudi Arabia in the centre it is 30-35m; and visibility less than 5m at some transects in the Southern Red Sea. This poor visibility in the south is reflected in lower coral cover at 8-12m compared to 3-6m. The highest coral cover is in the Red Sea of Yemen, despite the reefs being relatively poorly developed, compared to more complex reefs in the northern Red Sea. However, some of the most damaged reefs were seen in Yemen and Djibouti in the south, where there were more COTS and *Diadema* sea urchins damaging the corals. Edible sea cucumbers are currently being fished in most countries for export to Southeast Asia. Densities averaged between 3 and 5 individuals per 100m^2 respectively in Yemen (Red Sea and Socotra) despite the increasing trade.

The numbers of indicator fish differed markedly between regions; the highest numbers of snappers were in Yemen and in Farasan Islands (an order of magnitude higher than elsewhere) with large schools recorded. The largest fish, however, were found in Sudan, including the now rare large groupers and humphead wrasse (*Cheilinus undulatus*) and the only humphead parrotfish (*Bolbometopon muricatum*) were also found in Sudan. The lowest numbers of butterflyfish were found on Jeddah reefs which correlates with increasing pollution and fishing pressure from the city.

Conclusion and Recommendations

The Red Sea showed comparatively low levels of human impact, as most of the coastline is sparsely populated. However, there is increasing development of many coastal areas and problems are becoming evident for the reefs. The impacts are most obvious around the larger ports and major tourist resorts. Deterioration was also found away from coastal developments, where it is probable that COTS and other natural disturbances have damaged the reefs.

All countries have a legal framework for coral reef conservation, and the scope of the laws and the degree of implementation differs widely between and even within the countries of the region. Stronger enforcement of national and international laws, the development of public awareness programs and the adoption of sustainable management strategies are all needed for coral reef conservation to improve and for the current trend in deterioration of the environment to be reversed.

Acknowledgements

This survey was organised and funded by the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA). We would like to thank Mr. Abdullah Alsuhaibany, for his continuous support throughout the mission. We could not have conducted the surveys without the active participation of scientists or without the help of the National Program Coordinators of PERSGA in each country. In particular we would like to thank the following people: Djibouti: Nabil Mohammad, Nasser Djama Abdi, Hussein Rirach, Moussa Omar and Alexandre Galandrin; Egypt: Essam Saad-Allah, Ayman Mabrouk, Tamer Kamal El-Den, Ali Ahmed, Saied El-Sayed and Tamer Monir; Saudi Arabia: Khaled Hizam and Ehab Abo el Adel; Sudan: Mahgoub Hassan, Sheikheldin El-Amin and Eihab Omer; Yemen: Malek A. Abdal-Aziz, Aref Hamoud, Zahir Al-Agwan, Fouad Nasseb, Thabett Khamis and Mohammed Ismail. We would also like to thank Simon Wilson and Jeremy Kemp for their valuable input and information of previous surveys.

Author Contacts

Moshira Hassan, The American University in Cairo, Egypt, moshira@reefcheck.de; Mohammed M. A. Kotb, Suez Canal University, Ismailia, Egypt, kotb13@ismailia.ie-eg.com; Abdulmohsin A. Al-Sofyani, King Abdulaziz University, Jeddah Saudi Arabia

Supporting Documentation

Pilcher N, Alsuhaibany A, 2000. Regional Status of Coral Reefs in the Red Sea and the Gulf of Aden. In: Status of coral reefs of the world: 2000. Wilkinson, C. Ed. Australian Institute of Marine Science, Townsville: 35-54.

Spalding MD et al. (2001). World Atlas of Coral Reefs. Berkeley, University of California Press.

Coral Reefs in the Gulf of Aqaba

The Gulf of Aqaba is the northern-eastern extension of the Red Sea bordered by Egypt (200km of coastline), Israel (12km), Jordan (27km) and Saudi Arabia (150km). It is a semi-enclosed basin that is separated from the Red Sea at the Straits of Tiran. Fringing reefs, with 138 hard coral species, are found in the Gulf of Aqaba. Rapid surveys at 5 sites in the Gulf showed that live hard coral cover ranges from 13% at an industrial site to 22% in the marine reserve. Other coastal habitats include seagrass beds and mangroves. These coastal habitats provide food and shelter for 362 species of fishes, one damselfish is endemic and may be considered 'vulnerable' by the IUCN. The coral reefs in the Gulf of Aqaba are vulnerable to human impacts such as urban and industrial pollution, shipping and port activities as well as tourism. Until 1995, 6 million cubic meters of sewage per year from Eilat flowed freely into the Gulf of Aqaba. Today, sewage from Eilat and Aqaba is not discharged into the Gulf, instead it is treated and re-used for irrigation. This practice can also have negative impacts on coral reefs in the long term. Shipping is another threat and the port in Aqaba is the third largest in the Red Sea. The high amount of shipping increases the risk of accidents and there have been several recent ship groundings on the coral reefs of the Egyptian coast. The Port activities have increased impacts on adjacent coral reefs from sedimentation, nutrient input, coral destruction and increased heavy metal concentrations. This has caused changes in the fish communities through a reduction of total fish abundance by 50% and a shift in the trophic structure towards herbivore and detritivore fishes. Coral diseases have increased by a factor of 10, especially the number of coral colonies infected with black band disease. Tourism is generating increasing pressures on the coral reefs in Egypt, Israel and Jordan by coastal construction, sewage, solid waste and recreational activities, such as swimming, snorkelling and diving. Recreational SCUBA diving can have a severe damaging impact on coral reefs. In Eilat 250,000 to 300,000 dives are carried out each year, the highest number worldwide in a small area. Marine reserves have been established along the coast of the Gulf of Aqaba. The complete Egyptian coastline, including some terrestrial areas, is protected and divided in use and non-use zones. The 'Coral Beach Nature Reserve' covers 4km of the coastal waters on the southern Israeli coast and in Jordan and is protected as the 'Red Sea Marine Peace Park' with assistance of a US-funded bilateral project between Israel and Jordan. Despite political problems in the Middle East, international scientific programs have been carried out in the Gulf of Aqaba, bringing together local scientists from Egypt, Israel, Jordan and Palestine. The multilateral 'Red Sea Programme' (1995-2001) and the 'International Red Sea Cruise of the *RV Meteor*' (1999) were coordinated by the Centre for Tropical Marine Ecology in Bremen and funded by the German Ministry of Research and Technology. These multinational research projects are obtaining important baseline data for a joint environmental management by the countries bordering the Gulf of Aqaba. Contact: Marc Kochzius, Centre for Tropical Marine Ecology, Bremen, Germany, kochzius@uni-bremen.de

3. Status of Coral Reefs of the Persian/Arabian Gulf and Arabian Sea Region

Simon Wilson, Seyed Mohammad Reza Fatemi,
Mohammad Reza Shokri and Michel Claereboudt

Abstract

Corals growing in most of this region are subjected to extreme environmental conditions, in particular wide fluctuations of temperature and salinity. Mass coral bleaching and mortality in 1996 and 1998 reduced live coral cover significantly in many areas, particularly the *Acropora* species. However, the effects of the 1998 bleaching event in the Arabian Sea was minimised by the onset of the summer upwelling, which moderated the extreme temperatures in Southern Arabia. There are signs that recovery has commenced, but there have been new reports (September 2002) of bleaching in the Gulf of Oman and the Straits of Hormuz and it is too early to determine the ultimate effects of the bleaching on coral health. Human stresses to corals in the region are mostly caused by industrial activity, dredging and land reclamation. Cooling water discharges from desalination and power plants add to the thermal load of a naturally stressed environment. Fishing activity, particularly industrial trawling and the use of artisanal gillnets is causing low level damage to corals throughout the region. However, many of the other stresses that damage coral reefs around the world such as pollution in fresh water runoff, destructive fishing, and over-exploitation are largely absent.

Introduction

The Persian/Arabian Gulf (hereafter called 'the Gulf') is a semi-enclosed, sub-tropical marginal sea surrounded by very dry land. The Gulf is very shallow sea (average depth 35m), and was dry 10 thousand years ago during the last ice age. The Gulf is linked to the Gulf of Oman and the wider Indian Ocean by the narrow Straits of Hormuz which limits water exchanges. Freshwater inputs come from a few rivers that flow from Iran and Iraq, the largest of which is the Tigris/Euphrates, but these contribute little compared to the extreme evaporation rates in the Gulf. The combination of these conditions, particularly the arid desert climate and extensive areas of shallow water, cause extreme conditions for coral growth, with variations in salinity (28 to 60ppt; normal sea water around 35ppt) and temperatures (10 to 40°C) being among the most extreme in the world. Thus coral reefs and communities in the Gulf generally have relatively low biodiversity, and the ability of corals to survive is probably due to their strong genetic adaptability.

In contrast, the Gulf of Oman and Arabian Sea are deep seas (more than 2000m) with more stable and moderate physical conditions, compared to the Gulf. A particularly important feature in moderating summer temperatures in the Arabian Sea is the influence of upwellings. These are driven by the strong southwest monsoon winds that blow across southern Arabia. This upwelling cools the waters and protects corals from extreme temperatures (see Box). Coral reefs and communities in the Gulf of Oman and Arabian Sea have relatively higher biodiversity compared to Gulf reefs, but are still lower compared to the central Indian Ocean or the Red Sea. However, new research on coral taxonomy in the region is indicating that coral species diversity may be higher than previously reported.

Industry, shipping and fishing are the most significant human stresses to coral reefs in the region. With the abundance of cheap energy, heavy industry has developed rapidly in the past 15 years, with much of this industry located on the coast for easy port access and the abundance of seawater for cooling. Massive electricity generating plants provide power for desalination plants, which provide much of the freshwater in the region. However, thermal pollution from the cooling waters adds to the extreme temperature regimes in the industrialised coastal areas. Oil and gas production, processing and transport also add stress to coral reefs, particularly in the straits of Hormuz where there are major risks of shipping accidents.

The corals in the Gulf were adapted to wide temperature fluctuations and were considered to be temperature resistant, until the major El Niño related climate changes in 1996 and 1998. These resulted in virtually the total death of corals from bleaching in the shallow western side of the Gulf. The reefs on the Iranian side of the Gulf, and those off Oman in the Arabian Sea suffered only minor to moderate bleaching in 1998, due in part to protection from upwelling in June and July.

The Geography of the Coral Reefs

Coral reefs in the Gulf are mostly fringing along the coast and around the most of the islands on the Arabian side and grow on a hard base of old limestone. There are similar reefs on the Iran side, although the nearby waters are about 100m deep. While coral diversity is low, the fish diversity is much higher. Coral growth in the north of the Gulf is limited to southern Kuwait with small patch and fringing reefs inshore, some offshore platform reefs and coral cays, but all grow in relatively shallow water. The reefs along the coast of Saudi Arabia are similar, being a mix of small pinnacles, fringing and patch reefs, particularly around the offshore islands. Although there are also few coral reefs around Bahrain and along the coast of Qatar, in the mid and southern sections of the Gulf, most of the corals occur as isolated or scattered colonies because of the high sedimentation rates and lack of suitable substrate, and the only true coral reefs occur offshore. Much of the coast of the United Arab Emirates is a low-lying, salt-pan (known as *sabkha*) that is rich in seagrasses and generally unsuitable for corals. There are large areas of coral growth and patch reefs on shallow rocky platforms offshore and fringing reefs around many of the islands, but these have largely been destroyed by the bleaching in 1996 and 1998.

The best reefs in Iran are around Khark and Kharku islands in the far north of the Gulf, and from the Lavan to Hormuz Islands in the south, otherwise there are fringing reefs along much of the Gulf coast. Much of the Iranian coast in the Gulf of Oman is sedimentary and exposed, therefore unsuitable for corals, although patchy corals with low diversity are common in some of the more sheltered bays (e.g. Bahar).

In Oman, much of the coast is sedimentary and rocky with limited areas that are suitable for coral growth. Reefs are generally not well developed, although corals and coral communities do occur where there is suitable substrate. The best areas for coral growth are in the Straits of Hormuz, the offshore islands in the Gulf of Oman and areas in the south that are more protected from the full intensity of the rough sea conditions associated with the summer upwelling.

Status of Coral Reefs

Bahrain

No new information was received.

Iran

Some of the northern islands such as Kish and Qeshm in the Gulf are a continuation of the Zagros Mountain Range, and others grow on an uplifted salt dome (Bandar Abbas area). The eastern islands in the Straits of Hormuz are less influenced by the less saline and nutrient-rich waters from the upwelling that pass through the Gulf of Oman especially in the summer monsoon. The Inner Islands tolerate the most saline and least fertile conditions of the region, and coral communities growing around these islands are patchy in the shallow waters and protected areas along the shoreline (e.g. Bandar Taheri Port and Khalij-e-Nay Band Bay in Bushehr Province).

There are 27 species (9 families; 20 genera) in the Nay Band Bay, Kish and Farur Islands area, with the most abundant families being the Faviidae, Acroporidae and Poritidae. Coral species diversity is highest at Kish Island with 21 species, with 16 at Farur Island and 5 at Nay Band Bay. Dominant species for cover and frequency are *Porites lutea* and *P. compressa* in Nay Band Bay and Kish Island, and *P. compressa* and *Acropora clathrata* at Farur Island. There are only a few species of alcyonacean soft corals or reef building hydrozoa, which are common on other high-latitude reefs in the Red Sea and the Indian Ocean.

Live coral cover ranges from 9% on Kish Island, to 30% on Nay Band Bay, with coral extending 3m to 15m in depth. The highest coral cover on Kish Island is on the eastern and southeast margin, whereas the most dead coral cover is on the northern part, adjacent to the main shipping and harbour activities, and the desalination plant. Five years ago, coral, especially *Acropora,* was abundant with little or no dead coral. On Farur Island, live corals occur mostly on the eastern and northeastern part dominated by *Acropora*, with *Porites* dominant on other parts of the island.

In Nay Band Bay, the highest live coral cover was found in the northern portion of the bay, whereas sand flats dominate the southern parts facing the Gulf. Corals are found from 2m to 10m depth. Old dead corals are more abundant in the middle portion of the bay to the east. Outside the bay to the west, small coral patches extend for tens of kilometres. Recent oil and gas installation constructions have severely damaged these patches and they are now mostly dead.

No bleached corals have been observed in the study areas in the Gulf since 1999. However, considerable bleaching occurred throughout the area from 1996 to 1999. At Kish Island in 1999, approximately 15% of massive (*Favia*) and sub-massive coral (*Porites*) colonies showed bleaching, typically with 70% of each colony bleached. There was no evidence of bleaching in 2000 and 2001. Some Yellow-Band Disease was observed for the first time at Farur Island in 2000, and very low incidences were seen in 2001. The corals most affected were *Porites lutea*, *P. compressa*, *Favia pallida*, and *Platygyra daedela*.

Kuwait

No new information was received.

Oman

A bleaching 'hot spot' occurred in early July 2002 when warm water 2°C above the monthly average occurred near Muscat. There was some bleaching of *Goniopora* colonies in the Daymaniyat National Nature Reserve, 40km off the coast of Muscat in August, with most corals affected in shallow water. The most severely affected species were *Astreopora* (100% of colonies totally bleached), *Symphyllia recta* (60-70% of colonies bleached), *Goniopora* (50% of colonies bleached), *Platygyra* (20% of colonies partially bleached), and soft corals (25% of colonies bleached). These corals constitute approximately 20% out of the 85% hard coral cover. Minor bleaching was also observed at Qalhat in October 2002 (some *Goniopora* and *Acropora* only) but corals on the mainland coast of Muscat were largely unaffected.

Further bleaching was reported in the Straits of Hormuz along the coast of the Musandam peninsula during September 2002. The worst affects were in restricted water circulation, while areas with strong currents were unaffected. *Platygyra*, other faviids and *Porites* that are normally resistant to bleaching, were significantly affected with 60% of all colonies bleached or partially bleached. Seawater temperatures over the summer 2002 remained consistently at 33ºC for 30 days during July and August, while the temperature averaged 31.5ºC over the same months in 2001.

The bleaching in southern Oman in 1998 only affected very shallow corals on a small part of the coast near Mirbat, however, surveys in January 2002 showed 5-10% coral cover, compared to 20-30% cover in 1996. The decline is partially due to the bleaching in 1998, but more likely to be caused by summer upwellings, crown-of-thorns starfish (COTS), and the effects of abalone fishing and scuba diving. The density of coral recruits was low compared to other sites in Southern Arabia (e.g. Socotra Archipelago), indicating that recovery will be slow.

Hard coral cover at Qibliah Island in the Hallaniyat Archipelago in January 2002 was moderate in shallow areas (10m depth), with about 25-30% cover of the *Acropora* and *Porites* community, and 30-40% cover of dead, intact *Acropora* tables, suggesting significant mortality had occurred within 12-18 months, probably due to a COTS outbreak. No COTS were found, however, during searches in areas where there were feeding scars. There was a significant COTS outbreak in 2001 and 2002 at Bandar Khayran in the Muscat area where more than 50 starfish were found in each 30 minute survey. Coral cover was reduced by 10-80% by the COTS, affecting mostly acroporids and

Upwelling Areas as Thermal Refuges

The upwelling that occurs during the southwest monsoons provides a thermal refuge for marine life in southern Arabia during summer months when other parts of the region are exposed to maximum temperatures. In upwelling areas, there are two peaks in seawater temperatures during the year. One is in late May and one in October, and rarely do these maxima exceed 30°C. Temperatures during the upwelling season can fall to 18°C, but generally average 20°C. In contrast, non-upwelling areas in the region (e.g. Sohar, Oman) have a single annual temperature maximum in June, July and August of 32-33°C. The cool water brought to the surface by the upwelling also contains high levels of nutrients and can also contain very low levels of dissolved oxygen. The high nutrient conditions stimulate rapid growth of phytoplankton and seaweeds that reduces the amount of light reaching the corals and increases rates of bio-erosion, whereas the periodic anoxia results in large fish kills. Blooms of harmful algae are also common in areas influenced by upwelling. These also cause periodic fish kills and mass mortality of marine wildlife, such as that observed in Southern Oman, Yemen and Somalia in November 2001. Although the strongest effects of the upwelling are felt along the Arabian Sea coasts of Oman, India, and Pakistan, the influence occurs in many parts of the Gulf of Oman, particularly along the northern Iranian shores. On the southern coast of the Gulf of Oman, upwelled water remains below a strong thermocline that in turn is pumped up and down by long-shore winds. In shallow water, this rapid pumping of the thermocline induces rapid temperature fluctuations of up to 8°C in less than 2 hours. Corals appear unaffected by this rapid fluctuation and its cooling effect probably serves to reduce the thermal stress, which otherwise could cause bleaching. From Steve Coles and Simon Wilson.

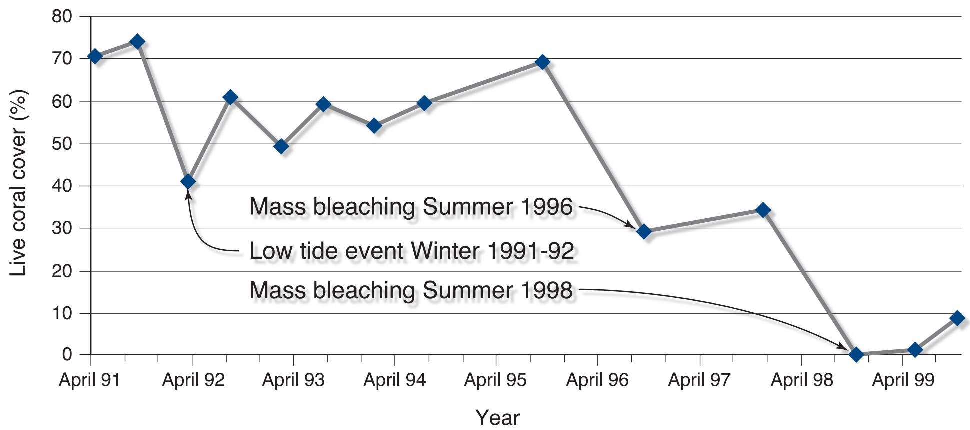
Platygyra. Only a few shallow water *Acropora* communities survive in the area and this suggests that chronic COTS infestations have caused a reduction of *Acropora* cover. Fishing activities have also damaged the corals, as many *Acropora* tables were broken by fishermen recovering their tangled nets. The outbreak has subsided although relatively high densities of COTS are still visible on some reefs (5-10 per 30min dive in September 2002). The numbers of COTS have been reduced by control operations organised by local dive clubs with the agreement of government ministries.

Qatar

No new information was received.

Saudi Arabia

No new information was received.



The early trends in coral cover at 5 sites along the Gulf coast of Saudi Arabia (Safaniya, Manifa, Abu Ali, Ras Tanura, Tarut Bay) amongst the major oil industry facilities were of minor changes, except for a period of extreme low water during the winter of 1991-92. Then two severe warm water events in the summer of 1996 and 1998 resulted in the almost total loss of live coral cover on these inshore coral reefs.

United Arab Emirates

The highest cover and diversity of corals along the mainland coast of Dubai is southwest of Jebal Ali Port in the Jebal Ali Wildlife Sanctuary (established 1997). There are 34 hard coral species and 77 species of reef fish and areas of corals have been surveyed extensively. The Sanctuary has a wide diversity of habitats (lagoons, seagrass beds and coral communities) all close together with strong ecological links. This is also the only stretch of the Dubai coastline that has remained free from industrial development, dredging and land reclamation.

Coral cover dropped from 90% in 1995 to 25% in 1999 after the bleaching events of 1996 and 1998, with most of the *Acropora* corals being killed. In 2000, there was a proposal to build a combined electricity generating and desalination plant at Ra's Ghantoot on the edge of the Sanctuary that would discharge chlorinated water 10ºC above ambient into the Sanctuary. The area immediately offshore of the development site had lower coral cover (1-5%, with patches at 10%) than in the coral rich area. If the development proceeds, the thermal pollution may exacerbate bleaching in the future.

Threats to Coral Reef Biodiversity

The Gulf

The major direct anthropogenic threats to coral reefs in the Gulf are industrial development, land-reclamation, dredging and shipping. Commercial trawl fishing, over-fishing, and anchor damage are also of concern. Most heavy industries (e.g. power generation, desalinisation, petrochemicals and oil refining, aluminium and steel smelting) are on the coast to make use of seawater for cooling purposes. The discharged cooling water results in localised thermal pollution that adds to the natural heat stress during summer months, which in extreme years results in coral bleaching mortality.

There has been extensive development of ports and airports, industrial estates, especially for the oil and gas industries, and some hotels and tourist facilities. Despite the high level of activity in oil and gas industries, oil pollution has caused relatively little direct damage to corals and reefs, although the risk of acute pollution from spills is significant. The effects of the 1992 Gulf War oil spills on the coral reefs were minimal along the mainland coast and offshore islands of Kuwait and Saudi Arabia. This is possibly due to acclimatisation to low levels of hydrocarbons in the water caused by a combination of natural seeps and chronic incidence of small operational spills. Dredging activity is high in the Gulf because of the need to maintain shipping channels in the shallow waters and to exploit sand for construction, shoreline nourishment, and land reclamation. Dredging has resulted in increased concentrations of suspended sediments in many areas and this has smothered corals e.g. dredging in the Muharraq area of Bahrain caused the loss of 182,000m^2 of reef area between 1985 and 1992.

The effectiveness of the EIA (Environmental Impact Assessment) process varies considerably from country to country, and national development takes a higher priority than environmental protection with the result that natural coastal resources are often destroyed by development. The situation is exacerbated by the lack of integrated coastal planning to allocate areas of lower ecological value for industrial development.

There is small-scale or subsistence level fishing for shrimp and reef fish using smaller trawls, traps and shore-based beach seine nets. There are also a few large commercial trawlers for shrimp. Both have caused anchor damage. Many trawlers fish close to reefs and damage corals and there are abandoned nets that continue to cause damage. Commercial fishing has been banned in Bahrain, and there are signs of coral recovery. In some places, such as Farur Island in the northern Gulf, anchoring fishing vessels are causing significant damage to corals especially *Acropora*.

The coral reefs have also been damaged by 'natural' stresses such as chronic infestations of crown-of-thorns starfish (COTS) and coral diseases, however the major source of loss to these reefs was massive coral bleaching and mortality in 1996 and 1998. These reefs will take many decades to recover because breeding stocks have been lost and natural recruitment is highly variable even under natural conditions. Recovery is dependent on no repeats of the high seawater temperatures of 1996 and 1998.

The Gulf of Oman and Arabian Sea

There are two major industrial developments in coral rich areas of the Gulf of Oman that could damage corals: a large hotel development; and a mineral fertiliser plant. Hotels are being built near the scenic Bandar Jissah, 10km southeast of Muscat. An EIA in 2001 identified threats to coral reefs from the approach road and small boat-landing site. The alignment of the approach road was altered, but the threat from the small boat landing site remains. Some corals have already been damaged during the construction of temporary landing sites, which is near one of the few remaining *Acropora* communities in the Muscat area. Construction of an ammonia and urea plant at Qalhat, 200km southeast of Muscat, will commence in late 2002 at a site adjacent to an existing natural gas processing facility. Pipelines and the loading jetty extend approximately 1km through coral-rich areas. Precautions are planned to mitigate the impact of construction on coral communities, and a marine environmental monitoring program is in place.

Marine Protected Areas and Levels of Management

The Marine Pollution Section of the Ministry of Regional Municipalities, Environment and Water Resources of Oman has implemented a National Coral Reef Management Plan in 2002 to include coral reef monitoring around Muscat, surveys to the southeast of Muscat, and public awareness campaigns. Coral reef rehabilitation trials using natural settlement on artificial reef structures (Reefballs) are currently underway and will be continued for a further 12 months. The general level of management in Marine Protected Areas in Oman is currently being reviewed, particularly at the Daymaniyat Islands National Nature Reserve, and an assessment is currently underway to indicate the feasibility of a World Heritage Site on the coast of Oman that would incorporate the country's best coral reefs.

Conclusions

There is considerable concern over the health status of corals following the mass coral bleaching and mortality in 1996 and 1998 in the Gulf. Mortality was widespread, however there is now evidence of recovery with new coral growth at Kish Island, Iran of mainly *Acropora* species. These corals are growing at around 10cm per year, suggesting that healthy *Acropora* populations will be established in a few years, provided there is no similar bleaching. Human impacts on the marine environment in the Gulf area, especially large oil spills in the last years and also the continuation of oil pollutants from shipping activity in the area (particularly through the smuggling of oil in old and uncertified Iraqi tankers in the northern parts of the Gulf), have narrowed the tolerance limits of these stressed coral species, therefore increasing their susceptibility.

Recommendations to Improve Conservation of Coral Reef Resources

The capacity for **Integrated Coastal Management** at national and regional levels is insufficient to develop and implement effective plans for the sustainable management of coastal resources. Weak or poorly disseminated plans underlie some developments in which serious environmental damage has resulted. Furthermore, plans should refer to the obligations of countries to international conventions particularly the Convention on Biological Diversity, MARPOL, and regional agreements such as Regional Organisation for the Protection of the Marine Environment (ROPME).

The EIA process is part of national legislation for any development. This is a significant achievement during the last 10 years, however, the system can be improved through the development of clearer and more detailed government policies, environmental quality standards and monitoring requirements, which would strengthen government control over private and public sector development. Discharges of cooling water, and dredging and land reclamation activities in coral rich areas result in direct damage and efforts should be focused initially on these issues.

The first priority in the region should be to strengthen the management of existing marine protected areas and parks so that they can meet their primary objectives. These MPAs should be used as a catalyst to train more marine park rangers and wardens, and use these staff to assess additional sites for conservation to ensure that a representative number of habitats and species are included in a network of effectively managed protected areas.

Greater awareness needs to be raised with the public, fishing communities and industry of the importance of reefs and how human activities may damage them. Fishing activity needs to be effectively controlled in MPAs to prevent damage from gillnets and trawling. By actively involving the public in practical measures (e.g. COTS control programs, net clearance, installation of mooring buoys, beach clean-ups, and reporting of spear-fishing) the necessary messages can be more effectively conveyed to targeted audiences.

In order to implement uniform management in the region it is recommended that a regional monitoring network be established through national and regional cooperation and contributions. Community based organisations, non-governmental organisations, governments and ROPME all have an important role to play in setting up and implementing such an initiative.

A panel of experts drawn from around the region should be formed to coordinate and oversee the monitoring network, and to advise on regional issues like COTS outbreaks, mass bleaching events, oil spills affecting reef areas, dissemination of reef related research and to improve on existing knowledge of coral taxonomy in the region.

Acknowledgements

We wish to thank Yusef Fadlallah and Kent Allen for the data on coral cover changes in Saudi Arabia.

Author Contacts

Simon Wilson, Dept of Biological Sciences, Warwick University UK and Oman, simon.wilson@adelphi-env.com Seyed Mohammad Reza Fatemi, Dept. of Fisheries and Marine Biology, Islamic Azad University, Tehran, Iran, fatemi@tavana.net; Mohammad Reza Shokri, Iranian National Center for Oceanography, Tehran, Iran, mrshok@hotmail.com; Michel Claereboudt, Sultan Qaboos University, Sultanate of Oman, michelc@squ.edu.om

SUPPORTING DOCUMENTATION

Allen KW, Fadallah YH (in press). Long-term Monitoring of Coral Reefs along the Saudi Arabian Gulf Coastline. Proceedings of the International Workshop on the Extent and Impact of Coral Bleaching in the Arabian Region, Riyadh 5-9 February 2000.

Coles, SL (1997). Reef corals occurring in highly fluctuating temperature environment at Fahal Island, Gulf of Oman (Indian Ocean). Coral Reefs: 16: 269 – 272.

Riegl B (2002). Effects of the 1996 and 1998 positive sea-surface temperature anomalies on corals, coral diseases and fish in the Arabian Gulf (Dubai, UAE). Marine Biology 140: 29 – 40.

Sheppard CRC, Wilson SC, Salm RV, Dixon D (2000). Reefs and Coral Communities of the Arabian Gulf and Arabian Sea. In: Coral Reefs of the Indian Ocean: Their Ecology and Conservation. Chapter 9. Ed. McClanahan TR, Sheppard CRC, Obura DO, Oxford University Press, New York.

Shokri MR, Haeri-Ardajkani O, Sharifi A, Abdoullahi P, Nazarian M (in press). Seawater Temperatures and Bleaching Events in Oman. Proceedings of the International Workshop on the Extent and Impact af Coral Bleaching in the Arabian Region, Riyadh 5-9 February 2000.

Subba Rao DV, Al-Yamani F, (2000). Arabian Gulf. Chapter 53 in: Seas at the Millennium. Ed. Sheppard CRC, Pergamon Press, UK.

Wilson SC, Claereboudt M, (in press). Seawater Temperatures and Bleaching Events in Oman. Proceedings of the International Workshop on the Extent and Impact af Coral Bleaching in the Arabian Region, Riyadh 5-9 February 2000.

Wilson SC, (2000). The Arabian Sea and Gulf of Oman. Chapter 54 in: Seas at the Millennium. Ed. Sheppard CRC, Pergamon Press, UK.

4. Status of Coral Reefs in Eastern Africa: Kenya, Tanzania, Mozambique and South Africa

David Obura and Contributors – Louis Celliers, Haji Machano, Sangeeta Mangubhai, Mohammed S. Mohammed, Helena Motta, Christopher Muhando, Nyawira Muthiga, Marcos Pereira and Michael Schleyer

Abstract

Eastern African coral reefs were severely impacted by the El Niño Southern Oscillation of 1997-98, with bleaching and mortality levels varying from <1% in South Africa to 80% and greater on reefs in northern Tanzania and Kenya. Recovery of affected reefs to 2002 has been poor to moderate, and patchy. Reefs strongly impacted by the El Niño that had high coral diversity and cover have recovered to less than one quarter of pre-bleaching coral cover. However, some high diversity reefs that escaped the bleaching impacts have remained healthy, with high coral cover and diversity. Degraded reefs outside Marine Protected Areas (MPAs) that were severely damaged by the El Niño have generally recovered to 50-100% of pre-bleaching coral cover. Recruitment of corals to reefs has also been moderate, with highest levels recorded on those protected reefs with high coral cover and diversity. In 2001-02, there has been additional damage to Eastern African reefs from threats that may be related to climate-change, including floods in Mozambique, Harmful Algal Blooms in Tanzania and Kenya, and an unknown fungal disease of corals in Kenya and northern Tanzania. Anthropogenic threats to Eastern African reefs cited in the 1998 and 2000 global reports continue, including over-fishing, destructive fishing, pollution, and sedimentation from construction and coastal development, mining and shipping activities. Socio-economic studies of coral reefs are becoming increasingly common in Eastern Africa, and include the development of socio-economic monitoring under GCRMN. While socio-economic losses from coral mortality from the 1998 bleaching event were predicted, particularly in fisheries and tourism, these have not yet been seen. MPA management in the region has benefited from increased national and international attention. Improvements include further development of management plans, identification of priorities and tools for improving management, and increased networking among MPA sites, regional and international organisations, and countries. With regional increases in levels of co-management of MPAs and fisheries, there are expanding efforts to develop coral reef and fisheries monitoring programs that are community based and participatory, and that contribute to regional level reporting and assessments of coral reef condition.

Introduction

The coast of Eastern Africa has an almost continuous string of coral reefs, whether fringing the coast and islands, or forming barrier or platform reefs offshore from Somalia to just into South Africa. This regional review focuses on the years 2000 to 2002 and builds on the report 'Status of coral reefs in Eastern Africa: Kenya, Mozambique, South Africa and Tanzania' by D. Obura, M. Suleiman, H. Motta, and M. Schleyer published in Status of Coral Reefs of the World: 2000. In Eastern Africa, coral reef monitoring data are collected by a variety of national institutions, as well as local and international NGOs. Monitoring activities are an increasingly part of projects to establish and manage Marine Protected Areas (MPAs), in addition to the more traditional scientific monitoring carried out through research organisations. Since 1999, following the massive loss of corals following the El Niño of 1998, increasing efforts are being made to improve regional consistency of monitoring and reporting of information, through the increasing development of national, international and global networks of scientists, coral reef managers and policy-makers. The year 2002 marks the first year in which an inter-governmental task force on coral reefs has been set up by the countries of Eastern Africa (and including the island states) through the Nairobi Convention, coinciding with the region's hosting of the World Summit on Sustainable Development in South Africa. With these two top-level political landmarks, regional coordination and support for coral reef conservation is increasing rapidly.

Geography, Environment and Population

The coast of Eastern Africa covers 40° of Latitude with the warmer temperatures in the central region, cool upwelling areas off the coast of Somalia (10°N) and cooler, temperate waters off South Africa (30°S). The major influence is the South Equatorial Current that splits from about the Kenya-Tanzania border to flow northward to Somalia and south to Mozambique. Little is known of Somali reefs, though well developed coral communities extend as far as the Socotra Archipelago. The extensive string of coral reefs in the central zone is broken by major rivers (e.g. Rufuji, Limpopo and Zambezi) that carry large quantities of sediments and nutrients that impede coral reef growth.

Fringing reefs are patchy in northern **Kenya** because of river discharges and cold Somali current upwelling, whereas a 200km fringing reef dominates the south. This continues for two thirds of the 1000km **Tanzanian** coast with fringing and patch reefs on a narrow continental shelf. The main reefs occur around Unguja (Zanzibar), Pemba and Mafia islands, and along the mainland at Tanga, Pangani, Dar-es-Salaam, Mkuranga, Kilwa (including the extensive Songo Songo Archipelago), Lindi and Mtwara. About 2 million people live on the **Kenyan** coast, mainly around Mombasa, with a significant percentage of them using reefs for fishing and tourism. The **Tanzanian** coastal population is about 8 million concentrated around Dar es Salaam, with many of them depending heavily on the coral reefs.

The **Mozambique** coast is the longest (2,700km) with all reef types present: fringing and island reefs near the Tanzania border as well as high latitude reefs near **South Africa**. The main reef tract is 770km long from the Rovuma River, to Pebane in the south. There are smaller isolated reefs on the 850km coast from Bazaruto Island to Ponta do Ouro. The most southerly coral reefs and coral communities in the western Indian Ocean are in **South Africa**, growing on a 2-7km wide continental shelf, and rarely reaching the surface. These reefs are remote from human populations, whereas over 6.7 million people with many involved in artisanal and commercial fishing, and tourism live on the **Mozambique** coast.

These coral cover reports for Eastern Africa, before (1997/98) and after (1999 and 2001/02) the El Niño bleaching clearly show the impact on the reefs with high subsequent mortality. Coral cover is listed in percent of the bottom.

	1997/98	1999	2001/02
KENYA			
Northern Kenya (>10 m)		5.7	1.2
(< 3 m)	13.2	5.1	9.9
Southern Kenya (Protected)	39.6	11.4	19.5
(Unprotected)	20.6	11.4	14.4
OVERALL	26.3	8.1	11.25
TANZANIA			
Tanga	53.0	33.3	
Pemba	53.7	12.3	16.3
Unguja	45.8	32.0	37.9
Kunduchi	43.0	35.0	
Mafia	73.3	19.4	24
Songosongo	35.0	37.5	
Mnazi Bay	60.0	20.0	
OVERALL	52.0	27.1	26.1
MOZAMBIQUE			
Quirimbas		48.4	35
Mozambique I.		32.5	30
Bazaruto		69.5	65
Inhambane		13.8	7
Inhaca			
		50.0	40
OVERALL		42.8	35.4

Mortality and Recovery from the 1998 El Niño Coral Bleaching Events

Coral bleaching and mortality during the El Niño event of 1998 was most severe in the north, and diminished to virtually nothing in the south. The bleaching started in the south in February–March 1998, and finished in May in the north, following the path of the solar zenith during the southern Summer. Damaged reefs showed marked increases in fleshy, turf, calcareous and coralline algae on the newly dead corals, especially where herbivorous fish populations were depleted; therefore there was less algal growth in protected fish reserves. The mortality not only included hard corals, but also many soft corals and other coelenterates (cnidarians) were killed.

The most severely damaged reefs were in **Kenya** and **Tanzania** with levels of coral mortality of 50-90%. Coral cover on lagoon patch reefs and fore-reef slopes in southern Kenya dropped from an average of 30% to 5-11% within and outside MPAs. There was similar bleaching in northern Kenya in shallow areas, but below 10m depth coral mortality was often less than half. In Tanzania, there was high bleaching (60-90%) at Tutia reef in Mafia Island Marine Park, and Misali reef on the west coast of Pemba, whereas there was 10% or less bleaching on Unguja Island, Zanzibar.

Recovery since 2000 has been patchy in both countries, for example in northern Kenya, shallow reefs are generally recovering from the bleaching (see Table), while deeper reefs have suffered continuing declines in coral cover. This variability in recovery also occurs between adjacent reefs, with some showing good recovery while neighbouring reefs do not. In general, reefs within MPAs have shown higher recovery rates of coral cover than those outside, especially on Chumbe Island off Zanzibar, and Mombasa Marine Park, Kenya. Some MPAs, however, including Malindi Marine Park did not show this pattern. Recruitment is overwhelmingly dominated by *Pocillopora* and has also been variable. Peak values of recruits >20 per m^2 were recorded for Mafia (Tanzania), and Kiunga (Kenya), though average levels are much lower in the range of 1-3 per m^2.

The most extensive bleaching in **Mozambique** was on exposed reefs in the north, with up to 99% mortality on some patch reefs. Reefs in sheltered bays, where there are naturally higher levels of nutrients and turbidity, and more variance in water temperatures, were least affected. Reefs affected by bleaching have shown little recovery by 2002, although inaccessible reefs (in the north) and those in MPAs showed greatest improvements in coral cover and had the most complex fish populations. Some recovery was recorded, in the form of primary colonisation by soft corals. Massive floods in southern Mozambique from February to May 2000 caused extensive damage to coral reefs by sedimentation. Hard and soft corals in the Xai-Xai lagoon suffered declines of 60% and 95% (from 19% and 5% cover respectively), with minimal recovery by December 2001.

There was no bleaching of hard corals in 1998 in S**outh Africa** because most corals grow at 12m or deeper. However a steady increase of 0.27°C has been measured *in-situ* since temperature recording began in 1994. During this time, hard coral cover has increased (from 15% to 30%) and soft coral cover remained stable (at 30%) on reef slopes at 12m depth. Conversely, on reef tops, hard coral cover has increased less (from 15% to 20%) and soft coral cover decreased (from 60% to 50%). While bleaching was absent in 1998, it did occur in 2000 associated with elevated temperatures over 28.8°C and clear water conditions. In the short term, it appears that warming temperatures may improve conditions for corals in high latitude reefs, however long-term increases in temperature are likely to be detrimental here as well.

Coral mortality during the 1998 El Niño event was more intense on the fast growing genera *Acropora*, *Pocillopora*, *Stylophora* and *Seriatopora*, as well as *Galaxea* and *Echinopora,* with up to 100% bleaching and mortality. In some other genera (e.g. *Fungia*, *Coscinaraea*, anemones) there was high bleaching, but high rates of immediate recovery. Many other coral groups (e.g. *Montipora, Astreopora,* faviids, agariciids, poritids, siderastreids, and most octocorals and zoanthids) bleached at variable levels, but the full impacts are difficult to determine in these relatively rare corals. Thus, there will be a shift in the structure of the coral community in the short to medium term away from species that grow and reproduce most rapidly to slower growing, massive species. Recovery will depend on available parent stock for new recruitment and the absence of short-term repeats of these damaging El Niño events. Higher coral recovery rates in MPAs suggest that a healthy parent stock improves local coral recruitment and regrowth potential, though these factors are yet to be tested in Eastern Africa.

Principal Threats Affecting Coral Reefs

Over-fishing and destructive fishing, pollution, mining, deforestation and poor land management practices, and poorly managed and planned tourism are the major stresses damaging coral reefs on the Eastern African coast. Excessive and destructive fishing was the major anthropogenic problem for reefs in Eastern Africa in the 1990s until the damaging 1998 El Niño bleaching event. The damaging fishing practices include using dynamite, pull-seine nets, poisons, over-exploitation of small fish in small mesh nets and traps, and over-harvesting of octopus, shellfish, sea cucumber and lobster. The countries have implemented measures to reduce fishing pressures, including controls on dynamite fishing in **Tanzania,** through joint community, NGO and government pressure, and put a ban on aquarium fish collection in **Mozambique** until it can be shown to be sustainable. All countries are devolving more power to local communities to monitor and manage their own fishery resources, largely through the mediation of conservation and community development initiatives.

Climate change is affecting Eastern African coral reefs through additional mechanisms to temperature-induced bleaching and mortality. In 2001, there were dramatic floods in southern Mozambique, which increased sediment flows into coastal waters and demonstrated the importance of sedimentation on controlling reef growth and survival. The slow background increases in water temperatures in the colder waters of South Africa apparently have a positive impact on hard coral growth and survival. However, this is likely to be reversed at higher temperatures when bleaching thresholds are reached, and when coral growth and calcification rates are reduced due to the effects of increasing CO_2 concentrations on the chemistry of seawater. In January-February 2002, a large-scale Harmful Algal Bloom (HAB) impacted the coasts of Somalia and Kenya, and smaller ones were reported simultaneously off Zanzibar in the South and Yemen in the North. Three weeks after the HAB, a fungal disease caused high mortality in *Montipora*, *Astreopora* and

Echinopora, and moderate mortality in *Pocillopora*, *Acropora* and *Platygyra* on many reefs in Kenya and Tanga in northern Tanzania. These epidemics may be related to oceanographic and monsoon changes influenced by climate change, and if so, are likely to increase in frequency and intensity in coming years.

Meanwhile, human populations are increasing rapidly throughout Eastern Africa and the associated local threats of increased sedimentation from rivers, rapid coastal development and construction, increased shipping and harbour development, increased coastal mining, and higher levels of pollution and rubbish disposal will continue to affect reefs near population centres. Tourism is a major industry in Eastern Africa, and coral reefs are a primary tourist attraction on the coast. Unplanned developments have resulted in serious reef damage in key areas. Now 'ecologically friendly' and community-based tourism developments are encouraged, especially smaller enterprises focused on diving and wilderness activities. In addition, reef restoration has become a focus of a number of community development and conservation initiatives, such as in the Kinondoni Integrated Coastal Area Management Programme off Dar es Salaam where restoration is an integral part of the ecotours, with local communities gaining economic benefits and environmental awareness. Another is the Kiunga Marine Reserve Project, managed by the Kenya Wildlife Service and World Wide Fund for Nature.

Socio-Economic Studies on Coral Reefs

The socio-economic role of coral reefs in Eastern Africa has received considerable attention in the last 2 years, stimulated by the sudden degradation of reefs during the 1998 El Niño, as well as long term declines in fisheries stocks and reef health. Community-based MPA projects are developing socio-economic assessments and monitoring as part of their regular activities, although standard methods have not yet been developed. A number of initiatives are attempting to advance understanding of socio-economic dependence on reefs at the regional level, including a 'Socioeconomists network'. This project is developing socio-economic monitoring methods as part of the GCRMN (supported by the Government of Finland through CORDIO), the Reef Livelihoods Assessment project, the Regional Fisheries Information Systems project (SADC) and the Fisheries Management Science Programme (the last 3 supported by DFID, UK). All of these focus on the local scale of community and sustainable livelihoods, because artisanal and small-scale fishing are the main socio-economic uses of coral reefs by the communities.

An analysis of the socio-economic impacts of the El Niño found that there were subtle changes in fish biomass and fisheries yields in Kenya and the Seychelles, but these could not be attributed to bleaching impacts. Furthermore, while assessments of 'Willingness to Pay' by tourists has indicated potential bleaching-related losses of US$5-9 million in 2001 for Mombasa, Zanzibar and the Seychelles, these theoretical tourism losses have not been seen in practice. Assessments by CRCP and KWS found no significant fish biomass changes after the bleaching coral death in MPAs.

Marine Protected Areas

There are effective and long-lasting MPAs in all countries, and most of the countries have plans to create new ones and improve the management of existing MPAs. This has in part been catalysed by the massive loss of coral reefs in 1998. Local and international NGOs (e.g. IUCN, WWF) and tourist operators have been active in assisting governments and communities establish MPAs. MPAs are centrally planned in Kenya, Mozambique and South Africa, whereas in Tanzania there is a larger component of local implementation and co-management. There has been considerable sharing of lessons learned along the Eastern African coastline and plans are underway to create a network of coordinated and linked parks across national boundaries. A major factor limiting success in these MPAs is the level of local acceptance and involvement, particularly when fishing areas are closed and it is difficult to demonstrate a 'spill over' effect with higher catches in adjacent areas. Most MPAs have a lack of resources and trained staff to be fully effective. The capacity for MPA management has increased through several training initiatives, including the recently concluded Regional MPA management course conducted by WIOMSA in collaboration with the Coastal Zone Management Centre of the Netherlands. There is also a keen interest among MPA managers to establish a network to enhance collaboration and information sharing.

Marine national parks and reserves in Eastern Africa.

Marine Protected Areas	Year Gazetted	Area (km^2)	Management Plan
Kenya			
Kiunga Marine National Reserve	1979	250	Yes
Malindi Marine National Park	1968	6.3	Yes
Watamu Marine National Park	1968	12.5	Yes
Malindi-Watamu Marine National Reserve	1968	165	Yes
Watamu-Mida Creek Marine National Reserve	1968	32	Yes
Mombasa Marine National Park	1986	10	Yes
Mombasa Marine National Reserve	1986	200	Yes
Diani Marine National Reserve	1995	75	No
Kisite Marine National Park	1978	28	Yes
Mpunguti Marine National Reserve	1978	11	Yes
Tanzania			
Maziwi Island Marine Reserve	1981	-	No
Misali Island Conservation Area	1998	21.58	No
Mnemba Controlled Area	1992	0.15	-
Chumbe Reef Sanctuary	1994	0.3	-
Menai Bay Conservation Area	1997	467.5	No
Dar-es-Salaam Marine Reserves System	1975		No
-Fungu Yasini Marine Reserve		7.5	
-Mbudya Marine Reserve		8.9	
-Bongoyo Marine Reserve		7.3	
-Pangavini Marine Reserve		2.0	
Mafia Island Marine Park	1995	822	Yes
Mnazi Bay-Ruvuma Estuary Marine Park	2000	650	
Mozambique			
Bazaruto National Park	1971	150	Yes?
Inhaca and Portuguese Islands Reserve	1965	20	-
South Africa			
Greater St Lucia Wetland Park (Maputaland and St Lucia Marine Reserves)	1979	822	Yes

Regional linkages between MPAs at the biological and management levels are increasingly recognised as important, with IUCN, WWF and ICRAN (International Coral Reef Action Network) all developing major initiatives in Eastern Africa. All three initiatives include strong participation and involvement from national MPA and marine management institutions. In addition, a Group of Experts in Marine Protected Areas (GEMPA) has been established in the region, hosted by WIOMSA and UNEP. IUCN has been developing a program for the assessment of Management Effectiveness of MPAs through a program supported by NORAD (Norway) to assist the countries in the region implement the Jakarta Mandate of the Convention on Biological Diversity. This has involved the establishment of a regional advisory group and implementation of a number of activities to assess and improve the understanding of effective management of MPAs, and to develop tools to achieve these ends. The WWF East Africa Marine Ecoregion programme has undertaken a series of consultative workshops to select priority sites for protection, and establish targets and actions to achieve a regionally consistent network of MPAs in the long term. The ICRAN project is being implemented in Eastern Africa by UNEP, with a focus on demonstration of good practices for MPA management at selected sites including the Malindi-Watamu MPA complex and Dar-es-salaam Marine Reserves, with a further series of target sites for improvement of management actions.

Two new MPAs were recently declared in Mozambique, greatly increasing the potential protection for large coral reef areas. The Tanzania Coastal Management Partnership (TCMP) has worked to develop a National Coastal Strategy to provide the framework and resources to assist districts develop coastal action plans for coral reef management and conservation. Success has been achieved in enforcing laws against dynamite fishing and developing strategies to boost ecotourism.

New MPA initiatives established in Mozambique in 2000-2002.

MPA Name	Region/Country	Institutions	Comments
Quirimbass Archipelago	Northern Mozambique	Mozambique government WWF-Mozambique	Announced by Mozambique government as a 'Gift to the Earth'. Remote archipelago but with significant resource use.
Bazaruto National Park (extension)	Mozambique	Mozambique Marine Parks unit	Extension of the existing Bazaruto National Park to include all islands in the archipelago, and large areas of marine environment (1,400 km^2).

National and International Policies and Institutions

All countries have a mix of cross-sectoral laws within different government ministries relating to coastal resources, including coral reefs. This results in poor enforcement and disputes over control. Now there is a move towards integrated coastal management and harmonised policy and legislation requiring Environmental Impact Assessments to control development. The approach in each country varies somewhat, with the following key national institutions mandated with coral reef management and conservation:

- Mozambique – Sustainable Development Center for the Coastal Zone (CDS-ZC), within the Environment Coordination Ministry, that operates under the umbrella of a National Coral Reef Management Programme;
- Tanzania – the Tanzania Coastal Management Partnership (TCMP), a partnership between the National Environment Management Council and University of Rhode Island and USAID, is coordinating the process to develop the National Integrated Coastal Management Strategy. The Strategy is providing a framework for management of coastal and marine resources including coral reefs at the national and coastal district levels. The Tanzania Marine Parks and Reserves Unit operates a growing number of MPAs;
- Kenya – the National Environmental Management Authority (NEMA), recently established under the Environmental Coordination Act will have overarching authority on environmental issues, with the Integrated Coastal Area Management Secretariat (chaired by the Coast Development Authority) and Kenya Wildlife Service having primary responsibilities in ICZM and MPAs respectively.

As part of the Eastern African region under the UNEP Regional Seas Programme, Eastern African mainland states are party to the Nairobi Convention. At the recent Conference of Parties held in Mozambique in December 2001, a Coral Reef Task Force was established under the Nairobi Convention to assist countries develop and coordinate coral reef management and monitoring activities. The countries also recognised the relevance of the International Coral Reef Initiative, which held a regional meeting and the Coordinating and Planning Committee meeting immediately preceding the Nairobi Convention COP. In the future, it is hoped that this alignment between the primary regional environmental convention and global initiatives on coral reefs will enhance support at the national level for coral reef monitoring, research and management.

Community-based coral reef monitoring has been running in Tanga, Tanzania since 1996, and KICAMP monitoring is conducted by local fishermen with supervision from scientists. This year TCMP is developing a National Coastal Monitoring Plan, which includes coral reefs, to promote community-based monitoring throughout the country and to standardise techniques.

Core Conclusions

- Eastern African coral reefs are recovering from the widespread devastation of approximately 30-50% of the reefs during the 1998 El Niño, with coral cover returning to similar levels to pre-bleaching conditions for heavily fished reefs, and to between one third to one half pre-bleaching levels on protected reefs.
- A number of new, large-scale impacts, such as floods, Harmful Algal Blooms and coral disease, occurred in 2001-2 that may be related to changing climate and have significant impacts on coral reef and marine ecosystems.
- Socio-economic studies of coral reefs, and programs to improve management of MPAs that contain coral reefs are becoming increasingly common in Eastern Africa, and feeding into an increasingly dynamic network of coral reef research and management organisations and institutions.

- Regional projects and networks relating to coral reefs are growing in number in Eastern Africa and more broadly in the Indian Ocean. They involve all levels of participants from local to international levels, providing multiple opportunities to address coral bleaching and climate change issues at a large scale.

Recommendations to Improve Coral Reef Conservation

- Greater integration of monitoring at the national levels is required, along with improvements in methodology, data standards and archiving tools. Reporting of monitoring information at national levels needs streamlining, to improve the comprehensiveness of information available regionally and internationally. Longer-term commitment of support, from local institutions to international donors, is needed to give the necessary longevity to monitoring at national and regional levels.
- Socio-economic assessments are being increasingly implemented, and a pilot monitoring program under the GCRMN is under trial. Greater technical and academic investment in socio-economic capacity is needed to improve data quality and standards, as well as to facilitate interpretation for management needs. Increased investment in research and activities centred on livelihoods and poverty alleviation will make important contributions to long-term sustainability of coral reef resource use.
- The increase in regional networks and collaborations among Eastern African countries, including the island states, needs to be supported with networking, communication and travel funds, to consolidate regional integration in monitoring, management and conservation of coral reefs.

Reviewers

Julius Francis Western Indian Ocean Marine Science Association, Zanzibar; Greg Wagner, University of Dar es Salaam, Tanzania;

Supporting Documentation

Goreau T, McClanahan, T, Hayes R, Strong A 2000. Conservation of coral reefs after the 1998 global bleaching event. Conservation Biology 14: 5-15.

ICRAN. 2002. East Africa Report.

McClanahan TR, Maina J, Pet-Soede L (2002) Effects of the 1998 coral mortality event on Kenyan coral reefs and fisheries. Ambio. 31: 543-550.

Mohammed SM, Muhando C, Machano H 2002. Assessment of Coral Reef Degradation in Tanzania: Results of Coral Reef Monitoring 1999-2002. CORDIO Annual Report, 2002.

Motta H, Pereira, M, Schleyer M. 2002. International Coral Reef Initiative/CORDIO Country Report: Mozambique. CORDIO Annual Report, 2002.

Obura D. (ed) 2002. Proceedings of the International Coral Reef Initiative (ICRI) Regional Workshop for the Indian Ocean, 2001. ICRI/UNEP/ICRAN/CORDIO.

Obura DO, Wells S, Church J, Horrill C (2002) Monitoring of fish and fish catches by local fishermen in Kenya and Tanzania. Marine and Freshwater Research 53(2) 215-222

Schleyer MH, Celliers L 2002. Biodiversity on Southern African coral reefs: what does the future hold? CORDIO Annual Report, 2002.

Author Contacts

David Obura, CORDIO Eastern Africa. dobura@africaonline.co.ke
Nyawira Muthiga, Kenya Wildlife Service, Kenya. nmuthiga@africaonline.co.ke
Christopher Muhando, Institute of Marine Science, Zanzibar. muhando@zims.udsm.ac.tz
Marcos Pereira, Sustainable Development Center, Mozambique. marcospereira@gmx.net
Michael Schleyer, Oceanographic Research Institute, South Africa. schleyer@freemail.absa.co.za

ICRAN | MAB

MALINDI AND WATAMU NATIONAL PARK AND RESERVE, KENYA – ICRAN DEMONSTRATION SITE

The Malindi-Watamu National Park and Reserve stretches 30km along the central coast of Kenya. Its jurisdiction extends 5km from the coast and includes beaches south of Malindi town. The MPA encompasses several different marine ecosystems, including coral reefs, seagrass beds and mangroves. There are important nesting sites for turtles, and several marine mammal species have been reported within the boundaries of the protected area. The Kenya Wildlife Service manages the MPA and the staff includes scuba diving, security and gate rangers (who collect revenue), as well as boat operators. Entrance fees from all National Parks and Reserves are managed by the Kenya Wildlife Service, and allocated from the central budget to protected areas around the country

Capacity for MPA management in Malindi-Watamu National Park and Reserve is developing. Current activities include training managers and users in resource management, creating management plans and codes of conduct for boat operators and their associations, upgrading the Malindi Boat Operators offices, boats, engines and snorkel equipment, and building fish landing sites at key locations within the reserve.

Ecological Monitoring: Several institutions are involved in ecological monitoring in Malindi, including the Kenya Wildlife Service, the Wildlife Conservation Society, Coral Reef Conservation Project (CRCP) and the Coral Reef Degradation in the Indian Ocean (CORDIO) project. Information on benthic cover, coral and fish diversity, coral recruitment, fish abundance, predation, herbivory and diversity and density of mobile invertebrates is collected at least annually. Data indicate there has been some recovery from the mass mortality 1998 e.g. through both coral recruitment and re-growth. There are also indications of more rapid recovery, higher species diversity and higher fish abundances in no-take zones of the Park, than in the surrounding Reserve.

Socio-economic Monitoring: There is increasing dialogue and communication between collaborating institutions including Fisheries and Forestry Departments, the local administration, fisher communities, tourism sector and local residents. The draft management plan that was developed through an extensive consultative process is in need of re-examination and adaptation. During the process, considerable socio-economic data were collected, and fisheries catches are monitored.

Monitoring Effectiveness: A regional management effectiveness initiative is being implemented by ICRAN and IUCN. Improved management activities will be initiated in Malindi in the near future, and the comprehensive ecological monitoring data, visitors statistics as well as numerous case studies will provide reliable information for an adaptive, effective management strategy. Additional parameters will be added as needed. Contact: Nyawira Muthiga, nmuthiga@Africaonline.co.ke

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

ICRAN

DAR ES SALAAM MARINE RESERVE, TANZANIA – ICRAN DEMONSTRATION SITE

The Tanzanian coastline is lined with fringing reefs, bays and estuaries. North of the capital Dar es Salaam, there are marine reserves around 4 islands: Mbudya; Bongoyo; Pangavini; and Fungu Yasini, which include coral reefs, mangroves and seagrass beds. Over-exploitation and unregulated tourist activity has resulted in environmental degradation within the Reserves. Recreational divers report a decrease in fish abundance and an increase in bleached and broken coral. Fishermen have observed a decline in fish catches, which they attribute to the use of small mesh nets (especially beach seine) and blast fishing.

The Dar es Salaam Marine Reserves were established in 1970 under fisheries legislation and in 1998 were transferred to Marine Parks and Reserves, and the Board of Trustees oversees the establishment and management of the Reserves. The most prominent stakeholder groups are fisher communities, visitors and tourists to the islands and the Dar es Salaam Yacht Club. There is an overwhelming support for the development of a management plan among all stakeholders. There are plans in progress to improve the success of the reserves. These include:

- Changing the status of the area from Marine Reserve to Marine Park, leading to a multi-user system in integrated coastal management for the Dar es Salaam coast;
- Creating fishery management plans;
- Improving enforcement by establishing regular patrols;
- Installing mooring buoys in sites that receive large numbers of visitors e.g. Bongoyo and Mbudya;
- Developing and implementing a structure for the payment and collection of MPA entry fees;
- Raising awareness of marine conservation and management issues; and
- Involving local communities in all management decisions

Ecological Monitoring: A comprehensive and regular program of ecological monitoring, including fisheries data collection and reporting, is planned. Coral cover and recruitment is monitored regularly. Studies aimed at assessing the marine habitats in the Dar es Salaam Marine Reserve have shown that the resources are heavily depleted, but the area is still viable as an MPA. Coral restoration projects have commenced.

Socio-economic Monitoring: Very little work had been carried out on the stakeholders and the interaction they have with the resources of the Dar es Salaam Marine Reserve. Recent work has identified the key stakeholders, assessed their attitudes and interests, determined the existing and potential socio-economic benefits and the social attitudes relevant to conservation and the sustainable use of the marine resources.

Monitoring Effectiveness: A management plan to promote sustainable uses of the Dar es Salaam Marine Reserve Work is being developed. A considerable amount of information exists on the biological status of the reserves though several areas still require attention.

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

WHA

RAMSAR

GREATER ST LUCIA WETLAND PARK, SOUTH AFRICA – WORLD HERITAGE SITE

The entire east coast of Africa is connected by a chain of coral reefs which extends into the Greater St Lucia Wetland Park World Heritage Site (north-east coast of South Africa). These are at the southern limit of coral reefs in the western Indian Ocean. This site also includes the Ramsar site of Turtle Beaches/ Coral Reefs of Tongaland. The coral reef comprises 3 reef complexes: the Kosi Reefs or Northern Complex; the Sodwana Bay reefs or Central Complex; and Leadsman Shoal or the Southern Complex. The Northern and Southern complexes both lie within highly protected sanctuaries, which limit recreational diver use. The Central Complex is the largest and most accessible by motor vehicle and boat and receives about 100,000 dive visits per year.

The major coral reefs in South Africa all are in the Greater St Lucia Wetland Park and the combined research and monitoring results have contributed towards the development of a management strategy for the central area. Research has also provided substantial input on the reefs for a proposal to proclaim the Greater St Lucia Wetland Park as a World Heritage Site. The reefs have especially rich biodiversity and tremendous potential for ecotourism. They constitute one of South Africa's most diverse and valuable, yet scarce and fragile ecosystems. The reefs are favoured by sport-fishermen and they have become increasingly popular for sport diving.

Ecological Monitoring: Monitoring began in 1991 to provide baseline information on the ecology and management of the reefs. The Oceanographic Research Institute (ORI) has conducted coral reef research and monitoring, including programs such as: species composition of the principle fauna; reef community structure; environmental stress factors; reproduction; interactions and human impacts; coral larval dispersal and recruitment; coral bleaching and causes; effects of climate change through biodiversity assessments; and details on the taxonomy and toxicology of various benthic taxa. Larval dispersal and recruitment is monitored on settlement plates, and the possibility of multiple settlement periods for different corals is being investigated. Data from temperature recorders shows an upward trend in sea temperature at Sodwana Bay (0.25°C per year) with a maximum reached in the summer of 2000 nearing those measured during the 1997-1998 El Niño event. While there was very mild bleaching in 1998, bleaching was severe enough to warrant measurement in 2000.

Socio-economic Monitoring: No information was provided.

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

MAB

KIUNGA MARINE NATIONAL RESERVE – MAN AND THE BIOSPHERE RESERVE

The 250km^2 Kiunga Marine National Reserve is a marine-protected area in northern Kenya, close to the Somali border. It was gazetted in June 1979, and together with the terrestrial Dodori National Reserve, became a UNESCO Biosphere Reserve in 1980.

The area is of local and global importance for its habitat, species and physical and biological processes. Mangroves, seagrass beds and coral reefs act as homes, nursery and spawning grounds for populations of fishes, crustaceans, invertebrates and mammals. It is a key nesting site for the 3 species of turtles found in Kenya, the Green, Hawksbill and Olive Ridley. Dugong are occasionally seen around the reserve. The area is also known for having the world's largest breeding populations of roseate terns, and is a key feeding ground for many migrant species.

Ecological Monitoring: Monthly catch assessments are made in each village around the reserve, providing valuable data to the management authorities and the local fishermen. Catch data are complemented by quarterly fish surveys and coral reef assessments. The Kiunga Marine National Reserve team, in collaboration with the Wildlife Conservation Society, carried out the first coral reef survey in 1998, just before the coral reef bleaching event. Thus it was possible to determine the rates of recovery of coral reefs recently protected from heavy fishing. There are also projects to assess methods to restore degrading reefs. A local community turtle-monitoring program, supported by Kenya Sea Turtle Conservation Committee, was established in 1997.

Socio-economic Monitoring: An environmentally friendly handicraft industry has been created to generate income for households and tidy up the beach. Rubber flip-flops washed onto the beach are collected and carved into a variety of handicrafts including key rings, necklaces, belts and bags. The income goes directly to the community and to finding long term management strategies for the area.

Coral reefs are **50%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **effective.**

ISRAEL CORAL REEFS OF EILAT, GULF OF AQABA (EILAT), RED SEA

Israel has approximately 12km of coastline in the northern Gulf of Aqaba (Eilat), between Jordan and Egypt, with one Marine Protected Area (155ha), and one Costal Protected Area (16ha). The reserves are governed by the state of Israel. These are among the most northerly coral reefs in the world (30°N), which grow on a narrow shelf before it drops to 400-700m. The hard coral diversity is relatively high with over 100 species, as well as about 350 species of reef fishes including a high proportion of endemics. Anthropogenic stresses from intensive tourism activity and poor water quality from mariculture effluents, sewage discharges, flood waters, ballast and bilge water, and discharges of fuel, oil, detergents, phosphates, pesticides, anti-fouling compounds are damaging the reefs. Monitoring of the coral community in the Nature Reserve of Eilat, reveals that the live coral cover has decreased in the last 15 years by 76% and the number of coral colonies by 73%. During this period, there has been a major decrease in the abundance and cover of the key coral species. Coral recruitment has been declining steadily by 53-96% since 1997. Bacterial diseases of fish are on the increase, in parallel with increases of diseases recorded of fish in the mariculture farms, located 5km north of the Nature Reserve of Eilat. During 1990-1998, the waters of the northern Gulf of Eilat contained 0.4µ mole. per litre Nitrate and 0.3µ mole. per litre Phosphate. In 1999-2000, the waters at 500m depth were nutrient enriched at 500m depth to 0.7 and 0.5µ mole. per litre, respectively. These increases result principally from the mariculture industry, which contributed 10 times more nutrients than all other sources. During winter and spring, nutrient-rich deep water rises and causes seasonal blooms of algae, which can smother corals and block light penetration. About 20% of shallow water corals died during a severe upwelling in 1992. During the last 10 years, the mariculture industry has grown exponentially from 300 tons of fish per year in 1993 to 2,000 tons per year in 2000. The fish are fed with 4150 tons per year of 'fish pellets' which adds 242 tons of Nitrogen and 40 tons of Phosphate annually into the area. Currents carry the nutrients from the mariculture industry into the Coral Nature Reserve, and are probably the major cause for 49% coral colony mortality and a decrease of 62% in coral cover between 1993-2000. By any criteria, the coral reefs of Eilat are extremely degraded and considered to be in a 'critical state'. If eutrophication of the water is not be stopped immediately, the final collapse and total destruction of the unique coral reefs of Eilat is almost certain. The only chances for restoration of the reefs are extreme protection measures against all human disturbances. From: Yossi Loya , Tel Aviv University, Israel yosiloya@post.tau.ac.il, and David Zakai, Israel Nature & National Parks Protection Authority Eilat, Israel, dudu.zakai@nature-parks.org.il

5. Status of Coral Reefs in the South West Indian Ocean Island Node: Comoros, Madagascar, Mauritius, Reunion and Seychelles

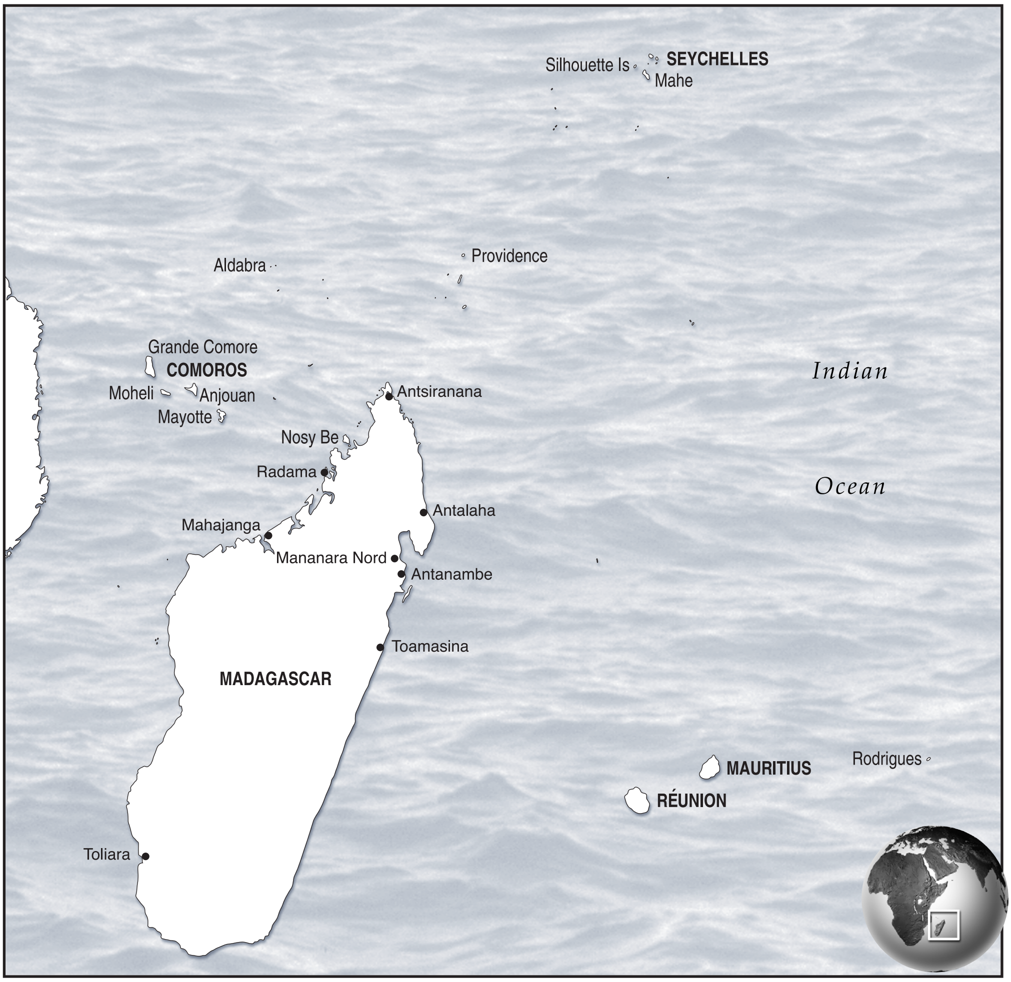
Said Ahamada, Lionel Bigot, Jude Bijoux, Jean Maharavo, Sabrina Meunier, Marylène Moyne-Picard and Naidoo Paupiah

Abstract

A regional monitoring network of the GCRMN was formed just after the major coral bleaching event in 1998. The goal was to assist the Comoros, Madagascar, Mauritius, Reunion and Seychelles manage their reef resources within the Regional Environment Programme of the Indian Ocean Commission. The Node is now being financed for 3 years by the Global Environment Facility (GEF and World Bank) and the European Union to continue coral reef monitoring to strengthen the capacity of national networks to provide data and advice for resource management. The extent of monitoring has increased from 43 stations in 1999/2000 to more than 70 stations in 2002, with more than 20 stations in Marine Protected Areas (MPAs). The trend on **Comoros** is for considerable coral regeneration following the 1998 bleaching. The recovery in the Moheli MPA is greater than in Grande Comoros, where regeneration and coral growth is slow. There is an urgent need for rational management of fishing, extraction of materials, and urbanisation on the coasts. In **Madagascar**, there are signs of damage on reef flats near human activities (North West, South East, East coast), whereas isolated reef slopes are in better condition. Reefs in **Mauritius** continue to be relatively stable, although domestic and agricultural pollution at some sites continues to degrade the coral reefs. While the damage in not alarming, the authorities should implement management to control damaging activities. Six new sites were added in 2002 on **Rodrigues** using GCRMN recommended methods. Coral communities on the fringing reefs have a healthy cover of hard coral, although species diversity is not high. The principal trends over 4 years on **La Reunion** are for relative stability of coral cover and fish populations in the Saint-Leu and Saint Gilles sectors. Corals on the inner granite islands of the **Seychelles** remain severely degraded since the 1998 bleaching event, however, there has been a slight increase in coral cover and more recruitment in the last 2 years. Coral bleaching and mortality in 1998 was most severe in the north (Seychelles and Comoros), whereas there was rapid recovery on Madagascar, Mauritius and Reunion, after less severe bleaching. There was localised bleaching in 2001 in Reunion, and in March 2002 on Rodrigues and Seychelles. The coral reef monitoring is fulfilling a need for the data as the foundation for Integrated Coastal Management.

Introduction

The coral reefs of the Indian Ocean have high biodiversity and include many endemic species. Moreover, these reefs are particularly important in the economies of Comoros, Madagascar, Mauritius, Reunion, and Seychelles, and provide considerable coastal protection from strong cyclonic activity. These 5 countries are all experiencing increases



in human populations and environmental pressures that are resulting in depletion and degradation of coral reef resources. If this continues, there will be severe economic losses in fisheries, tourism, and shoreline protection, as well as a loss of biodiversity. The need for urgent and improved conservation efforts in the face of these human pressures as well as damage from natural events was emphasised during recent regional meetings.

The coral reefs of the region vary from those fringing large to medium sized islands (Comoros, Madagascar, Mauritius, Reunion, Seychelles), to isolated atoll reefs (Comoros, Mauritius, Seychelles), and the region also includes the large submerged banks of the Mascarene Plateau. Most reefs near large land masses show obvious signs of degradation, whereas many of the isolated reefs remain in good condition.

A regional monitoring network was formed in 1998 to assist these countries in managing their reef resources with the guidance from the Indian Ocean Commission (Regional Environment Programme; 1995-2000). This network functions as a GCRMN Node, 'South

West Indian Ocean Island States', with funding from a new, 3 year program of the Global Environment Facility (administered by the World Bank) and the European Union, which builds on the initial activities and focuses on strengthening national monitoring capacity. The countries are increasing the scale and frequency of monitoring and assembling data into accessible databases to improve the information available for implementing integrated management and conservation of the reefs.

This report updates the reef monitoring and coral recovery after the 1998 bleaching event in the report presented in 2000: 'Status of coral reefs of the Southern Indian Ocean: the Indian Ocean Commission Node for Comoros, Madagascar, Mauritius, Reunion and Seychelles', by L. Bigot, L. Charpy, J. Maharavo, F. Abdou Rabi, N. Paupiah, R. Aumeeruddy, C. Villedieu, and A. Lieutaud, in 'Status of Coral Reefs of the World: 2000'.

Status of Coral Reefs 2002

The number of regional Sites monitored has increased considerably since 2000 for most of the countries (from 43 monitoring stations in 1999/2000 to 74 in 2002). A focus of establishing new stations was to ensure improved monitoring within MPAs with 20 new sites established in 2001-2002.

These Sites (larger areas) were chosen to determine trends in reef status over time at representative sites, which however, cannot cover the full complexity of reefs in this region. Within regional Sites there are often several monitoring Stations where transect assessments are performed.

Country	Stations in 1999 - 2000	Stations in 2002	New Sites in 2002	MPA Sites in 2002
Comoros	11	16	10	6
Madagascar	14	19	11	2
Reunion	8	14	7	7
Mauritius (inc. Rodriques)	4	13	8	0
Seychelles	6	10	8	5
TOTAL	43	72	44	20

Comoros

In 2002, 10 survey Sites were monitored within 6 geographic sectors - 3 around Moheli (Itsamia, Nioumachoi, Fomboni) and 3 on Grande Comores (Mitsamiouli, Itsandra, Comotel). There is a general trend for strong regeneration of corals following the 1998 bleaching event that caused the death of more than half of the corals. The recovery was better at sites remote from intense human pressures like Moheli, as well as those protected from the 'Kussi' southern trade winds. Other sites like Candzoni and Itsandra had moderate coral recovery, whereas on Grande Comoros, there was slow regeneration and coral growth.

Mitsamiouli is the main tourist area, where the local population actively conserves the reefs by prohibiting sand and coral mining, and attempts to manage fishing damage, which is the main economic activity. Coral cover on the reef flat has shown a slight decrease from 46.8% in 1998 to 36.5% in 2002. Most of the corals are sub-massive or massive, possibly because these corals are more resistant to bleaching. The corals on the reef slope have been extensively degraded by destructive fishing (dynamite, anchors, small mesh nets) and the study site shows a drop in cover from 75% in 1998 to 24% in 2002, and few fishes. Groupers and other predatory fish are small probably due to strong fishing pressure. Coral recovery after the 1998 coral bleaching has been slow, although the reef flats appear more stable. Human pressures have increased following the closure of the Galawa Hotel, which had previously provided protection to adjacent areas. There is a similar trend on reef flat areas at the Itsandra site, however the outer slopes (12m depth) have shown some slight growth in the last two years (37% cover in 2002), like many of the outer slopes of Grande Comoros.

Coral and algal cover as % on Comoros at study sites.

Sector	Sites	Cover	1999	2000	2001	2002
Mitsamiouli – Grande Comore	Trou du Prophète Reef Flat	Hard Coral	44.2	-	-	36.5
		Algae	0.5	-	-	23.6
	Trou du Prophète Outer Slope	Hard Coral	25.2	-	-	24.8
		Algae	0	-	-	19.8
Itsamia - Moheli	Itsamia Reef flat	Hard Coral	-	-	-	5.0
		Algae	-	-	-	20.0
	Itsamia Outer Slope	Hard Coral	35.5	-	-	38.3
		Algae	33.0	-	-	22.3
Nioumachoi - Moheli	Candzoni Reef flat	Hard Coral	40.0			20.0
		Algae	55.0			-
	Candzoni Outer Slope	Hard Coral	20.0	-	-	41.2
		Algae	78.0	-	-	47.5
	Mea Reef flat	Hard Coral	-	-	-	22.8
		Algae	-	-	-	47.4
	Mea Outer Slope	Hard Coral	18.0	-	-	52.6
		Algae	51.0	-	-	20.7

There is clear damage to the coral reefs in front of the Itsamia River which dumps excess sediment, leaving only massive and opportunistic corals on the reef flat (5% cover). Live coral cover on the reef-slope is 38% (no change since 2000) and 22% cover of algae, with the genus *Halimeda* dominant. Rock and rubble cover has increased since 2000 (13% to 35% in 2002) which is probably linked to the reef flat degradation.

The Nioumachoua sector contains a series of islets in the centre of the Moheli Marine Park (Candzoni, Mea, Ouenefou), and more monitoring stations because this is a key location for conservation. The remote Candzoni islet has been severely damaged by blast fishing and trampling by fishermen over the reef flat, with coral cover down to 20% and 67% dead coral cover, mostly *Acropora*, which died in 1998. The protected outer-slope has 41% coral cover, which is an encouraging increase over the 20% cover after 1998. The recovery is a mix of stressed corals regrowing and strong recruitment of new corals. There is evidence, however, of poaching of turtles and blast fishing.

The remote Mea sites receive less human pressure and are protected from the southern 'Kussi' Trade Winds. The reefs are in good condition with more than 50% live coral cover, and a diversity of species, including many branching forms (12% branching *Acropora*, 11% table *Acropora*). This, and the strong recovery at the Candzoni site, indicates good potential for coral regeneration in the Moheli MPA. There have been no significant changes in coral cover on the reef flats of the 3 other Nioumachoua islets (Mea 20%, Candzoni 22%), and coral cover on the outer slopes is also good.

Madagascar

There are now 22 stations (from 16) at 11 Sites at Tanikely and Dzamandja in the north (Ifaty, Grand récif de Toliara, Belo sur Mer, and Antrema) in the south and west, and Lokaro, Fouplointe, Nosy-Antafana, Antanambe and Masoala in the south and east. Monitoring in 2002 has shown no significant change for the reef slopes in the north and west sector, however, there has been severe degradation on the reef flat at Dzamandjar with only 35.8% live corals (compared to 53% at Tanikely). This is correlated with strong urban and industrial (sugar wastes) pressure. Coral cover on the reef flat at Tanikely was 66% in 1999, and has decreased by 7% since 1998 on the Dzamandjar reef flat.

There was no significant change on the reef slope of Nosy Be, and similarly at Tanikely where coral cover was 68% in 1999, and 69% in 2002. The increase in anchor damage to corals is matched by coral recovery, although sediment impacts are increasing from external sources. The fish populations in the Tanikely protected area are probably the largest in the northwest, confirmed by the most recent rapid surveys which show few changes. Tanikely is not a declared marine park, however the tourist operators and NGOs provide management and protection e.g. 121 fish species were counted during one dive.

There was 30% coral bleaching at Belo-sur-Mer in 1998, however, the majority of the corals have recovered aided by clean water and few human impacts, even though there is considerable algal cover on corals killed in 1998. These coral banks are remote with limited access, which favours protection. The main activities are line fishing and skin diving for shells and sea cucumbers. The presence of abundant groupers and other predators, including the rare Napoleon wrasse (*Cheilinus undulatus*), indicates lower fishing pressures.

Cover of coral and algae (%) in the monitoring sites in Madagascar.

Sector	Sites	Cover	1999	2000	2001	2002
North West – Nosy Be	Dzamandjar Reef Flat	Hard Coral	-	-	-	35.8
		Algae	-	-	-	0.5
	Dzamandjar Outer Slope	Hard Coral	50.9	-	-	48.2
		Algae	4.0	-	-	3.8
West – Belo/Mer	Belo Outer Slope	Hard Coral	30.0	-	56.7	-
		Algae	-	-	14.4	-
East – Foulpointe	Foulpointe Reef flat	Hard Coral	47.1	-	13.0	-
		Algae	0.5	-	20.8	-
	Foulpointe Outer Slope	Hard Coral	35.0	-	36.4	-
		Algae	6.7	-	3.2	-
South West – Tulear	Ifaty Reef flat	Hard Coral	25.2	28.8		28.7
		Algae	4.7	26.5	-	37.8
	Ifaty Outer Slope	Hard Coral	40.7	41.9	-	42.0
		Algae	27.5	20.0	-	15.0

Coral cover has also dropped from 47% in 1999 to 13% in 2001 on the Foulpointe reef flat in the east. This is due to intense over-exploitation and sand accumulation in the lagoon, whereas cover on the outer slope has not changed much since 1999. Foulpointe has the only beach close to Taomasina, therefore it should be a good tourist destination, but intense human pressure has maintained a relatively low coral cover of 36% (unchanged since 1999) on the outer slope. These are mostly of massive, resistant species, along with coral rubble and rocks. The reefs are further degrading due to a proliferation of sea urchins (*Echinometra mathaei*), which are grinding away at the coral bases.

In the southwest (Toliara/Tulear), the reef-flat has been seriously damaged by sedimentation, and seagrass beds are now taking over. There is also a decrease in coral cover on the Ifaty reef flat with an increase in coral covered with algal turf, following the 1998 bleaching (reef flat coral cover for Toliara and Ifaty 24% and 29% respectively). In 2002, the outer slopes of the great barrier reef of Toliara and the fringing reef outer slope of Ifaty show coral cover of 45% and 42% respectively. The slightly higher level of dead coral covered with algal turf (15%) is a probable consequence of the 1998 coral bleaching. Anecdotal evidence is that the Toliara great barrier reef previously had much higher coral cover. There have been changes on the reef flat between 2000 and 2002, with an increase in dead coral with algal overgrowth (12% in 2000, 21% in 2002). Coral cover has decreased slightly (31% in 2000, 28% in 2002), possibly reflecting the intensive exploitation and rapid infilling by sand at the great reef.

Mauritius and Rodrigues

The reference site of Trou aux Biches on the sheltered, tourist coast has been relatively stable since 2000, although runoff from agriculture continues to degrade the corals with sediments and fertilisers, causing eutrophication in the lagoon. Coral cover is relatively unchanged with 44% in 2000 and 39% in 2002, with a slight decrease in algae from 9% to 5%. There is apparently a ‘normal’ population of fishes, with damselfish and butterflyfish well represented, and abundant herbivorous species. Agricultural and tourist pressures are increasing and the clarity of the water is decreasing.

The Bambou Virieux site, on the exposed coast, is influenced by the Grand River South with large sediment inputs, fertilisers and agricultural wastes. Live coral cover on the reef flat site near the coast decreased from 52% in 2000 to 38% in 2002, while algae have increased from 8% in 2000 to 23% in 2002, possibly due to the impact of the agricultural effluent dumped in the lagoon. This corresponds to increased eutrophication in the lagoon. There is a clear dominance of territorial damselfish on the reef flats, along with abundant butterflyfish (Chaetodonts) and surgeonfish (*Acanthurus* spp.).

The Reef Check data from the Shoals of Rodrigues staff is presented for the first time in these reports. In early 2002, the staff surveyed 6 more sites around Rodrigues, with assistance from the Fisheries Protection Service and National Coastguard, using the recommended GCRMN methods. The fringing reef around Rodrigues appears to be healthy, with high coral cover, but relatively low species diversity. Algae are not prevalent and dead corals are rarely encountered on the reef slopes; these facts indicate healthy reef conditions. However the reef flat in the north was seriously affected by mass coral mortality in early March 2002, possibly correlating with elevated sea temperatures. The

Coral cover (%) at sites in Mauritius and Rodrigues.

Sector	Sites	Cover	1999	2000	2001	2002
Mauritius Nord Ouest	Trou aux Biches Reef Flat	Hard Coral	41.0	-	-	40.0
		Algae	26.0	-	-	25.0
	Trou aux Biches Outer Slope	Hard Coral	43.0	44.6	-	39.1
		Algae	8.0	9.1	-	4.8
Sud Est	Bambou Virieux Back reef flat	Hard Coral	30.0	52.3	-	37.9
		Algae	30.0	6.5	-	23.2
	Bambou Virieux Shore reef flat	Hard Coral	48.0	49.8	-	36.6
		Algae	17.0	33.8	-	50.4
Rodrigues Riviere Banane	Rivière banane Reef flat	Hard Coral	-	-	-	15.8
		Algae	-	-	-	81.8
	Rivière Banane Outer Slope	Hard Coral	-	-	-	62.9
		Algae	-	-	-	36.5
Passe Armand	Passe Armand Reef flat	Hard Coral	-	-	-	17.0
		Algae	-	-	-	73.9
	Passe Armand Outer Slope	Hard Coral	-	-	-	43.2
		Algae	-	-	-	47.8

flats are also subject to higher levels of fishing and wave energy during storms, but species diversity is higher here than on the slope and soft corals are abundant.

Hard coral cover at the reef slope stations ranged from 44% at Passe Armand to 63% at Riviere Banane, with less than 5% dead coral, and large areas of hard limestone platform covered with turf algae (44% and 37% respectively). *Acropora* species, particularly the branching forms, dominated at all sites except Passe Armand, with more than 50% of the cover. Table *Acropora*, and massive and encrusting corals were the next most abundant forms. There was low diversity and numbers of reef fish on the reef flat sites, which are visited regularly by octopus collectors and seine net fishers resulting in trampling, habitat destruction and over-fishing. Over-exploitation is illustrated by low numbers of larger herbivorous fish. There are, however, many fish at Passe Armand, Riviere Banane and Grand Bassin, probably due to recent increases of filamentous algae after the bleaching event of 1998. Butterflyfish (Chaetodonts) numbers are down, reflecting changes coral cover. The most common predators are small groupers (Serranids), which are targets for line fishers.

The cover of live coral was much lower at the reef flat stations, ranging from 15% at Riviere Banane to 28% at Trou Blanc, as well as 35% soft coral. Dead coral, either bleached or covered with algae was very high at Grand Bassin and Passe Armand. *Acropora* was more abundant than other corals except at Riviere Banane, and table *Acropora* covered 16% at Trou Blanc. Damselfishes (Pomacentrids) were common at all sites, along with a good diversity of butterflyfish (Chaetodonts) at Riviere Banane, and large schools of algal grazing fishes. The only predators were small groupers.

La Reunion

There are now 14 monitoring Stations in 4 sectors, each with 2 monitoring sites: St Gilles-La Saline with Toboggan (healthy), and Planch'Alizes (disturbed); St Leu with Varangue a reference site, and Corne Nord, near the canal exit; Etang Salé a 'classic reef site'; and St Pierre - Ravine Blanche (healthy) and Alizé Plage (disturbed). Coral cover and fish populations were relatively stable over 5 years at Saint Gilles-La Saline, with slight increases in coral cover on parts of the reef flat (around 30-38%), even though tropical cyclones 'Dina' and 'Harry' passed in early 2002. This is a balance between the degradation from human activities and new coral growth, with *Acropora* species being the dominant forms. There has been a slight decrease in coral cover on the outer slopes. Fish populations have also been relatively stable, with more butterflyfish and few predatory fish, even in protected zones, showing continued fishing pressures.

Coral cover (%) on Reunion study sites.

Sector	Sites	Cover	1999	2000	2001	2002
St Gilles	Toboggan / Planch	Hard Coral	35.5	32.4	37.9	37.9
	Reef Flat	Algae	15.3	31.5	18.8	29.4
	Toboggan / Planch	Hard Coral	40.6	44.7	44.2	36.4
	Outer Slope	Algae	45.5	45.0	45.9	52.2
St Leu	Corne Nord / Varangue	Hard Coral	54.1	50	55.9	49.8
	Reef flat	Algae	21.3	30.4	19.7	33.6
	Corne Nord / Varangue	Hard Coral	59.8	62.2	60.9	61.2
	Outer Slope	Algae	31.0	33.8	25.0	27.5
Etang Sale	Bassin Pirogue	Hard Coral	-	50.3	44.1	-
	Reef flat	Algae	-	9.4	7.6	-
	Bassin Pirogue	Hard Coral	-	57.8	49.4	-
	Outer Slope	Algae	-	31.8	38.6	-
St Pierre	Ravine Blanche	Hard Coral	-	58.1	63.6	-
	Reef flat	Algae	-	18.9	0.0	-
	Ravine Blanche	Hard Coral	-	34.4	42.8	-
	Outer Slope	Algae	-	53.7	47.4	

There is similar stability in coral cover on the outer slopes. There has been little change in coral cover (around 8% total) both at Toboggan (North reef) and Planch'Alizé (back reef). Fish populations, especially those in the higher trophic level (groupers, snappers, emperors) have decreased, even though this is a no-take reserve.

The cyclones in early 2002 particularly affected the Saint Leu reef flat areas, after a series of other damaging events (bleaching, high sedimentation, low salinities). There was strong recovery in the coral communities to 40-50% coral cover by February 2002 (coral mortality 12-18%), but also about 10% increase in algal cover. There is higher coral cover on the outer slope, including the highest reported for Reunion (more than 70% coral cover at La Corne, and 45 to 50% at La Varangue). Algal cover is stable and moderate (<30%). Predatory fish populations are low, showing the general trend of over-exploitation on Reunion, while plankton feeding fishes have increased, and coral feeders (Chaetodonts) have remained stable.

The Etang Salé and Saint Pierre sites show healthy coral cover on the outer slopes, which are exposed to the southern swells and SSE trade winds. The reef flat of L'Etang Salé

Benthic cover (%) at Seychelles monitoring sites.

SECTOR	SITES	Cover	1999	2000	2001	2002
Mahe – Bay Ternay	Middle reef Outer Slope	Hard Coral	3.5	5.1	6.7	20.1
		Algae	0.0	2.6	0.2	1.2
Mahe – Ste Anne	Ile aux Cerf Reef flat	Hard Coral	-	-	-	5.0
		Algae	-	-	-	-
	Ile aux Cerf Outer Slope	Hard Coral	-	-	-	14.9
		Algae	-	-	-	40.3
Silhouette Island	Silhouette Reef flat	Hard Coral	-	9.0	-	-
		Algae	-	0.5	-	-
	Silhouette Outer Slope	Hard Coral	-	31.9	-	-
		Algae	-	0.5	-	-
Curieuse Island	Anse Papaie Reef flat	Hard Coral	-	-	-	2.5
		Algae	-	-	-	9
	Anse Papaie Outer Slope	Hard Coral	-	-	-	25.7
		Algae	-	-	-	0.2
Alphonse Island	Oasis 1 Reef flat	Hard Coral	--	-	-	57.2
		Algae	-	-	-	0.0

consists of large, coalescing coral colonies of compact, massive *Porites* (coral cover above 40%). Algal cover is relatively low (<10%). Butterflyfish are quite common (26% of the population) as well as plankton-feeders (70%), but predatory fish are virtually absent, indicating strong fishing pressure. The coral cover on the outer slope is fairly high (49%) for a zone subject to very strong wave action. Most of the corals are massive (Poritids, Faviids) or abundant encrusting colonies (Faviids, Montiporids). The area is also rich in calcareous and other algae (38%), which is typical of slopes exposed to strong ocean swells.

The southern reef flat of Saint Pierre experiences strong human pressures, with large inputs of freshwater from the d'Abord River and the port. The coral populations contain resistant or opportunistic species that have a quick turnover (montiporids, poritids). The northern reef-flat has higher coral cover (above 63%) dominated by healthy populations of *Acropora*. The diversity and numbers of fishes are low compared to other reef flats, except for Ravine Blanche where coral- and plankton-feeders are fairly abundant in the branching *Acropora*. Calcareous algae are prominent on the outer slopes where they contribute to reef construction, and there are also large areas of turf algae with abundant populations of herbivorous fish (Acanthurids).

Seychelles

Corals on the inner granite islands retain a severely degraded appearance, with less cover than before the 1998 coral bleaching event. In 2000, 91% of sites had less than 5% coral cover, and since then, there has been some improvement in coral cover, although new coral recruitment rates are still low. There are 8 sites in 3 sectors being monitored with several new sites added in 2002, but the Silhouette sites were not monitored due to logistic constraints.

The more protected Ternay Bay has had a slow increase in coral cover after massive losses in 1998, but is still much lower than the pre-bleaching level. *Acropora* corals are not increasing as fast as other species, and soft coral cover has almost doubled between 2000 and 2002, indicating that this site is favourable for soft coral recruitment. Low fish abundances may reflect a regional pattern whereas the eastern islands around Praslin have more fish e.g. only 2 large predators and 1 butterflyfish were recorded at Middle Reef.

Coral cover was low at all 3 sites on St Anne with limited coral recruitment. The highest coral cover (15%) was on the reef-slope at Cerf, followed by Moyenne and Anse Cimetière (10%). Sedimentation from the reclamation sites is probably the most important factor limiting coral recruitment at Cerf, and considerable damage is apparent near the sediment plumes. The algal cover differences between the sites reflects the degree of wave exposure; Cerf 1 is sheltered, and the other 2 sites are more exposed. The high abundance of plankton feeding damselfish is related to the nearby St Anne Channel which supplies more plankton.

Silhouette is a new site since 2000. The reef flat is heavily impacted by the south-east monsoons and always has low coral cover e.g. no *Acropora*, and 9% cover of other corals, plus some soft zoanthids (*Palythoa*). The outer slope has a mix of live and dead massive corals (>15%), sub-massive corals (>15%), some encrusting corals, and 0.7% branching young *Acropora*. This area appeared to be unaffected by the 1998 El Niño bleaching, possibly due to the proximity of cooler, deeper waters.

The Curieuse island reef slope has 26% coral cover at Anse Papaie, 31% at Coral Garden, whereas the reef flat at Anse Papaie had only 2.5% coral cover. *Acropora* corals were in low abundance. No target fish were recorded on the reef slope of Anse Papaie, whereas 1 predator and 5 butterflyfish were recorded on the reef slope, but more were recorded at Coral Garden (16 predators and 12 butterflyfish).

The Oasis 1 site on Alphonse island has 57% coral cover with some of the rare blue coral *Heliopora* (0.8%) but no *Acropora*, or bleached corals. Fish abundances are high, with 24 large predators and 10 butterflyfish being recorded. Most of the corals are massive, including a high proportion of species that are known to resist coral bleaching (e.g. like 1998). The high fish abundance is probably related to the low fishing pressure and high coral cover.

Recovery from the 1998 Coral Bleaching and Mortality Event

Coral bleaching and mortality in 1998 was more severe in the Seychelles and Comoros than in the south (Madagascar, Mauritius and Reunion), where there was recovery of the bleached corals within a few months. Since 1998, there has been localised bleaching in Reunion (2001), and on Rodrigues and Seychelles (March 2002).

On the **Comoros** in 1998 there was 50% bleaching on the former pristine reefs of Moheli, and 40 to 50% coral bleaching at Mitsamiouli, with *Acropora* species worst affected. In the last 4 years there has been a significant recovery in Moheli (Marine Protected Area of Mohéli – Nioumachoua) e.g. the Candzoni site was heavily damaged in 1998 and now shows a recovery to 41% from 20% in 4 years. A major pulse of new coral recruitment was observed in the 2002 survey, particularly on the outer slope. There is Sea Surface Temperature monitoring on Mayotte using automatic data loggers.

On **Mauritius**, there was relatively minor coral bleaching in the lagoons and outer slopes in 1998, probably because cyclone Anacelle produced wet and cloudy weather in February.

At Trou aux Biches there was less than 6% bleaching and 27% partial bleaching, especially amongst the *Acropora* species. All corals 'recovered' within 9 months. At other sites there was less than 10% bleaching with some dead standing coral seen on the Barrier Reef off Mahebourg. On **Rodrigues**, there was a serious incident of coral mortality in March 2002. Rapid assessments recorded coral death at 6 of the 22 sites, with mortality concentrated in the north and west of the island. Coral colonies were still standing and being overgrown with turf algae. The coral species most affected were *Acropora* and *Pocillopora*. Mortality ranged from 10% at Chaland to 75% at Trou Malabar and Ile au Fou.

On **Madagascar**, corals were bleached at many sites (few data are available), but recovery has been encouraging e.g. the reef at Belo-sur-Mer showed about 30% bleaching in 1998, however the majority of corals had recovered by 2002 to 57% coral cover.

There was no widespread bleaching on **La Reunion** in 1998, with less than 10% of the coral communities affected, and most of these recovered. There was additional coral bleaching in February 2001, with most affected coral colonies regenerated after 4 months. The branching corals were the most effected, but there was around 10-15% mortality in soft corals (Alcyonaria) at Saint Gilles, and 80-95% mortality at the Livingstone site. Outer slopes were less affected. High fish mortality occurred in March 2002 at Saint Gilles/La Saline and a *Streptococcus* bacterial pathogen was found in the spleen of the fish. This mortality could be linked to changes in water quality following the heavy rains in early 2002.

The reefs of the **Seychelles** suffered extensive coral bleaching and mortality from February to May, 1998 after seawater temperatures reached 34°C. Approximately 40-95% of corals bleached in irregular patterns across the archipelago, with mortality from 50-95%. There was 40-50% bleaching in the southern islands (Aldabra, Providence, Alphonse), and there was 95% mortality in the Ternay Bay Marine Park (Mahe). Slight coral regrowth and new larval recruitment has started and small colonies are evident in various places. This poor recruitment is a reflection of high adult mortality. The largest pool for coral larvae appears to be from deeper zones unaffected by bleaching. The Alphonse sector is showing the highest coral cover followed by Curieuse, St Anne and Ternay Bay, with most corals being non-*Acropora* that survived after 1998. There are no *Acropora* in the data, which indicates the seriousness of the bleaching, as they are the usually the first colonisers.

There are now reports of new, localised coral bleaching around the granite islands and Mahé, with mostly *Pocillopora* corals bleaching, but very little in *Acropora* and massive species. Around 50% of *Pocillopora* colonies have bleached, including 14.4% that are totally bleached. The bleached colonies will probably recover as water temperatures have dropped below 29°C, but this will depend on available larvae and suitable substrate covered in coralline algae. Many sites, however, are covered in coral rubble which will impede recovery.

Threats to Coral Reef Biodiversity

Most reefs in this region are exposed to ocean forces with regular strong winds and large ocean swells (alizés). There are also relatively regular cyclones in summer, that usually sweep in from the northeast. The other major 'natural' factor is coral bleaching and mortality associated with elevated sea surface temperatures. The reefs have developed with these pressures (with the possible exception of coral bleaching) and usually recovered from damage relatively rapidly. Now the major threats are anthropogenic stresses that are causing serious reef decline in some large areas.

Over-exploitation of fisheries resources is a major damaging factor in all countries, especially **Madagascar**, **Comoros** and **Mauritius**, where a large proportion of the population lives by subsistence fishing. This has resulted in depletion of fish stocks on most reefs, and efforts have been made in **Madagascar**, **Mauritius** and **Comoros** to reduce in-shore fishing by anchoring fish aggregating devices (FADs) in the open sea to attract pelagic species. **Mauritius** is also shifting effort by promoting employment in longline fishing offshore or buying out fishing licenses to reduce fishing pressures in the lagoons. Blast (dynamite) fishing has been a major damaging factor in the **Comoros**, and many reef areas have been reduced to rubble. Reef gleaning at low tide for octopus, fish, molluscs etc. causes extensive damage to reef flat corals in **Comoros** and **Madagascar**, particularly as iron bars are used to break open hiding spaces.

Domestic wastes (including solid wastes) are usually discharged directly into the sea, resulting in eutrophication in reef areas. Sewage treatment is a common only on **Reunion**, although new developments on **Mauritius** and **Seychelles** require 'adequate' treatment. Chemical and bacterial pollution from industrial or domestic sources is a serious public health problem and one that could seriously impact on tourism, as many of the islands rely on return visits or 'word-of-mouth' recommendations to maintain occupancy rates e.g. Mauritius has a 30% tourist return rate. Water pollution is a critical factor in the coral reef lagoons of **Mauritius** and **Reunion**, which are their principal recreation areas.

Deforestation and poor agricultural practices have resulted in major soil erosion and downstream smothering of corals, especially in **Madagascar**, **Mauritius**, and to a lesser extent around Victoria and the St Anne Marine Park in the **Seychelles**. Sugar cane farming is a main cause of pollution by fertilisers, pesticides and sediment on **Mauritius** with cane farms occupying 88.5% of the cultivated land and the sugar mills discharging wastes directly into rivers or the sea.

A major problem in **Madagascar** and the **Comoros** is the extraction of coral and sand for building. In Mauritius the industry was worth US$10 million per year, employing 1,100 people. Near Toliara, **Madagascar** it is anticipated that the current rate of removal of corals will destroy large areas of reef flat within the next few years. There is an urgent need for legislation to control this coral extraction. **Mauritius** is legislating to control these activities by progressively reducing the number of licences for sand extraction.

Tourism is a major component of the economies of **Seychelles**, **Mauritius** and **Reunion**, but less so in **Madagascar** and **Comoros**. For example, in 2001 tourism generated 26% of the foreign revenue in the **Seychelles**, however, poor developments and maintenance of the facilities have resulted in damage to the most attractive and accessible coral reefs in all countries. This is most evident when the tourist resorts are concentrated in the attractive locations. Tourism should be harnessed as a major factor in promoting reef conservation e.g. a hotel manager near Toliara, **Madagascar** purchases most of the fish catch in return for decreased fishing activity on popular tourist reefs.

Most countries have laws requiring Environmental Impact Assessments (EIAs) as management controls prior to all coastal developments, but few adequately police developments. Most assessments are conducted by private consultants, but the government departments often lack the capacity to verify assessments and recommend changes. Many of the new control laws were proclaimed after tourist resorts were constructed, thus they are not required to install sewage treatment facilities.

Legal Instruments, Monitoring and MPAs

There is an urgent need for rational management of socio-economic activities (fishing, extraction of materials, and urbanisation) in the coastal zone. The Moheli Marine Park (**Comoros**) has stopped some destructive fishing, but no alternative revenue generating activities have been provided and this is making life difficult for some fishermen. The GEF biodiversity management project in the Park ends in 2003, and there is no guarantee of another financing mechanism to continue the resource co-management. The Moheli Park has brought together some key institutions (DGE and CNDRS; and NGOs, AIDE and Ulanga) to encourage sustainable management and monitoring of these Comoros coral reefs, however, the specific laws have not been enacted to conserve coral reefs, and existing legislation is not enforced.

Few marine parks have been established in the region, although many are under active consideration. There are more than 20 monitoring stations in the existing MPAs, but most are under-funded and under-staffed, with little enforcement of regulations. For example, **Reunion** has French coastal law that recognises that 'the coast is a geographic entity needing a specific planning, protection and development policy'. A natural reserve project has been launched by DIREN (Government agency) on Reunion Island, which aims to 'designate' the coral reefs as a Natural Reserve and this should become reality in 2003. The status of the APMR Marine Park will be amended to manage coastal zones.

Following a series of meetings in **Madagascar**, a special effort was made to link all sectors, programs and MPAs for better integration. Conservation International has started a Rapid Assessment Programme to select sites to strengthen national development policy for the coastal zone.

Considerable training (database, monitoring methods, statistical analysis) was conducted in 2001 for the **Seychelles** Marine Parks Authority, the Seychelles Coast Guard, the Seychelles Island Foundation and the Maritime Training Centre. Similarly in 2001, the Shoals of Capricorn programme completed a two-year scientific study on the effect of sedimentation from the East Coast Reclamation project on coral reefs in St Anne Marine Park. These are now being completed by the GEF-funded Seychelles Marine Ecosystem

COUNTRY	NO. OF MPAs	STATUS OF MPAs	PROGRESS SINCE 2000
Comoros	1 MPA established 1 MPA in planning	Marine Park of Moheli -GEF Biodiversity project (UNDP/GEF) 'Coelacanth Park' project in preparation - UNEP-GEF	6 monitoring stations No news – in preparation phase
Madagascar	1 established (Nosy Be) Several proposed: Biosphere marine - reserve Belo/mer, Biosphere marine reserve in Sahamalaza region (NW)	Not an official reserve – no legal status, but managed locally. Feasibility study Feasibility study	Monitoring site since 1999 New monitoring site in 2002 No monitoring
Mauritius	2 MPAs established. (Blue Bay & Balaclava) 6 existing marine reserves	Fisheries & Marine Resources Act, 1998 (defines different activity zones; multiple-use zone, strict conservation, recreation, anchoring, boating areas).	5 monitoring sites (data not available for 2001-02). Future data available for 2003
Rodrigues	No official MPA	Shoals of Rodrigues NGO involved in education & awareness raising	
Reunion	1 marine park- APMR	Run by NGO (Association Parc Marin de La Reunion – APMR)	Regular education & monitoring (7 sites & controls). Natural marine reserve status being investigated for legal designation by France.
Seychelles	6 Marine Parks in Mahé (Ternay Bay, St Anne, Port Launay, Silhouette, Ile Cocos 3 Special Nature Reserves elsewhere (Aldabra, Cousin, Aride)	3 MPAs have enforcement & management staff; others not Other MPAs visited regularly. Monitoring starting in Aldabra, no data available	Rehabilitation activities in progress near Ternay Bay under GEF SEYMEMP. 2 Monitoring sites in Curieuse & Alphonse islands

Management Project under the coordination of the Division of Environment, as a Coral Reef Restoration Project. The Seychelles have been active in recognising the critical role of coral reefs within their tourism industry, and their protected areas include the Aldabra World Heritage Area.

Two new marine parks (Balaclava and Blue Bay) were officially declared in June 2000 on **Mauritius,** making a total of 8 around the island. The development of active management is still rudimentary, and there is a program to map the vulnerability of coastal areas by the Mauritius Oceanography Institute and AFRC. The Shoals Rodrigues are conducting assessments of fisheries, and coral growth and recruitment rates, as well as implementing conservation strategies for MPAs and placing permanent mooring buoys. The most important activity in the **Comoros** is the GEF biodiversity project (UNDP/GEF, 1999 - 2003) which established the Moheli Marine Park. The 'Coelacanth Park' project is in preparation.

The countries have prepared guidelines on good conduct of impact assessments, as the basis for future legislation, and they are also developing an ecolabelling system for tourist developments to encourage sustainable management of coastal resources, in parallel with impact assessments and monitoring of developments.

There are two training and reef monitoring programs in the region: the Indian Ocean Commission established a program (now funded through GEF and EU partnership) with at least 6 permanent monitoring sites (more than 12 stations) in each country and to assist management with advice on reef status and performance evaluation; the CORDIO (COral Reef Degradation in the Indian Ocean) project is assessing the 1998 coral bleaching impacts on the reefs and human communities of the wider Indian Ocean with funds from the World Bank, the Swedish Development Agency (SIDA), other governments, and the WWF.

Conclusions and Recommendations

The South West Indian Ocean Island States Node of GCRMN and ICRI has gradually developed national monitoring networks for these countries, first through the Indian Ocean Commission, and now with assistance from GEF and the European Union. Over the past 3 years there have been a series of regional workshops, forums and training sessions to establish the network and appoint national technical focal points, operational units and supervisory bodies. The Node developed a methods guide 'Coral reef status monitoring in the south-west Indian Ocean', which was published in English and French as both hard copy and CD-ROM format. A regional database (COREMO-I in Microsoft Access 97) for these countries is being constructed using the AIMS Reef Monitoring Data Entry System as the basis. The bleaching in 1998 occurred before countries had established baseline monitoring, but if it occurs again, the countries are prepared for both rapid and long-term assessment of impacts and recovery, especially in collaboration with the CORDIO program.

The network has matured over the last 5 years, linking people and institutions to facilitate communication, data gathering and quality control. An increasing number of institutions and NGOs are being included to broaden the network and work with local communities. This regional network is available for GCRMN and ICRI activities and has developed the capacity for integrating these countries into global coral reef conservation and research strategies, and for providing data and advice to resource managers. There is a need to gather data from other islands like Mayotte or Anjouan (Comoros archipelago) to improve coverage in the region.

The monitoring methods recommended by the GCRMN are being successfully applied by the network members to provide annual data for national and regional reports. If necessary, twice yearly data collection can be included to provide supplementary information following exceptional events (bleaching, cyclones etc.). There is a need to continue monitoring method development to ensure that the data are appropriate for the end users. Although there have been many training sessions in 2001 and 2002, network members have requested more advanced training ('train the trainers') in monitoring and database operations over the next 2 years.

Progress during 2000-2002 has seen an increase in monitoring: 23 stations in 1998; 43 in 1999/2000; and 70 stations from 44 sites in 2002. This increase has resulted from a progressive structuring of the network to include MPAs and the addition of new partners e.g. Rodrigues Island. Further increases are expected.

This regional report summarises a large amount of data on reef status in the 5 countries, with a focus on MPAs. The complete National and Regional reports will be available from the authors and on www.reefbase.org. A major emphasis is on using pertinent bio-indicators (corals, fish) to assess the consequences of exceptional events like the massive El Niño coral bleaching of 1998, and cyclones. These data are being provided to decision-makers to improve resource management in the region and provide early warning of coral reef degradation. The Node is also linking with, and reporting on, other programs in the countries. Most importantly, the Node activities have improved understanding of coral reefs and catalysed a network of people, institutes and government agencies that are cooperating to conserve the reefs in this region.

Reviewer

David Obura, CORDIO-East Africa, Mombasa, Kenya;

Acknowledgements

The Node and authors wish to thank the following: Ministry of Environment (Mr Joseph François) and Mr R. Aumeeruddy of the Seychelles; Direction Générale de l'Environnement (Mr Y Ahamadi, Mme F. Abdalla) in the Comoros; Direction Générale de l'Environnement (Mr G. Refeno) in Madagascar; Ministry of Environment DIREN (Mrs A. Lieutaud), and ECOMAR (Mme P. Chabanet) on Reunion; Mauritius Oceanography Institute (Mrs R. Moothien Pillay), Albion Fisheries Research Center (AFRC), Shoals Rodrigues, and Min. Environment – ICZM Cell (Mr Molloo) for Mauritius and Rodrigues; and Agence pour la Recherche et la Valorisation Marine (Mr JP Quod for regional coordination).

Authors Contacts

Western Indian Ocean Regional Node Coordinator, Lionel Bigot: lbigot.arvam@wanadoo.fr; General Secretariat, Indian Ocean Commission, Didier Slachmuylders: didierslach@coi.intnet.mu. Nodes: Reunion technical focal point, Moine Picard, parcmarinreunion@wanadoo.fr; Comoros focal point, Said Ahamada, aide_km@yahoo.fr; Madagascar focal point, Jean Maharavo, emad@dts.mg; Mauritius focal point, Naidoo Paupiah, Fish@intnet.mu; Rodrigues focal point, Sabrina Meunier, shoals.rod@intnet.mu; Seychelles focal point, Jude Bijoux, jbijoux2000@yahoo.co.uk.

Supporting documents

Regional report COI 2002 and 1999/2000 – General Secretariat, Indian Ocean Commission, Av Sir Guy Forget, 4 Bornes, Mauritius. National reports 2002 can be obtained on www.reefbase.org or from: Comoros (AIDE or DGE, BP 1292, Moroni, Rep des Comores);

Madagascar (DRA/GIZC-CNRE, BP3911, Fiadanana, Antananarivo 101, Madagascar);

Seychelles (MPA, Baie Ternay, Mahe, Rep des Seychelles); Reunion (DIREN, Rue de Paris, 97400 St Denis, La Réunion, France); Mauritius and Rodrigues (AFRC- ICZM Unit, Ministry of Environment, Port Louis, Mauritius and MOI (Rodrigues), (4th Floor France center, Victoria Avenue, 4 Bornes, Mauritius).

ICRAN

ST. ANNE MARINE PARK, SEYCHELLES – ICRAN DEMONSTRATION SITE

St. Anne National Marine Park is 5km east of Mahé, the capital island of the Seychelles, and contains 3 important marine habitats: coral reefs (both sheltered and exposed fringing reefs); extensive seagrass beds; and sand flats. The islands in the group are also important turtle nesting sites. Tourism is putting enormous pressure on the marine park with more than 20,000 tourists visiting per year. About one-third of visitors to the Seychelles tour the marine park. Major threats to the system come from coastal reclamation, port activities, oil pollution, sewage discharge (new treatment plant in operation in 2001), coastal development (a resort is opening within the marine park in late 2002), garbage, marine debris, and fish wastes also threaten the ecology of the park. The Marine National Park was designated in March 1973 and a management plan was prepared in 1995. The purpose of the St. Anne Marine Park is to conserve the resources and protect coral reefs and other marine habitats from harmful disturbances and to manage the uses of the park. The park has 3 different zones:

- Underwater Diving Zones (areas to be used by glass bottom boats and for snorkeling);
- Protected Zones (areas with reefs, seagrasses, turtle nesting beaches); and
- General Use Zones (for picnics, boating, swimming and other soft leisure activities).

There are improvements being made in the management of St. Ann Marine Park. Existing legislation is being updated to improve enforcement effectiveness and there are plans to revise the current management plan to involve a wide stakeholder consultation process. Problems that need to be addressed include clarification of zone boundaries and augmentation of both financial and human resources.

Ecological Monitoring: Coral reef monitoring is carried out twice a year. There is also monitoring of turtle nesting (turtle and track counts, size measurements). A beach monitoring program is planned to begin at the end of 2002 and a seagrass monitoring program is targeted to start at the beginning of 2003. There is also a record of marine mammals spotted on patrols.

Socio-economic Monitoring: There is little socio-economic monitoring, however, the number of foreign tourists visiting the park is well known because they pay a park entry fee. A mooring fee also gives an indication of boats using the park. A questionnaire was administered to the general public, stakeholders, environmental professionals and tourists regarding perception of park management.

Monitoring Effectiveness: Monitoring in St. Anne has just started, so there is insufficient information to guide management planning, however available data are taken into account.

Coral reefs are over **50%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **occasional.**

ICRAN

COUSIN ISLAND MARINE PROTECTED AREA, SEYCHELLES – ICRAN DEMONSTRATION SITE

Cousin Island is a small marine reserve, about 4km southwest of Praslin Island, one of the main islands in the Seychelles. A rich coral community with at least 217 species of fish surrounds this Island, and 30 to 100 hawksbill turtles nest there annually, making it one of the most important breeding sites in the Western Indian Ocean. Seven species of breeding seabirds also nest in numbers exceeding 300,000 individuals. The coastal environment, however, is threatened by coastal reclamation, port activities, oil pollution, sewage discharge (new treatment plant in operation in 2001), garbage, marine debris and fish wastes.

The island was purchased by Birdlife International and designated a Special Reserve in 1975 under Seychelles national law. The initial purpose was to protect endemic birds, but current management objectives also focuses on the marine environment and an awareness orientated and non-interventionist approach has been taken to protect the biodiversity. These objectives of this approach include:

- Protect and maintain the integrity of the island's coastal and littoral habitats, especially the coral reef and its associated flora and fauna and the internationally important breeding population of hawksbill turtles;
- Understand and mitigate long-term and external influences; and
- Raise and maintain public awareness.

Activities on the island have been guided by a series of management plans. Approximately 125 scientific papers, articles and reports have been written on Cousin's biodiversity to date.

Ecological Monitoring: There have been several studies undertaken in the past on the coral and fish composition and attempts have been made to establish regular monitoring sites on the surrounding reefs. Groupers, emperors, and snappers are more abundant and diverse within the reserve than in fished sites.

Socio-economic Monitoring: Tourist visitation (6,000 to 8,000 per year) to the island is regulated and managed by island based staff. The economic benefits to the surrounding communities and private sector are based on educational tourism and it is estimated that these activities generate US$600,000 through direct and indirect revenues. Contact: birdlife@seychelles.net

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

ICRAN | **MAB**

NOSY ATAFANA MARINE PARK, MADAGASCAR – ICRAN DEMONSTRATION SITE

The Nosy Atafana Marine Park is in the province of Toamasina, northeast Madagascar. Marine turtles and dugongs frequent the park and migration of humpback whales occurs just outside of the park's borders. Overexploitation and coral bleaching are the primary threats to marine resources.

The Marine Park is a component of the UNESCO Biosphere Reserve of Mananara-Nord and is jointly managed by local communities and ANGAP (National Association for Protected Areas management).

The Mananara Biosphere Project aims to develop integrated management based on communication, co-operation, education and training. Objectives of the park management focus on:

- Maintaining the quality and quantity of biodiversity;
- Conservation and rational management of marine resources; and
- Protection of the ecosystem of Nosy Atafana.

The overall management goal for the biosphere reserve was to develop the region and improve the quality of life of the coastal communities whilst achieving these objectives. The park is managed by local communities, through a local contract with the managers, and the biosphere reserve is divided into 6 geographical regions for logistical purposes. Each regional sub-committee meets 2-3 times a year to evaluate the programs, activities and management of the reserve. Every sector of the coastal community is represented. Managers of the Marine Park are currently focusing their attention on raising support and awareness in local communities and building the capacity of enforcement officers

Ecological Monitoring: UNESCO has accumulated baseline information on the park. Ecological inventories and a management plan 2002-2006 for the Nosy Atafana Marine Reserve has recently been completed. This includes extensive qualitative descriptions and species lists for the coastal marine ecosystems of the national park, and a proposed zoning for the marine reserve. Ecological monitoring and a comprehensive inventory of biodiversity, including stock assessments and studies of exploited resources will be undertaken within the context of ICRAN.

Socio-economic Monitoring: To date there has been no socioeconomic monitoring, but it has been identified as an important component in the park action plan that is being developed.

Monitoring Effectiveness: There are diverse examples of how the participatory management approach of the Mananara Biosphere Project has been successful in terms of meeting the goals of the Nosy Atafana Marine Park. These will be used in capacity building for other regions of Madagascar.

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

WHS

ALDABRA ATOLL, SEYCHELLES – WORLD HERITAGE SITE

Aldabra Atoll, which is one of the world's largest, is in the Southwest Seychelles (34km long by 14.5km wide). It has a large shallow lagoon surrounded by islands and coral reefs. Aldabra has unique flora and fauna and is a refuge for 200,000 giant tortoises and huge colonies of seabirds, including the only flightless bird in the Indian Ocean, the white-throated rail. It is also an important nesting site for green and hawksbill turtles. Aldabra has been protected from human influence because it is remote, dry and dominated by dense scrub and rocky terrain. In the 1960s, Aldabra Atoll was to be developed as a military base until concerned scientists and the Royal Society campaigned for its preservation. It was designated a strict nature reserve in 1976 under the Protection and the British Preservation of Wild Life Ordinance, 1970 and a special reserve in 1981 (Seychelles National Parks and Nature Conservancy Act). Aldabra was handed to the Seychelles Island Foundation for the management and protection of Aldabra to protect the atoll's significance and importance to natural science. Aldabra Atoll was designated a UNESCO World Heritage Site in 1982.

Intensive research over the whole atoll was initiated by the Royal Society in 1967 and a fully equipped research station was established in 1971. It is maintained by the Seychelles Islands Foundation with external funding from the World Bank and the Global Environment Facility. WWF started monitoring tortoise and turtle populations in 1982, and scientists from the Smithsonian Institution and Cambridge University regularly work there. The Seychelles Islands Foundation produced a management plan for Aldabra in 1997, which was accepted by the Seychelles Government as a guideline for future management. The management priority is to ensure minimum human interference, while continuing research and monitoring. The Foundation is dependent upon donations and a shortage of funds is a potential danger for continued management. Development is restricted to very small-scale tourism.

Ecological Monitoring: The Aldabra Marine Program has 11 permanent monitoring sites (coral and reef fish) on the outside of the atoll and in the lagoon following the 1998 El Niño bleaching event to track reef recovery (see Box on Aldabra bleaching). Coral recruitment studies and investigations of echinoderms have also been initiated. It is anticipated that the mapping of the lagoon habitats and aerial surveys of the atoll will begin in 2003.

Socio-economic Monitoring: This is considered unnecessary as there are few humans on the atoll.

Monitoring Effectiveness: Monitoring in the Aldabra marine environment has become more frequent and research station staff have had received training in resource maintenance.

Coral reefs are **60%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **not planned.**

MAB

MANANARA NORD MARINE RESERVE – MAN AND THE BIOSPHERE RESERVE

The Mananara Nord Biosphere Reserve, in the northeast part of Madagascar, has merged nature conservation, buffer zone development and participation of local communities. Madagascar has extremely rich biodiversity with more than 85% endemism among species; for this reason, conservation of this area is considered an international priority. A project on conservation and sustainable development in the Mananara-Nord region started in 1987 with funds from UNDP and in 1990, UNESCO declared the area a Biosphere reserve in three parts: the core area under national protection; a 1,000ha marine park; and a terrestrial park. The Biosphere Reserve contains 47,000 inhabitants.

The strict closure of 3 islets in the marine national park created tension among the communities. A management plan was developed to avoid conflict and reconcile the needs of the population and the conservation of the marine national park. The plan defined: which villages had the right to use the reefs and the conditions of reef use to be enforced: the limitation of fishing days; the prescribed size of nets; the species that could be collected and their size; and a ban on harpoons and fishing guns. Village committees are now involved in the enforcement and fulfilment of the plan and the activities of the fishing department consist in finding alternatives in effort to reach a long-term solution.

Ecological Monitoring: This includes marine and terrestrial biodiversity, biological inventories, vegetation studies including ecological succession and regeneration, rehabilitation of degraded areas, multiple resource use and land use planning and impact of local communities on national terrestrial and marine parks.

Socio-economic Monitoring: The population has adopted environment-friendly techniques introduced by the UNDP conservation and sustainable development project. Examples include a diversification of rice cultivation and fishing methods. The introduction of co-management of the marine park has influenced the way the population responds to the notion of conservation.

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

MAB

SAHAMALAZA-ILES RADAMA, MADAGASCAR – MAN AND THE BIOSPHERE RESERVE

This new Biosphere reserve in Madagascar was designated in September 2001. It has followed Mananara Nord in aiming to alleviate poverty while conserving the country's unique flora and fauna. It contains 12,402ha of core area (4,183ha of which is marine) and 40,900 of buffer zone (28,000ha of which is marine). Sahamalaza-Iles Radama lies in the extreme northwest of the country and its marine component contains a complex of coral islands and reefs. It is threatened by pressures from traditional and international fishing. The majority of the current research in this area is focused on sustainable use of natural resources. Topics include monitoring of regional shrimp fishing, investigation of alternatives for sustainable management of natural resources, feasibility studies for reforestation, feasibility studies for agricultural irrigation, and studies of insect control in agriculture.

Ecological Monitoring: No information provided.

Socio-economic Monitoring: No information provided.

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

Coral Reef Recovery and Conservation in the Comores

Mohéli Marine Park was a finalist in the Equator Initiative Award at the 2002 World Summit for Sustainable Development, recognising the partnership between communities and the government to establish the Park in 2001 (the first MPA in the Comoros). The park covers 404km^2 and extends out to 100m depth to include the rich fringing reefs that encircle 7 small islands opposite the village of Nioumachoi. There are also major green turtle nesting beaches. The park was established through collaboration with 10 local communities on the park boundaries and the government to reduce deforestation and destructive fishing. Fishermen and community associations defined the rights and responsibilities for the management, including the boundaries, zoning, management and regulations. Locally recruited 'eco-guards' help to raise public awareness and assist with policing and monitoring. Each village has a 'no-take' marine reserve within the Park boundaries, and the 10 reserves constitute 5.5% of the park area. After just 1 year, fishermen report significant improvements in fish catches and the reappearance of some fish species where fishing is allowed. The extent of recovery is being monitored. Much remains to be done to improve the Park: a management plan is being prepared; funds are required for management; regular monitoring must be introduced; and technical and management training is essential. Impacts from tourism are few, but could increase as the country is now more politically stable. The support from all levels of government and the community provides great hope for the long-term survival of the Park and Moheli's coral reefs. From: Said Mohammed, Fouad Abdou Rabi, Michel Vely, Rob Conway, Sue Wells, smw@iucnearo.org

6. Status of Coral Reefs in South Asia: Bangladesh, India, Maldives, Sri Lanka

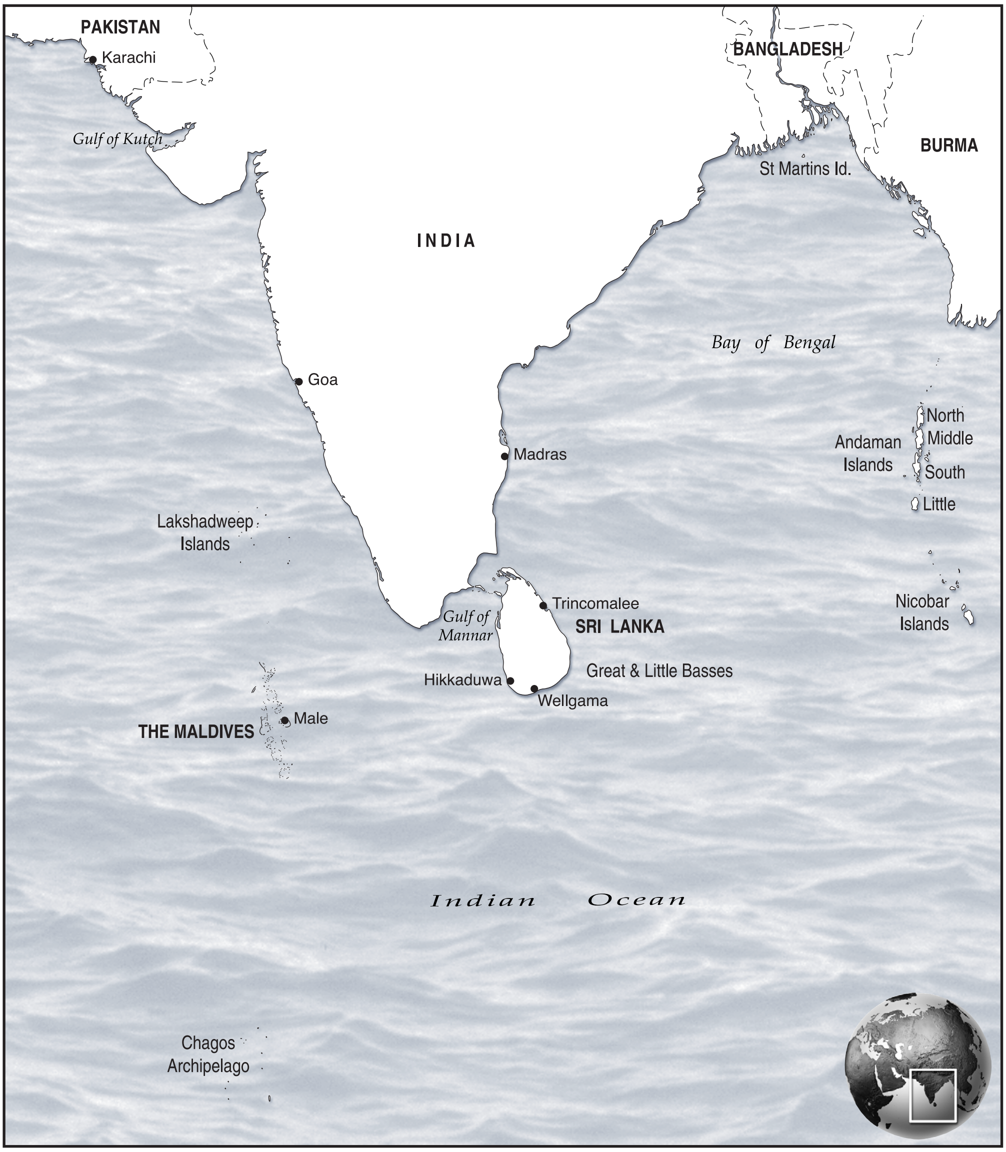
Arjan Rajasuriya, Venkataraman K., Muley E.V.,
Hussein Zahir and Ben Cattermoul

Abstract

Coral reefs in South Asia are either oceanic atolls such as those of Lakshadweeps, Maldives and Chagos or growing adjacent to the high islands of Andaman and Nicobar, the Gulf of Mannar and Gulf of Kutch in India and around Sri Lanka. In Bangladesh, the only coral reef is St. Martin's Island, and there are only scattered corals. There are no reefs in Pakistan. Recovery of corals killed during the 1998 El Niño bleaching event is slow, but should continue if there are no further major high temperature events. Other damaging impacts, such as the crown-of-thorns starfish, coral mining, destructive and unmanaged resource harvesting, sedimentation and pollution continue on the reefs in South Asia and reduce their capacity for recovery. This report contains more data on reef status, as a result of major increases in capacity for monitoring and more donor assistance. However, rarely are the monitoring data used in management decision making. Marine protected areas management continues to be weak, with a lack of government will, funding and capacity for conservation, as well as a lack of income generating alternative livelihoods for the user communities. A large Ramsar site has been established in Chagos, however, augmenting several Strictly Protected areas. Progress in designating more protected reef areas is also slow. This report highlights the increasing need to adapt policy and mechanisms for reef management to adequately reflect the local social, cultural and environmental conditions. This can only be achieved if the researchers and scientists produce information that can effectively inform and influence management and policy. More specific recommendations for improved use of information for management, sustainable use and conservation of coral reefs in South Asia are identified.

Introduction

The major coral reef resources are in India, Maldives, Sri Lanka and the vast Chagos Archipelago, in addition there is one coral reef in Bangladesh (St. Martin's Island) and only sparse coral communities in Pakistan. This status report updates the more detailed report produced in 2000 by Arjan Rajasuriya and others. Coral reef monitoring has been supported in this region since 1997 as a GCRMN Node by the UK Department for International Development (DFID) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The Coral Reef Degradation in the Indian Ocean (CORDIO), project supported mainly by Swedish aid funds, has also assisted with coral reef and socio-economic monitoring.



The largest coral reef areas are offshore in the Maldives, Lakshadweep (India) and Chagos atolls, and the large reefs off the Andaman and Nicobar Islands (India). There are also large areas of reefs off the coast of India (Gulf of Mannar and Gulf of Kutch) and around Sri Lanka, but these are generally in poor condition due to the activities of large populations of coastal people who depend on coral reef resources for their livelihood. The major physical influences are the southwest and northeast monsoons, and cyclones are very rare in the major oceanic reef areas, which are within 7°N and 7.30°S latitudes.

The macro economic benefits provided by coral reefs are the most apparent in the Maldives where the attraction of the coral reefs has contributed to the steady increase in

How the Poor Value their Reefs

There has been considerable work on the economic valuation of reefs to assist in forming policies related to both conservation and sustainable use of reef ecosystems. As part of efforts to support the livelihoods of the poor in coastal areas, the UK Department for International Development (DFID) wanted to know how the poor value reefs themselves. DFID commissioned Integrated Marine Management Ltd of the UK to work with reef-dependent communities in the Gulf of Mannar, the Andaman Islands and Lakshadweep Islands in India, and in Mozambique to collate examples of how different communities benefit from reefs and how they assess those benefit flows within their wider livelihoods. The benefits include not only the more obvious concerns, such as access to fish for food and sale, or the protection provided by reefs, but also spiritual benefits, a basis for learning, increased opportunities for women to engage in fishing, a focus for social collaboration, and increased access to a diversity of market opportunities provided by the wide range of species available. The project with the coastal poor will end in November 2002; progress can be followed at: www.ex.ac.uk/imm/rla.htm

numbers of tourists over the last 30 years, helping the sector to provide 33.1% of the GDP. The benefits to the other countries of South Asia from the coral reefs are the contribution to food and livelihoods of the nearby coastal communities.

A major climate related warming event in the first half of 1998 destroyed large areas of corals of the Maldives, Chagos and Lakshadweep atolls, reefs around Sri Lanka, and in India in the Gulf of Mannar. There were reports of mortality of 90% or more of corals following mass bleaching on reefs to 20m depth and beyond to 40m in the Maldives and Chagos. The dominant branching and table corals were the most affected, with almost total losses in many areas. This report provides data on the initial signs of recovery and new recruitment.

Bangladesh

St. Martin's is the only coral reef and it is heavily influenced by monsoons, frequent cyclones and heavy sedimentation from the Ganges, Brahmaputra and Meghna rivers. Corals exist as aggregations in seagrass beds and rocky habitats.

Chagos Archipelago

These 6 major atolls, many small islands and atolls, and submerged shoals form the southern end of the Laccadive-Chagos ridge. These constitute the largest area of near-pristine reefs in the Indian Ocean, and have high biodiversity. They belong to the United Kingdom with a US military base on Diego Garcia.

India

Coral reefs are found in 4 major areas. Two are adjacent to the mainland of India: Gulf of Mannar; and the Gulf of Kutch (Kachchh). The other two are the offshore island chains of the Andaman and Nicobars and Lakshadweep Islands. Fringing, platform, patch and barrier reefs occur around 21 islands (2 of which are submerged below 3m) along the

132km Gulf of Mannar coastline. Corals are also found along the mainland coast. One island in the Tuticorin group has disappeared below the surface due to coral mining. Most of the other reefs in the Tuticorn group are also mined, along with strong pressure from fisheries, including harvesting of sacred chanks (*Turbinella pyrum*), sea cucumber, pipefishes, and sea horses. Seaweed harvesting occurs in some islands of the Mandapam group. Particularly rich reefs grow around the 530 mountainous islands in the Andaman and Nicobars, of which only 38 are inhabited. The Lakshadweep (Laccadive) Islands consist of 12 atolls, 36 islands and 5 submerged banks at the northern end of the Laccadive-Chagos ridge. The islands are surrounded by 4,200km^2 of lagoon, raised reefs and banks and are the base for an important tuna fishery with minimal tourism. Coral and sand mining, erosion, coastal reclamation and crown-of-thorns starfish (*Acanthaster planci*) infestations affect the health of the reefs. In the **Gulf of Kutch**, 34 out of 42 islands have fringing reefs, but these have been severely damaged by sedimentation, industrial pollution, extraction of coral sand, fishing with poisons and explosives. As well there are stresses of high temperatures, salinity changes, turbid water and exposure during extreme low tides (range to 5.9m).

The Maldives
These islands form an archipelago (864km long, 130km wide) on the Laccadive-Chagos ridge, with 1,190 coral islands (300km^2), many sand cays and faroes within 23 atolls. The reefs are particularly rich and predominantly not impacted by anthropogenic activities. Coral reef tourism and offshore tuna fisheries are the major components of the economy.

Pakistan
There are a few isolated patches of coral growth on hard substrates, but more extensive growth is limited by the high sedimentation and very turbid conditions. There is almost no information available on these corals.

Sri Lanka
Corals grow on old limestone, sandstone and rocky reefs and also on 2% of the coastline as fringing reefs. The largest areas are in the Gulf of Mannar to the northwest and along the east coast. Reefs are important for fisheries, coastal tourism, and preventing coastal erosion.

Coral Reef Status and Biodiversity

Bangladesh
Coral communities extend to about 200m offshore of St. Martin's Island with maximum coral cover of 7.6% and colony density of 1.3 colonies per m^2. These consist of 66 hard coral species, the most common being *Acropora*, *Favites* and *Goniastrea*, which are the target for coral harvesters, as well as *Porites*, *Goniopora*, and *Cyphastrea*. There also many soft corals, sea fans, and sea whips. Other invertebrates are only represented by a few species, with molluscs being the most abundant large invertebrates, however, these are declining due to unregulated harvesting. Reef fish diversity is low (86 species) with damselfish (pomacentrids), surgeonfish (acanthurids) and parrotfish (scarids) being the most abundant. There are also 5 species of butterflyfish (chaetodontids) and one angelfish (*Pomacanthus annularis*). Predator species (groupers, snappers, and emperors) are heavily fished. There are no reports of coral bleaching from St. Martin's Island.

Chagos

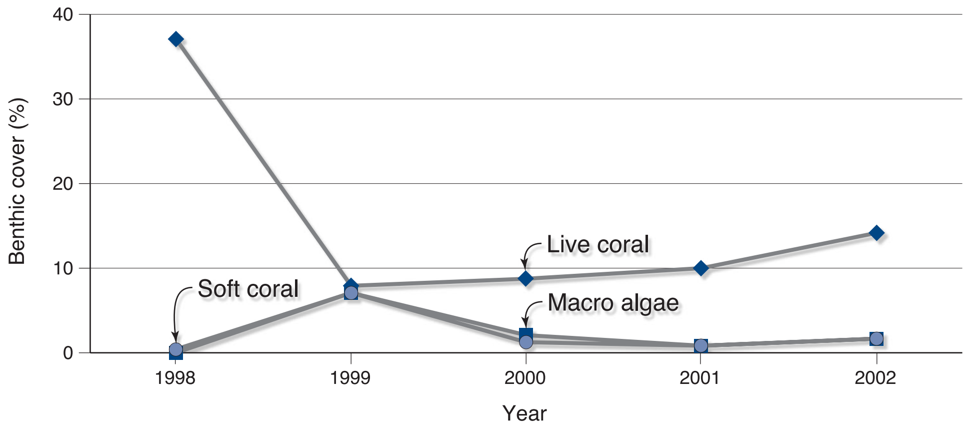
These reefs have among the highest species diversity of corals and molluscs in the Indian Ocean. There are several comprehensive studies on reef fish and other invertebrates, and reef-building corals have been relatively well studied. The smaller islands support large colonies of sea birds, sea turtles and 2 species of small cetaceans. Several of the uninhabited islands and surrounding reefs have a Strict Conservation status, while much of Diego Garcia is now a Ramsar site. Corals around Chagos were seriously affected by the bleaching event in 1998. Before this bleaching event, there was 50-70% live coral cover, 10-20% soft coral cover and approximately 10-20% bare substrate. However, after 1998, most of the live coral cover on the outer reefs was killed, including almost all of the table corals. Soft corals, fire coral (*Millepora* sp.) and blue coral (*Heliopora caerulea*) were also heavily impacted, while large *Porites* colonies on the outer slopes were only partially bleached, and calcareous algal ridges around the atolls appear to have been reduced. The corals in the reef lagoons survived better than those on the outer reefs, probably because they normally experience higher temperatures and have built up tolerance to temperature increases.

India

Biodiversity on the reefs in the **Gulf of Mannar** includes 94 hard coral species, with the most common being *Acropora*, *Montipora* and *Porites*. The 1998 bleaching event destroyed most shallow water corals and live coral cover was reduced by over two thirds, such that about 25% of live corals remain. The most affected were branching *Acropora* and *Pocillopora*. Massive corals now dominate on all island groups, with branching corals almost wiped out in the Tuticorin group, while only 1-2% survive on the other islands. Some patchy coral recruitment was seen on the mainland coast by the Zoological Survey of India, in 1999. There has been a further reduction in the live coral cover with more bleaching in early 2002 in shallow areas. Bleaching also affected many massive corals, but most have since recovered. There is now an average of 19.5% live coral cover on the 7 islands of the Mandapam group (dead coral 21.4%; sand and rubble 53.4%). Reef fish diversity and abundance has not been well documented.

The **Andaman and Nicobar Islands** have about 12,000km^2 of reef lagoons, coral banks, reef slopes and reef flat areas. North and South Andamans are dominated by *Porites*, while the Middle Andamans and Nicobars are dominated by *Acropora*. In all, 203 hard coral species occur on the islands such that coral diversity is much higher than reported previously. In the last 'Status' report, nearly 80% of the reefs in the Andaman and Nicobar groups were reported as being bleached, however recent surveys indicate that 56% of corals remain alive, with 20% dead coral and 11% coral rubble. There is no evidence of recent bleaching or damage caused by *Acanthaster planci*.

The highest live coral cover on the Nicobar Islands is 73.5% on North Reef, and cover in Car Nicobar and Outram are 72.7% and 67.3% respectively. These numbers, and the continued dominance of *Acropora* on the Middle Andamans and Nicobars, indicate that there has been no recent bleaching mortality. More than 1200 fish species have been recorded around the Andamans and Nicobars. Sponges, sharks, spiny lobsters, dugongs, dolphins and sea turtles are also exploited in the islands.



There is a clear signal in coral cover on the Lakshadweep Islands from the 1998 coral mortality event. Corals died off, and were followed by growth of soft corals and macroalgae (almost identical graphs), but now there are clear signs of coral recovery. From Rohan Arthur.

In the **Lakshadweep Islands,** 95 hard coral species were reported prior to the bleaching in 1998, which destroyed between 43% and 87% of the live corals. Then coral cover declined to about 10% around Kadmat Island, and current coral cover in shallow areas is about 1%. Now fleshy algae dominate in back reef areas, but not on fore-reef slopes. The atolls suffered different levels of coral mortality; Kadmat and Agatti were severely damaged with new evidence of rapid recovery, while Kavarati was affected less in 1998 and not much has changed since 2000. Reef recovery is better on the western side of the atolls e.g. many new coral colonies were observed in 2000 on the eastern side of the islands, but were lost by 2002, due to the higher wave energy. So far 603 species of reef and oceanic fish species are known from the Lakshadweeps.

Coral reefs in the **Gulf of Kutch** occur around 34 islands and grow under extreme environmental conditions of high salinity, low tides and large variations in temperatures. Most corals (42 hard coral species; 10 soft corals) grow on the northern side in the stronger currents, whereas on the East, there are mostly dead corals. Corals are also found on rocky reefs along the **Malvan** coast of India about 35km from Mumbai. Coral distribution is sparse with about 1-2 colonies per m^2, suspended sediment loads are high and the salinity often decreases to <15 ppt for several months of the year.

Maldives

Along with Chagos, the coral reefs of the Maldives also have particularly high coral diversity. A detailed biodiversity inventory has not been undertaken but 250 species of hard corals in 55 genera have been recorded in the central Maldives, with an even higher diversity on the southern atolls. Reef fish populations are diverse and extremely abundant, and over 1200 fish species have been recorded so far for the reefs and surrounding areas, with many of these being of economic and recreational importance. The invertebrates are poorly documented, but provisional estimates indicate that the Maldives is one of the richest marine areas in the region.

Live coral cover data 6 months after the bleaching in 1998 in the Maldives and again in 2002, showing that not all reefs were devastated, and some are showing slow recovery.

Reef Sites	1998	2002
Reef flat (1-2 m)		
Hodaafushi	1.6%	1.7%
Finey	0.7%	1.4%
Hirimaradhoo	0.9%	1.1
Emboodhoofinolhu	1.3%	1.9%
Bandos	1.7%	6.9%
Udhafushi	1.9%	2.9%
Fesdhoo	3.3%	22.1%
Mayaafushi	0.6%	2.7%
Velidhoo	0.2%	2.3%
Ambaraa	1.2%	2.9%
Wattaru	2.8%	3.7%
Foththeyo	5.0%	5.0%
Villingili	4.3%	13.2%
Kooddoo	1.0%	6.0%
Gan	4.0%	12.9%
Reef flat (3 m)		
Hithadhoo		51.6%
Reef slope (7 m)		
Gan		42.8%
Reef slope (10 m)		
Villingili		54.3%
Hithadhoo		40.9%

Coral reefs of the Maldives were in excellent condition prior to 1998, but were heavily degraded during the bleaching event. Surveys show that about 2% live coral remains on the reef tops at study sites (15 sites, with 3 in each region of: Haa Dhaal; North and South Male; Ari, Vaavu and Addu atolls). Observations by tourist divers and others indicate a similar status throughout the country, with approximately 90% loss of live coral cover compared to pre-bleaching observations. There was slight recovery by 2002 at almost all 15 sites surveyed in 1998.

There was more coral cover in the far south (Gan and Villingili) and central atoll sites (Bandos and Fesdhoo). It was encouraging that some sites added in 2002 had high coral cover indicating that the bleaching had been less damaging on the atolls in the south (coral cover 40 to 55%). Some corals that had not been seen since 1998 were observed for the first time in 2002 e.g. *Stylophora pistilata* and *Seriotopora hystrix* at Hithadhoo. These corals were thought to be locally extinct (not observed at 15 sites), however, it appears that some breeding stock has survived. Encouraging levels of recruitment have been observed at all the sites, with many acroporids and pocilloporids amongst the new recruits.

Pakistan

Detailed information on the biodiversity of reef habitats in Pakistan is lacking, although a marine reference collection and resource centre was set up in the University of Karachi in 1969.

Sri Lanka

The healthiest reefs in Sri Lanka were those remote from human settlements prior to 1998, with coral cover estimated at 80% on coral reefs of the Bar Reef Marine Sanctuary, more than 50% at Weligama on the south coast, and about 35% in the Hikkaduwa Marine Sanctuary, also in the south. Most shallow reefs of Sri Lanka were destroyed in 1998 including reefs around the northwest to the east coast, except near Trincomalee. Coral recovery is now variable. There were many small colonies of branching *Acropora* and *Pocillopora* in the shallows of the Bar Reef Marine Sanctuary in early 2002, indicating strong natural recovery. The number of tabulate *Acropora* colonies was higher than the branching *Acropora* colonies in 1-3m depth, with the largest new *Acropora* colonies about 100cm in diameter and 35cm high. However, new growth of live coral is patchy and much of the reef remains bare. The reef structure is largely intact due the growth of encrusting coralline alga. Coral growth was better at 7-8m depth with more species and 14% live coral cover (*Acropora* – 3.1%, plus *Montipora, Favites, Favia, Pavona, Cyphastrea, Hydnophora, Galaxea* and *Podabacea*). Butterflyfish are still rare on the Bar Reef, and some juvenile damselfishes were seen along with numerous herbivores (siganids, scarids and acanthurids).

There has been a slight improvement in the live coral cover in the Hikkaduwa Nature Reserve from 7% in 1999 to 12% in 2002, due mainly to an increase in *Montipora* species which escaped the bleaching. The only other coral survivors are the sediment tolerant species such as *Favia, Favites, Montastrea* and *Porites*. No new *Acropora* recruits were seen in 2002. A reef on a nearby limestone platform had much higher live coral cover and different species, including *Porites* (4.4% cover), *Acropora* (3.9%), *Favites* (2.4%), *Montipora* (1.3%) and *Platygyra* (1.2%).

The shallow reef at Kandakuliya, south of the Bar Reef Marine Sanctuary has been completely overgrown by *Halimeda* algae killing almost all the new coral recruits seen in 2001. The Rumassla (Buona Vista) reef in the south had 19.6% coral cover and recovery

Cover of live corals on reefs in Sri Lanka before and after the 1998 bleaching mortality, showing the extent of damage, with some recovery.

Location	Depth (m)	Pre-bleaching- live coral cover	1999 – 2000 live coral cover	2001-2002 live coral cover
Bar reef	0-3	78.5% overall in 1993-1994.	Nearly 100% mortality	Some new colonies; too few to measure cover.
Bar reef	7-8		Nearly 100% mortality	14%
Kandakuliya	0-5	22%	Small colonies present	Corals smothered by *Halimeda*.
Hikkaduwa Nature Reserve	0-4	47.2%	7%	12%
Hikkaduwa, South of Nature Reserve	7-13	Not estimated	Not estimated	17%
Rumassala	1-5	45%	19.6%	Better recovery at 4-5m; cover not estimated
Weligama	0-2	92%	28.0% 31.04%	54%

was mainly due to *Acropora*, *Hydnophora*, *Galaxea*, *Favia* and *Favites* species. The Weligama reef in the south also had encouraging recovery of branching *Acropora* after 1998, however this reef is being damaged by ornamental fish collectors operating amongst the live corals. Live coral cover was 21%, plus 28% *Halimeda* cover. The number of new coral recruits was 4.8 per m^2.

The Pigeon Islands in Trincomalee largely escaped the 1998 bleaching, but were damaged by a storm surge and cyclone in 2000, however some recovery has been observed. Crown-of-thorns starfish continue to be a problem and large numbers of local visitors are also damaging the reefs. Coral on the offshore reefs below 10 to 15m remain healthy.

Coral Reef Fisheries

There is little information on fisheries in this region, although they are of great importance to local communities and economies. Substantial information is available on the fisheries of Chagos, which is a well protected fisheries area in comparison with much of the Indian Ocean, with a permanent and active fisheries protection vessel. The tuna fishery is licensed, and a modest reef fishery is permitted and regulated. Elsewhere, most fisheries are for subsistence, hence data are not gathered for national fisheries statistics. This is also the case for marine ornamental fisheries, which are important in the Maldives and Sri Lanka.

Coral reefs provide approximately 25% of the marine fish catch in **India**, e.g. the annual catch in the Gulf of Mannar is 45,000metric tonnes per year, mostly demersal fish with some reef fish. The collection of sponges, gorgonians, corals, molluscs and shark fins was banned here and elsewhere in India in July 2001 as a reef conservation measure. In the Andaman and Nicobar Islands, the fish catch is around 26,550mt, mostly pelagic fishes including sardines. Tuna are the major fishery in the Lakshadweep and the **Maldives** and the live bait sprat are caught in coral reef lagoons. Recently a grouper fishery commenced in the Maldives for the live food fish trade and also to supply tourist resorts. Shark (for the fins) and sea cucumbers are fished exclusively for export. In **Sri Lanka**, the bulk of fishery products are consumed in local communities, thus there are poor statistics. The export fishery includes lobsters, sea cucumber, sacred chanks and ornamental fish. Reef fish are not differentiated in fisheries statistics, but are included as ‘rockfish’ within the coastal fisheries which average from 9,000 to 10,000mt each year (10,585mt in 1994; 9,100mt in 1997; 9,200mt in 1998). The aquarium trade accounts for 40-50% of the US $6.6 million export trade. Export of molluscs is also a major component. The main reef fishery in **Bangladesh** is small-scale using bottom-weighted gill nets and hook and line. There are also export fisheries for sea cucumber and molluscs.

Threats to Coral Reefs and Management Issues

The region can be divided into two groups when considering threats to coral reefs: Chagos, the Maldives and the Indian Lakshadweep and Andaman and Nicobar Islands are relatively remote from human impacts; whereas the coastal reefs off Bangladesh, India, and Sri Lanka are heavily impacted by human activities with these increasing as populations and economies increase.

The major threats to the coral reefs in coastal Bangladesh, India, and Sri Lanka are high levels of destructive fishing, industrial, agricultural and domestic pollution, sedimentation and coral mining. This is combined with major changes to coastal habitats from human settlements and increased industrial development. There are two main categories of fishing activities that occur within the coastal waters of South Asia, industrial and artisanal, each posing threats to the coral reefs of a different type and magnitude. In the Gulf of Mannar, bottom trawling by semi-industrial vessels is a major threat to the reefs.

In a sector which is characterised as labour intensive with low mechanical sophistication, the artisanal fishermen of South Asia receive a wide range of benefits from the coral reef resources. The proliferation of damaging gears and crude fishing techniques (bamboo traps, set nets and blast fishing) in **India** and **Sri Lanka** are, however, posing serious threats to the sustainability of the resources. There is also widespread collecting for the aquarium trade and harvesting of molluscs, as well as turtles and dugongs, which are all seriously endangered. Coral and sand collection for building, making of lime and curios continues to damage coastal reefs. Industrial and domestic pollution continues to be a significant threat, particularly in the Gulf of Kutch, where industrial growth is having a severe impact on the coral reefs.

The more remote **Indian** reefs on the Andaman and Nicobar Islands are being impacted by increased sediment flows to the nearshore reefs due largely to unregulated logging and encroachment into the forestry reserves by settlers. Some damage has occurred through coral mining, dredging and blasting of corals for navigational channels. Fishing activity is increasing on these reefs as well as on the Lakshadweep Islands where fishing in the lagoons for live bait for tuna is increasing. There are some minor examples of pollution from untreated sewage. Bleaching on the Lakshadweeps was severe in 1998 with major losses of corals.

Most reefs in the **Maldives** are better protected, mainly because of their isolation from human activity. The main damage to reefs occurs around the heavily populated islands e.g. the capital Male and nearby islands. Coral mining, dredging of channels for boats and coastal construction have resulted in extensive damage to the reef flats around some of these islands or major changes in sand distribution and erosion. Reef fisheries are increasing, and the extensive grouper fishery may already be affecting the grouper stocks. Infestation by crown-of-thorns starfish has also impacted on the reefs in the past (1980s) but no major incidences have been reported recently. Damage during the 1998 El Niño bleaching event was severe on both populated and remote reefs. The only threats to the **Chagos** reefs are through coral bleaching and more recently through illegal fishing, including the collection of sea cucumbers, shark and possibly live fish for the restaurant trade in East Asia. The fisheries protection vessel now appears to be deterring the shark fishing.

Climate Change and Impacts

The areas which are vulnerable to sea level rises are the low-lying parts of atolls and coastal regions, whereas the coral reefs themselves will be only minimally affected provided they still contain healthy coral populations. There has been coastal erosion, and saline intrusion into fresh groundwaters along the western and southern coasts of Sri

Lanka and a possible increase in cyclone activity in the Bay of Bengal (Bangladesh and India) will cause greater erosion and loss of economic activities.

Awareness by governments increased radically with dramatic rises in seawater temperatures in the Indian Ocean during the first half of 1998, accompanied by widespread coral bleaching and destruction of coral reefs in Chagos, the Maldives, Sri Lanka and western Indian regions. Average sea surface temperatures have risen by 0.12 to 0.16°C per decade during the last 50 years and a continuation will have major impacts on the coral reefs.

Status and Gaps of Marine Protected Areas (MPAs), Monitoring and Capacity

The need for Marine Protected Areas (MPAs) covering coral reefs has been recognised by all governments, but commitments to the management of existing MPAs and the planning for new areas are still inadequate to ensure conservation of the coral reef resources. However, monitoring capacity has improved greatly in South Asia, particularly in India following activities of the GCRMN South Asia Node, funded by the UK Government. Monitoring and area protection increased significantly recently on Chagos.

India has 36 MPAs of which 20 are entirely coastal areas (intertidal, mangroves, coral reefs, lagoons, estuaries, beaches), and 13 have major marine ecosystem components. These include 3 Man and the Biosphere reserves. There are 5 coral reef MPAs in **India**: Gulf of Mannar Biosphere Reserve 10,500km^2 which includes Gulf of Mannar Marine National Park (Ramathapuram to Tuticorin, 1980, 6.23 km^2); Gulf of Kutch Marine National Park - 400km^2 (includes Marine Sanctuary, Gulf of Kachchh, 1980, 295.03 km^2); Mahatma Gandhi Marine National Park/Wandoor Marine National Park in Andamans -

Sri Lanka and Maldives Coral Reef Forums

The GCRMN South Asia has initiated coral reef forums in Sri Lanka and the Maldives to build communication networks. These forums brought many of the coral reef stakeholders together to share ideas and information, and to suggest new ways of tackling the highly complex issues facing coral reefs. Representatives from a diverse range of organisations and institutions including User Group Associations, NGOs, Universities, Government Ministries, Government Agencies, Divisional Secretaries, Donor Projects and International Initiatives, discussed issues relevant to the long term future of their coral reefs. As the forums develop, it is hoped that they will encourage a more coordinated and coherent approach to coral reef management and permit the exchange of ideas, information and best practice. A positive start has been made in Sri Lanka where CORDIO and SACEP are working with the Sri Lanka Coral Reef Forum to review past alternative livelihoods initiatives within Sri Lanka and produce recommendations for future initiatives. For further information see: www.ioc.unesco.org/gcrmn or contact the GCRMN national coordinators -National Aquatic Resources Research and Development Agency (Arjan Rajasuriya arjan@nara.ac.lk) Maldives: The Marine Research Centre of the Ministry of Fisheries Agriculture and Marine Resources (Hussein Zahir - marine@fishagri.gov.mv)

Current status of Marine Protected Areas in South Asia and an indication of slow progress.

Marine Protected Areas	MPA Status	MPA Management	Major issues
Bangladesh St. Martin's Island (in National Conservation Strategy protected area programme).	Small coral reefs & scattered coral growth on limestone, rocky habitats; corals and other reef resources rapidly degrading	Management weak due to single sector approach; lack of trained manpower in coastal and marine affairs for enforcement & management.	Sedimentation, coral mining, mangrove cutting, pollution, over-exploitation. No progress since 2000.
Chagos (B.I.O.T.) Several protected areas; 1 Ramsar site. Management plan being prepared to recommend extension of strictly protected areas.	Massive mortality in 1998. Extensive new coral recruitment from surviving patches; mostly on eroding table corals & rubble substrate	Diego Garcia Strict Nature Reserves and Ramsar site currently effective; some recreational fishing allowed. All other Strict nature Reserves no-entry areas; no human disturbance.	No specific major issues as archipelago uninhabited; good compliance in Diego Garcia.
India mainland Gulf of Mannar Biosphere Reserve (1989)	Some areas highly degraded; damaged in 1998 bleaching. damage continues due to over-exploitation & sedimentation	Action Plan prepared; weak implementation & management.	Coral & sand mining, over-exploitation, sedimentation & industrial pollution. No progress since 2000.
Gulf of Kutch Marine National Park (1980)	Heavily degraded.	Action Plan prepared but weak management. No buffer zones, & possible losses for industrial development	Coral mining, mangrove cutting, industrial pollution and sedimentation. No progress since 2000.
Lakshadweep One national park declared	Corals not recovered after the 1998 bleaching.	Management is weak	Subsistence fishing & coral mining. No progress since 2000.
Andaman & Nicobar Islands Mahatma Gandhi Marine National Park, (Wandur National Park) Andaman Islands (1983)	Coral reef resources relatively well protected.	Action Plan has been implemented	Sedimentation, crown-of-thorns starfish, tourism & souvenir collecting. No progress since 2000.
Rani Jansi Marine National Park, Ritchie's Archipelago (1997)	No information	Action Plan has been implemented	No information. No progress since 2000.
Maldives 25 MPAs established. (15 Sites in 1995) (10 Sites in1999)	Good condition except for 1998 bleaching; massive coral losses.	All are tourist & popular dive sites. Little active management or enforcement. Lower human impacts than other countries in region.	Boat anchoring, dive tourism, crown-of-thorns starfish, conflicts between tourism & fisheries users. No progress since 2000.
Sri Lanka Hikkaduwa Nature Reserve (1979 upgraded in 1998.	Very poor condition, 7% coral cover in 1999, poor recovery except some large corals.	Management plan exists since 1996, no active management, MPA zones lost due to lack of maintenance.	Sediments, physical damage by glass bottom & fishing boats, reef trampling, sewage pollution.
Bar Reef Marine Sanctuary (1992)	Shallow coral areas highly degraded in 1998 bleaching. no management.	Management issues identified, recommendations made,	Crown-of-thorns starfish, over-exploitation of fish, chanks, sea cucumbers, ornamental fish. No progress since 2000.

THE MARINE PROTECTED AREAS PROJECT – THE MALDIVES

The Maldives Protected Area project has been funded by AusAID (Australian aid agency) to contribute to the protection of ecological resources in the Maldives, and thereby supporting long-term ecological sustainable development and biodiversity maintenance. The project began in 1997 and is focused on establishing a system of protected areas by first establishing pilot or prototype sites. The aim is to use the pilot sites to illustrate the constraints for the establishment of a national system and suggest remedial methods. The first pilot site on the island of Hithadhoo in Addu Atoll, is representative of many of the biological, cultural, community and institutional issues that face the Government of the Maldives and many other small island developing nations. After site selection, the project undertakes biological and socio-economic surveys as well as establishing the potential boundaries and management options. It also conducts a community participation program, instigates an educational program, and transfers the skills to national counterparts. Recommendations arising from the establishment of the pilot sites focused on changes to legislation and institutional arrangements, community awareness systems and the level of assessment and monitoring required for the site as well as the type of management plan that could be adopted. Contact: Geoff Dews, AusAID MPAs Office, dews@ozemail.com.au

282km^2; Great Nicobar Biosphere Reserve - 885km^2; and Rani Jhansi Marine National Park 256 km^2 (Richies Archipelogo). All MPAs suffer from encroachment by coastal populations with destructive activities and loss of resources, although the more remote MPAs on the Andaman and Nicobar Islands and in the Lakshadweeps are better protected. Resources, both human and logistic, for management and enforcement are inadequate. Virtually all the MPAs in the **Maldives** are small and associated with tourist locations; hence the management is provided by the tourist operators, with little involvement of the government. This management focuses on large fishes and associated fauna. The 2 MPAs with coral reefs in **Sri Lanka** have adequate management plans and protective legislation, however, there is no effective management and the boundaries are ignored by local communities.

Many more sites are under consideration for management, often through the assistance of external project activities, but greater government commitment towards conservation is essential for success. The one coral reef area in **Bangladesh** continues to decline in status.

India had no coral reef monitoring prior to 1998 due to a major lack of equipment and trained scuba divers, and also to a lack of government and community support. Since then, Coral Reef Monitoring Action Plans (CRMAPs) have been prepared for all areas, and programs are in progress to train people to monitor the reefs. Progress, however, is slow. Several Indian scientists were given scuba and coral taxonomy training in Australia through the GCRMN, and a Handbook of Corals of India is being prepared. The Zoological Society of India started a 3-year ecological monitoring program in the Gulf of Mannar to provide ground truthing of maps being constructed by the Space Application Centre, Ahmedabad. These activities are linked into the Global Environment Facility project on the Biodiversity of Gulf of Mannar.

While there has been considerable reef monitoring in the **Maldives**, this information is scattered and virtually none is used to support decision-making. Moreover, many monitoring programs have been discontinued when projects have finished with the government not providing continuity. The **Maldives** needs a coordinated approach to the monitoring and management of these resources that are critical for the tourist industry. The reefs in MPAs in **Sri Lanka** have been well monitored in the past, however, this information is not used by government for site management. All sites close to shore in Sri Lanka show clear signs of human damage, and this was compounded in 1998 during the mass bleaching event.

Government Policies, Laws and Legislation

All countries in the region have established laws to conserve natural resources, with some including specific legislation on corals and coral reefs e.g. the **Maldives**. However, these laws are rarely enforced through a lack of government and community awareness of the problems facing the coral reefs and the need for management, and through a lack of capacity in government and private sectors to implement monitoring and management.

In **Bangladesh**, the government has the power to establish a national park for their one coral reef, St Martin's Island, but this has not been implemented, despite calls for its conservation.

The government of **India** also has laws to protect coral reefs and other coastal environments and prohibit the collection of corals. All the hard corals and gorgonians were included in 2001 in the Schedule List of Wild Life Act of 1972. The Indian Coral Reef Monitoring Network and the Indian Coral Reef Initiative were established in late 1990s to provide a cross-sectoral approach for coral reef management. The Ministry of Environment has funded training programs in monitoring, conservation and management in the 4 major coral reef areas; data are stored in a GCRMN, South Asia database as a further aid for management. The National Coral Reef Research Institute has been established in Port Blair (Andamans) to provide research support for coral reef management and conservation. Similarly an Indian Society for Coral Reef Studies was formed and there is a capacity building program through Australian assistance.

Many government sectors of the **Maldives** are involved in coral reef management, particularly in recognition of the importance and value of reefs to their economy, especially through tourism. Some of the more remote atolls still have systems of traditional management and some of these have been incorporated into fisheries law. Regulation of coral mining was seen as a key issue in 1992 and specific regulations were enacted then to prevent coastal erosion.

Similarly, many ministries and government departments in **Sri Lanka** have coastal management responsibilities, but this results in cross-sectoral disputes, or else problems are ignored. Environmental issues have received lesser focus in government recently due to the ongoing instability. A coastguard has been established to control illegal fishing, but it is under-resourced.

Linking Reefs to Policy

Much has been done to develop conservation of coastal resources in South Asia, but the poor still find themselves marginalised by coastal development. A project was developed by DFID, UK to explore the linkages between coastal policy and poverty and to develop guidelines to overcome some of these difficulties. The Sustainable Coastal Livelihoods project (IMM Ltd. UK) focused on India, Bangladesh and Sri Lanka, and identified key policy problem areas that affect the involvement of the poor to determine ways to skirt these problems. A critical issue was the need for the right information about coastal issues to reach the target audience in the most appropriate format to facilitate appropriate behaviour change. The project developed an approach to influence strategy formulations that has been piloted through GCRMN workshops in Sri Lanka, India and Maldives. This has helped workshop participants view their informing and influencing roles in relation to reef issues in a much more collaborative way, realising that working together provides greater influence than working alone. More information is available on: www.ex.ac.uk/imm/SCL.htm

Coral Reef and Coastal Resources Management Project in Sri Lanka

A project for coastal rehabilitation, harbour construction and institutional strengthening of the Sri Lanka Ministry of Fisheries and Ocean Resources has been funded by the Asian Development Bank and the Netherlands. The objective is to establish 6 Special Management Areas along the coast, with 3 of these focused on the protection and conservation of significant coral reef resources. The project aims to protect Bar Reef by: offering 'best industry practices' information to fishermen to sustain fish stocks; organising public awareness and education programs to publicise the value of sustainable exploitation of the reef to stakeholders; assisting with the development of a management and zoning plan to protect the reef ecosystem, perhaps by promoting it as a marine sanctuary; and implementing alternative livelihood schemes to remove pressure on the reef resources.

At Hikkaduwa, a Special Area Management Committee has been established to develop a clear boundary and zonation of the coral reef sanctuary to separate swimmers, tourist boats and fishermen from research and re-growth areas of the reef. The sanctuary must first be up-graded to National Park status before the zonation can have firm authority.

The project is providing technical and financial support to the Community Coordinating Committee (CCC) of Unawatuna to prepare a Special Area Management plan and for activities that assist the community with habitat rehabilitation and coral reef conservation. The Unawatuna fringing reef is an important attraction for tourists that generate a major livelihood for many Unawatuna stakeholders.

Conclusions

- The 1998 El Niño bleaching destroyed most branching shallow water corals in the Maldives, Sri Lanka and Southwestern India, with lesser impacts in Gulf of Kutch and Andaman and Nicobar Islands. Recovery is slow, with patchy, but encouraging, recruitment observed in most reef areas of South Asia.
- The coral reefs of South Asia affect, and are affected by, a wide range of stakeholders, which complicates the issues faced by resource managers. The problems will not be solved with isolated interventions, but an integrated response is necessary. This will require greater will by South Asian governments, assisted by the international community. There are now the resources and skills to potentially have a positive impact, but coordinated and coherent action is required.
- Degradation of the coral reefs continues, with populations growing and coastal development increasing. The major threats come from uncontrolled resource exploitation, coral mining, sedimentation and pollution. The reefs are also subject to a range of 'natural' impacts, crown-of-thorns starfish and impacts related to climate change, such as coral bleaching and cyclones, but the reefs normally can recover after these, if there are no additional stresses.
- Monitoring capacity has improved to a major extent since the GCRMN Node for India, Maldives and Sri Lanka was established in 1996. Progress is most apparent in India, where there was virtually no capacity before 1996. Despite the increased availability of information, management and policy decisions at national and local level continue to be made with little regard for the local social, cultural and environmental conditions. This results in management and policy, which is not effective in reversing reef degradation in the region. Where information is produced, it is important to ensure that there is effective dissemination to inform and influence the stakeholders that affect and are affected by the benefits of coral reefs.
- The Chagos Conservation Management Plan will focus on the uninhabited islands and the reefs, and effective environmental management exists for Diego Garcia. Emphasis is shifting to extensive protected areas, and most of Diego Garcia atoll was declared a Ramsar protected area. The entire archipelago is considered as a 'virtual' World Heritage site, but designation is currently impeded for legal and logistical reasons. There is now effective fisheries protection.
- The role of the GCRMN is evolving within the region to one of coordination, guidance and targeted support for the information providers and information users at the local, national and international levels.

Regional Recommendations

- International policy, and donor funding decisions are too frequently made with little regard for local social, economic, cultural and environmental conditions. There is a clear need to ensure that the international decision making process is grounded in the reality of local conditions.
- There is a need to highlight past and present research and management interventions and build upon these, rather than simply repeating past approaches.

- Stakeholders at all levels need to be involved in management and policy decision making.
- There is a need to build confidence between the stakeholder organisations within South Asia, particularly between government and NGOs.
- Linkages between Indian and Sri Lankan researchers and managers in the Gulf of Mannar need to be explored and developed.
- National level policy, management and enforcement needs to be stable and applied, if progress is to be made towards a sustainable future.
- Reef fisheries require improved evaluation and viable alternative and sustainable livelihoods should be identified and developed for communities dependent on threatened reef resources;
- The capacity to develop and implement regulations relating to resource extraction should be strengthened.

Bangladesh

- There is a need to develop and implement government directed conservation, management and protection programs to conserve St. Martin's Island, with ecological, socio-economic and user monitoring programs included.

Chagos

- The Conservation Management Plan needs to be completed and current conservation enforced and, where applicable, strengthened. Designation as a World Heritage Site would be an advantage.

India

- There is a need for central government recognition of the essential economic and social values of each coral reef area, then integrated action between government departments, institutions and local groups to implement Management Action Plans;
- Networks of coral reef information providers within India should be developed and strengthened, including the ICRMN, to provide information, analysis, coordination and coherence for policy and programs to conserve coral reef resources;
- Capacity in coral reef ecological and socioeconomic assessment should be strengthened, to include involvement of reef dependent communities as the basis for raising awareness and influencing change in the behaviour of stakeholders who affect and are affected by coral reefs;
- There is a need to provide training and awareness across India on concepts of conservation and sustainable use of coral reef resources.

Maldives

- More training is required in marine resource conservation, management and assessment;
- Collaboration between government research groups, policy formulators, local communities, NGOs and international organisations is required;
- The role of the tourist industry in reef conservation needs to be recognised and it needs to be urged to collect and use coral reef monitoring information;

- Training and awareness raising at all levels is required to better appreciate the concepts of conservation and sustainable use of coral reef resources.

Pakistan

- There is a need to locate and identify reef resources and develop the capacity to assess them with a view towards conservation.

Sri Lanka

- Information collection and dissemination on the social and economic benefits of coral reefs is required to convince decision makers of the need for reef conservation;
- Communities reliant on the reefs require the development of alternative sustainable livelihoods and assistance in vocational training to develop alternative skills within fisher communities;
- Existing marine resource use plans need to be strengthened and implemented and the capacity for management developed to adequately reflect the importance of the coral reefs to Sri Lanka;
- Management of marine protected areas should be improved by delineating boundaries, increasing capabilities of day to day management such as patrolling and training of personnel, and educating local communities of the long term benefits of sustainable use of reef resources.

Reviewers

Rohan Arthur, James Cook University, Australia; Barbara Brown, University of Newcastle, UK; Alasdair Edwards, University of Newcastle, UK; Charles Sheppard, University of Warwick, UK; Ole Vestergaard, IOC/UNESCO, Paris; Dan Wilhelmssen, Stockholm, Sweden; Susie Westmacott, U.K.

Acknowledgements

We would like to thank participants from the GCRMN South Asia who contributed not only to this report, but also the continued progress within the region towards securing a future for coral reef resources.

Supporting Documentation

Muley EV, Alfred JRB, Venkataraman, K, Wafar MVM (2000). Status of coral reefs of India, 9 Int Coral Reef Symp Proceedings (in press).

Rajasuriya A, Zahir H, Muley EV, Subramanian BR, Venkataraman K, Wafar MVM, Munjurul Hannan Khan SM, Whittingham E (2000). Status of Coral Reefs in South Asia: Bangladesh, India, Maldives, Sri Lanka. In: Wilkinson, C. (ed). Status of Coral Reefs of the World: 2000, Australian Institute of Marine Science and Global Coral Reef Monitoring Network, Townsville, 363p.

Kulkarni S (2002). Coral reef research in the Andaman and Nicobar Islands; The conservation status the coral reefs. (Report presented at GCRMN South Asia India National workshop 8-10 September 2002)

Patterson Edward JK (2002). Report on coral reef work in Tuticorin coast, Gulf of Mannar by SDMRI Suganthi Devadason Marine Research Institute (SDMRI), (submitted for the GCRMN South Asia India National workshop 8-10 September 2002)

Sampath V (2002). Status of coral Reefs of India (Report presented at GCRMN South Asia India National workshop 8-10 September 2002)

Turner JR, Vousden D, Klaus R, Satyanarayana C, Fenner D, Venkataraman K, Rajan PT, Subba Rao NV (2001). Report of Phase I: Remote sensing and Rapid Site Assessment Survey, April 2001. Coral Reef systems of the Andaman Islands. Government of India and United National Development Programme, Global Environment Facility, 76p, with 8 Appendices and 55 Figures and Plates.

GCRMN South Asia Node

Since 1997, the GCRMN South Asia Node has evolved to fit the changing needs of its partners. The work program was revised in 2001 by the participating governments, the Node coordinator, and the financial and technical supporters DIFD (UK) and IOC of UNESCO (respectively). Now the focus is on these core activities:

- Enhancing the capacity developed among national and regional counterparts to develop and implement coral reef monitoring programs;
- Developing monitoring systems for the ecological and socio-economic aspects of coral reefs designed and adapted for national, regional and global use;
- Enabling processes for more effective use of coral reef monitoring data so that it feeds through to coral reef management planning; and
- Generating public awareness and understanding of issues related to sustainable use and management of coral reefs.

During the project, the capacity to collect and store ecological and socio-economic data has been significantly improved in India, Sri Lanka and the Maldives. This is reflected by increasing numbers of government departments, NGOs and universities who are undertaking research and management work to improve the status of the reefs and the reef dependent communities across the region. In order to develop this further, the project has focused on developing the skills needed to use information to inform and influence a change in the stakeholders deriving benefits from the coral reefs of the region. This work has been done in conjunction with Integrated Marine Management UK and the DFID funded Sustainable Coastal Livelihoods project within South Asia. The Node has continued to form strong links with other national and regional initiatives to improve coordination and coherence within the coral reef work undertaken. The 2nd phase of funding for the South Asia Node of the GCRMN, provided by the UK Department for International Development, is due to finish in December 2002 and negotiations over future funding options for the project are underway.

Node Contacts and Representatives: India: The Ministry of Environment and Forests (E.V. Muley, muley@vsnl.com); Sri Lanka: National Aquatic Resources Research and Development Agency (Arjan Rajasuriya, arjan@nara.ac.lk); Maldives: The Marine Research Centre of the Ministry of Fisheries Agriculture and Marine Resources (Hussein Zahir, marine@fishagri.gov.mv); Regional Coordinator: Ben Cattermoul, 53 Horton Place, Colombo 7, Sri Lanka: reefmonitor@eureka.lk; IOC/UNESCO (Ole Vestergaard; o.vestergaard@unesco.org). GCRMN South Asia: www.ioc.unesco.org/gcrmn

MAB

GULF OF MANNAR, INDIA – MAN AND THE BIOSPHERE RESERVE

The Gulf of Mannar Biosphere Reserve, the first Biosphere Reserve in South and Southeast Asia regions, is one of India's biologically richest coastal regions. The Reserve stretches for 180km along the coast of the Gulf of Mannar in Southern India and encompasses 21 small islands. The area is home to 3,600 species of plants and animals and is endowed with a combination of different ecosystems including mangroves, seagrass beds and coral reefs. Forty villages dot the coastline opposite the Reserve. Most of the 50,000 people inhabiting these villages are directly dependent on fishing, seaweed collecting, or other coastal activities for their livelihoods. Significant elements of the Gulf of Mannar are the extensive and diverse seagrass beds, which are some of the largest remaining feeding grounds for the globally endangered dugong and 5 species of marine turtles; Green, Loggerhead, Olive Ridley, Hawksbill and Leatherback. The Gulf's seagrass communities are valuable habitats for commercially harvested species, particularly the green tiger prawn, sea cucumbers, and several species of seaweeds. The Gulf of Mannar also has 117 species of coral belonging to 7 genera and 17 different mangrove species, one of which is endemic to the area.

In 2002 the UNDP, in association with the Global Environment Facility (GEF), financed an initiative in the Gulf of Mannar Biosphere Reserve aimed at strengthening the capacity of local communities, particularly women, for managing the coastal ecosystem and wildlife resources. The project will demonstrate new approaches to the integration of conservation, sustainable coastal zone management and livelihood creation through an innovative institutional and financial mechanism.

Ecological Monitoring: Many Indian research and development institutions, including the Central Marine Fisheries Research Institute, National Institute of Oceanography, and Madras University, have on-going research and monitoring programs in the Gulf. Research focuses on climate change, coral mining, pollution, bio-prospecting, and threatened species. Long-term monitoring of fisheries and of marine flora and fauna has contributed to the development of an integrated ecosystem management model for sustainable resource harvest.

Socio-economic Monitoring: No details were provided.

Coral reefs are **50%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **unknown.**

7. Status of Southeast Asia Coral Reefs

Loke Ming Chou, Vo Si Tuan, PhilReefs, Thamasak Yeemin,
Annadel Cabanban, Suharsono and Ith Kessna

Abstract

Most of Southeast Asia's coral reefs continue to remain under threat, mainly from anthropogenic impacts. Weak management capacity contributes to the further degradation of reefs, particularly from destructive and over-fishing. The lack of monitoring capacity in some areas adds to the difficulty of reaching more accurate assessments. Amid the general widespread trend of declining health are isolated instances of effective management and successes in reef protection. The reefs of Indonesia that were monitored under COREMAP showed improvements in live coral cover. Active management resulted in improved reef health from monitoring reports in Thailand and Vietnam. Also evident is the recent and renewed expansion of reef monitoring and management activities supported by international agencies. The transfer of lessons learned from successfully managed reefs and the overall enhancement of management capacity are strong requirements to overcome the general decline of reef health in the region.

Turning a Bomb Fisher Into a Resource Manager in Indonesia

In North Suluwesi, Indonesia, awareness raising within the Blongko community transformed the life of Salindeho (Pak Deho) Adilang, who once gained his livelihood from bomb fishing on coral reefs. Now he is a member of the community sanctuary management board and firmly on the side of reef conservation. A theme in Proyek Pesisir (a USAID funded project) was to teach community members how to assess and monitor reefs to prepare maps of the resources as a prelude to management. They trained Pak Deho how to assess reefs over a large scale using the manta tow technique (a method recommended by the GCRMN) and took him to an area where blast fishing was rampant. When he saw the damage that the bombs were causing to the corals, he reformed his illegal behaviour to become a supporter of the reefs. He subsequently joined the sanctuary management committee, and when a Canadian film crew asked him about the change, he replied that he started bomb fishing when he was young and did not know what he was doing.

Proyek Pesisir recommend seeking out the bomb fishers and involving them in monitoring training, thereby complementing their expertise on the water. Some can take up a leadership role in further training and eventually resource management. This approach is a start, but cannot tackle the problems of bomb fishers from outside the community. The value of involving community members in monitoring and mapping activities has been in transforming many stakeholders into stewards – 'when you start mapping, things happen'. After training in assessing coral reef quality, the community generated their own coral reef map. The head of the nearby Talise marine sanctuary management committee stated that the map produced by the exercise was the catalyst for the community to establish a sanctuary; 'the project did a survey of the resources here, and the villagers thought it was important to keep it'. From Proyek Pesisir. Johnnes Tulugen (tulungen@manado.wasantara.net.id) or Brian Crawford (crawford@gso.uri.edu)

Introduction

Southeast Asia's 100,000km^2 of coral reefs is 34% of the world's total, and also contains the highest coral biodiversity. The recent Reefs at Risk analysis estimated that 88% of the region's reefs were at risk, with half at 'high' or 'very high' risk. Over-fishing threatens 64% of the reefs while destructive fishing threatens 56%. Coastal development affects 25% of the reefs, and a further 20% face the impact of agriculture and deforestation. Over 90% of the reefs of Cambodia, Philippines, Vietnam, and Singapore are threatened, as are the Spratly Islands in the South China Sea. For Malaysia and Indonesia, over 85% of the reefs remain under threat. It was further noted that the region's 646 Marine Protected Areas (MPAs) covered only 8% of its reefs. This inadequacy in management is further emphasised by the fact that only 14% of the 332 MPAs where management effectiveness could be assessed were considered to be well managed.

Increased attention from international agencies was more evident in the past two years. A UNEP/GEF regional project 'Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand' was implemented in 2001 with coral reefs as one of its focus ecosystems. In an ICRAN (International Coral Reef Action Network) project, also implemented this year, capacity transfer in reef management was targeted. Reefs under different but successful management regimes were identified to serve as demonstration sites to benefit identified target sites through transfer of learning experiences and expertise. Three management regimes were selected: integrated coastal management; ecotourism; and community-based management. UNEP's Regional Coordinating Unit for East Asian Seas (RCU-EAS) is currently managing a small grants initiative to enhance coral reef monitoring in the region. At an international workshop on World Heritage sites held in Hanoi early this year, over 20 reef sites throughout Southeast Asia were identified as having outstanding universal value and feasible for nomination for World Heritage status. The Sulu-Sulawesi seas are identified as one of the world's marine ecoregions by WWF, based on its marine biodiversity. A Biodiversity Conservation Vision for the Sulu-Sulawesi Marine Ecoregion has been formulated and joint activities between the three countries sharing those seas (Philippines, Indonesia, Malaysia) are being developed.

In October 2001, the Universiti Malaysia Sabah, conducted the 'Regional Workshop to Establish a Network of Marine Protected Areas in the East Asian Seas Region' with funding from the UNEP/ RCU-EAS and ICRAN, and in May this year, The World Commission on Protected Areas, Nature Conservancy, and U.S. National Oceanic and Atmospheric Administration collaborated in a joint project to develop a Regional Action Plan (RAP) aimed at strengthening and improving the effectiveness of a network of 'marine reserves' in Southeast Asia. A WCPA-SEA Marine Working Group was established to further develop the RAP.

A more coordinated approach was adopted in the preparation of this regional report. National coordinators were identified and participated in a meeting in Ishigaki, Japan in March 2002, hosted by Japan's Ministry of the Environment. It was agreed that national coordinators contribute directly to the present report as co-authors. National workshops of Malaysia and the Philippines were supported by Japan's Ministry of the Environment, while those of Thailand and Vietnam were supported by the Regional Coordinating Unit (East Asian Seas) of UNEP. Summarised data of reef status derived from the national reports appear in this paper. In addition, reports were received from a number of people in response to the call for additional information. Relevant pieces of information from these reports are incorporated.

Status of Coral Reef Benthos and Reef Fishes

This section provides updates to the 2000 report. National reports containing more detailed information are being prepared by participating country coordinators. While monitoring of reef benthos remained at an active level, a paucity in information on reef fish was evident.

Cambodia

Rocky bottoms along the 435km coastline support variable development of coral communities. Fringing reefs are found on some of its 64 islands. An assessment of the reefs in the Koh Sdach group of islands in the Koh Kong province was carried out in March and December of 2001 by a volunteer group from Singapore organised by the

Singapore International Foundation and the National University of Singapore. Both Line Intercept Transect (LIT) and Reef Check surveys were conducted. Live coral cover of 10 fringing reefs from LIT data ranged from 4.1 to 72.1% while dead coral cover was between 5.6 and 78.8%. A couple of reefs showed clear evidence of bleaching, but recovery was vigorous from the large number of growing coral recruits.

Indonesia

Data from 2002 indicated that 520 stations from 56 locations throughout Indonesia have been surveyed with LIT. The results showed that 32.3% of the reefs were in poor condition, 35.3% fair, 25.5% good and 6.7% excellent. Compared to the 2000 data, there is a shift towards improvement. Reefs classified as poor decreased from 34.7 to 32.3% and those in the fair category decreased from 35.3 to 33%. Reefs in the good and excellent categories increased by about 2% each. The monitoring programs in Banda Islands, Wakatobi Islands, Komodo Island, Bangka Islands, Belitung Islands, Taka Bone Rate Islands and Senayang-Lingga Islands all showed improved reef condition. For example, live coral cover in Taka Bone Rate increased significantly by 6.3% from 23.8 to 30.1% over the two-year monitoring period. The increase was attributed to a 4.0% rise in non-*Acropora* and a 2.3% improvement in *Acropora*. In Senayang – Lingga (Riau province), live coral cover increased by 11%. Both, Taka Bone Rate Islands and Senayang-Lingga Islands, are representative locations of the Coral Reef Rehabilitation and Management Programme (COREMAP). The improved reef condition provides encouraging evidence that COREMAP is positively benefiting the reefs. During 2001-2002, new locations surveyed were Anambas Island (South China Sea), Malaka Strait and Raja Ampat Islands (West Papua). Reefs in western Indonesia are subjected to greater anthropogenic impact than those in central and eastern Indonesia. For example, 70% of reefs in the Seribu Islands near Jakarta are in poor condition.

Malaysia

Coral reef surveys have continued in both East and West Malaysia during 2000 to 2002. In East Malaysia, the Universiti Malaysia Sabah and Greenforce conducted surveys of reefs and associated marine organisms in the islands off Kudat, Sabah. Rangers in the Turtle Islands Park, managed by Sabah Parks, maintain a continuous survey programme for coral reefs and fishes and the sandy beaches for turtle hatchings. In West Malaysia, the Marine Parks, Department of Fisheries- Malaysia, conducted surveys with the assistance of Coral Cay Conservation. Detailed analysis of the data is being prepared and will be included in the National Report. A volunteer group from Singapore (organised by the Singapore International Foundation and National University of Singapore) conducted additional Reef Check surveys of the reefs off Kudat (Pulau Molleangean and north Pulau Banggi) in June this year and found live coral ranging from 27.5 to 71.3% at the reef crests and from 10.6 to 60.6% at reef slope depths between 3 and 6m.

Philippines

The Philippines report contains an update on time-series data of over 50 coral reef sites along the length of the archipelago, most of which started in the 1990s. Unfortunately, this is a biased data set since an overwhelming majority of these time series data focused on managed (protected) reef sites. Despite the data bias towards managed reef sites, Philippine reefs still exhibit an overall declining trend. In the South China Sea, hard coral

Management, Tourism and Conservation at Mabini and Tingloy, Batangas, The Philippines

There are diverse and abundant coral reefs in the Mabini and Tingloy area in the Province of Batangas. These reefs have become famous for providing tons of fish to local communities and for attracting thousands of tourist scuba divers and snorkellers. This mix presents a problem of balance for reef managers. The history of management of these coral reefs is closely linked to tourism. Scuba divers called for protection of their best dive sites, when one of the first diving resorts in the Philippines started in 1975. The tourist operators were concerned about the rampant illegal and destructive fishing and proposed a national marine park for Sombrero Island and parts of Caban and Maricaban Islands in 1982, after the first surveys in 1980. Since then a series of NGOs (Haribon Foundation; 5 Earthwatch expeditions; Biodiversity Conservation Network; World Wildlife Fund; Mabini Tingloy Coastal Area Development Council; The Friends of Balayan Bay Association; and Coastal Conservation and Education Foundation, formerly Sulu Fund) have worked with the local communities to promote conservation of the reefs and develop alternative livelihoods. These NGOs have also monitored the reefs, including observations on human uses e.g. number of fishing boats, dropping of anchors, divers, shoreline development and any other human activities likely to damage the reefs.

Destructive (bomb and cyanide) fishing has decreased markedly in recent years, but damage continues from anchors, fishing and novice scuba divers. Sediments from deforestation and building on land are deposited during heavy rainfall and there is increasing construction along the shoreline, irrespective of the Land Management Act order for a setback of at least 20m from the high tide level. There was also major storm damage in the late 1980s, but many of the corals are regrowing. Despite all this, the reefs continue to grow and now appear healthy.

The condition of the reef sites surveyed has been stable since 1997, with an abundance of new coral growth and little evidence of physical damage. The White Sand Reef near El Pinoy Resort is an exception, because a crown-of-thorns starfish infestation caused severe damage in 1999 and 2000, killing most of the shallow branching corals.

Major bottom cover	Deep sites – 5-9m				Shallow sites – 2-5m			
	1993	1995	1997	2001	1993	1995	1997	2001
Hard Coral	28.1%	38.1%	32.3%	29.9%	35.8%	49.0%	53.7%	53.7%
Soft Corals	16.6%	19.2%	19.9%	14.1%	10.9%	12.4%	12.5%	8.4%
Recent Dead Coral	2.2%	1.4%	4.6%	0.2%	1.3%	2.4%	4.7%	1.1%

Mean percent cover of living and recently dead coral at 9 sites in the Mabini-Tingloy area, Batangas.

It is important that management in the Batangas area be continued and expanded, to build on the activities that are showing encouraging results. The Barangay Sto. Tomas has recently declared the Batalang Bato Reef (known as Pulang Buli Reef to divers) as a marine sanctuary which is off-limits to diving and fishing activities. CCE Foundation started a Community-based Coastal Resource Management project in Tingloy in late 1999. The local community increased their interest in conservation which is now assisting in the management of the marine sanctuary. The conservation was initiated by the tourism sector, and now the community and the municipality are showing concerns about their environment accepting responsibility in caring for their surroundings.

The problems have remained the same over the last 10 years, but the communities and managers have a better understanding of what is required for effective and sustainable conservation. Many problems remain which need to be addressed, but there has been good success in reducing overfishing and illegal fishing. The communities have formulated their own recommendations: The reserve and sanctuary project and the involvement of the dive industry can be used to spread the idea of sustainable use of the reefs to surrounding communities; Destructive fishing and spear fishing using compressed air needs to be totally stopped in the area; More anchor buoys are needed at every site, and a small fee for their use can provide some revenue; Raising awareness about waste disposal is needed, and all partners from local communities to large ship owners should assist; While the Friends of Balayan Bay Association can assist in conservation, they need guidance, assistance and coordination with government agencies; An integrated management plan for the area is needed, along with workshops and educational programs for stakeholders; Guidelines are needed for shoreline developments that cause erosion or increase pollution; User fees need to be collected in a transparent way and used to support sanctuaries, anchor buoys and conservation costs. From:

Alan White, Melody Ovenden, Anna Meneses and Danny Ocampo, Coastal Conservation and Education Foundation, Cebu City, The Philippines; awhite@mozcom.com; ccef@mozcom.com

cover is stable for Ilocos Norte and La Union, variable for Pangasinan, stable to slightly increasing for Zambales, stable to slightly decreasing for Batangas, and decreasing for Mindoro and Palawan. Reef fish abundance is increasing for Ilocos Norte and La Union, stable for Palawan, and decreasing for Zambales, Pangasinan and Batangas. In the Visayan Seas, hard coral cover and reef fish abundance in the sites monitored are generally improving. In the Philippine Sea, hard coral cover is decreasing and reef fish abundance is stable to decreasing. Hard coral and reef fish abundance trends are variable across sites in the Sulu Sea. In the Celebes Sea, hard coral cover increased at 21% of sites, but decreased at another 33% of sites. There was no clear trend for the remaining 46% (although these tended to decline). Reef fish abundance was stable to decreasing.

Singapore

The coral reefs continue to suffer from the impact of sedimentation. A renewed survey program was initiated recently and data for 2 of the 10 permanent reef sites being monitored indicated an extension of the trend of steady, but small decline in live coral cover. A mass spawning event was confirmed in April this year, and further observations are being prepared for October to determine if mass spawning coincided with the intermonsoon period. Many coral recruits were recently discovered on coral rubble covered by calcareous algae and a project is currently planned to examine the potential of exploiting this phenomenon for coral culture and reef rehabilitation.

Thailand

The coastal areas of Thailand between latitudes 6° and 13°N, offer suitable environmental conditions for coral reef development. There are an estimated 153km^2 of coral reefs along the total coastline of 2,614km and around 300 islands. These are classified in 4 distinct areas with different oceanographic conditions: the inner part of the Gulf of Thailand (Chonburi); the east coast of the Gulf of Thailand (Rayong, Chanthaburi and Trad); the west coast of the Gulf of Thailand (Prachuab Kirikhan, Chumporn, Surathani, Nakhon Si Thammarat, Songkhla, Pattani and Narathiwat); and along the coastline of the Andaman Sea (Ranong, Phuket, Pang-Nga, Krabi, Trang and Satun). Three reef types can be recognized: coral communities with no true reef structure; developing fringing reefs; and early formation of fringing reefs. A comprehensive reef survey program covering 251 sites in the Gulf of Thailand and 169 sites in the Andaman Sea was conducted by the Department of Fisheries between 1995 and 1998. In the Gulf of Thailand, 16.4% of the reefs were rated excellent, 29% good, 30.8% fair, and 23.8% poor. Reefs in the 'poor' category increased considerably after the severe 1998 bleaching event. For instance, certain areas of Trad Province showed reduction in live coral cover of 80-90% from previous levels. In the Andaman Sea, 4.6% of reefs were excellent, 12% good, 33% fair, and 49.8% poor. The 1998 bleaching event affected coral reefs in the Andaman Sea to a much smaller extent than in the Gulf. Some reefs showed a declining trend in live coral cover, but other sites registered slight increases of live coral cover. In general, coral reefs in the Andaman Sea were relatively unchanged. Monitoring of reef fish was less extensive and it is difficult to provide a clear indication of reef fish status because of high temporal variations. However, fish communities were more abundant on reef slopes than on reef flats. Reef fish abundance gradients from nearshore to offshore were influenced by reef types and environmental factors. Most Thai coral reefs are used for fisheries but no records are maintained of reef fish harvesting. Many reefs in rural areas are used by small-scale fishermen and for the collection of shells and ornamental fish. The reefs provide fishery products as important sources of both food and income.

Vietnam

The extensive coastline stretches north to south across more than 15° of latitude and the 3000 islands all contain a wide range of reef diversity and structure. The marine environment is classified into 5 distinct areas: the western Tonkin Gulf; middle-central; south-central; south-eastern; and south-western Vietnam. The reefs support over 350 species of hard corals. The greatest coral diversity lies in the south-central area with more than 300 species belonging to 65 genera. Data from 30 transects monitored in 2000 and 2001 showed 60% of reefs as fair (live coral cover of 26-50%), 20% as poor (0-25%), 17% as good (51-75%) and only 3% as excellent (>75%).

Monitoring the Hon Mun MPA in Vietnam for Improved Management

Hon Mun in Nha Trang Bay is the first MPA in Vietnam and is recognised for its rich biodiversity with has strong biogeographic links to the Indo-west Pacific centre of diversity. There are 9 islands with about 6,000 local villagers who rely on the reefs and waters for subsistence fishing, but the area is also the focus of rapidly developing commercial fisheries, aquaculture, shipping and tourism. These provide both threats and opportunities for successful management. For these reasons, the Government of Vietnam and the World Conservation Union (IUCN, with support from Global Environment Facility - World Bank and Danish Government) established Hon Mun as a model for an integrated MPA network in Vietnam. Ecological and socio-economic monitoring programs were established to assist management through collaborations among the MPA Project, the Institute of Oceanography and the local villagers. They are documenting the present status of the resources to be used to detect trends and management effectiveness. The ecological monitoring has three tiers based on GCRMN protocols: habitat assessment using manta-tow; community-based resource assessment by local villagers using Reef Check and local indicators; and more-detailed scientific assessment of diversity and coral cover, abundance of demersal fish, molluscs, echinoderms and algae and the quality of the water. The socio-economic assessments use participatory rural appraisal (including village mapping and interviews) to identify local concerns and aspirations, and fisheries logbooks, surveys and government statistics to define trends in demography, employment, living standards and resource-use. Initial results indicate that coral cover and diversity in a few small areas remain in excellent condition, with up to 100% cover and 350 hard coral species. However, many other reefs in the MPA have suffered severe damage from blast and poison fishing, crown-of-thorns starfish (COTS) outbreaks, careless anchoring and river run-off. The villagers report that fisheries resources are heavily over-exploited with declining catches and some local extinctions. The findings are the basis for education and awareness campaigns to improve compliance with MPA regulations, especially enforcement, and in refining the MPA zoning plan. These findings have also fostered new community-based management initiatives, including a COTS control program by local villagers and dive clubs.

From: Lyndon DeVantier, Chu Tien Vinh, Truong Kinh, Bernard O'Callaghan, Vo Si Tuan, Nguyen Van Long, Nguyen Xuan Hoa, Hua Thai Tuyen, Kim Hoang, Nguyen Thi Hai Yen, Nguyen Thi Ha Nguyen; contact: general@honmunmpa.org.vn

Impact of the 1998 El Niño Event

Indonesia

No bleaching was reported for Indonesia during the 1987-88 or 1991-92 events, which were severe elsewhere in the world. During the 1998 bleaching event, however, there was moderate to severe damage reported from number of sites throughout Indonesia. In early 1998, bleaching was first observed in west Sumatra centred on the Mentawi Islands, which resulted in over 90% mortality. Towards mid 1998, bleaching occurred at several sites: North Sulawesi; Togian and Banggai Islands; Taka Bone Rate and Lombok Islands; Bali;

Reefs at Risk in Southeast Asia

The coral reefs of Southeast Asia are severely threatened, however, there is insufficient specific information on the status and nature of threats to specific reef areas for effective decision making to conserve coastal resources. The *Reefs at Risk* project has developed standardised indicators to raise awareness about specific threats to coral reefs and highlight the linkages between human activities and coral reef condition. The World Resources Institute and 20 other partner institutions consolidated available information on the location, status and protection of coral reefs across the region, and estimated threats from human activities. The project developed standardized indicators of threats from coastal development, marine-based pollution, watershed-based pollution and sedimentation, over-fishing and destructive fishing in Southeast Asia. Coral reef area and threats were estimated to compare the sustainable economic value of healthy reefs and the losses from damaging activities. The key findings, maps of threats to coral reefs, and downloadable GIS data sets, are at www.wri.org/reefsatrisk.

Biological Endowment: Southeast Asia has nearly 100,000km^2 of coral reefs (34% of the world total) with the world's highest marine biodiversity (over 600 hard coral species). This is also the global center of biodiversity for coral reef fishes, molluscs, and crustaceans, mangroves and seagrasses.

Threats to Coral Reefs: Population growth, associated development, and resource demands are threatening the coastal resources of Southeast Asia, via over-exploitation and degradation of many coral reefs, particularly those near the cities. The main threats are as follows:

Coastal Development: Dredging, landfilling, mining of sand and coral, coastal construction, and discharge of sewage threaten 25% of the coral reefs at medium to high threat. Reefs of Singapore, Vietnam, Taiwan, the Philippines, and Japan are the most threatened by coastal development, each with over 40% at medium or high threat;

Marine-based Pollution: Pollution from ports, oil spills and leakage, ballast and bilge discharge, and dumping from ships threaten 7% of the coral reefs, with Japan and Taiwan having the highest threats at 15%. Cambodia and Singapore have few coral reefs, but most of these are threatened (medium or higher) by marine pollution (30 and 100%, respectively);

Sediment and Pollution from Inland Sources: Over 20% of coral reefs are at risk from land-based sediment and pollution. Many reefs in Vietnam, Taiwan, and the Philippines are threatened by sedimentation - 50% threatened in Vietnam and Taiwan and 35% in the Philippines;

Over-fishing: This is the most pervasive threat and 64% of coral reefs are at risk (medium threat or higher) from over-fishing, with 20% at high risk. In most countries, more than 50% of reefs are threatened by over-fishing. Cambodia, Japan, and the Philippines have even higher pressures from over-fishing, with over 70% of their reefs threatened and over 35% at high risk;

Destructive Fishing: Over 55% of the coral reefs are at risk from destructive fishing practices. Poison fishing for the live reef fish trade targets the most pristine and isolated coral reefs, where observations are limited. The threat from destructive fishing is particularly high in the Spratly and Paracel Islands and in Vietnam. In the South

China Sea, almost all reefs are under medium threat from destructive fishing, and this is the only significant human threat. Over two thirds of reefs in the Philippines, Malaysia, and Taiwan as well as over 50% of the reefs in Indonesia are threatened by destructive fishing.

When these threats are aggregated, human activities threaten 88% of coral reefs in Southeast Asia, jeopardizing their biological and economic values. Nearly 50% of these reefs are under high or very high threat, with only 12% of reefs at low threat.

Coral Bleaching: Global climate change is an additional threat to coral reefs, which was not included due insufficient information on the most vulnerable areas for bleaching. Elevated sea surface temperatures are an important threat and have resulted in severe and frequent coral bleaching.

Economic Value: The value of the coral reefs in Southeast Asia is staggering e.g. sustainable coral reef fisheries are worth US$2.4 billion per year. Coral reefs are vital for food security, employment, tourism, pharmaceutical research, and shoreline protection. The coral reefs of Indonesia and the Philippines provide annual economic benefits of US$1.6 billion and US$1.1 billion per year, respectively. However, over the next 20 years, blast fishing, over-fishing, and sedimentation could cost Indonesia and the Philippines more than US$2.6 billion and US$2.5 billion, respectively.

Management: Protection of coral reefs is inadequate in the region. The 646 MPAs cover only 8% of the coral reefs, and management effectiveness was determined for 332 MPAs. However, only 14% have effective management, 48% have partially effective management, and 38% have inadequate management.
Contact: Lauretta Burke, World Resources Institute, Washington DC, USA, LAURETTA@wri.org; www.wri.org\reefsatrisk.

Riau; Seribu; and Karimunjawa Island. This resulted in live coral cover decreases between 30 and 90%. Recovery has been variable, however, for west Sumatra and Lombok Islands, live coral cover remained depressed at less than 10% cover, but in the Seribu islands, live coral cover has reached 40%.

Philippines

Recovery from the 1998 mass bleaching has been documented in Tubbataha. Mean live coral cover decreased by 19% after bleaching, but remained constant from 1999 to 2001. No immediate decline in fisheries after the bleaching event was seen. Fish biomass and density increased in 1999 and 2000 after the bleaching event and subsequently declined in 2001, accompanied by a drop in species richness. A two-year study at Danjugan Island, Negros Occidental where coral mortality was high in the first few months of the 1998 bleaching, showed that recovery of *Pavona clavus* was related to depth. The species recovered better in medium depths (12m) than in shallow water (6m).

REEFS AT RISK SUMMARY BY COUNTRY

Country	Reef Area (sq. km.)	Reef Area as % of total in region	Percentage of Reefs by Threat Index			
			Low	Medium	High	Very High
Indonesia	50,875	51.1%	14%	39%	46%	1%
Philippines	25,819	25.9%	2%	27%	63%	7%
Spratly and Paracel Islands	5,752	5.8%	0%	100%	0%	0%
Malaysia	4,006	4.0%	13%	44%	38%	4%
India (Andaman & Nicobar Islands)	3,995	4.0%	45%	53%	2%	0%
Japan	2,602	2.6%	22%	38%	37%	3%
Thailand	1,787	1.8%	23%	24%	51%	1%
Myanmar	1,686	1.7%	44%	36%	20%	0%
Vietnam	1,122	1.1%	4%	22%	49%	25%
China	932	0.9%	8%	14%	76%	3%
Taiwan	654	0.7%	0%	29%	56%	15%
Brunei Darussalam	187	0.2%	79%	16%	5%	0%
Singapore	54	>0.1%	0%	0%	100%	0%
Cambodia	42	>0.1%	0%	0%	90%	10%
Regional total	99,513	100.0%	12%	39%	45%	3%

Source: *Reefs at Risk in Southeast Asia,* World Resources Institute, 2002.
Note: The analysis was performed on 1km resolution grid cells . Reef area estimates presented are summaries of grid cells of mapped coral reefs.

Thailand

The first extensive coral bleaching phenomenon in the Gulf of Thailand occurred in April-June 1998, and there were clear spatial variations in the extent of coral bleaching. Observed corals exhibited varied degrees of bleaching, and bleaching of coral recruits was observed at many sites. Bleaching was widespread on shallow reefs, however, certain coral communities on deeper pinnacles, such as Hin Luk Bat in Trad Province, approximately 10-15m in depth, showed no signs of bleaching. From long-term studies, *Acropora* and *Pocillopora damicornis* were severely affected. Several species of *Acropora* showed local extinction in certain locations, while *Goniopora* showed complete recovery after the bleaching event. Coral recovery in the inner Gulf of Thailand will require a longer period due to low coral recruitment. However, on the east and west coasts of the Gulf, large numbers of coral recruits, mainly *Pocillopora*, *Acropora, Fungia* and faviids are present.

Vietnam

The 1998 bleaching event resulted in bleaching of 37% of the coral colonies in the Con Dao islands. This was additional to the 10% of corals killed previously. The soft coral, *Sinularia* and fire coral, *Millepora* were most affected with almost 100% and 83% of colonies bleached respectively. Hard corals that were most affected included *Porites* (57%), *Symphyllia* (42%), *Leptastrea* (40%), and *Acropora* (19%, many newly killed). Bleaching also caused decreased fish diversity especially among butterflyfishes, illustrating the relationship between reef fish and coral health. Surveys from 1998 to 2001 have indicated a slow recovery. In many places, coral bleaching exacerbated anthropogenic stresses and have resulted in continued reef decline since the El Niño event. Continued coral loss from sedimentation is evident in Ha Long Bay and the Cat Ba Islands. However, reefs of Binh Thuan and Ninh Thuan provinces, which are near an upwelling, recovered well. Recovery from bleaching was slow in the Con Dao islands, but restoration of fish density was better than elsewhere based on monitoring data from 1999 to 2001.

Anthropogenic Threats to Coral Reef Biodiversity

Indonesia

Human impacts, direct and indirect, are the greater threat than natural impacts. The major causes of coral reef degradation in Indonesia are blast and cyanide fishing, increased sedimentation, and sewage and industrial pollution. The majority of the human population is concentrated in the coastal area. Rapid economic development, particularly around major population centres results in large amounts of sewage and industrial pollution, causing the decline of many reef areas especially those near growing cities such as Jakarta, Ambon and Ujung Pandang. Two coral species of the Genus *Montipora* used to occur in Jakarta Bay, but not any more. Average live coral cover in Jakarta Bay is 2.5% and in Ambon Bay, 24.0%. Muro ami fishing (driving fish into set nets by bashing the corals) and blast fishing are considered the major factors contributing to physical damage of reefs. These fishing techniques break corals and damage the bottom habitat. At least two groups of fishers engage in blast fishing. Small-scale fishers use self-made bombs from fertiliser to blast small areas in shallow reefs near their homes. There are however, medium to large-scale fishers using stronger blast devices with detonators. They fish in remote areas (about 7 to 10-day trips), destroying vast areas of reef, from the reef slope to about 20m depth. They also use compressors to supply air to divers sent down to collect the fish. The demand for reef dwelling grouper and humphead (Napolean) wrasse has risen dramatically over the past few years and Indonesia is now the largest supplier of live reef food-fish to the Asian market. It is estimated that more than 50% of the total wild-caught live reef fish are currently supplied to Hong Kong and Singapore. Cyanide is a broad-spectrum poison causing damage to the liver, intestine and reproductive organs of the fish and also causing extensive damage to corals. Blast and cyanide fishing have caused irreversible damage to many Indonesian reefs. These destructive fishing techniques continue throughout Indonesia. Some of the traditional fishing methods may have also contributed to the degradation of marine resources. It becomes imperative therefore to introduce new, more environmental-friendly fishing techniques as part of the management of a sustainable coastal fishery. Lift net fishing 'Rompong' and hand line fishing are currently considered non-threatening to demersal and sedentary marine

A Government-NGO Partnership in Komodo, Indonesia

In 2000, at the International Coral Reef Symposium in Bali, the director of marine activities at the Indonesian Institute of Sciences proclaimed that Indonesia was losing between 3 and 6% of their coral reefs per year. These are the reefs that are the most diverse aquatic ecosystem in the world. This was an alarm call to government. Much of the losses were due to over-exploitation and destructive fishing practices such as blast fishing. Unfortunately, there is no silver bullet magic solution, because over-exploitation and destructive fishing are caused by many different and widely varying factors. A lack of education, a lack of alternatives, and sometimes greed can turn a 'traditional' fisher into a blast fisher, and usually the local law enforcement agencies do not have the capacity to apprehend offenders. The increasing demand for fish and a lack of management results in too many fishers who catch more fish than nature can provide over the long-term. Fortunately, there are examples of conservation partnerships that are making a difference. In Komodo National Park, the Indonesian Park Authority is collaborating with The Nature Conservancy to implement a conservation program that has virtually stopped blast fishing throughout the 200,000ha Park, resulting in a clear increase of live coral cover. For example, in one of the most heavily damaged areas of the Park, the live hard coral cover increased from 13% to 22% between 1996 and 1998 and has since stabilised. Coral cover has increased significantly by 4% in 2 years averaged over 185 sampling sites. The partners have endorsed a zoning system that addresses over-exploitation, and is now being implemented. These results were achieved not by a silver bullet approach, but through a strategic combination of activities that focused on planning, policy-making, awareness raising, surveillance and community development. Dedicated staff and the formation of a growing conservation coalition, that includes the local people were the critical factors for the success of the program. The Park Authority and The Nature Conservancy are now working to establish an innovative financing mechanism to sustain this success and use this site as a model to show to other communities (see Komodo ICRAN Site). From Rili Djohani, The Nature Conservancy, Bali, Indonesia; rdjohani@attglobal.net or www.komodonationalpark.org

resources. Lift net is mainly used to catch squid and anchovies. 'Rompong' or fish aggregating devices are made from palm leaves and bamboo rafts anchored in deep water, which attract pelagic fish. These fishing methods have already been established among reef fishing coastal communities to catch Spanish mackerel and tuna and therefore shift fishing pressure away from coral reefs.

Philippines

Over-fishing and destructive fishing (blasting and poisons) continue to top the list of anthropogenic impacts on Philippine coral reefs. Poaching (including the weakness of local communities and poor governance) and fishing-related threats were identified as the worst threats to reefs in the Visayan Seas (particularly in protected areas). Sedimentation, tourism-related activities and crown-of-thorns starfish (COTS) infestations were next in rank. In the Sulu and Celebes Seas, destructive fishing, over-fishing, sedimentation, pollution and climate change were identified as the most common threats to coral reefs. The estimated threats

Detecting Blast Fishing

A system for detecting and monitoring underwater explosions is being developed as a tool for reef managers. A triangular array of hydrophones separated by 1m is linked to a computer that can accurately determine the direction of travel of the shock wave coming from a blast, and the origin of a blast can be pinpointed using two or more arrays. When this was tested in mid-2002, it could calculate the direction to within 0.2˚, which is an accuracy of ±30m at a range of 10km. When a bomb goes off underwater, a high proportion of the chemical energy is converted into acoustic energy, which can be detected from a distance of at least 30km. The sensitivity and range of the system has been improved using algorithms that filter out background noise, particularly the tiny shock waves from nearby snapping shrimp. This tool can be used for real-time fisheries surveillance and enforcement, and particularly the monitoring of management projects aimed at preventing coastal communities from blast fishing. From: Simon Wilson and George Woodman, simon.wilson@adelphi-env.com

mapped in Reefs at Risk in Southeast Asia provide probably the most updated national picture of coastal development, marine-based pollution, over-fishing, destructive fishing and climate change impacts. However, the sedimentation map reflects a modelled risk, the impact of which may either have already occurred in the past, is happening now or is yet to occur. A large proportion of the impacts on Philippine reefs stem from the very high population density of the nation (and associated food and income requirements).

Thailand

The reefs support a variety of human activities that can be categorised into three main groups: tourism and recreation; fisheries-related uses; and other uses. A clear pattern of change in reef use is evident, as small-scale or traditional fisheries are gradually being replaced by tourism activities. Locals convert their fishing boats into tour boats and also collect shells for the souvenir trade. This is seen in several provinces, such as Trad, Surathani, Pang-Nga, and Trang. Tourism and recreational activities include diving, underwater photography, glass-bottom vessels, sea walkers, and sport fishing. Poorly managed tourism affects reefs through anchor damage, garbage accumulation, diver damage and wastewater discharge from coastal hotels and resorts. Live coral coverage on Nang-Yuan Island in Surathani, one of the most popular snorkelling sites has declined 17% within a 5-year period. Reefs close to beach resorts are used intensively for tourism-related activities. Chanthaburi, Rayong, Surathani, Phuket, Trang, and Krabi are the major provinces for reef-related recreation. Reefs in several localities such as Pattaya, Koh Samet, Koh Hae and Mu Koh Phi Phi group face the impact of conspicuously heavy tourism demand. Many localities are also facing a rapid and steady growth in tourism, with obvious increases in coral reef-related activities. A project to establish mooring buoys at reef sites in the Andaman Sea has successfully reduced anchor damage. Shell and ornamental fish collection with the use of chemicals is among the serious problems causing coral reef degradation in the Gulf and the Andaman Sea. Dynamite fishing is rarely observed, even at remote islands. Sedimentation and wastewater pollution associated with rapid coastal development are recent and increasingly severe problems in

PROYEK PESISIR, NORTH SULAWESI, INDONESIA

This is an area of exceptionally high biodiversity where, however, the coral reefs are being degraded by unsustainable human activities. Proyek Pesisir is a partnership between the U.S. Agency for International Development (USAID) and the Coastal Resources Center at the University of Rhode Island to implement community-based integrated coastal management to conserve the marine resources of a part of North Sulawesi. The first major activity was to create a marine sanctuary in Blongko, a small village of 1,250 people who depended on fishing for a living. The project used Apo Island in the Philippines as a model, and asked the community to collect data, identify a proper site, and develop a local ordinance to regulate fishing in the proposed protected area. The village government also received support from the regional and national governments to implement the ordinance. The sanctuary is now paying dividends for local villagers because of income from tourism. This model is now being replicated in the Likupang vicinity in North Sulawesi, where 18 local communities are initiating marine sanctuaries. These community efforts were given a major boost when the legislature of the Minahasa District passed a landmark law to support locally approved plans and village ordinances. This legal framework demonstrates an institutional commitment to uphold local regulations and assist communities that want to establish marine sanctuaries. Potentially 150 villages in the Minahasa District can benefit as they work to protect their coral reefs. The process has been assisted by publishing a number of manuals in Indonesian (Bahasa), including a monitoring manual, a guide for organising community controls the crown-of-thorns starfish, and a manual on establishing community-based marine sanctuaries is planned. Contacts: Lynne Hale, lzhale@gso.uri.edu; Richard Volk, rvolk@USAID.gov

many provinces along the coastline. Jetty construction in several locations, especially in the west coast of the Gulf of Thailand, resulted in coral reef and seagrass degradation.

Vietnam

These coral reefs continue to be stressed by a variety of threats, particularly in high human population areas. From interviews conducted in early 1999, over-fishing and the decline in marine resources were cited as problems in all of the 29 provinces surveyed. Local communities identified destructive fishing as a problem in 21 of 29 provinces. Poison fishing for the live food fish and ornamental trades is particularly acute in the northern and central parts of Vietnam even around Con Dao National Park. Illegal trade and collection of endangered species is still largely uncontrolled. A strong correlation exists between reef quality and distance from human developments. The pristine reefs are generally the most remote. Almost all of Vietnam's reefs were reported as being threatened by human activities during the Reefs at Risk analysis, with 50% facing high threat and 17% at very high threat. Destructive fishing is the most pervasive and significant threat, with over 85% of the reefs at medium or high threat. Over-fishing threatens about half of Vietnam's reefs.

Public Awareness Raising in Indonesia

A public communication program under COREMAP (Coral Reef Rehabilitation and Management Programme) has demonstrated positive results, although it has not reached the desired levels because of the vast expanse of Indonesia. Activities and materials were developed or supported as part of the public communication program and included television and radio messages, and a variety of outreach techniques such as special education programs, posters, stickers, campaign songs, billboards, children's games, exhibitions, field guides to coral reefs, newsletters, press releases, web sites, interpersonal contacts, entertainment-education events, community meetings and workshops. A communication impact evaluation conducted in the main COREMAP areas showed that 63% of the general public and 71% of coastal community residents were aware of the immediate need to save coral reefs. People more exposed to COREMAP outreach were more likely to recognise the serious issues and be able to participate in reef protection. They were also more aware of how reef destruction affects them personally. All COREMAP locations registered positive response from the public and coastal communities. COREMAP is useful in helping to reinforce the urgency of reef management and to support community-based resource management. These positive attitudes on the part of concerned communities should spread out to others over time. From Suharsono.

Current MPAs and Conservation Management Capacity

Malaysia

More reefs are being managed and protected in East Malaysia in the last two years. The *de facto* marine park in the Semporna Islands is expected soon to be declared as a marine park under the management of Sabah Parks. Another group of islands in the northern part of Sabah in the Balabac Strait will be managed as the North Borneo Marine Managed Area. The Langkayan-Bilean Islands, off Sandakan in the east coast of Sabah, are now established as a conservation area under the Wildlife Conservation Act. Several coral reef areas in East Malaysia, particularly Sabah, were given international recognition. A team of experts from Indonesia, Malaysia, and Philippines under the auspices of the WWF Sulu-Sulawesi Marine Ecoregion Programme has identified three Priority Conservation Areas (PCAs), namely: Semporna-Tawi-Tawi Islands; Turtle Islands; and the Balabac Strait Islands (including Banggi-Balambangan Islands off Sabah). The two PCAs that were identified were proposed to the World Heritage Area Workshop in Hanoi in March 2002 for consideration for WHA listing; Semporna Islands (and the Tawi-Tawi Island chain) and the North Borneo-Balabac Islands were ranked with high priority.

Philippines

Conservation International and the Worldwide Fund for Nature have both conducted geographic priority-setting exercises for management/protection of Philippine marine biodiversity. Management is still clearly inadequate for the Spratly Islands, the Babuyan Channel, the Sulu Archipelago and the San Bernardino Strait. Community-based management, while sometimes very effective, continues to be successfully implemented only in very small areas. Management in conjunction with local government (including coastal law enforcement) continues to rapidly gain ground but its conservation

Con Dao National Park, Vietnam

The 14 islands of the Con Dao Archipelago are 220km offshore, south of Vung Tau City and 60 km to the mouth of the Mekong river on mainland Vietnam near 8°40'N and 106°40'E. The National Park includes all the islands and surrounding waters with an overall area of 20,000 ha. Forest covers more than 80% of the islands and some forests are in pristine condition, especially the original humid hill forest growing above 500m. The Con Dao Islands are representative of the southeastern marine waters of Vietnam and are close to the centre of marine biodiversity of the Indo-West Pacific Region. The shallow waters of the archipelago include 1000ha of coral reefs, over 200ha of seagrass beds and some mangroves. The ocean currents favour the great diversity of marine biota in the archipelago, such that the species list includes 200 hard corals, 202 fishes, 130 polychaetes, 110 crustaceans, 46 echinoderms, and 153 molluscs. There are also populations of rare species such as the dugong and hawksbill and green turtles, and 17 beaches in the park are nesting sites of marine turtles, with 4 of these having thousands of nesting turtles annually. Con Dao National Park is one of the most pristine natural areas in the country, and has significant values for conservation and eco-tourism activities such as snorkelling, scuba diving, catch-release sport fishing, and nature viewing.

The Management Unit of the Con Dao Special Use Forest focused largely on forest protection from 1984 to 1993, Since 1993, management activities were expanded to cover the marine environment and protection and patrolling form the bulk of the marine activities. Con Dao National Park is considered as the best marine reserve in Vietnam with effective regulations to protect marine ecosystems, limit fishing activities, and prohibit destructive fishing. The Park's staff have implemented a marine turtle rescue program with the support of WWF. Recently, a marine zoning plan was developed based on the biological assessments by scientific institutions and was approved with the cooperation of the district government. Coral reef monitoring since 1998 has provided information to improve understanding of reef changes after the coral bleaching and for formulating management plans. The success of the Con Dao National Park is a good lesson for developing more marine protected areas in Vietnam. From Vo Si Tuan.

effectiveness is not yet evident from the reef data. A new and relevant legislation is the Wildlife Resources Conservation and Protection Act of 2001 (Republic Act 9147) that aims to (a) conserve and protect wildlife species and their habitats to promote ecological balance and enhance biological diversity; (b) regulate the collection and trade of wildlife; (c) pursue, with due regard to the national interest, the Philippine commitment to international conventions, protection of wildlife and their habitats; and (d) initiate or support scientific studies on the conservation of biological diversity. The Coastal Environment Programme of the Department of Environment and Natural Resources (DENR) was institutionalised in 2002 as the Coastal and Marine Management Office.

There is a need to form alliances between individual and isolated protected areas and link them into larger national and international frameworks to address large-scale economic and political forces beyond the protected area. The requirement for widespread replication must be addressed alongside the need for sustainability of human and financial resources. The Philippines does not yet have a nationally recognised national coral reef action plan. Reef monitoring still needs to be better coordinated to overcome uneven sampling distribution and unnecessary re-establishment of new transects (as opposed to re-sampling old transect sites). Some capacity for socio-economic assessments is available but not yet been been used specifically for monitoring.

Singapore

There are no marine protected areas in Singapore. The Labrador Nature Park, a coastal park with a rocky shore and reef communities was gazetted in 2001. Many of the initiatives by non-government groups can be considered effective in contributing towards management within the limitations of the lack of government intervention. These efforts have raised public consciousness and government agencies responsible for development now direct more attention to reef protection.

Thailand

Close to 42% of Thailand's reefs lie within its 21 Marine National Parks and several Fisheries Sanctuaries. In addition, many islands are under the control of the Thai Royal Navy and bird nest concession holders, who strictly prohibit visitors. The reefs of these islands are in good condition as they serve essentially as protected areas. Over 50% of Thai coral reefs are under some form of protection. Many government and non-government institutions are involved in coral reef monitoring, and the monitoring methods used are the manta tow survey, line intercept transect, permanent quadrat, fish visual census, and Reef Check.

Coral reef management in Thailand rests on laws and regulations that apply to all coral reefs and additional measures applicable only to marine protected areas. In recent years, central agencies, provincial governments and the private sectors have undertaken non-regulatory action aimed at improving coral reef conditions through restoration, preventive measures and education. Several laws are used to protect coral reefs in Thailand, e.g. the Fisheries Law of 1947, the National Park Act of 1961, the Enhancement and Conservation of National Environmental Quality Act (NEQA) of 1975, etc. These regulations are mainly enforced by the Department of Fisheries (DOF) and Royal Forestry Department. There have been problems in enforcing coral reef protection regulations. A National Coral Reef Strategy was adopted by the cabinet in 1992. However, there were no signs of reversing coral reef degradation because the strategy did not function at the local level and it is under revision.

Vietnam

There are positive signs of the effectiveness of management in some locations, such as at Con Dao National Park and some of the tourist sites in Nha Trang Bay. In the Hon Mun Marine Protected Area pilot project, various agencies have initiated a programme among local island villagers and the recreational dive clubs of Nha Trang to control the crown-of-thorns starfish, which have increased in recent years.

Gaps in Monitoring and Conservation Capacity

The importance and significance of monitoring are not fully appreciated by government agencies resulting in inadequate resources to support effective monitoring and data management. Many monitoring programs are not supported over a long term and the information derived lacks the foundation to support good management decisions. Monitoring data are also not analysed in a timely manner to be useful to management. Some countries lack reef monitoring capacity altogether. There are also obvious information gaps of coral reefs from Myanmar and Brunei Darussalam that need to be addressed to provide a more complete regional assessment.

The common problems associated with the lack of management capacity such as inadequate legislation, inadequate public education, inadequate manpower, limited financial support and agency conflicts all point to the political unwillingness to invest in the management of coral reefs for sustainable development. In most cases, there is a lack of a national or provincial policy on coral reefs.

In Thailand for example, most of its coral reefs are being used for ecotourism. Lessons learnt from the past showed very obviously that protection measures against reef degradation were mostly delayed. In order to avoid or minimise coral reef degradation in the future, a more effective action plan is absolutely required. Public awareness and participation are also important for coral reef conservation, and they require long-term support from several agencies.

Conclusions and Recommendations

The disparity in reef monitoring capacity among the region's countries has to be addressed, and the present level of monitoring enhanced to make monitoring more relevant and useful to management. Monitoring must be long-term to avoid the decisions based on short-term and temporary phenomena. Efforts should be increased to ensure that reef monitoring data are analysed and presented quickly to influence policy responses for reef conservation. In addition, better policy actions can lead to enhanced monitoring. The Philippines is developing a quality control certification process to assist in reef management, which is also linked to funding from the government. Scientists must also be responsible for giving proper interpretation of reef monitoring data to prevent sending misleading messages to the public, which may lead to further deterioration of reefs.

A review of different management regimes which have proven effective in conserving or protecting reefs should be conducted and publicised, as these will serve as effective learning lessons that can be replicated across the region to suit different localised conditions and settings. A clear expansion of such efforts will help to increase management of more reefs and help to alter the trend of degradation. This will help governments realise and appreciate the full economic benefits that can be derived from well managed reefs. The coral reefs of the Philippines for example, are estimated to have a potential sustainable economic value of approximately US$9 billion (net present value) and net annual benefits of US$1 billion per year.

Acknowledgements

The preparation of this report was facilitated by a meeting of national coordinators in Ishigaki, which was hosted by Japan's Ministry of the Environment. The national workshops of Malaysia and Philippines were supported by Japan's Ministry of the Environment, while those of Thailand and Vietnam were funded by UNEP RCU/EAS. The following readily provided relevant reports and further information: Doug Fenner (Australian Institute of Marine Science), Jean-Luc Solandt (Coral Cay Conservation), Simon Wilson (Adelphi Environmental), Melody Ovenden (The Coastal Conservation and Education Foundation Inc.). The co-authors wish to express their deep appreciation to Clive Wilkinson for carrying out the unenviable task of editing the report.

Author Contacts

Chou, Loke Ming, National University of Singapore, Singapore dbsclm@nus.edu.sg; Vo Si Tuan, Institute of Oceanography, Nha Trang City, Vietnam, thuysinh@dng.vnn.vn; PhilReefs, c/o Marine Science Institute, University of the Philippines, Quezon City, Philippines alino@upmsi.ph; Thanasak Yeemin, Ramkhamhaeng University, Bangkok Thailand, thamasakyeemin@hotmail.com; Annadel Cabanban, UNEP/GEF Project Co-ordinating Unit, UNEP, Bangkok, Thailand, cabanban@un.org; Suharsono, Coral Reef Rehabilitation and Management Program, LIPI, Jakarta, Indonesia, shar@indo.net.id, Ith Kessna, Nature Conservation and Protection Dept., Phnom Penh, Cambodia, kessna_ccu@hotmail.com

Supporting Documentation

Burke L, Selig E, Spalding M (2002). Reefs at Risk in Southeast Asia. World Resources Institute, Washington DC, USA.

PhilReefs (in prep.) Philippine Coral Reefs through Time. Coral Reef Information Network of the Philippines, c/o Marine Science Institute, University of the Philippines, Diliman, Quezon City. Approx. 200 pages.

Solandt JL, Beger M, Dacles TP, Raines PS (in prep.) Effects of 1998 bleaching event on large *Pavona clavus* colony in a Philippine marine protected area. Coral Cay Conservation and the Philippines Reef and Rainforest Conservation Foundation Inc.

Uychiaoco AJ, Alino PM, White AT (2002) Marine Protected Areas in the Philippines: Towards Harmonizing Goals and Strategies. 4th IUCN/WCPA-East Asia Conference.

White AT, Christie P, Apurado J, Meneses A, Ovenden M, Tesch S, White E (2002) Summary Field Report: Coral Reef Monitoring in Cebu, Negros and Siquijor, Philippines, Mar 23-31, 2002. The Coastal Conservation and Education Foundation Inc. and Coastal Resource Management Project, Cebu City, 126 pages.

Local Commitment to Conservation: a Philippine Success Story

The Danjugan Island Marine Reserve in Negros, Philippines was awarded the '2002 Best Managed Reef Award' by the Philippine Council for Aquatic and Marine Research. In 1994, the community near Danjugan Island, Barangay Bulata, was suffering increasing poverty because their marine resources were deteriorating, and fish catches were declining due to over- and destructive fishing. A local NGO was established to acquire and manage the island in partnership with Coral Cay Conservation Ltd. and the World Land Trust. The community, with help from the NGOs, developed short-term and long-term projects to conserve the environment. They set up their own self-governing organisations, developed alternative livelihoods, and encouraged conservation through education and awareness raising. They held marine camps for the youth, had shore clean-ups, and planted mangroves, with the goal of developing a conservation ethic in the community. Fishers were trained in mud-crab farming and pig raising, and the community participated in fish catch monitoring and underwater surveying of corals and fish. The best indicators of a successful marine reserve are committed and satisfied communities; and this success has triggered curiosity in neighbouring villages who want to establish their own marine reserves. These community-based management processes may not be perfect, but each one nurtures change, transforms attitudes and paves the way for long-term ecological benefit and sustainability. From: Kristin Sherwood, James Cook University, Australia, kristin.sherwood@jcu.edu.au; and Philippine Reef and Rainforest Conservation Foundation, Negros Occidental, Philippines prrcfi@mozcom.com

ICRAN

BUNAKEN NATIONAL PARK, INDONESIA – ICRAN DEMONSTRATION SITE

Bunaken National Park is on the northern tip of Sulawesi Island in Indonesia. Designated in 1991, it covers 900km^2 of diverse reefs and particularly large mangrove forests. The park focuses on the promotion of ecotourism and is exclusively financed through user fees, and managed by the Bunaken National Park Management Advisory Board, with advice from local communities, NGOs, academia and dive operators. A management plan and marine zoning plan was created for the park using a consultative process. The park management is currently involved in improving garbage and sewage management, improving enforcement and surveillance, promoting sustainable use of the park's resources, and researching alternative income opportunities.

Ecological Monitoring: The Bunaken National Park Office has monitored reefs for the last 5-6 years, and management is interested in conducting further training on coral identification, monitoring and mapping

Socio-economic Monitoring: There has been some monitoring of villager income.

Monitoring Effectiveness: There is a need for additional benthic, fish and spawning site monitoring.

Contact: Widodo S. Ramono, Department of Forestry, Jakarta Pusat, Indonesia, wsramono@eudoramail.com

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

ICRAN | **WHS** | **MAB**

KOMODO NATIONAL PARK, INDONESIA – ICRAN DEMONSTRATION SITE

Komodo National Park, between the islands of Sumbawa and Flores in the Lesser Sunda Islands of Indonesia, is a site of both terrestrial and marine significance. It encompasses a number of islands, the largest of which are Komodo (34,000ha) and Rinca (20,000ha). It is best known for the large endemic lizard, the Komodo dragon, but the reefs surrounding the islands also deserve special recognition. These waters are some of the richest in the world, possessing over 200 hard coral species, seagrasses, mangroves, manta rays, 16 species of cetaceans, turtles, and over 1000 species of fish. Nearly 113,500ha of surrounding waters are under the jurisdiction of the park.

Komodo National Park was established as a Biosphere Reserve by the United Nations in 1977, pronounced a National Park in 1980 and declared a World Heritage Site in 1991. A 25-year management plan was developed for the park in 1995 by the Directorate General of Forest Protection and The Nature Conservancy. The goal management was a well-managed, self-sustaining park i.e. effectively protecting the biodiversity in the park, enhancing fisheries around the Park, maximizing benefits to the local communities, and ensuring the use of park's resources for tourism and education in a sustainable way.

The park is still threatened by over-exploitation of the natural resources and destructive fishing. In an effort to reduce these threats, managers of Komodo are planning comprehensive community outreach and conservation awareness campaigns, promotion of sustainable livelihood activities, a strong cross-sectoral patrolling and enforcement program, and ecotourism development.

Ecological Monitoring: The Nature Conservancy conducts monitoring every 2 years at 185 sites. Included in the monitoring schedule are coral and fish monitoring programs and monitoring of grouper and wrasse spawning aggregation sites.

Socio-economic Monitoring: The Nature Conservancy also conducts socio-economic studies and assessment.

Contact: Rili Djohani, The Nature Conservancy - Coastal and Marine Program Indonesia, Bali, Indonesia, rdjohani@attglobal.net

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

ICRAN

APO ISLAND, PHILIPPINES – ICRAN DEMONSTRATION SITE

Apo Island is of one of the earliest community-based marine reserves. Reef protection began informally when Silliman University initiated the Marine Conservation and Development Program in 1982. Three years later, the island community and the local council formally agreed to the establishment of a marine reserve surrounding the entire fringing coral reef of the island and a smaller ($0.45 km^2$) 'no take' fish sanctuary at the southern end of the island. The island is now protected under the municipal law and managed by the Marine Management Committee of the Apo Island community with support from the Municipal Government, the Department of Environment and Natural Resources and Silliman University.

The sanctuary is a renowned success story. Reef monitoring during the 1990s indicated that live coral cover and fish populations within the sanctuary have increased substantially. The biomass of large predators increased 8-fold in the reserve and mean density and species richness of large predators in fishing grounds also increased. To emphasize these results, the community testifies that their fish catch has increased and their fishing time has decreased since the establishment of fish sanctuary on the island. Apo Island's success was no easy battle. When reserve status was declared at a national level, Apo lost much of its hard won community management to government control. This meant that all the revenue collected from tourism in the fish sanctuary went straight into the government for 'planned' distribution to the community. The problem was recently settled and a 1.2-million Philippine peso (US$24,000) fund was released to the island in 2001.

The community management committee also plans to improve quality of life on Apo and further improve management of the sanctuary. Increased tourism management is a primary objective, as unregulated numbers of snorkellers and divers and anchor damage from boats threaten the health of the reef. The committee also seeks to enhance alternative livelihood options, work towards financial sustainability and refine the current management plan.

Ecological Monitoring: A fish monitoring program is in place and Reef Check surveys have been undertaken since 1998. The major studies have been done by Silliman University.

Socio-economic Monitoring: A monitoring program that examines the impacts of tourism on the coral reef is planned to commence in 2003.

Contact: Laurie Raymundo, Silliman University, Dumaguete City, Philippines, lauriejr@dgte.mozcom.com

Coral reefs are **70%** of the natural resources.
Ecological Monitoring is **effective**.
Socio-economic Monitoring is **planned**.

ICRAN

MO KOH SURIN, THAILAND –ICRAN DEMONSTRATION SITE

Mo Koh Surin National Park is in the Andaman Sea, about 50km off of Thailand's west coast. The Surin Islands are the southerly extension of the Mergui Archipelago and are surrounded by extensive reefs, mangroves and seagrass beds. A population of sea gypsies inhabit the islands and are responsible for much of target species fishing. The primary resource users, however, are tourists and the Park fees, dive fees and boat permits contribute significantly to the Park budget. The Marine National Park Division and the Royal Forestry Department jointly manage the park. They developed a 5-year strategic plan, which ends in 2002, and contains zoning plans, mooring buoy installations, ranger patrols and reef closures. The strategic plan designed for Surin was also adopted by neighboring Similan Marine National Park. Institutions that are involved in research and planning for the marine park include regional universities, Marine National Parks, Phuket Marine Biological Center, Office of Environmental Planning, Chulalongkorn University and the Phang-Nga Province. The site is currently under consideration for World Heritage status.

With the help of ICRAN, there is the intention of revising the management to include zoning, maintaining mooring buoys, conducting legislation and enforcement training, and providing decision support analysis. Plans are also in progress to improve tourism and public awareness, build local capacity and evaluate program success.

Ecological Monitoring: The Phuket Marine Biological Center and Reef Check are responsible for much of the ecological monitoring in Surin. Current research priorities include updating reef data, reef mapping, carrying capacity and biodiversity research.

Socio-economic Monitoring: There has been socio-economic evaluation of indigenous sea gypsy livelihood, but there are no established monitoring programs.

Contact: Suraphol Sudara, Chulalongkorn University, Bangkok, Thailand, ssurapho@chula.ac.th

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

WHS **RAMSAR**

TUBBATAHA REEF MARINE PARK, PHILLIPPINES – WORLD HERITAGE SITE

The Tubbataha Reef National Marine Park consists of two uninhabited coral atolls in the Sulu Sea, 150km southeast of Puerto Princesa City, Palawan. The coral reef biodiversity is outstanding, which makes this location important ecologically as well as a popular site with divers. The park covers 33,200ha and has many species: 372 corals; 417 fish; 6 sharks; 7 seagrasses; 79 algae; and 6 cetaceans. The islets are nesting sites for sea birds and marine turtles. Despite being remote, the Tubbataha reefs deteriorated in the late 1980s because of destructive fishing by local and migrant fishermen from the South and Central Philippines, Taiwan and China. Although fishing was limited by the monsoons, living coral on the reef-flats decreased by 24% in 5 years. The introduction of seaweed farming in 1989 and El Niño bleaching in 1998 also damaged the reefs. The Tubbataha Reef Strategic Environmental Plan is managed by the Palawan Council for Sustainable Development, and technical assistance is provided by research institutions and NGOs, with financial support from the government, external grants, and user fees.

Long-term collaboration by the stakeholders reversed the damage from illegal fishing, anchors, and collection of marine animals. Dedicated NGOs conducted research, installed mooring buoys, and built field stations, and now are 'responsible' for park management, in association with the Philippine government. Tubbataha is the only MPA in the Philippines where the Philippine Navy routinely patrols the park and the Philippine Coast Guard controls illegal fishing. Private tourism operators assist in law enforcement and management decision-making. This strong collaboration between government, NGOs, and the private sector is critical for the conservation of this valuable marine resource.

Ecological Monitoring: There has been annual ecological monitoring since 1997 by WWF-Philippines. Rangers collect data on water temperature, rainfall and coral populations. Training on seabird censuses for the rangers is scheduled for 2003. Ecological monitoring is substantial and included in the annual and financial plans of the management board.

Socio-economic Monitoring: The Tubbataha Management Plan stipulates socio-economic monitoring in the areas surrounding Tubbataha, including sustainable resource management initiatives on Cagayancillo island, 80 nautical miles northeast of Tubbataha, which has political jurisdiction over the Park. Information, education and communication activities have strengthened local law enforcement, developed training packages, and established a micro-credit facility; all in partnership with the local government, which conducts socio-economic monitoring in partnership with WWF-Philippines.

Monitoring Effectiveness: Ecological monitoring has been effective in management decision-making. Baseline data were gathered in 1997 and used to compare with recent surveys. Socio-economic monitoring has identified the community interventions that are expected to improve the standard of living in Cagayancillo.

Coral reefs are **90%** the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **effective.**

WHS

UJUNG KULON, INDONESIA – WORLD HERITAGE SITE

This world heritage area is located in the extreme southwest tip of Java on the Indonesian Sunda Shelf. It includes the Ujung Kulon peninsula and several offshore islands, and it encompasses the natural reserve of Krakatoa. Ujong Kulon is the last stronghold of the rare Javan rhinoceros and is home to a variety of other endangered animals and plants. In addition to its terrestrial beauty and geological interest, the park contains an array of diverse and threatened coastal habitats.

In February 1992, the Ujung Kulon National Park complex and the Krakatoa Nature Reserve were declared a World Heritage Site under the authority of the Minister of Forestry. The terrestrial area of the park encompasses 76,214ha (Krakatoa Nature Reserve: 2,500ha) and the marine component contains 44,337ha. The coastal areas of the park include coral islands and their associated fringing reefs to the north, sand dune formations and areas of raised coral reef to the south, and the exposed west coast boasts extensive coral reefs and spectacular volcanic formations. The coral reef environments of the Ujung Kulon coast rank among the richest in Indonesia.

Management in the park is focused primarily on the terrestrial environment. The coastal environments, however, are under threat from siltation due to deforestation activities, oil pollution from passing tankers and overfishing. The managing bodies aim to strengthen coastal management by improving the capabilities of the guard force by provision of equipment such as radio communication and coastal patrol boats and implementing a buffer zone to reduce the effects of siltation.

Ecological Monitoring: No information received.

Socio-economic Monitoring: No information received.

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

MAB

SIBERUT ISLAND, INDONESIA – MAN AND THE BIOSPHERE RESERVE

Siberut Island, lying 130km off the western coast of Sumatra, is the home of Mentawai indigenous people and an ecosystem with remarkable conservation value. The Mentawaian chain of islands has been separated from the mainland for around 500,000 years, allowing wildlife to evolve in isolation from that of the rest of Asia. The result is a high level of endemism, particularly among mammals. Siberut was declared a Man and Biosphere Reserve in the early 1980s in an attempt to preserve the region's unique wildlife and human culture.

Despite the island's biological prominence as a Biosphere Reserve, many elements of the ancient way of life of the Mentawai people have disappeared, due to the activities of missionaries and government officials, and through logging company involvement. A large part of the remaining mangrove forest in Siberut is not under any conservation management and coral reef fish are reported to be over-harvested. Thus the UNESCO Man and the Biosphere Reserve started a new program in 1998 to empower the indigenous people through participatory rural appraisal, training and promoting traditional knowledge of the use of natural resources.

Monitoring: A significant amount of both social and biological research occurs in Siberut, and current projects include research on marine resources along Saibi Sarabua (proposed as a marine recreation park), ecotourism development, and investigation of the empowerment of local communities in the sustainable use of medicinal plants. Coral reefs are indicated as habitats of special interest on the southern and eastern coasts of the island, but there is little long-term monitoring.

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

MAB

PALAWAN, PHILIPPINES – MAN AND THE BIOSPHERE RESERVE

The Palawan Biosphere Reserve includes the entire Province of Palawan, in the Philippines, covering around 14 000km^2 and populated by 750,000 people. Palawan has 1,700 islands and islets, and was declared as a Biosphere Reserve, one of only two in the country, by UNESCO in 1991. Within its territory is the Tubbataha Reef which was listed as a World Heritage Area in 1994. The province has a unique and diverse fauna and flora and is known as a 'last ecological frontier'. Palawan has some of the best developed coral reefs in the country, with fringing and patch reefs along most of the coast and live coral cover reaching between 50 - 90% in some places. However, agriculture, fishing (especially with explosives and poisons), mineral extraction and offshore oil and natural gas, as well as tourism, threaten the environment.

In 1992, a 'Strategic Environmental Plan' for Palawan was adopted and through it an 'Environmentally Critical Areas Network' is being implemented. The Environmentally Critical Areas Network is a system of management zones graded from strictly protected to development areas. The terrestrial component has a core zone, a buffer zone (divided into a restricted, controlled and traditional use areas) and a multiple /manipulative use area. The coastal/marine component also has a core and multiple use zone.

Ecological Monitoring: Reef Check has been conducted in Palawan since 1997 and the Marine Science Institute of the University of the Philippines has included Palawan in their occasional nation wide surveys of coral reef health.

Socio-economic Monitoring: Rapid Rural Assessment (RRA) of the coastal areas of in Palawan is on going.

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

MAB

PUERTO GALERA, PHILIPPINES – MAN AND THE BIOSPHERE RESERVE

The Puerto Galera Biosphere Reserve is in the central part of the Philippines on the island of Luzon, and contains both a terrestrial component and a substantial coastal and marine component. Coral reefs, seagrass beds and mangrove forests irregularly border the shoreline of Puerto Galera. The entire area is facing increasing pressure from growing numbers of both residents and visitors, as well as from rapidly expanding development. Deforestation and cutting of mangrove trees for fuel and housing material have substantially reduced the mangrove area. Coral reef and seagrass ecosystems are suffering from reduced water quality, unsustainable fishing and increased sedimentation and eutrophication. These are obvious indications that the status of Puerto Galera as a Biosphere reserve is being jeopardized.

Conservation measures have been undertaken at the national, local, and community levels in the Puerto Galera area, for example the establishment of a marine sanctuary and underwater nature trail in 1987. The majority of projects such as this, however, have met with limited success. These challenges necessitate a strong management plan if Puerto Galera is to survive as a Biosphere Reserve.

Ecological Monitoring: The Marine Science Institute of the University of the Philippines has maintained a biological station in the area and MAB interagency members have carried out inventory work and environmental monitoring. The status of the reefs is fair with an average of 31% live coral cover.

Socio-economic Monitoring: No information was provided

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

8. Status of Coral Reefs in East and North Asia: China, Japan, Korea and Taiwan

Chang-Feng Dai, Chen Gang, Makoto Inaba, Kenji Iwao, Fumihito Iwase, Shinichiro Kakuma, Kenji Kajiwara, Tadashi Kimura, Yoshihiko Kotera, Yoshikatsu Nakano, Satoshi Nojima, Keiichi Nomura, Katsuki Oki, Kazuhiko Sakai, Takuro Shibuno, Hiroya Yamano And Minoru Yoshida

Abstract

These reefs are on the boundary of the Southeast Asian centre of biodiversity and share many species and characteristics of reefs in this centre. After serious coral bleaching in 1998, most of the reefs are recovering in Japan and Taiwan, and possibly also in China. However, more bleaching has occurred in Japan in July - September 2001. The southern islands of Ryukyus, Japan experienced the most severe coral mortality of the region with 46-69% death. In addition, there appears to be a crown-of-thorns starfish (COTS) outbreak in Okinawa, Kerama and Amami Islands in 2001 and 2002. Sedimentation from terrestrial run-off is still a major threat to corals in Japan and Taiwan, and mass mortality of *Porites* corals caused by soil run-off was observed in 2001. The Japanese government established an international coral reef centre on Ishigaki Island, in the southern islands of Okinawa in 2000 to facilitate coral reef monitoring, conservation in the region and to act as a Node for the GCRMN. However, enhanced coordination is needed to build capacity in monitoring and management for effective coastal resource conservation.

Introduction

The coral reefs of China, Taiwan and Japan lie just north of the global centre of biodiversity for coral reefs, and those of Japan and Taiwan are influenced by the Kuroshio current which carries coral reef larvae from this centre. Biodiversity is high towards the south, but diminishes to the north, with reef coral growth ending adjacent to Tokyo. These reefs are also at the centre of the largest human populations on earth, such that many are under extreme pressure, which has resulted in major reef modification and damage. This report summarises material presented in 'Status of Coral Reefs of East and North Asia: China, Japan, Taiwan' by S. Fujiwara, T. Shibuno, K. Mito, T. Nakai, Y. Sasaki, Dai C-F, and Chen G. in the Status of Coral Reefs of the World: 2000 report. It also presents new data on the reefs and information on new coordination mechanisms for coral reef monitoring in the region.

The major reefs of mainland **China** are on Hainan Island, to the north of the South China Sea. Connections exist between these reefs and those of Vietnam and the Spratly Archipelago in the South China Sea. Reef growth continues north from Hainan along the

coast of Guangdong, Guangxi, and Hong Kong. China also has strong interests in the Paracel and Spratly islands (Xisha and Nansha Islands). Human population pressures have resulted in considerable damage to the mainland reefs, but there are government efforts to create MPAs to protect these resources.

Coral reefs grow around all the southern Ryukyus islands, **Japan** and around the east coast of the large island of Kyushu, and thin out to coral communities growing on rocky surfaces northwards to the latitude of Tokyo Bay. These are under the influence of the

Kuroshio Current from the south, whereas the Oyashio cold current determines the northern limit of coral growth. In addition, there are major reef areas around islands well to the east of the main islands of Japan. There are three types of reefs: fringing; barrier; and one raised atoll (Daito Island). The Yaeyama Islands in the south are particularly important because they have high species diversity, including many endemic species. The highest latitude coral reef is on Iki Island, Nagasaki Prefecture, which was regarded as a non-reef area in 2000.

Coral reefs or coral communities are found around Taiwan except in the sandy area on the west coast. The main reef area is on the southern tip of the island, the Hengchun Peninsula, and offshore islands including Lutao, Lanyu, Hsiao-Liuchiu and Penghu Islands, as well as Tungsha Island (Pratas Island) and Taiping Island (Itu Aba Island) in the South China Sea. Species diversity of reef organisms on the coral reefs around Taiwan is relatively high with approximately 300 species of hard corals, 50 species of soft corals, 20 species of gorgonians, 130 species of decapod crustaceans, 90 species of echinoderms, 1,200 species of reef fishes and 150 species of algae having been recorded.

The **Korean** Peninsula has a 11,500km coastline (Republic of Korea only) including the coastlines of 3,153 islands in the Korean Sea. The characteristics of the eastern, western and southern coasts are quite different from each other. The eastern coast is quite steep, and borders a deep sea-basin with a narrow continental margin. Sandy beaches and rocky shores are relatively well developed on this coastline. The southern and western coasts are much more complex with calmer waters and contain many islands scattered over the southern and western shallow seas. These coastal and marine environments provide diverse habitats for marine life and abundant marine resources.

Status of Coral Reef Benthos

China
No new information has been received.

Japan
Coral bleaching in 1998 damaged all coral communities from the Ryukyu Islands to southern Honshu, except for the western Shikoku, Miyake and Ogasawara Islands. New coral recruitment has been recorded at the damaged areas in Okinawa Island and Amami Islands and coral cover was increasing in the Kerama Islands, Ishigaki and Sekisei Lagoon in 2000. While most coral communities were recovering from the bleaching, another bleaching occurred from Ryukyu Islands to Amami Islands in summer 2001. Higher mortality at 45.7-68.8% loss was evident in the southern Sekisei Lagoon and Ishigaki Island, southern Ryukyus, but there was no mortality in Miyako Islands and Amami Islands.

In contrast, corals are increasing their distribution around Kyushu and southern Honshu and remain in good condition. The coral cover was 34.6-80% in Kushimoto, Honshu and 5-80% in Amakusa, Kyushu in 2001. High recruitment of *Acropora solitaryensis* was observed in Amakusa, and this increase may have been caused by increasing minimum water temperatures in these areas, compared to increasing summer temperatures that caused bleaching damage to corals during summer in the Ryukyus to the south. The highest latitude coral reef (33°48' N, 127°40' E) was reported in Iki Island, Nagasaki Prefecture in 2001. The reef area is about $900m^2$ and consists of *Favia*, *Echinophyllia* and *Cyphastrea* species, which cover 50-90% of the reef. Temperatures range from 13.3°C in March to 26.5°C in August.

Crown-of-thorn starfish (COTS) appeared to be at outbreak levels in Okinawa Island, Kerama Islands and Amami Islands in 2001 and 2002. Millions of individual starfish have been killed by the local municipality and volunteers, but the numbers of COTs appear to be increasing in Sekisei Lagoon. The coral eating snail, *Drupella* is still a serious threat to the coral community in Kochi, Shikoku and Kushimoto, Honshu. In both areas, *Drupella* are constantly collected in protected areas by local scientists and volunteers. Miyake Island is a volcanic island in the Izu Islands, about 200km south of Tokyo. The volcano on Mt. Oyama erupted repeatedly in 2000 and seriously damaged part of the coral community around the island by smothering it with volcanic ash and run-off from the land after heavy rain.

Taiwan

Fringing reefs are found in the coastal waters around the southern Hengchun Peninsula, Lutao, Lanyu, Hsiao-Liuchiu, and Penghu Islands. Patchy fringing reefs occur along the east and north coasts of Taiwan, where non-reef coral communities are more common. Tungsha Island is an atoll in the northern part of the South China Sea. Taiping Island is a tropical reef island in the Spratlys in the South China Sea.

Reef Check data from 8 localities in Taiwan including Northeastern coast, I-lan County, Eastern coast, Hengchun Peninsula, Penghu Islands, Hsiao-Liuchiu, Lutao, and Lanyu from 1997 to 2002 show that coral cover at 5 sites was higher than 50% indicating reefs were in relatively good condition. Coral cover at 9 other sites was between 25 and 50% indicating reefs under possible stresses. Cover at the remaining 16 sites was below 25% indicating severe damage to these reefs, hence their poor condition. Coral cover was highest (50-75%) at Lutao, an offshore island on southeast Taiwan, however, cover on the northeastern coast, I-lan County, Hsiao-Liuchiu Island, and Penghu Islands was below 25%, as a result of localised damage. The low abundance of fishes and indicator invertebrates organisms suggest that most reefs were over-fished. In addition, sediment accumulation was evident and numerous discarded fishing nets were found at most localities indicating that coral reefs in Taiwan were under severe threats from human activities.

Most of the reefs remain in a similar condition as that reported in 1998 and 2000, although several reef sites in Nanwan Bay, southern Taiwan and Penghu Islands were heavily damaged by typhoons in 2001. No COTS have been reported during Reef Check surveys of Taiwan's reefs in 2002, and very few cases of predation by gastropods were recorded. Coral predators are not making a significant impact on coral reefs in Taiwan.

Korea

There are no 'typical' coral reefs formed by reef building corals in Korean waters, however, there are distinct soft coral reefs with tropical and subtropical elements at Jejudo on the southern tip of Korea. A branch of the warm Kuroshio current passes through the southern part of the Jejudo and this brings 127 coral species to Korea. There are 97 species found on Jejudo, 65 coral species are restricted to the Jeju area, and 15 coral species in Jejudo have been declared for preservation by the Natural Environment Preservation Act.

Coral Bleaching and Recovery After the 1998 Climate Change Event

The coral reefs of southern **Japan** suffered the most severe coral bleaching and mortality ever observed from July to September 1998. Coral mortality was: 40-60% in Nansei Island; under 20%, in Koshikijima Island western Kyushu, eastern Shikoku and Kushimoto; 30-40% on Hachijo Island (80-90% in parts); 70-90% on south Yoron Island; and 30-60% on north Yoron Island. In the Sekisei Lagoon, 40% of *Acropora* died and 8% of coral cover was lost. Coral cover showed a 62% decrease on Ishigaki Island, with most *Acropora* lost, while mortality in *Heliopora coerulea*, *Porites cylindrica* and branching *Montipora* was not significant. In 2001, another bleaching event occurred when water temperatures increased between July and September in Ryukyu Islands and Amami Islands. The mortality observed was 7-45.7% in Sekisei Lagoon and 0.8-68.8% in Ishigaki Island. Okinawa Island and Kerama Islands had lower levels of mortality at 0.3-25.3%, and no mortality was observed in Miyako Islands and Amami Islands.

There was extensive coral bleaching in southern **Taiwan** in 1998, with 30% to 50% of colonies bleached on Penghu Islands, Lutao, and Lanyu. Subsequent mortality was about 20% of coral colonies in 1998. Reports of coral bleaching in 2002 on Taiwan were scattered. Only three reef sites in south Taiwan and one site in east Taiwan reported with sporadic bleaching of corals (<15% of coral colonies).

Japan has recognised the potential for long-tem damage from global climate change and the Marine Science and Technology Center (JAMSTEC) has surveyed bleaching damage and modelled meteorological and oceanographic data correlated with the bleaching. They showed that elevated sea surface temperatures around the Equator showed up around Japan several months later and concluded that global oceanographic variations were the driving forces for coral bleaching, but no clear meteorological signals could warn of future events.

Status of Coral Reef Fishes and Fisheries

No new information has been added for this report. In general, there are insufficient data on coral reef fisheries as most data sets do not distinguish the origin of fisheries products sold through the markets. There are some fisheries statistics for coral reef fishes collected by the Okinawa Prefecture, however it is likely that these data could contain a bias. These should be analysed carefully to detect any trends or relationships between fisheries resources and coral reef condition.

Anthropogenic Threats to Coral Reef Biodiversity

Over-fishing of resources such as reef fish, molluscs, octopus, cuttlefish, crabs and algae has resulted in major changes to the reefs in East Asia. These resources are important for the livelihood of many millions of people and continued exploitation will threaten this resource base. The major threats to reefs in this region are from over use of the resources and extensive modification of coastal and watershed habitats through development by very large human populations. Most of the reefs near the land have been damaged by excessive sediment and nutrient pollution discharges, over-exploitation of resources including coral and sand mining, and direct modification of reefs during development. Offshore reefs have come under strong fishing pressures, including blast and cyanide fishing, with the global centre for the live reef fish trade for restaurants being in Hong Kong, China.

Terrestrial runoff of red clay soils is the major threat to reefs of the Ryukyu Islands, **Japan**. Excessive sediment is generated from poor land development and agriculture, road building and forestry. Planned construction of an airport on Ishigaki Island to attract more tourists to the reefs, will release more sediment and damage the reefs. Public awareness has been raised over reef damage from the many coastal developments including other airports, small boat harbours, tourist resorts etc. Attempts have been made to reduce sediment flow by returning rivers to their natural state and regulating domestic land activities, but runoff still continues from smaller construction sites. In 2001, there was a mass mortality of *Porites* corals caused by heavy runoff of red clay soil and fresh water from Todoroki River on Ishigaki Island. More than 75% of corals died in a 8ha area and the mortality was over 25% in a 27ha area near the river. Construction activities and soil erosion still damage the coral reefs in Kushimoto, Okinawa and Ogasawara. A large community of *Catalaphyllia jardinei*, which was one of only two in the area, was destroyed by the construction of marine port in Kushimoto. In Sesoko Island, 5,000m^2 of coral reef was destroyed during shoreline construction.

Already the reefs off Okinawa, **Japan** have shifted from coral reefs to turf algal reefs through damage from sedimentation, crown-of- thorns starfish and overfishing of the predators of sea urchins. Coral harvesting for the aquarium market is another threat to the coral reefs. Illegal collection of live coral and live rock operates in Okinawa, and although the Coast Guard patrols the area and arrests illegal fishers, the extent of the problem has not been assessed. The Okinawa Government is attempting to revive the fishery by releasing juveniles, establishing artificial reefs and implementing fisheries management.

Tourism is a major growing industry in the region, especially in the Ryukyu Islands, **Japan**, with over 4 million tourists per year using the coral reefs for leisure. However, poor planing for tourist resorts, such as reclaiming reef flats, blasting access for ports, and building groynes to protect beaches have resulted in damage to the major attractions for the tourists. Tourists continue to trample over live corals, use jet skies on reef flats, and scuba divers damage and collect corals. Now underwater walking with helmets is creating new threats. Some operators are aware of the problems, but there is insufficient education of the tourists to ensure the industry is sustainable. In the Kerama Islands, local protected areas have been established by diving operators, fisheries associations and local municipality to protect corals from the pressure of sport divers.

There are similar sedimentation problems on coral reefs around Hainan and Hong Kong, **China**, and around **Taiwan**.

Many types of pollution threaten the reefs of **Taiwan**, with the most critical and widespread environmental issue being terrestrial run-off, which is affecting reefs of southern Taiwan, the northeastern coast, eastern coast, Hsiao-Liuchiu and Penghu Islands. The sediment is caused by poor land development, agricultural practices, road building and deforestation. Many examples of sediment covering coral colonies and accumulating on reef surfaces have been seen at most reef sites. Previous reports showed that sedimentation has caused severe damage to reefs. Reefs of the Penghu Islands, Lutao and Lanyu, **Taiwan** have been extensively damaged by dynamite fishing, trawling, and sedimentation. Over-fishing is prevalent and some fishermen also collect reef fish for the aquarium trade. Tourism in reef areas has expanded rapidly in recent years, and includes scuba diving, snorkelling, surfing, boating, etc. It is estimated that about 300,000 people rely on reefs for their livelihood. Destructive fishing methods such as dynamite, cyanide poisoning, and bottom trawlers have been widespread for many years. Dynamite fishing started over 50 years ago in Penghu Islands and since then, it has become common in coastal areas around Taiwan. It is now clearly evident that most of the benthic resources in many reef areas, especially in Penghu Islands and Hsiao-Lichiu, have been either badly damaged or completely wiped out by destructive fishing. However, this is now coming under control in most areas.

In **Korea**, the major threats to the marine life, including corals, are also sediments from coastal development and construction, organic pollution from the land, and sewage and other wastewater. The MPAs and adjacent areas in Jejudo are popular for recreational fishing, boating and underwater diving. In the Munsom area, a submersible is being operated for tourists. Many different tourist activities are allowed, except the visitors cannot collect any marine organisms or damage habitats under National law. However, recreational divers and the tourist submersible frequently damage coral communities, especially soft coral reefs on sub-tidal cliffs.

MPAs, Monitoring and Management Capacity

Current efforts to conserve the coral reefs in the region are proving to be insufficient, as the reefs continue to degrade. Most countries have laws and plans for reef conservation, but these are regarded only as recommendations and are rarely enforced. Moreover there are inter-sectoral disputes on control over coastal resources, with a lack of coordination for land and coastal conservation. MPAs are being established to conserve coral reef resources, but conservation is virtually ignored outside the protected areas, with development always taking priority. There is a need to provide better environmental education to communities and restore the traditional cultural ethic about sustainable use of the resources.

No MPAs for coral reefs have been established in **China** and research and monitoring capacity is generally low. In 2000, people in Hainan, Guangdong, Guangxi and Hong Kong have been trained in coral reef monitoring using Reef Check methods. In **Japan**, there are 6 Natural Parks with coral reefs in the Amami, Ryukyu and Ogasawara Islands and 23 Marine Park Zones in National and Quasi-National Parks in these coral reefs islands (1.7% of the coral reef area of Japan). These MPAs are considered to be too small to conserve coral reef resources, and overall management of Japanese reefs is required to reduce damage from land based activities, especially sediment and pollution runoff, and over-fishing.

There are many coral monitoring programs in **Japan** conducted by the Government, prefectural governments, local municipalities, research institutions, researchers, NGOs and local communities. As most of the local government monitoring programs are operated with a single fiscal year budget, there are often breaks in the regular monitoring, or there is monitoring for a specific impact, such as assessing red soil runoff, COTS or bleaching etc. The survey results are usually published internally and not for public access. Monitoring by research scientists is usually for specific projects and tends to have a longer period than management programs. However, recent scientific focus on degradation of coral reefs is contributing to raising public awareness by making research data available.

The Environment Agency of Japan conducted a broad scale survey on coral in all of Japan during 1989 to 1992. Long term monitoring has been continued in Sekisei Lagoon, which is a part of Iriomote National Park, after it was initiated to survey a COTS outbreak in the Yaeyama Marine Park Research Station in 1983. The monitoring has been extended to Ishigaki Island since 1998. Spot check methods are employed in this monitoring on 123 sites in Sekisei Lagoon and 75 sites around Ishigaki Island. Coral cover, type of coral community, maximum diameter of tabulate *Acropora* and number of COTs are recorded during 15 minutes snorkelling at each site. Reef Check, the Coral Network and other individual groups are also involved. Community members in the Yaeyama area, between Ishigaki Island and Iriomote Island, conduct voluntary monitoring of their own reefs to observe trends. Ishigaki is a coordination centre for coral reef research, monitoring and conservation in Japan and eastern Asia.

Fishing and diving associations have declared protected areas from diving and anchor damage in the Kerama Islands. Another fishing association protects an emperor fish spawning ground in the Yaeyama area. Those are a few cases of protected areas being managed by local communities. The International Coral Reef Research and Monitoring Center, established in Ishigaki, Okinawa by the Ministry of Environment in 2000, is the Node for East Asia and national node of Japan for the GCRMN. The centre is still trying to establish the system of information gathering on coral reefs in Japan and the East Asian region.

In **Taiwan**, most of the reef areas are already within national parks or national scenic areas. The management is entrusted in the following Authorities: Kenting National Park in South Taiwan; the NE Coast National Scenic Area; the East Coast National Scenic Area; and Penghu National Scenic Area. Unfortunately, the effectiveness of this management is poor, because these authorities lack adequate laws to protect the reefs and enforce existing laws. However, both scientists and sectors of the government are encouraging the conservation and sustainable use of coral reefs and there are plans to establish MPAs. The scientific and local communities formed the Taiwanese Coral Reef Society in 1997, which is helping to raise public awareness about the threats to coral reefs and their value to Taiwan. This society has implemented Reef Check surveys from 1997 to the present and details can be found at http://www.tcrs.org.tw. Another long-term ecological research program was launched in 2001 to study and monitor the changes of coral reefs in southern Taiwan. The National Scenic Council of the Taiwanese government sponsored this program and data are managed by the Institute of Zoology, Academic Sinica (http://140.117.92.194/lter). In addition, a community-based management project was established in 2000 at Lutao, an offshore island in SE Taiwan and appears to be the first example of effective management in Taiwan. A committee that contains representatives of local fishermen, dive shops and resort owners, and the local government runs the project and sets the rules that govern reef use.

In **Korea**, there are 6 types of national coastal and marine protected (or managed) areas that have been designated for different purposes under different laws or acts since the 1960s. The first marine national park was the Hallyeosudo Marine National Park in the South Sea of Korea, established in 1968. In 2000, 4 areas along the coastal zone of Jejudo totalling 29.1km^2, were established as Natural Monument Protection Areas (NMPA) to conserve unique marine life and biodiversity. These areas were designated under the Cultural Property Protection Law of the Ministry of Culture and Tourism and are the first MPAs to include coral reefs. Although many terrestrial surveys have been implemented, there is no long-term monitoring or research of the marine components of the parks. There are currently 20 coastal and marine protected areas, which are shielded from land development impacts by the prohibition of developments within 500m of the coastal zone. However, most protected areas have not been effective due to poor design, enforcement, management and funding. Moreover, an insufficient number have been designed to focus on sustainable management of coastal and marine ecosystems to be effective as a whole.

Government Policies, Laws and Legislation

The collection of corals for lime has been stopped in Hainan, **China** and all lime kilns have been destroyed. Reef conservation awareness is improving and there has been a reduction in previous levels of degradation. **Japan** continues to develop the Basic Environment Plan of 1994, to conserve natural resources, both within the country and internationally to ensure sustainable benefits for all stakeholders. They are focusing on improved environmental education with more community participation. Special attention is being paid to the biodiversity value of coral reefs through: the establishment of Natural Parks, which contain specific Marine Park Zones; the protection and management of fishery resources; and prevention of runoff of sediments onto coral reefs. Japan is also seeking to assist people in Asia and the Pacific with their efforts in environmental conservation and governance.

The responsibility for managing the Natural Monument Protection Areas in **Korea** is shared between the central and local governments. For example, the NMPAs in Sungsan Ilchulbong, Munsom and Bumsom, Chagwido and Marado of Jejudo belong to 3 different local governments. Even though the NMPAs were established by one ministry, the management of coastal and marine ecosystem and integrated coastal management are carried out by a different ministry, the Ministry of Maritime Affairs and Fisheries (MOMAF).

Conclusions and Recommendations

Although most of the coral reefs in the Ryukyu Islands in **Japan** are recovering from bleaching damage in 1998, they are still under severe stress from terrestrial run-off, repeat bleaching and COTS.

Taiwan also has similar problems of terrestrial run-off, with most coastal reefs severely damaged by sedimentation caused by poor land development, poor agricultural practices, road building and deforestation.

A coordination mechanism involving all stakeholders concerned with coral reefs should be formed to develop active conservation measures and programs for each country. A regional coordination system is also needed to improve the capacity of management in those countries.

Authors and Contacts

Dai Chang-feng (coral reefs in Taiwan), Institute of Oceanography, National Taiwan University, <corallab@ccms.ntu.edu.tw>; Chen Gang (coral reefs in China), Hainan Marine and Fishery Department, <gchen@han.cei.gov.cn>; Makoto Inaba (Ogasawara Islands, Japan), Ogasawara Institute of Boninology, <inaba@ogasawara.or.jp>; Kenji Iwao (Kerama Islands, Japan), Akajima Marine Science Laboratory, <iwao@amsl.or.jp>; Fumihito Iwase (Kochi Prefecture, Japan), Kuroshio Biological Research Foundation, <iwase@kuroshio.or.jp>; Shinichiro Kakuma (Fishery Statistics, Japan), Subtropical Research, <kakuma@subtropics.or.jp>; Kenji Kajiwara (Miyako Islands, Japan), Sea-Farming Center of Hirara City, <pulchra@lime.ocn.ne.jp>; Tadashi Kimura (Sekisei Lagoon, Japan), Japan Wildlife Research Center, <tkimura@jwrc.or.jp>; Bon Joo Koo (coral reefs in Korea), Korean Ocean Research & Development Institute, <bjkoo@kordi.re.kr>; Yoshihiko Kotera (Sekisei Lagoon, Japan), Kushimoto Marine Park Center; Yoshikatsu Nakano (Sesoko Island, Japan), University of Ryukyus, <ynknssk@ryukyu.ne.jp>; Satoshi Nojima (Amakusa, Japan), Kyushu University, <satoshi@mbox.ambl-unet.ocn.ne.jp>; Keiichi Nomura (Kushimoto, Japan), Kushimoto Marine Park Center, <alpheus.nomura@nifty.ne.jp>; Katsuki Oki (Amami Islands, Japan), Amami Marine Exhibition Hall, <kaiyo@po.synapse.ne.jp>; Kazuhiko Sakai (Sesoko Island, Japan), University of Ryukyus, <sakaikz@lab.u-ryukyu.ac.jp>; Takuro Shibuno (Fishery resources, Japan), Ishigaki Tropical Station, Seikai Fisheries Research Institute, <shibunot@affrc.go.jp>; Hiroya Yamano (Iki Island), National Institute of Environment Studies, <hyamano@nies.go.jp>; Minoru Yoshida (Ishigaki Island, Japan), Kaiyu Co. Ltd., <kaiyu-yoshida@isis.ocn.ne.jp>

Supporting Document

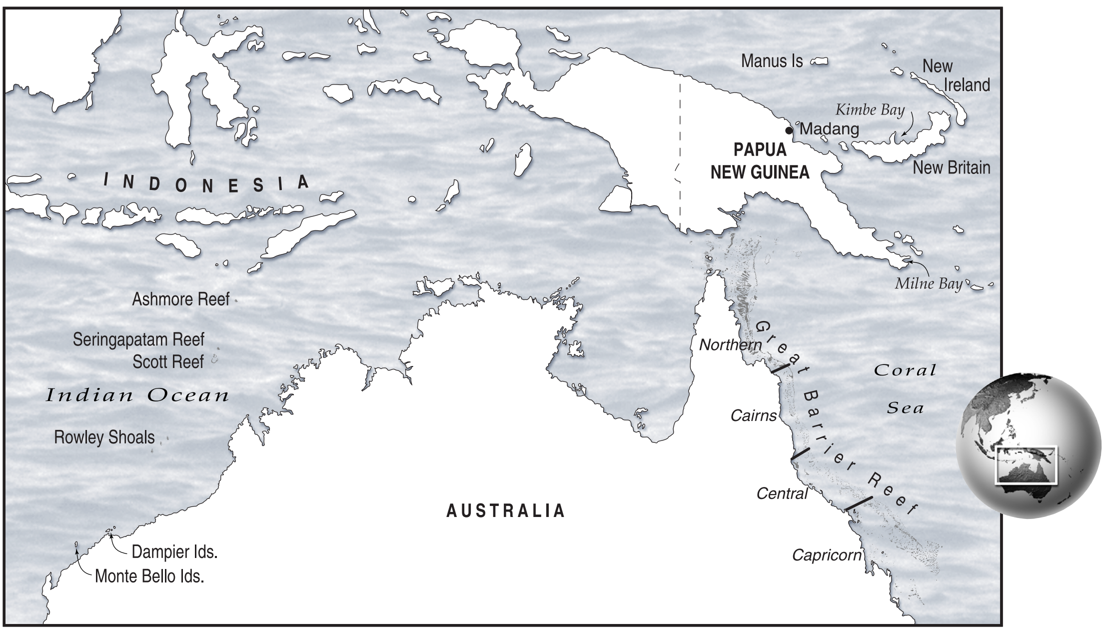
Fujiwara S, Shibuno T, Mito K, Nakai T, Sasaki Y, Dai C-F, Chen G. (2000). Status of Coral Reefs of East and NorthAsia: China, Japan, Taiwan. In: Status of Coral Reefs of the World: 2000. Wilkinson C. (Ed.) Australian Institute of Marine Science, Townsville p. 131-140.

9. Status of Coral Reefs of Australasia: Australia and Papua New Guinea

Hugh Sweatman, Kate Osborne, Luke Smith, Tim Grubba, Jeff Kinch, Geoff Jones and Vagi Rai

Abstract

Australia contains over 17% of the world's coral reefs, second only to Indonesia. These reefs are predominantly in good condition due to low levels of human pressure and supported by substantial research and monitoring. They are well protected from a relatively low level of stress from the small population that is not dependent on reefs for subsistence. These reefs have exceptionally high biodiversity, favoured by the massive size and diversity of habitats. An extensive system of marine protected areas has been implemented, the best known of these is the Great Barrier Reef Marine Park (which is also a World Heritage Area). This is the world's largest marine protected area and serves as a model for the establishment of many other similar multi-user areas. The Great Barrier Reef (GBR) is amongst the best studied coral reefs in the world, with probably the largest and most extensive monitoring program, which is used as model for projects elsewhere. It attracts very high capacity in all areas of coral reef science, management and education. Crown-of-thorns starfish (COTS) predation and coral bleaching have been the primary disturbances affecting GBR reefs since 2000. The current outbreak of crown-of-thorns starfish (COTS) originated in the Cairns section of the GBR and has been travelling south



since 1992. The central region of the GBR is currently experiencing outbreak levels of COTS, while reefs in the Cairns section are showing signs of recovery. A second outbreak of COTS is active in the southern Swains reefs. There was damaging coral bleaching over considerable areas of the GBR in 2002. Bleaching was once again correlated with elevated temperature 'hotspots' but these varied from the areas affected in 1998. Bleaching was more extensive and inshore reefs were once again the most affected. Mortality rates from this event are not yet known. Coral disease is emerging as a new threat to the GBR with surveys in 2002 showing increased coral mortality due to an unknown group of pathogens colloquially termed 'white syndrome'. The coral reefs of Papua New Guinea (PNG), however, are less well known with few protected areas, but with strong traditional management. There are reefs with high biodiversity and great scenic beauty, which are in relatively good condition, although there are warning signals of increasing human pressures and threats from global climate change. Countering these negative trends, there has been strong recent interest by larger NGOs which are intent on conserving much of this high biodiversity through involving communities in resource management. The largest threats on the horizon are major deforestation activities, increasing fishing pressures from steadily growing populations, and the unknown threats from coral bleaching.

Introduction

The coral reefs around Australia and Papua New Guinea (PNG) collectively contain approximately 17.2% of the world's total, and include some reefs with almost the same high biodiversity as those in the 'biodiversity hot spot' of Indonesia and the Philippines. The critical difference to those 'hot spot' reefs is that most in this region are under low human pressures and those around Australia are subject to high level research and monitoring activity that is supporting strong resource management. Thus these reefs remain as some of the least impacted with the best prognosis for the future, with the exception of climate change related coral bleaching and mortality.

The Great Barrier Reef (GBR) is the major Australian reef structure, with 3,000 fringing, submerged, platform and barrier reefs spread over 2,700km of the Queensland continental shelf, from the reefs of the Torres Strait and Papua New Guinea to 23°S. All of the reefs are contained within the GBR Marine Park (339,750km^2), which is also a World Heritage Site. There are also remote reefs in the Coral Sea to the east and south of the GBR, and also extensive coral reefs off the coast of Western Australia, including 4,000km^2 at Ningaloo Reef. Australia's EEZ includes reefs well out into the Indian Ocean, as far as the longitude of western Sumatra.

Papua New Guinea (PNG) includes a series of large (New Britain, New Ireland and Bougainville) and small islands as well as the eastern half of the large island of New Guinea. The coastline of over 10,000km and the EEZ of several million square kilometres includes all major reef types, with an estimated area of 40,000km^2. The diversity of reef fishes and corals at the few locations that have been studied ranks among the highest in the world. Coastal communities depend significantly on coral reefs for coastal protection, subsistence food, medicines and cultural products e.g. the names for PNG currency are based on reef species recognising that these were once traditional currency. The reefs are important for dive tourism and export fisheries, especially the live reef food fish trade.

This report summarises the previous report of 2000, with the addition of more data on reef monitoring from Australia, and some anecdotal reports from PNG.

Status of Corals, Other Benthos and Fishes

PNG

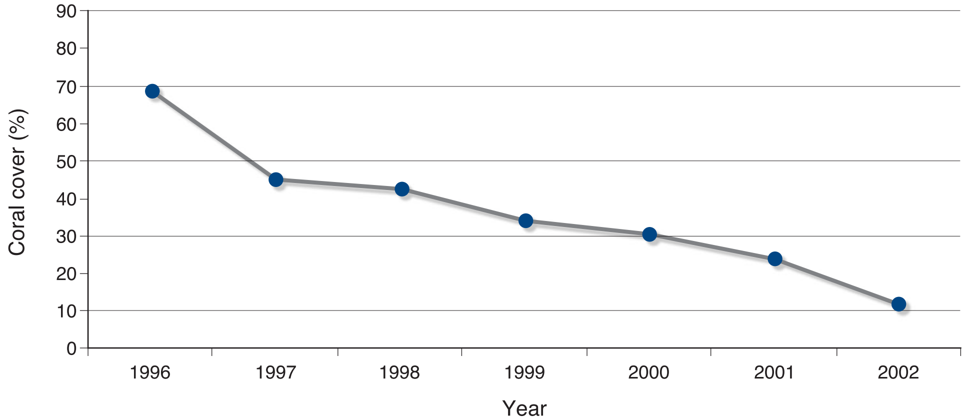
Reports continue to state that most reefs in PNG are relatively stable with healthy populations of corals and fishes. Reefs show relatively little evidence of damage from human activity, and 40% to 50% coral cover is the norm in most areas. Effects of bleaching appear to have been uneven, with some incidences of high mortality, but most reefs have been unaffected. A conspicuous recent development has been the increasing presence and influence of conservation NGOs in PNG. These have been responsible for numerous surveys of biological resources emphasising biodiversity, and of the socio-economic importance of coastal resources, particularly reefs. Conservation International has a very active association with UNEP in the Milne Bay Province, where surveys have reported exceptionally high levels of biodiversity. WWF has a program to monitor water quality in Madang Lagoon and is assisting community groups establish their own conservation areas. The Wildlife Conservation Society has conducted biodiversity assessments in 7 locations.

The first surveys of the isolated Lak region in southern New Ireland, Papua New Guinea were undertaken in 2002 by local and outside scientists as part of an Integrated Conservation and Development project to determine the conservation value of the marine resources, assess the sustainable development potential, and consider projects for conservation. The fringing reefs are exposed to high wave energy, with few other stresses, other than the potential for sediment damage from uncontrolled logging and the possibility of coral bleaching. The reefs consisted of massive *Porites* corals, table and other *Acropora* corals, and soft corals. Dead branching *Acropora* was prevalent, indicating possible recent high temperature events. Coral cover was generally above 40%, with above 20% dead coral cover in some locations. Soft corals were prevalent in some areas to 45% cover. At 10 sites there is hard coral cover of over 50% (Cape Narum, Cape Bubun, Toua Island, Beriota, Li, Lavinia Cove, Watun, Tauwanlik Pt, Watlongor and Wasir).

Subsistence and artisinal fishing is the predominant human activity on PNG reefs, and destructive fishing practices are uncommon compared with other regions of the ‘Coral Triangle’ (including Indonesia and Philippines). In general, reef fish harvests are considered to be within sustainable levels, but there is evidence of over-fishing around large coastal centres. There is also good evidence of substantial over-fishing in many locations of invertebrates such as sea cucumbers, trochus, green snail and clams for export. These exploitation pressures will increase as populations grow, and there are few alternative mechanisms for generating income in a developing county economy.

Australia

The scale and extent of the coral reefs in Australia dictates that, irrespective of the considerable amount of research and monitoring, there will still be gaps for large areas. The most extensive coral reef monitoring program in the world is conducted by the government funded, Australian Institute of Marine Science (AIMS). This covers a



The average coral cover on 8 reefs in Kimbe Bay, New Britain PNG, shows a serious declining trend from 70% cover to around 20% in 6 years following several bleaching events and damage from sediments from lands cleared for oil palm plantations flowing onto the reefs during floods.

representative sample of inner, middle and outer shelf reefs of the Great Barrier Reef, as well as reefs off Western Australia (Ningaloo, Scott Reef and Rowley Shoals). Other agencies of national and state governments and universities conduct additional coral reef monitoring on the Solitary islands to the south of the GBR and on some spatially separated reefs of northern and western Australia. There are an increasing number of local NGOs that are undertaking coral reef monitoring, mainly using Reef Check methodology

The GBR Marine Park is classified into four sections of the GBR, with hundreds of reefs in each section. Thus, observations on reef condition in each sector are based on observations of a representative proportion of those reefs. The best information on reef status is for the GBR Marine Park and some reefs of Western Australia. However there are large areas of reefs and coral communities for which there is only anecdotal information.

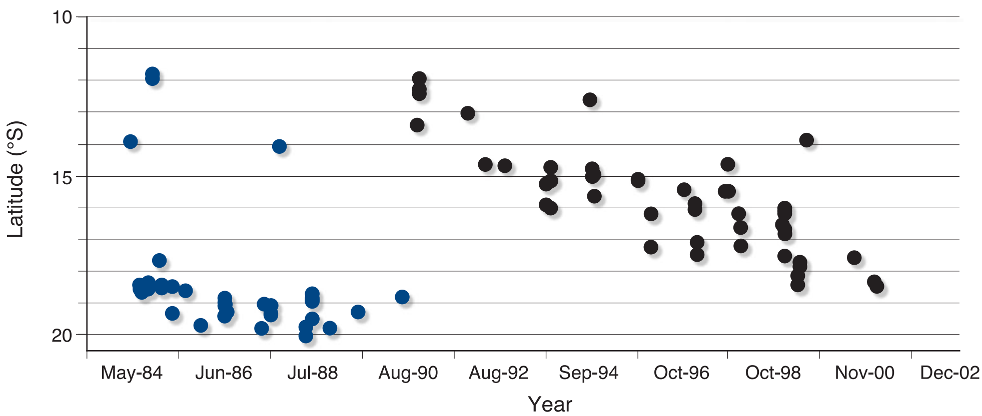
Eastern Australia

GBR Far Northern Section: Because these reefs are remote, monitoring is irregular; 10 reefs were surveyed in 2001 and average reef wide coral cover was 27% (range 10-43%) which is the similar to the 2000 report (26%). COTS were seen on most reefs but in very low numbers.

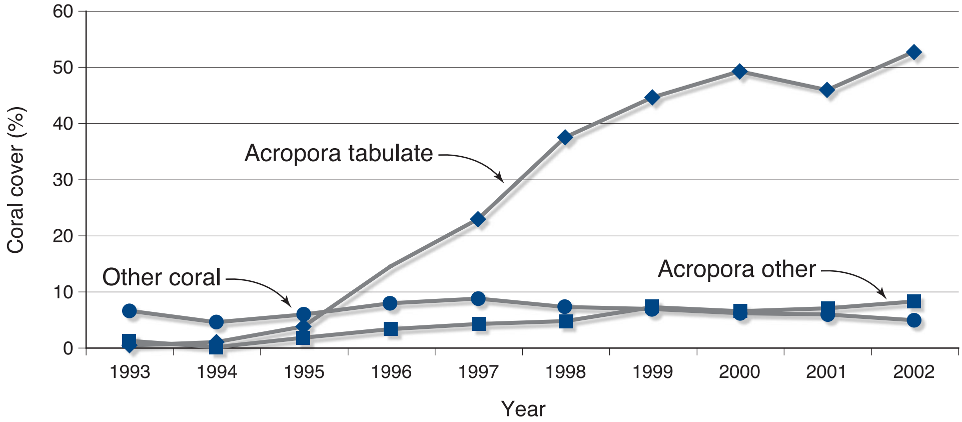
GBR Cairns Section: These reefs are close to shore and the basis for a major tourism industry, and are also close to a mountainous hinterland that receives high rainfall. The amount of fresh water, nutrients and sediment flowing towards the inshore reefs is higher than most other areas of the GBR. There was a repeat of coral bleaching on inner-shelf reefs in 2002 and increased levels of 'white syndrome' disease on outer shelf reefs in the north. In 2001, 32 reefs were surveyed by manta tow and had a mean reef-wide hard coral cover of 21% (range 3-43%). These results are the same as reported in 2000. Video surveys of sites on the northeast sides of 18 reefs indicates there has been a small decrease in coral cover from 31% in 1999 to 27% in 2001.

GBR Central Section: This section includes the accessible reefs for tourists and fishers in the Whitsunday Islands. Manta tows of 28 reefs found reef-wide coral cover to be 20% (range 5-43%), which is the same as 2000 report. Hard coral cover on the northeast facing sites of 18 reefs showed 28% cover. Outbreaks of COTS in the north of the section have resulted in declines in coral cover since the 2000 report, while reefs in the south generally have increasing coral cover. The pattern of COTS outbreaks is that they appear first in the north of the Cairns Section and then follow a wave-like pattern of outbreaks moving south. This is similar to what was observed in the 1980s. It is presumably driven by southerly drift of larvae with the East Australian Current. Some inshore reefs in the south of the section were severely bleached in 2002.

GBR Mackay-Capricorn Section: This is the southern end of the GBR and contains the remote Pompey Group and the Swain Reefs as well as the Capricorn-Bunkers which have been studied intensively from the Heron and One Tree Island research stations. There was high average coral cover on all parts of 15 reefs of 36% (range 17-61%), with consistently high reef-wide coral cover on outer-shelf reefs in the Pompey Group and the Capricorn-Bunkers. Intensive surveys of NE facing sites on 11 reefs in the Swains and Capricorn Bunkers had mean hard coral cover estimated at 41% in 2001. Outbreaks of COTS on the Swain reefs do not follow the episodic pattern of outbreaks in northern sections. Starfish numbers have been increasing slowly here since surveys started in 1992 and in 2001, 4 of the 7 reefs surveyed had outbreaking populations. Some inshore fringing reefs were severely bleached in 2002.



The results of 18 years of observing crown-of-thorns starfish populations show an apparent 'wave' pattern of the coral predator, starting in the north, around Latitude 12°S and moving steadily southward towards Latitude 19°S. This figure illustrates a 'wave' that started in 1990-91 in the north and has progressed through 1,000km during 12 years. The figure shows the earlier 'wave' between 18 and 20°S which is the remnant of an outbreak that had started in the early 80s. The second 'wave' arrived at the same reefs at 18°S about 17 years later. The spots are of outbreak populations on reefs at that latitude. An animation of the 'wave' can be viewed on the AIMS website: www.aims.gov.au/monmap/COTSAnimation/COTS.htm



Reefs of the Capricorn Bunker group had high coral cover until 1988 when it is probable that a storm removed most of the coral cover. After a lag of several years, the coral cover has increased steadily from virtually zero to over 60% cover, which is mostly rapid growing table Acropora species. This illustrates the value of long term observations.

Elizabeth and Middleton Reefs: These large atolls are particularly remote and there have been no surveys since the 2000 report. They are remote from human impacts but exposed to strong waves and storms.

Lord Howe Island: This is one of the most southern coral fringing reefs in the world (31°40'S) and also a World Heritage Site. The reefs have low species diversity with mostly tropical species mixed with more temperate species. Surveys between 1978 and 1993 showed significant differences in coral species, suggesting that the rare species may become locally extinct after impacts of COTS, coral bleaching and storms. Replacement by larvae from reefs to the north may be a very irregular event. A habitat mapping program is in progress, but there is no regular monitoring.

Other Areas: There is coral growth on rocky reefs south of the GBR in southern Queensland: the Gneering Shoals (26°S), Flinders Reefs (27°S) and northern New South Wales (28°S 30'S) with populations up to 50% coral cover.

Western Australia

Ashmore and Cartier Reefs, Scott and Seringapatam Reefs and Rowley Shoals: These remote oceanic and shelf-edge reefs receive no mainland influence, being at least 300km of the Western Australian coast. Ashmore Reef is now a Marine Reserve and currently closed to all exploitation except subsistence fishing by Indonesian fishermen. Scott and Seringapatam Reefs (14°S) are fished by Indonesians for sea cucumbers, trochus and sharkfin and is a prospective site for extraction of liquid natural gas. In 1998, elevated sea-surface temperatures caused massive coral mortality down to a depth of 30 metres. Since 1998, the corals on these reefs have recovered only slightly (see Chapter 1). Further south, the three reefs of the Rowley Shoals (17°S) are protected as State and Commonwealth marine parks. Anthropogenic impacts on the Rowley Shoals are minimal, with fishing for most species banned. Coral communities at all reefs were in good condition through most

Over- Fishing of Trochus and Bêche-De-Mer off Western Australia

Stocks of trochus and bêche-de-mer have been heavily fished on many of the world's reefs over the last 100 years. Bêche-de-mer, also known as holothurians, trepang, or sea cucumbers, have been fished for centuries by Indonesians off the northwest of Australia by reef walking or by shallow free diving. The preferred species are *Holothria nobil*is (black teat fish), *Holothuria fuscogilva* (white teat fish) and *Thelenota ananas* (prickly red fish). The collected animals are cleaned, boiled, and sun-dried or simply cleaned and salted. Bêche-de-mer is high in protein, but its value is related more to the belief that it is an aphrodisiac. The large marine snail, *Tectra niloticus* (trochus shell) is collected in a similar way, but the meat is discarded, because the value is in the lustrous shell, which is used to produce buttons, jewellery, ceramics, ornaments, cosmetics and metallic paints. These are sold in Asia, Europe and America. Extensive surveys of coral reefs of north-west Australia (Ashmore, Cartier, Scott Reefs) have found low, to very low densities of trochus and bêche-de-mer at most locations. This is indicative of over-exploitation that has lowered breeding stock densities. For example, trochus densities on heavily fished northwest Australian reefs are 0.2 to 7.5 individuals per hectare compared to 45 – 500 individuals on fished and unfished reefs in other regions. The most commercially valuable species of trochus and bêche-de-mer are now only found at 18-35m depth, beyond the reach of snorkel divers. Management strategies are now being implemented to protect remaining stocks on these isolated coral reefs. From Luke Smith, l.smith@aims.gov.au

of the 1990s. In 1995, Imperieuse Reef, the most southern reef of the Rowley Shoals, suffered significant cyclone damage. Average cover on reef slope sites before the cyclone was 64% and was reduced to 11%. Many branching *Acropora* species have become almost locally extinct, dropping from 50% to less than 1% after the storm. In the 6 years following the cyclone, live coral cover has rapidly recovered to 42%. The Department of Conservation and Land Management (CALM) has a long-term monitoring program (58 permanent sites) at the Rowley Shoals Marine Park, and developed the Rowley Shoals Management Plan.

Cocos (Keeling) Island Reefs: These islands are extremely isolated with a small human population. Consequently, localised anthropogenic impacts on the fringing reefs are minimal. In the past, the atoll lagoon has been periodically exposed to long periods of flat calm weather that has caused the water to stagnate and become anoxic. This has resulted in major mortality events of the resident coral community. In addition, crown-of-thorns starfish are, at times in high numbers but don't have a major impact on the coral communities. In 1998, Cocos escaped the major bleaching event that affected much of the Indian Ocean, however the reefs were affected by bleaching in 1996.

The Dampier Archipelago and Monte Bello Islands: Coral bleaching affected many reefs on the inner part of Dampier Archipelago in 1998 and presently these reefs are recovering. Other than these impacts, there is no evidence on human impacts to these reefs. They are managed and monitored by CALM, which is planning for the establishment of two proposed State Conservation Reserves to include the Dampier Archipelago/Cape Preston Marine Conservation Reserve and the Montebello/Barrow Islands Marine Conservation Reserve.

Ningaloo Reef: This is a 280km long fringing reef separated from the shore by a sandy lagoon. There are minimal land impacts from the arid coast with the only major future impacts likely to come from the rapidly developing tourist industry e.g. boat traffic, anchor damage, recreational fishing. The reef front is exposed to oceanic swells, however coral cover may reach 40% on these slopes. Recovery is generally rapid after major storms. Coral cover behind the front and in channels can be up to 75% with more cover in the south. The coral-eating snail (*Drupella*) has caused some loss of corals in the last two decades. Another significant impact has resulted from coral spawn decomposing and depleting oxygen causing major coral kills in same sections of Ningaloo. Fish populations are abundant with fishing only permitted in some parts of the Ningaloo Marine Park. CALM manages the Park and has established a monitoring program at 72 permanent sites.

Abrolhos Islands: These are at the southern limit of reefs in Western Australia and have an interesting mix of kelp and corals growing together. The area supports a major and sustainable rock lobster industry, which causes minimal damage to the coral and fishes, and the reefs are generally in excellent condition. Plans are being developed for an MPA over the area, but no coral reef monitoring exists in the Abrolhos islands.

Anthropogenic Threats to Coral Reefs

The most serious threats to coral reefs in PNG are from uncontrolled forestry and agriculture on the steep slopes, from increasing rates of fishing pressure and pollution from sewage. The island of New Guinea is recent in origin, particularly steep and has high rainfall, therefore terrigenous sediments are easily dislodged after logging and agriculture and flow directly onto the reefs growing on the narrow coastal shelf. Like many countries in the region, populations are growing in coastal areas and putting increased pressures on fish stocks. Blast fishing is apparently increasing, as is the illegal capture of live fish for the restaurant trade in Hong Kong. Coral mining, oil spills, industrial pollution, mine waste, land reclamation, ship groundings are all localised threats, and COTS populations occur on many PNG reefs, with occasional outbreaks.

There are few human pressures on the extensive Australian reefs, mainly due to the low population density of relatively wealthy people who do not depend on the reefs for subsistence, and the high level of community support for resource management. Also, most of the Australian continent is dry, therefore freshwater runoff from the mainland is low, but there are occasional major floods after cyclonic rainfall. Inshore reefs of the GBR are showing signs of stress from sediment and nutrient pollution (nitrate and phosphate) due to over grazing of cattle and sheep, runoff from sugar-cane and banana farming, and domestic sewage. Now tourist resorts and cruise boats are required to reduce sewage pollution, and most towns have either secondary or tertiary sewage treatment. Pollution is minimal on reefs off Western Australia, freshwater runoff is particularly low and fishing pressures are slight. Australia is attempting to control subsistence fishing for shark, fish, trochus, giant clams and sea cucumbers by Indonesian nationals on the remote reefs.

Australia hosts some of the largest populations of endangered dugong and turtles in the world, although numbers have declined in some areas. Dugong populations are threatened

Learning From 2002 Great Barrier Reef Bleaching Event

The vast extent of the 2002 high temperature anomaly on the Great Barrier Reef (GBR) indicated by the NOAA 50km^2 hotspot maps prompted the Australian Institute of Marine Science (AIMS) to use their high resolution SST data to guide site selection in a large study of bleaching impact and survival. AIMS collated 3-day average satellite sea surface temperature (SST) maps at 1km^2 resolution for the period December 2001 to March 2002. This enabled the identification of reefs in a 500,000km^2 area that had been exposed to the greatest physical stress (i.e. highest temperature anomalies), for field verification. Moreover with the maps, it was possible to select reefs in relatively hotter and cooler reef waters (as controls), and select relatively hotter and cooler habitats within hotter and cooler reefs as the pixel scale was 1 km^2. Fieldwork was conducted in June - July 2002 at 64 sites on 32 reefs from the central to the southern Great Barrier Reef (over 1000km, from 1km from the coast, to 200km out in the Coral Sea).

In the coolest water patches, there were no reefs with damage from coral bleaching at any site or any depth. However, in the hottest water patches, there was significant coral mortality from bleaching with some unusual patterns. Some ubiquitous hard corals that were considered to be the most sensitive (e.g. family Pocilloporidae) survived well, where others (Acroporidae and Faviidae) had suffered significant levels of injury and mortality. Within ubiquitous genera, there was range of sensitivities (e.g. *Acropora* and *Porites*) with some showing little mortality. Many coral species that normally have low stored energy reserves (e.g. *Acropora, Montipora*) were still alive or white in mid-winter (when temperatures were 20°C plus or minus a few degrees) suggesting they were obtaining their nutrition from capturing food from the water (heterotrophic nutrition). These results indicate that there are more heat tolerant corals that may increase in abundance to replace losses of the more sensitive species in coming decades. There was also local variability in bleaching and mortality within reefs that may be related to the local shape of the reef and variations in currents. Selected species are being examined to determine if there are genetic markers in the symbiotic algae (zooxanthellae) that code for greater heat tolerance. The final goal is to identify reefs with more resistance to bleaching as these should be the focus for coral reef MPA planning around the world. The study was conducted with support from the Nature Conservancy and the David and Lucille Packard Foundation. From: Terry Done, Australian Institute of Marine Science, <tdone@aims.gov.au>

by habitat loss, particularly the die-off of inshore seagrasses after flooding, drowning in set gillnets, boat strikes and indigenous hunting. Pressures on turtle populations in Australian waters include trawl and shark nets, traditional hunting, floating rubbish and boat-strikes, as well as habitat loss and destruction of nests by feral pigs and foxes. While there is strong protection for turtles in Australian waters, these animals often migrate thousands of kilometres to areas where they are hunted and nests are emptied.

Status of MPAs and Reef Conservation

There is a major contrast between the high level of protection for reefs in Australian waters, to virtually no protection in PNG waters. This should provide an opportunity to transfer the experience for conservation to these coral reefs, which contain near maximum levels of marine biodiversity, before they are damaged by increasing human pressures. Unfortunately, the government structure in PNG is not favourable for environmental conservation, with little national leadership to protect valuable resources. The best chances to conserve the reefs lie in strong traditional ownership in most regions, combined with the encouragement and support from major NGOs. The Worldwide Fund for Nature, Conservation International, The Nature Conservancy, and the Packard Foundation have all launched major projects to conserve reefs in PNG in recognition of their high biodiversity, low immediate threats, but potential for major threats in the future. These initiatives are based on strengthening community based protection of local areas. The Milne Bay province is a priority area as it contains many different habitat types, and a mix of biodiversity from seas to the north and south. Hence this site was recommended recently for listing as a World Heritage Site.

In contrast, Australia has a National Oceans Policy that includes strong commitments to protect marine biodiversity and is backed up by financial and human resources to plan marine protected areas and provide considerable enforcement of legislation. The area of coral reefs under protection is increasing and human pressures that are resulting in

Protecting Biodiversity: Representative Areas in the Great Barrier Reef Marine Park (GBRMP)

The task for the Great Barrier Reef Marine Park Authority (GBRMPA) is to ensure that the incredible biodiversity in the many different habitats of the GBRMP is conserved. Managers use a number of tools to achieve this goal: zoning; education; permits; and management plans. The coral reefs have traditionally been favoured with a higher level of protection within the Marine Park, but other less-known and less-spectacular habitats are also important and should be represented within marine sanctuaries (or 'no-take' areas). Thus a 'representative area' is selected to represent a typical ecosystem of the habitats surrounding the coral reefs with all components considered e.g. physical features, oceanographic processes, biodiversity and ecological patterns. The approach arises from the realisation that protection of representative examples of the diversity of habitats is needed, more than a focus on specific habitats or individual species. The 'Representative Areas Program' is a component of the Australian Oceans Policy released in 1998, which recommended marine and terrestrial areas that required protection for biodiversity. The Representative Areas Program has classified 70 regions of biological diversity and found that the existing level of protection was inadequate. Using information gathered from scientists, stakeholders and community members, GBRMPA will increase the number of marine sanctuaries to include examples of every 'bioregion' and habitat in the Marine Park. The process involves full community consultation and a draft zoning plan will be available for further community input in 2003.

Coordinating Centre for Tropical Marine Research in Australia

A unique partnership has been developed on the Great Barrier Reef (GBR) to bring all players around one table to ensure clear lines of communication. In 1993, the Australian Government established a Cooperative Research Centre (CRC) to focus research in the GBR World Heritage Area. The CRC Reef Research Centre is a collaborative venture of key coral reef managers (GBR Marine Park Authority), researchers (Australian Institute of Marine Science, James Cook University, Queensland Department of Primary Industries), industry associations (Association of Marine Park Tourism Operators, Queensland Seafood Industry Association, Sunfish Queensland Inc) and non-government organisations (GBR Research Foundation). Another 50 national and international organisations are also associated with the Centre.

In addition to Australian Government support, funding for CRC Reef Research Centre comes from reef industry groups, state governments and research institutions. Each visitor to the GBR pays a small fee, some of which is directed to research by CRC Reef Research Centre. These contributions support more than 80 research tasks and university postgraduate training valued at more than US$40 million over 7 years. Through its members, CRC Reef Research Centre facilitates and coordinates the efforts of hundreds of researchers to provide science to protect, conserve and restore the world's coral reefs by ensuring industries and management are sustainable and that ecosystem quality is maintained. CRC Reef Research Centre provides research to improve understanding of major issues such as coral bleaching, water quality, crown-of-thorns starfish, and use and conservation of biodiversity. For more information see www.reef.crc.org.au

CRC Reef Research Centre has established a separate non-profit organisation, the International Marine Project Activities Centre Ltd (IMPAC) which hosts international marine project managers in the same location as CRC Reef in Townsville. The CRC and IMPAC share office facilities and strong communication links and databases. IMPAC is a partnership of international agencies undertaking projects in the Indo-Pacific marine tropics. This is new concept to further the sustainable development and conservation of critical habitats in tropical coastal areas (coral reefs, mangrove forests, seagrass beds and the associated fisheries) by bringing together major UN agencies, and international NGOs, development banks and foundations under one roof to tap into the existing tropical marine expertise in Townsville. IMPAC has the goal of building cooperation among international agencies that are involved in tropical marine research, conservation and management. In the next few years, IMPAC aims to support cooperative research and education partnerships in all areas where there are coral reefs. For more information see
www.reef.crc.org.au/research/consult/intercentre.html

damage to some reefs are being addressed. Thus the major future threats to the Great Barrier Reef and other areas are considered to be from global climate change with rises in sea surface temperatures and concentrations of dissolved carbon dioxide.

Monitoring and Gaps in Reef Monitoring and Management

There is a lack of trained scientists and technicians able to monitor coral reefs in PNG, and many that have been trained from government departments and academic institutions have either moved to other tasks or recruited by NGOs, mining companies or tourism operators. Thus, similar to most developing countries, there is a need to continually train people in baseline monitoring methods such as the Reef Check and methods recommended by the GCRMN. The University of Papua New Guinea (UPNG) has a program to train students in survey techniques in association with local dive operators. The best potential for a regular monitoring program is through dive tourism and their capacity to visit many reefs areas, with the PNG Divers Association already playing a significant role in monitoring and establishing marine conservation programs. The other major opportunity for monitoring is through the major NGOs working with communities to establish and manage marine protected areas.

Probably the most extensive long-term coral reef monitoring in the world has been run by the Australian Institute of Marine Science's Long-term Monitoring Program. It first started in the early 1980s with monitoring of the COTS on the GBR, and has continued in various incarnations to cover almost 20 years of continual assessment of benthic organisms and reef fishes. Individual scientists at AIMS also have long-term monitoring within research projects. There has also been a long-term water quality monitoring programme for the GBRMPA, including nutrient concentrations that flow into reef waters from coastal rivers. Monitoring also covers populations of seabirds, turtles, dugongs and fisheries catch statistics. A recent innovation is a combined Australia-USA project of remote sensing (NOAA-NESDIS) combined with real-time recording from AIMS automatic weather stations to identify locations at risk of coral bleaching. This was particularly valuable in providing the locations for direct observation to assess the 2002 coral bleaching event on the GBR. The Government of Western Australia and AIMS also have monitoring programs at Ningaloo Reef, Scott Reef and the Rowley Shoals in Western Australia. There are however, large areas of reefs across northern Australia where there is no monitoring and little baseline information.

Legislation and Regulation

While there are adequate laws and legislation to conserve and manage natural resources in PNG, most of these do not recognise traditional rights. Most are also not specific for coral reefs and are spread across different sectors (e.g. fisheries, mining, environmental protection), thereby leading to confusion over priority of laws and responsibility for management. The government has minimal capacity or will to enforce laws, quotas and regulations, with local communities often assuming the role of enforcing fisheries and MPA regulations. A national surveillance strategy has been suggested which would involve all sectors, but the most effective will continue to be through local communities by expanding community based management programs.

Using Science in the Management of the Great Barrier Reef

Management of the world's largest MPA is facilitated by having a single administrating agency, the Great Barrier Reef Marine Park Authority (GBRMPA), which is supported by strong legislation and some of the best available tropical marine science. However, the MPA is enormous in scale and complexity and it is impossible to have sufficient science to cover all aspects. Thus the task for the resource managers is to develop a mechanism to gather the best available scientific information for management. The GBR Marine Park is one of few in the world in which science plays an important role in management, as the managing authority is committed to ensuring that management decisions are based on the best available science. As a matter of policy, GBRMPA obtains scientific information from external research agencies, consultants and institutions, enabling it to focus on management and coordination. But first it had to identify its specific research and information needs.

In 1999/2000, GBRMPA identified and prioritised the research needs for management. The identification of research priorities required the collaboration of government agencies and scientists with extensive knowledge of the GBR and the critical management issues. The major research provider, the Co-operative Research Centre for the Great Barrier Reef World Heritage Area (CRC Reef), was heavily involved in organising interactive workshops to determine the priority management issues, and the information required to address those issues. The next step was to identify the research that would provide the information. Some examples of priorities include: monitoring natural variability and long-term trends of reefs, and associated habitats; understanding critical species like dugong, turtles and seabirds; assessing the major fisheries; measuring environmental parameters like water quality, seawater temperatures and how they interact with the ecosystem; and measuring key social, economic and cultural parameters. The strategic research was widely disseminated on the internet (www.gbrmpa.gov) to ensure that science, management and the community was fully informed. The listing provided the resource managers with a mechanism to be pro-active in seeking the research, and to select which research projects to support and how to use the information. It has also guided scientists wanting to develop research proposals for funding. The priorities form the basis for open discussions between scientists and managers to develop research tasks and continually update the priorities to ensure that results from science are relevant to management needs and produced within relevant timeframes to support management decisions.

The process has been useful in focusing GBRMPA managers on the need for science in decision making and ensuring that scientists produce the results that managers require. The greatest benefit is that the discussions between science and management are based on a mutually accepted strategic plan and on the need for partnerships to ensure that the best scientific advice is available for management. From: Alison Green, Great Barrier Reef Marine Park Authority, Townsville, Australia, alison@gbrmpa.gov.au

In contrast, there are very specific laws and legislation aimed at managing coral reefs and a single organisation has the authority to manage the GBR – Great Barrier Reef Marine Park Authority, in association with the Queensland State Government. This was reviewed in the Status 1998 report. 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 the 3 nautical mile limit, and the former managing fisheries beyond that to 200nm (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 are showing signs of over-fishing with stock sizes and populations decreasing. This is leading to increases in government regulations through input controls by limiting the number of vessels, the time and place of fishing, and the type gear permitted. A major focus of management on the GBR has been to reduce the damage done to the benthos by trawling on inter-reef bottoms, as evidence of damage to the environment became available. A new mechanism for management has been to seek protection for habitats, other than the coral reefs, within the GBR World Heritage Area. There are also specific laws to protect endangered species and to limit unintended marine catch. The developing trade in live reef fish for the Chinese restaurant market, principally in Hong Kong, is coming under strict regulation to ensure sustainability. This is a major theme for the International Marinelife Alliance, which is using the GBR as a base to assist countries of the region with the management of their fisheries.

Recommendations

Papua New Guinea

- More training in coral reef science and management is required in PNG; and more importantly to fund programs that employ the trained people. The best prospects for improved monitoring lie with NGOs and the private dive operators. There is also a major lack of trained divers and dive equipment.
- There is a need for integration between environmental planning and any economic developments, especially in urban development, watershed degradation and forestry, and large-scale commercial activities.
- Most reefs of PNG have not been mapped, making resource conservation more difficult.
- The best potential for reef conservation lies in community-based programs by allowing communities to establish and manage their own MPAs. The involvement of NGOs should be encouraged as they have shown success in working at this level.
- Effective enforcement of fisheries regulations is lacking and required. Moreover, PNG does not have the infrastructure to patrol their waters and control the developing live reef-fish trade.
- Community education and alternative income programs are essential to arrest damaging fishing practices, pollution and over-exploitation.

Australia

- The current levels of monitoring and management of coral reefs needs to be maintained; there are, however no signals that effort or funding will be reduced or radically changed.

- The major threats to Australian reefs are from chronic pollution from river runoff, coastal developments and coral bleaching. These are areas that require closer attention from management and research.
- There is a need to maintain and possibly strengthen the management of fishing activity and reduce this if it is shown that current levels are harmful for stocks and sustainability of commercial and recreational industries.
- The representative areas program has the potential to conserve both the reefs and their environs. This program needs support from all stakeholders and should also be considered for other coral reef areas around Australia.

Author Contacts

Hugh Sweatman, Kate Osborne and Luke Smith, are at the Australian Institute of Marine Science Townsville, h.sweatman@aims.gov.au; k.osborne@aims.gov.au, l.smith@aims.gov.au; Jeff Kinch, Conservation International,j.kinch@conservation.org; Geoff Jones and Tim Grubba are at James Cook University, Townsville, Geoffrey.Jones@jcu.edu.au; Vagi Rai, Department of Conservation and Environment, Boroko, PNG, pngccap@datec.com.pg

Supporting Documents

Useful web addresses for further information or copies of these reports:

www.environment.gov.au – Environment Australia

www.gbrmpa.gov.au – Great Barrier Reef Marine Park Authority

www.aims.gov.au – AIMS

www.calm.wa.gov.au - Western Australia Department of Conservation and Land Management

www.nt.gov.au/paw/ - Parks & Wildlife Commission of the Northern Territory

WHS

LORD HOWE ISLAND, AUSTRALIA – WORLD HERITAGE SITE

Lord Howe Island is 700km northeast of Sydney in the South Pacific Ocean, and is a remarkable example of a isolated oceanic island. It boasts spectacular volcanic topography and numerous endemic species, primarily birds. The entire island region, 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. It covers approximately 1,540ha of land area and a total of land and sea area of 136,300ha. Complementary to its status as a World Heritage Area, it is also a Marine Park that consists of State and, more recently, Commonwealth waters (June 2000). The management plan for the Commonwealth component of the Park came into effect in September 2002.

The island supports the most southern true coral reef in the world, but the reef habitat differs considerably from the more northerly warm water reefs. The fluctuations of hot and cold water around the island have induced the development of an unusual mixture of temperate and tropical organisms, for example, 477 fish species have been recorded in 107 families of which 4% have not been recorded elsewhere other than in Norfolk Island-Middleton Reef waters.

There is currently a resident population of 300 people on Lord Howe. 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. Interpretation and environmental education activities, are proposed in the current management plan.

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. In the early 1970s the Australian Museum undertook a terrestrial environmental survey of the island which led to a recommendation to establish an extensive land reserve. The biodiversity and oceanography of the shallow portion of the marine environment has been extensively studied and this environment appears to be in good condition.

The Lord Howe Island Board administers the management of Lord Howe Island and the smaller offshore islands. The management plan for the greater area states that fundamental management objectives include: maintenance and protection of landforms, plant and animal populations, and natural land-forming processes; reduction of human disturbance and the impact of introduced species; restoration of damaged areas and assurance of continued livelihood of the local population.

Ecological Monitoring: The Lord Howe Island Marine Park management plan applies to Australian Government waters (3 to 12nm offshore) and indicates that Environment Australia will liase with research organizations and other stakeholders in the development and implementation of monitoring activities. The activities will include monitoring the status of the ecosystems of the park with non-intrusive techniques and conducting further survey work to build on existing knowledge of conservation values of the park.

Socio-economic Monitoring: The monitoring system described above will also include monitoring of activities occurring within the park and compliance of park regulations as well as furthering existing knowledge of socio-economic conservation values.

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

WHS

THE GREAT BARRIER REEF, AUSTRALIA – WORLD HERITAGE SITE

The Great Barrier Reef World Heritage Area (GBRWHA) is the world's largest site and also the world's most extensive stretch of coral reefs. It covers 34,870,000ha and extends more than 2,000km along the east coast of Australia, from the Tropic of Capricorn to Papua New Guinea waters. The GBRWHA includes over 2,900 coral reefs, 300 coral islands and 600 continental islands. The GBRWHA includes some State Islands and inshore areas, therefore it is larger than the Great Barrier Reef Marine Park. The GBRWHA was inscribed on the World Heritage list in 1981 and is one of few sites that satisfy all 4 World Heritage criteria for natural heritage. It would also satisfy criteria for cultural heritage listing, although these were not included on the listing. The values include:

- Integrity, with the resources predominantly in near pristine condition;
- The geomorphological links between reefs, islands, dunal systems, and coastal complexes;
- Aesthetic values;
- High biological diversity expressed through species diversity and latitudinal scale. Many rare and threatened species are included 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; and 242 birds; plus a great diversity of sponges, anemones, marine worms and crustaceans. The GBRWHA contains 15% of Australia's dugong population, as well as cetaceans (humpback, minke and killer whales; and bottlenose, Irrawaddy and Indo-Pacific humpback dolphins). There are major nesting grounds for green turtle and loggerhead, and 4 other turtle species.

The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for the protection and wise use of the World Heritage Area, guided by the principle of balancing conservation and use. GBRMPA has created a management framework that allows for reasonable human use alongside conservation measures. However, the increasing use and development in and adjacent to the Marine Park and World Heritage Area remains a concern. Key issues are the management of a large reef-based tourist industry, commercial and recreational fishing, shipping, urban growth, coastal development, and the downstream effects of land use. The cumulative impacts of these place critical pressures on the World Heritage Area and require significant management inputs. At present, only 4.7% of the Marine Park is included in fully protected, no-take zones, but a comprehensive rezoning process is currently underway.

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 has become more critical after the GBR was included as a World Heritage Site, after coral bleaching events and crown-of-thorns starfish outbreaks, and with intensifying human demands on the resources. The Cooperative Research Center for the Great Barrier Reef World Heritage Area (CRC Reef), James Cook University and the Australian Institute of Marine Science (AIMS) have extensive coral reef research and monitoring programs that cover 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 crown-of-thorns starfish 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 GBRWHA.

Socio-economic monitoring: Social and economic data on communities and industries in or adjacent to the GBRWHA 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 the monitoring data for management decisions. The CRC Reef is the primary research provider 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.

Coral reefs are **90%** the natural resources:
Ecological Monitoring is **substantial.**
Socio-economic Monitoring is **effective.**

10. Status of Coral Reefs in the Southwest Pacific to 2002: Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu

Reuben Sulu, Robyn Cumming, Laurent Wantiez,
Lynette Kumar, Antonio Mulipola, Malwine Lober,
Samasoni Sauni, T. Poulasi and Kalo Pakoa

Abstract

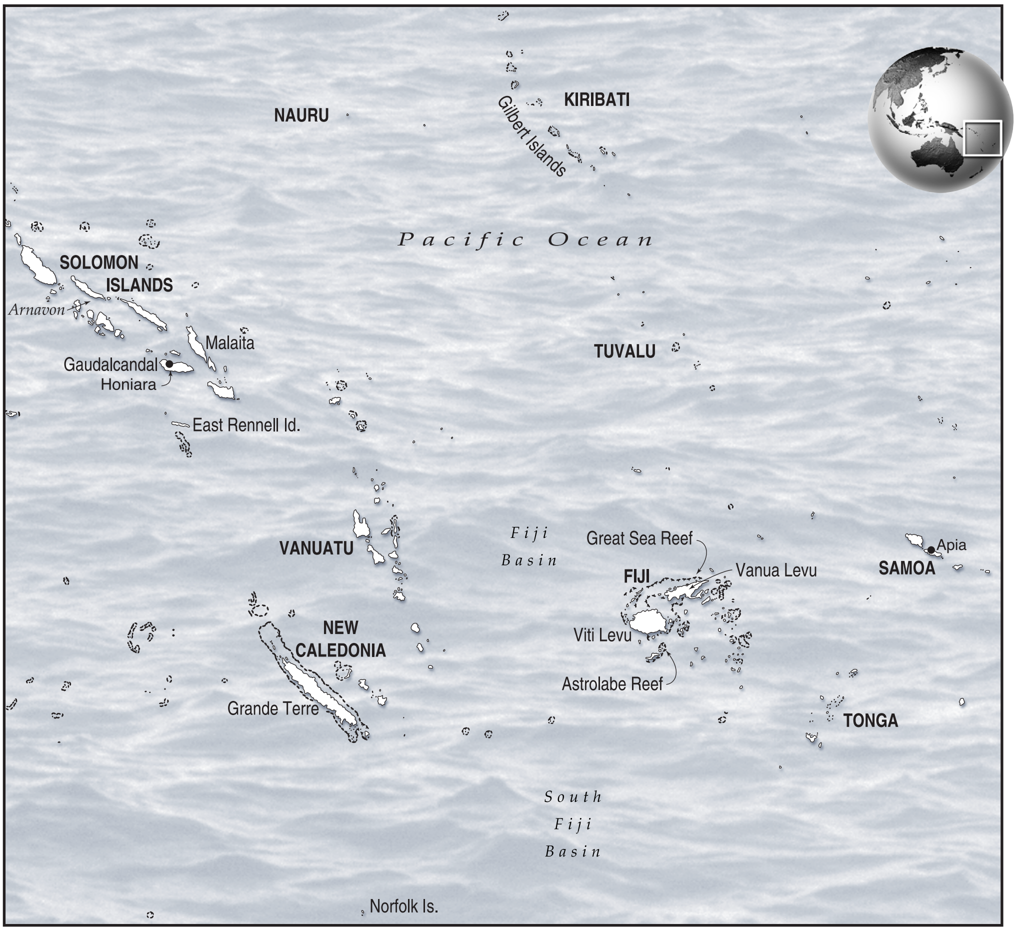
The coral reefs of these 7 countries continue to degrade as a result of human pressures, with a new threat emerging in 2000 and 2002. Coral bleaching and mortality was not a problem during the major global bleaching event of 1997-98, but there have been severe bleaching episodes since then, particularly in Fiji, and to a lesser extent in Tuvalu and Vanuatu. Bleaching mortality now ranks as probably the major threat to the reefs in this region, along with over-exploitation of reef fisheries. On the brighter side, there have been expansions of coral reef monitoring activities and capacity within the GCRMN and Reef Check frameworks. Similarly, many local and international NGOs have assisted communities to establish their own MPAs to monitor and conserve their coral reef resources. This is strongest in Samoa and Fiji, with some encouraging initiatives in Vanuatu and New Caledonia. Coral health and fish populations are now increasing in some of these MPAs. Ethnic tension in the Solomon Islands has meant an almost total breakdown in government conservation activities, and the immediate prospects for conservation are not encouraging.

Introduction

The Southwest Pacific Node is now coordinated by the Institute of Marine Resources (IMR), University of the South Pacific and consists of: Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu. The node was previously coordinated by the International Ocean Institute – Pacific Islands.

The IMR-Southwest Pacific node has over 2,100 islands, islets and cays with combined Exclusive Economic Zones (EEZs) of over 6.5 million km^2, but the land area is only 81,000 km^2 (1.2%). There are 3 cultural groups consisting of Melanesia (Fiji, New Caledonia, Solomon Islands and Vanuatu), Polynesia (Samoa and Tuvalu) and Micronesia (Nauru), with an estimated population of about 1.8 million.

Abundant and diverse reef types exist within the Node. Narrow fringing reefs border most high island shorelines and are frequently separated from the shore by a shallow channel. Much wider barrier reefs are separated from the shore by deep lagoons up to 70 m deep in Fiji, New Caledonia, Solomon Islands and Vanuatu. The Great Sea Reef of Fiji is 370km long and one of the largest reefs in the South Pacific. Double barrier reefs are rare and occur only in the Solomon Islands and New Caledonia, where there is a reef lagoon area of



40,000km^2. Atolls occur on drowned sea mounts in Tuvalu, as well as the Solomon Islands, Fiji and New Caledonia. Patch reefs occur in most countries.

The majority of reefs are in good condition but are under increasing pressure from anthropogenic impacts as well as climate change, and some reefs have been severely degraded. The status of reefs reported in the previous 'Status 2000' report was based mostly on anecdotal information, as quality data were lacking. The national monitoring coordinators reported that their reef resources were being damaged by coastal development and over-fishing. They acknowledged that reef monitoring was hindered by poor coordination and knowledge of the marine resources.

The IMR-Southwest Pacific Node has advanced towards mitigating some of the problems in monitoring identified by the countries, mainly through financial assistance of the Conservation Action Fund, the International Ocean Institute – Pacific Islands, and the Canada-South Pacific Ocean Development Program – Phase II (C-SPODP II). The need for continuing support of the member countries, individuals, NGOs and the private sector cannot be overstated. There are still major gaps and the calls for assistance from external partners are re-emphasised.

Update IMR-Southwest Pacific Node 2000-2002

The Node received financial support from the Canada-South Pacific Ocean Development Program – Phase II (CSPODP II) USP 05 to fund an inaugural workshop in August 2001 in Fiji (Naviti 2001 report). There were 39 participants from 34 organisations, including the Coordinators of GCRMN and ReefBase, the coordinators of 3 other Pacific Nodes (Polynesian Mana, Micronesia, Australia-PNG) and SPREP. National monitoring action plans were presented and revised during the workshop and the 4 following recommendations were presented to the ICRI-Coordination and Planning Committee meeting in Maputo, Mozambique, November 2001:

- As a matter of urgency, training assistance in sampling design, data entry, and database design and management, needs to be provided in support of the GCRMN at the national and regional levels in Pacific Island Countries;
- A Pacific Regional Node Coordinator of the GCRMN be employed full-time, and based at a suitable organisation, for example the South Pacific Regional Environment Programme (SPREP) to work in close collaboration with existing Nodes and National Coordinators;
- The positions of National GCRMN Coordinators should be partially or fully funded, in those nations where institutional support for monitoring is fragile;
- All countries should obtain old or 'exported' data for addition to National databases and ReefBase and that donors provide assistance to countries to obtain these data. Where possible, countries should resurvey these sites to obtain long-term data sets.

Status of Coral Reefs

Coral reefs in the southwest Pacific are generally in good condition, however, the pressures are increasing from exploitation for subsistence and income generation, increases in sea temperatures resulting in widespread bleaching and other anthropogenic impacts, such as pollution, mining and refuse disposal. Coral bleaching has been an important phenomenon affecting coral reefs within the region since 2000, with almost continuous bleaching throughout the period 2000-2002.

The call during the Naviti, Fiji workshop in 2001 to collate all data resulted in two NGOs (Greenforce and Coral Cay Conservation) providing their data on Fijian coral reefs. This process needs to continue and assistance is requested to ensure that data are repatriated to the Node and individual countries.

This summary report for 2002 is based largely on new reports by the national coordinators and a summary of South, R. and Skelton, P. 2000. Status of Coral Reefs in the Southwest Pacific: Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu. P 159-180, in Wilkinson, C. (Ed). Status of Coral Reefs of the World: 2000 Australian Institute of Marine Science. 363 pp.

MAQTRAC – Monitoring the Effects of the Marine Aquarium Trade

The Marine Aquarium Council (MAC) is working with stakeholders around the world to develop and implement standards and certification to achieve the goal of a sustainable trade in marine ornamentals. To obtain certification, requirements for managing the fishery and the associated reefs must be met. There was also a need to develop methods to monitor the status of invertebrate and fish stocks in collection areas and assess, and improve the effectiveness of local management for sustainable use.

The global ornamental trade involves about 1000 species of marine fish and 150 species of coral and non-coral invertebrates from over 40 countries. The overall import value is around US$200 million per year. Indonesia and the Philippines are the major sources, with Brazil, the Maldives, Vietnam, Sri Lanka, Hawaii, and Fiji providing much of the remainder. Rural villagers with limited economic opportunities depend on selling aquarium specimens, which bring a much higher profit than other types of reef use. Aquarium fish sell for around US$550 per kg compared to non-live reef food fish exports at US$7 per kg. The USA, Europe and Japan dominate the consumer market.

Some industry operators currently use destructive collection methods, that result in unnecessary damage to reefs. This damage, along with over-collection of target fish, may threaten marine biodiversity at the local level and cause local extinctions of rare or endemic species. The selective removal of target fish species may lead to shifts in community structure and function. In addition, poor handling practices often lead to high mortality rates in the harvested animals, increasing the pressure on fish stocks via increased collection to replace lost stocks. This also causes financial losses for marine ornamental retailers and hobbyists who purchase the fish.
MAC has established a certification process to manage the trade from field collection to the final consumer - "from reef to retail" - in the search for sustainability. The assessment and monitoring of both the stocks of target species and other reef organisms are essential to this goal.

MAC formed a partnership with Reef Check/GCRMN to develop the Marine Aquarium Trade Coral Reef Monitoring Protocol (MAQTRAC). The protocol is designed to assess the status and condition of reefs and fish stocks in collecting areas and to monitor the effectiveness of management plans in collecting countries as outlined in the MAC Core Ecosystem and Fishery Management Standard. MAQTRAC was field tested in the Philippines, Indonesia, Fiji, Hawaii and the Maldives from mid 2001 to early 2002. The protocol was refined based on feedback from two peer review workshops.

MAQTRAC will enable collectors and researchers to perform site selection and monitoring on a consistent basis to comply with the MAC certification program. We hope that this protocol will help facilitate the sustainable extraction of marine ornamentals and provide fisher communities with sustainable livelihoods, while simultaneously conserving reef resources. From: Craig Shuman, cshuman@ucla.edu, Domingo Ochavillo, ochavill@yahoo.com, Marine Aquarium Council, info@aquariumcouncil.org, Gregor Hodgson gregorh@ucla.edu

Fiji

Effective coral reef monitoring continues in Fiji due to the presence of the main campus of the University of the South Pacific (USP) and many NGOs: World Wide Fund for Nature (WWF); Foundation for the Peoples of the South Pacific (FSP); Coral Cay Conservation (CCC); Greenforce; and International MarineLife Alliance (IMA).

Most of Fiji's reefs were affected by mass coral bleaching in March-April 2000, except those in the far north, with more than 40% of colonies dead at many sites. There was also variable bleaching in 2001 and 2002, except for intense bleaching in 2002 in very shallow areas. Many affected reefs are making a strong recovery e.g. increasing densities of *Acropora* recruits at sites around Suva.

Direct human impacts from sewage pollutants, heavy gleaning, coastal development and siltation continue to damage reefs near large urban centres. Destructive fishing is also causing serious damage in some areas, through the use of 'dynamite' and poison from the *Derris* root. Stocks of invertebrates such as giant clams, trochus and beche-de-mer have been reduced by moderate to heavy fishing. The highly targeted reef fish species such as emperors (*Lethrinus*), and mugilid (mullet) species have been overfished in Fiji. The large bump headed parrot fish (*Bolbometopon*) has been fished to local extinction in most areas, but Greenforce reports regular sightings at Yadua. Outbreaks of the crown-of-thorns starfish (COTS) have been reported annually since 1996 at widely dispersed sites, including the Mamanucas, Wakaya, Lau, Taveuni, southern Viti Levu, Kadavu and Gau, and there is an outbreak now on the Great Astrolabe Reef, Kadavu.

Fiji is the world's second largest exporter of live reef products for the aquarium trade, after Indonesia, and the market is expanding. There are no export limits or management plans for the trade, but these are being planned. An assessment of the impact of harvesting has started with Reef Check conducting pilot field testing of the MAQTRAC monitoring protocols.

The 2000 mass bleaching event catalysed the first major GCRMN activity in the region, when 8 independent research groups collaborated to assess bleaching at 19 sites throughout Fiji. Since 1996, the GCRMN has assisted with the Seawater Temperature Monitoring Programme at the University of the South Pacific (USP) to record temperatures throughout Fiji. Data on about 100 Fiji reefs comes from researchers, tourist resorts, and reef-based tourist operations, such as the Fiji Dive Operators Association, Greenforce and Coral Cay Conservation. A campaign to involve tourist resorts in monitoring their local reefs was initiated in 2002 at 7 permanent GCRMN and Reef Check sites around Suva timed in March/April to coincide with the potential bleaching season.

Nauru

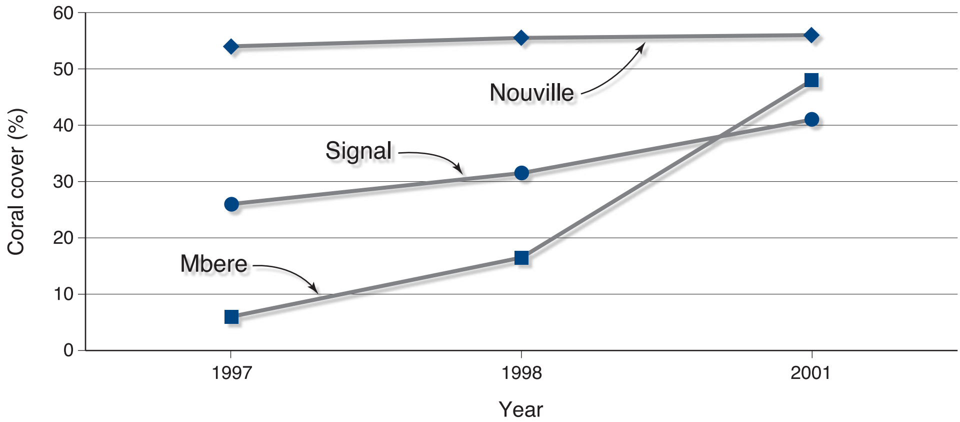
There is a narrow fringe of coral reefs around this island country. There has been limited research and no monitoring on these reefs during 2000-2002 due to a lack of capacity. Reefs on the west and to a large extent, the north and south sides of the island are in good health and show little sign of stress or destruction. However, reefs on the windward east side and in Anibare Bay have been disturbed by pounding waves from the east and construction of the Anibare Bay community harbour. The blasting destroyed many reefs within a 100m radius and the area is littered with debris and silt. Some damage occurred while installing an inlet pipe for the desalination plant at Meneng Hotel. Higher rainfall in early 2002 lowered salinity and caused coral bleaching on shallow reef areas.

New Caledonia

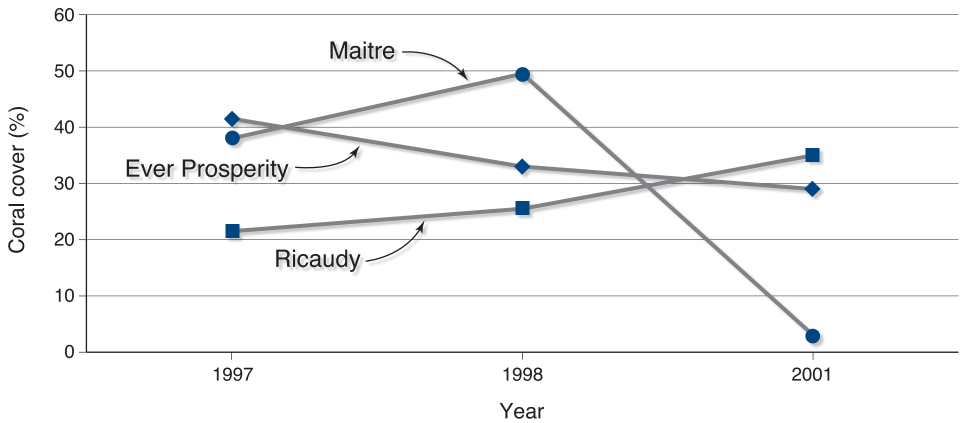
The most advanced coral reef monitoring among the Southwest Pacific countries occurs in New Caledonia. The 'Coral Reef Observatory' (ORC) was established in 1997 and surveyed 8 reef sites in 1997 and 1998. Funding ceased until 2001 when an NGO took over the monitoring. The crews of the Southern Province patrol boats were trained and now survey two sites – North Noumea (Nouville, Signal and Mbéré) and South Noumea

GREENFORCE – STUDIES ON FIJI CORAL REEFS

Greenforce, a non-profit UK organisation, provides host country institutions with biodiversity monitoring in areas with important natural resources. In 1998, the National Trust of Fiji asked Greenforce to collect baseline data and monitor the coral reefs around Yadua island and Yaduataba, and provide coastal management reports as a precursor to the establishment of a marine reserve and an application to UNESCO for World Heritage listing. Yaduataba is the home of the rare and endemic crested iguana. Greenforce has contributed monitoring data for 20 permanent sites, including pre- and post - 2000 bleaching reports, to the SW Pacific Node database. Before the 2000 bleaching event, hard coral cover was 30% at 5m and 10m, but afterwards it dropped to 14% at 5m and 12% at 10m. Recovery has been very slow at 5m, with only a 3% increase in coral cover, but at 10m, coral cover doubled to 24%. The proportion of stressed corals decreased at all depths from May to December 2000, but they now appear to be stressed again, although the massive and encrusting corals show less stress. The bleaching in 2000 had little impact on fish communities in Yadua, although an increase in the abundance of herbivorous fish was observed e.g. surgeonfish increased significantly from 18.4 (per 1000m^2 area) at 5m in 1999 to 30.7 in 2000 and 15.5 to 20.7 at 10m. Parrotfish increased from 21.7 to 39.1 at 5m and 26.2 to 38.09 at 10m. These increases may be due to increases in algal cover. Humphead wrasse and bumphead parrotfishes (major target species) are commonly sighted in Yadua. The most common length of the wrasse being 80cm (39 observations), with few over 120cm or under 30cm. The bumphead parrotfish occur in schools of up to 20 in some parts of the Island. Manta rays are also common with at least 9 individuals being regular visitors, and white tip reef sharks are seen in abundance on almost every dive. These trends may indicate that the management appears to be helping the fish populations recover. From: Andrew Finlay finlayrao@yahoo.co.uk and Oliver Taylor taylor_ojs@yahoo.com



Changes in coral cover over four years in North Noumea.



Changes in coral cover over four years in South Noumea with an unknown impact causing losses after 1998.

(Ricaudy, Maitre and Ever Prosperity), all in MPAs. In South Noumea, coral cover varied between 4% and 35% with evidence of considerable losses in 1998 and 2001, due to large numbers of crown-of-thorns starfish, coral bleaching, or coral disease. Unfortunately no monitoring was done in 1999 to confirm the cause of these declines. In North Noumea, coral cover ranged from 41% to 56% in late 2001, all being greater than the last observation in 1998, indicating a healthy recovery.

Fish densities in these MPAs were reasonably healthy and included populations of major target species, such as coral trout or grouper (*Plectropoma leopardus*), Humpback grouper (*Cromileptes altivelis*) and Napoleon Wrasse (*Chelinus undulates*). There were also many butterflyfish, parrotfish and rabbitfishes at all sites. Surveys in December 2001 (southern summer) showed large populations of grouper and rabbitfishes, which were

Palolo Deep National Marine Reserve – Status in 2002

This reserve on Upolu Island was established in 1974, and is the only recognised marine reserve in Samoa (13°49 S; W171°45 W). It is also one of the first coral reef protected areas in the world. The major feature is the 'Deep'; a blue-hole (25m depth) in the reef flat of the 137.5ha reserve, which also extends 500m out to sea to include the fringing reef down to 25-30m. The unique part of Reserve is that the Deep provides protection for corals and other organisms during cyclones and storms. This protection is evident by the rapid recovery of the reef flats and slopes after two major cyclones in 1990 and 1991, and severe shallow water bleaching in 1998 when waters drained off the reef flat. The data below came from the few surveys by Ed Lovell and Toloa in 1994, Foua Toloa in 1999, and Posa Skelton in 2002, with the Deep data obtained by combining measures from two different, but comparable sites.

Sites	1994 (%)	1999 (%)	2002 (%)
Inshore Reef Flat			
Live corals	28	4	42.0
Algae	35	56	41.5
Deep			
Live corals	46	51	69.0
Algae	17	17	4.0
Outer Reef Slope			
Live corals	'0'	91	57.8
Algae	dominant organisms	-	36.5

The destruction by the cyclones in 1990 and 1991 was so severe on the outer reef slope that there were virtually no corals in 1994, and the area was dominated by algae. At the same time the corals on the slopes of the Deep survived the storms (46% cover), as well as some corals on the reef flat protected by the Deep. However, just 5 years later corals on the outer slope had recovered amazingly to 91% cover. But by that time the reef flat corals had suffered 100% coral mortality in 1997 following prolonged and extreme low tides during the El Niño event. Throughout these two different damaging events, the Deep continued to act as a buffer protecting the corals from damage and providing new coral larvae to colonise the damaged areas.

In 2002, the live coral cover at all the sites in the reserve averaged 60% and 34% algae. Outside the Reserve, the outer slope near Vaiala village had 10% cover at one site, which was dominated by a large bed of brown alga (*Spatoglossum* sp.), and 96% cover at another, with the average of 51% cover (similar to the Reserve). Some corals were affected by a coral disease and a few crown-of-thorns starfish were seen, but generally the area appeared very healthy. The same, however, cannot be said about the fishes as there is evidence of over-fishing. The lack of big fishes was obvious, with low fish diversity and abundance at all sites. The dominant fishes were damsel-fishes along with some algal grazers, especially surgeon fish (Acanthurids). The reserve is managed by the Samoan Government Division of Environment and Conservation with an on-site manager. Monitoring and further studies are planned in the Reserve to provide the administrators with ammunition to improve the management. From: Posa Skelton, International Ocean Institute – Australia; Posa.skelton@impac.org.au

probably aggregating to spawn. There were also healthy populations of giant clams, trochus, and various sea cucumbers, along with starfishes and other echinoderms. Some crown-of-thorns starfishes (COTS) were also noted, but there were no significant variations in invertebrate populations from 1997 to 2001 at the sampling stations. Larger COTS populations occur in some bays adjacent to Noumea.

Samoa

There has been sporadic reef monitoring by many visiting scientists, but 6 long-term, national monitoring sites have been selected. There is also community monitoring through the Village Level Coral Reef Monitoring Project (VLCRMP) at many community MPAs, including the fishery reserves. Long-term monitoring is being conducted in 9 of these MPAs. There was monitoring in 21 community fish reserves in the two main islands of Savaii and Upolu in 2000-2001. On Savaii, which is less populated than Upolu, live coral cover was high (55%) comprising mostly of *Acropora* species. On Upolu, 78% of the cover was dead coral or rubble and only 22% live coral. The higher coral cover may be attributed to fewer pressures on the marine resources of Savaii, while on Upolu, there has been major urban migration and increased demands for seafood.

The monitoring is now showing that the protected coral reefs are undergoing marked improvements, with increased coral recruitment and regrowth in areas previously damaged by coral bleaching, storms and destructive fishing practices.

There is less coral cover on heavily populated Upolu, than Savaii.

Island	Hard Live Coral		Dead Coral	Other categories
	Acropora spp.	Other corals		
Savaii	16.6%	38.2%	35.0%	10.2%
Upolu	7.5%	14.0%	14.0%	64.5%

There are 59 villages working with the Samoan Fisheries Division to manage their marine resources under the Village Fisheries Management Program. Villages develop their own management tools such as devising and enforcing village by-laws (within local and national circumstances), establishing fish reserves and seeking alternative livelihoods. The Fisheries Division collects baseline data prior to establishing the fish reserves. The villagers now report greater fish abundance, and more coral recruitment and re-growth in the protected areas. The crown-of-thorns starfish continues to be a threat to coral reefs.

Unfortunately, there are still reports of destructive fishing practices such as dynamite fishing, the use of chlorine and *Derris* roots in more remote rural villages. Efforts to curb the practice include awareness raising through the fisheries extension and training program and empowering villagers to take action through the Village By-laws.

Solomon Islands
The ethnic conflicts in 2000-2002 have hindered coral reef monitoring activities, despite the initiation of the Solomon Islands Global Coral reef Monitoring Network in April 2001. Despite these difficulties, there are some ongoing activities in coral reef conservation. The harvesting of marine resources for the Live Reef Food Fish Trade (LRFFT) and the aquarium industry threatened many of the reef systems, and some relief occurred due to flight disruptions during the conflict. Many communities are now rejecting the LRFFT, particularly the targeting of spawning aggregations, following assistance from NGOs. The Pacific Development and Conservation Trust (NZ), the Solomon Islands Development Trust and the Baha'i community in Malaita are attempting to reverse the damage from the curio and aquarium trades by training locals to grow corals. As a result, corals have been transplanted to degraded areas and rampant dynamite fishing at Langalanga lagoon has been reduced. Assistance from ICRAN has allowed the resumption of coral culturing and reef restoration in the Marau Sound, Guadalcanal. Sedimentation as a result of logging activities in Makira, Central, Western, Vangunu and Choisel provinces is a major concern. The Marovo Lagoon, one of the largest lagoons in the world, may be irreparably damaged as a result of sedimentation and shipping. Subsistence over-fishing, destructive fishing methods and the harvesting of *Acropora* corals for betelnut chewing have caused major shifts in coral reef communities.

Tuvalu
There are few long-term reliable data on coral reefs and fisheries resources in Tuvalu. Anecdotal evidence suggests that coral reef fish resources are declining, due to subsistence over-fishing, especially in lagoons and on the reefs. Over-fishing, along with road and foreshore damage, land reclamation, sewage pollution and natural impacts, are contributing to significant changes in the coral reef communities. These changes include increased turf and blue-green algae, decreased hard coral cover, and lower populations of butterflyfishes.

The incidence of Ciguatera fish poisoning is increasing with 11 new cases in 2000, that correlate with an increased in cell counts of the causative alga (*Gambierdiscus toxicus*) from 450-1,700 cells per 100g coral rubble or seaweeds in 1994 to 7,000-144,000 cells/100g in 2000. The reasons are not clear, but attributed to either reef damage or pollution from World War II military equipment dumped in the lagoons.

There was minimal coral bleaching (about 1%) during the 2000 event and subsequent bleaching that damaged other reefs in the region. Surveys in May 2002 indicated that about 30-40% of coral reefs were bleached during the 2002 bleaching event, when there was a 1°C rise to 31-32°C in water temperatures.

Vanuatu
No monitoring has been conducted by the Vanuatu Fisheries Division, however they have started planning with the establishment of the Vanuatu Coral Reef Monitoring Network (VCRMN). Monitoring sites have been selected on Malapoa reef outside of Port Vila and Hat Island, off Efate, as well as Aore and Elephant Islands on the main island of Santo. Some staff have been trained in coral reef monitoring, but further training is required before monitoring can start.

The major threats to coral reefs in Vanuatu are over-fishing (both subsistence and commercial), soil erosion, tropical cyclones, earthquakes and seismic activities, and potential climate change impacts. Coral bleaching was observed around Erakor Island in 2001, and also in 2002 in Vila Harbour, Hat Island and Moso islands on Efate. There may have been more incidents of coral bleaching, but there has been no monitoring or surveying to confirm this. Collecting for the aquarium industry is a potential threat to coral reefs, with 3 operators currently exporting stock. Populations of species targeted for the aquarium trade are small and easily susceptible to over-exploitation. Harvesting of the giant clam *Tridacna crocea* is now banned.

Coral Reef Fisheries

Sustainable coral reef fisheries are critical for these countries, particularly as subsistence and artisanal fisheries. The economic value of subsistence fisheries is estimated at US$71.04 million. Most countries still use traditional, non-mechanised methods but as catches decline, the people resort to more innovative and destructive methods such as night spear fishing, dynamite fishing and use of poisons. Fisheries departments and regional organisations (Secretariat of the Pacific Community, University of the South Pacific, and the World Fish Center - ICLARM) are promoting aquaculture of important species to generate income and alleviate pressure on reef resources. There is an urgent need to implement improved management of coral reef fisheries. Some traditional management measures still exist but these are failing to arrest the decline in coral reef fisheries. A new initiative through the Locally Managed Marine Areas project encourages communities to manage their coral reef resources in partnership with government and NGOs.

Threats to Coral Reef Fisheries

It is critical to achieve sustainability of coastal reef fisheries to maintain food security for the people. Management, however, is hampered by a lack of data and trained people. Traditional subsistence fishing methods have been displaced by modern methods when Pacific Island populations doubled between the 1960s and 1990s. Now the emphasis is on economic returns above environmental concerns. Destructive fishing with dynamite, plant (e.g. *Derris*) and chemical poisons, and overuse of seine nets have resulted in large-scale damage and reductions in fish breeding stocks, particularly of the top predators. Other threats include destruction of breeding and feeding habitats through coastal development and habitat destruction.

Climate Change Impacts

Three potential climate change impacts have occurred in this part of the Pacific in the past decade: increases in cyclone frequency; increases in sea surface temperatures resulting in coral bleaching; and sea level rise. The apparent increase in the incidence of cyclones since the early 1990s has caused considerable damage on land and increased sediment loads onto coastal reefs of Fiji, Samoa and Vanuatu. There were also serious coral bleaching events associated with raised sea surface temperatures in early 2000 and 2001 affecting Fiji and Solomon Islands (e.g. up to 90% of corals were killed in parts of Fiji). Previous bleaching in Fiji was apparently not as severe as the event of early 2000. There are, however, huge gaps in coral cover data prior to the bleaching; this is now an issue being addressed by the IMR Southwest Pacific GCRMN Node. Low-lying Pacific islands are particularly susceptible to sea level rise associated with climate change. Tuvalu stressed this at the World Summit on Sustainable Development in Johannesburg in September 2002 noting that the upward growth of the islands is unlikely to keep pace with the predicted sea level rises of 15-95cm by 2100. There is already evidence of accelerating shoreline erosion on some islands.

Status of Reef Conservation

These countries, assisted by SPREP, developed National Environment Management Strategies (NEMS) prior to the 1992 UNCED Conference. As most are relatively small countries, SPREP assists them with compliance with Conventions and Agreements on marine conservation and sustainable development (Convention on Biological Diversity, Ramsar Convention on Wetlands, UN Framework Convention on Climate Change etc). The Activity Plan for the Conservation of Coral Reefs in the Pacific Islands Region (1998-2002) targets 5 areas: education and awareness; monitoring, assessment and research; capacity building; legislation; and networking and linkages across people and programs.

Customary marine tenure that was often designed to conserve marine resources existed in all countries prior to Western influences and was based on ancestral rights and administered at various levels (tribe, village, clan, family). However, many of these traditions have been devalued through the more 'western' governance and zoning structures that emphasise resources as common property. The challenge for these countries is to retain and where possible re-instate traditional management into future MPA and coastal zone management plans. It is necessary, however, to use care in adopting traditional rules into modern contexts; they should be a source of inspiration, and will not work in all areas.

Fiji

Traditional systems still exist in Fiji, but are collapsing under commercial pressures to exploit coastal resources. Fiji has no national system of MPAs, however there is a growing network of village owned and managed MPAs under the Locally Managed Marine Areas (LMMA) project. This is modelled on the traditional system, but adapted to suit the changing circumstances. Dive operators and NGOs are also very active in raising awareness and promoting reef conservation.

The USP and other agencies established the LMMA project to promote coral reef conservation, using a system modelled on the village-owned and managed MPAs following the Fijian traditional customary marine tenure system. An important component is training villagers to monitor the resources within the protected areas. The goals of these MPAs vary: fishing grounds in Macuata and Verata are closed to allow recovery of overfished reefs; other areas prohibit poison fishing; some limit gillnet mesh size to 7cm; others ban turtle and coral harvesting; or suspend the issuing of commercial fishing licenses to outsiders. Locals have been trained as guides in a protected area in Waitabu, Taveuni for an average of 22 snorkelling tourists per month. The Foundation for the Peoples of the South Pacific (FSP) has assisted villagers in Viti Levu in coral gardening to rehabilitate damaged coral reefs, and to establish 4 MPAs. They also collaborate with the Shangri-La resort on sewage management and mitigation of freshwater and pollution impacts. The Fiji Dive Operators Association, and the Cousteau and Namenala resorts also work with their neighbouring communities to establish protected areas. Other initiatives include: a SPREP funded MPA at Ono-I Lau, which may be nominated as a UNESCO Man and the Biosphere reserve, in collaboration with USP; the Women in Fisheries network with the Southern Cross University in Australia; promotion of village level resource management in Gau; and a Fisheries Department managed MPA around the research station at Makogai Islands, East of Viti Levu.

Nauru

There is no system of MPAs, no relevant legislation and no traditional marine tenure in Nauru. Some conservation planning is underway.

New Caledonia

Coral reef conservation in New Caledonia is more advanced than the other countries with MPAs covering 37,500ha, plus a 1km wide commercial gillnet fishing restriction zone around the islands. The current Environment Plan for the North Province proposes 10% of coral reefs for strict protection and 10% for subsistence use, with recognition of customary reserves and fishing zones. There are complex legal problems to be resolved before this can be implemented. Fishing regulations prohibit fishing with scuba at night, nets set in estuaries and mangroves and the use of explosives and poisons. There are specific regulations on turtles, dugong, corals, aquarium fish, rock oysters, lobsters, mangrove crabs, trochus, mullets and rabbitfish. Mooring buoys have been established around Noumea, where recreational fishing and boating pressures are quite high.

Samoa

The traditional management system still exists in Samoa, with more than 50 fish reserves being established under the Village Fisheries Management Plan. The only national marine reserve is the Palolo Deep Marine Reserve and 2 new MPAs in Aleipata and Safata districts, on Upolu Island are being established by IUCN and the Samoan government.

Solomon Islands

There are still extensive traditional conservation practises in the Solomon Islands, but the only national MPA is the Arnavon Marine Conservation Area (Isabel and Choiseul Islands) because it is an important turtle nesting area. Current plans to establish community-based marine conservation areas are on hold because the government is non-functional. The Nature Conservancy (TNC) is encouraging community involvement in the management of the Arnavon MPA.

Tuvalu

The traditional marine tenure system in Tuvalu has broken down, but a conservation ethic remains and the first marine park was established at Funafuti Lagoon. Recent conservation efforts include a ban on using coral rock and sand in construction, the restriction of fishing to only hook and line methods in the lagoons, and the closure of some lagoon areas to fishing.

WHS

WHA – EAST RENNELL – SOLOMON ISLANDS

Rennell Island is located in a remote corner of the Southwest Pacific and is an area of outstanding geological, biological and scenic value. It is the second largest uplifted coral atoll in the world and contains Lake Tegano, the largest lake in the Pacific islands. Rennell is largely undeveloped and the geology, flora and fauna are of international interest. The Solomon Islands have a greater diversity of animal species and higher degree of endemism than almost anywhere else in the Pacific. Another particular value is that the endemic species on Rennell have escaped destruction from invasive predators such as the ship rat and introduced predatory land snails, that have caused major damage on other islands. Rennell occurs in the cyclone belt and another remarkable feature of the island are the adaptations by all forms of life to this recurring natural phenomenon.

The southeastern half of Rennell and all the coral reefs and sea out to 3 nautical miles was selected as a World Heritage Area in 1998 (814km^2). Rennell is the island used by zoologists to demonstrate Island Biogeography and on-going processes of species evolution. This is evident in the large numbers of endemic bird species. The vegetation shows adaptations to regular cyclones. These were major factors for listing of East Rennell as a World Heritage area. The coral reefs are also an important component and still in a very natural state. The reefs occupy 12 km^2; (1.5%) and the rest of the sea (432 km^2; 53%) of the Word Heritage area. The coral communities on the oceanic platform reef around the island reflect the high degree of wave exposure. Most exist as wave-resistant massive, encrusting and digitate forms of coral. These coral communities show no indication of human impact, and the fish populations are rich in both diversity and abundance, reflecting low fishing pressure. The most significant environmental change to Rennell has been the construction of a road in 1995, which runs from the airstrip and administration centre to the lake.

About 500 Polynesians live within the World Heritage Area and all the land, reefs and lake are under customary ownership. The people live a largely subsistence lifestyle and catch fish and shellfish for their immediate needs. There are no fish processing plants nor freezers for storage. In the past, there was some lobster and sea cucumber harvesting for export, but this had ceased by 1999. The Council of Chiefs were active in the preparation of resource management guidelines based on traditional practices but this was interrupted by the ethnic tension that developed in 2000. The 5 villages at East Rennell have been working with the New Zealand and Solomon Islands Governments as part of a bilateral aid programme to conserve the natural and cultural heritage of their island, while developing sustainable income-generating options. Family-based ecotourism, bee-keeping, poultry and sale of custom crafts are some examples.

Ecological Monitoring: A rapid ecological assessment of the coral reefs, fishes, shellfish and other reef resources of Rennell and the Indispensable Reefs were made in 1995 by external NGOs. Unfortunately, this study acquired commercially valuable information and was followed by the decimation of the clam and shark populations on Indispensable Reefs. There has been no scientific monitoring since this initial assessment, and any monitoring programme on Rennell by outside organisations would likely be viewed with suspicion.

To set up a monitoring program, someone trusted by the Council of Chiefs would need to explain to them why it was needed. The Chiefs would then select young people from each clan to be trained and the information acquired would belong to each clan. It is important to realise that this process would develop at their speed and the time between monitoring exercises would be decided by the Council of Chiefs.

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 no marine-based industries at present.

Monitoring Effectiveness: Management is based on traditional knowledge and data gathering, not on formal processes of scientific monitoring.

Coral Reefs (and associated lagoons) are **10%** of the natural resources.

Ecological Monitoring: occasional (no long-term monitoring is planned).

Socio-Economic Monitoring: occasional (required as part of the New Zealand and Solomon Island bilateral aid programme).

Vanuatu

There are still extensive traditional conservation practices that manage a network of customary marine tenure protected areas. These are recognised by the government and an Environmental Resource Management Bill (1999) seeks to establish Community Conservation Areas. National conservation efforts continue through both government initiatives and indigenous management systems. New draft laws pertinent to reefs are: *Water Resources Act; Public Health Act, Fisheries Amendment Bill;* and the *Environment and Resources Management Bill*. Some tourist resorts are establishing recreational marine reserves and communities are imposing traditional 'taboo' measures to conserve green snail and trochus (Anelgauhat reef-Aneityum Island, Wiawi -Northwest Malekula) and giant clams on Maskelynes. Two new national MPAs are proposed: Mistry Island Marine Reserve on Aneityum; and the Hat Island Archaeological Reserve on Efate. There are other initiatives in progress: a formal fisheries policy plan; strengthening coral reef monitoring activities; education and awareness; assisting private sector development in aquaculture; and strengthening co-management with traditional resource owners for MPAs.

Monitoring and Gaps in Reef Monitoring and Management

All countries prepared monitoring programs in September 2001 with support from the Canadian Government, but a lack of expertise and funding was identified. Coral reef monitoring capacity varies from virtually none in Nauru, Solomon Islands and Vanuatu, to some in Samoa and Tuvalu, and reasonably strong capacity in Fiji and New Caledonia. There has been regular training in GCRMN and Reef Check level monitoring over the last 6 years, but rarely is the training followed by in-country monitoring activities and many of the trained people have moved to other government positions. The University of the South Pacific (USP) and the Fiji dive industry maintain the strongest programs with an emphasis on involving the principal resource owners in monitoring and management of their reef areas.

USP has surveyed the Suva Barrier Reef and Great Astrolabe Reef in **Fiji** since 1987, and focused on assessing the impact of the February-April 2000 mass coral bleaching event, with help from the tourism industry. There has also been active Reef Check monitoring and permanent monitoring sites have been established, however a more efficient data management and dissemination system is required. There are limited fisheries surveys in **Nauru**, but monitoring is planned for the future.

The research programs run by IRD (formally ORSTOM) in the lagoon of **New Caledonia** changed direction in 1999, and most activities are now at the Reef Check level with experienced divers coordinated by the Coral Reef Observatory and consultants. There are, however, insufficient trained personnel for the surveys and some programs with funding have been delayed. A monitoring program was established in 1997 in the Southern Province with 18 stations monitored for Reef Check. A local NGO has requested listing of the barrier reef system for World Heritage status and prepared a detailed assessment of reef status in 2000. They reported recovery after crown-of-thorns damage and increases in fish populations after enforcement of regulations was implemented.

The **Samoan** Fisheries Division, coordinated by the IOI-Pacific Islands Node, trained over 40 villagers in coral reef monitoring to assess 54 fish reserves established under the Village Fisheries Management Plan project since 1998-1999. Two larger reserves in Aleipata and Safata are monitored by the IUCN and the Division of Environment and Conservation, but capacity and expertise to assess reef status across all islands is still required. Monitoring has virtually stopped in the **Solomon Islands** due to the unrest, and capacity and expertise has been lost. The Fisheries Department in **Tuvalu** monitors some fisheries and coastal erosion indicators, but capacity for more detailed monitoring of reef resources is lacking. **Tuvalu** is unable to report adequately on the status of resources and damage from shipwrecks, spills, cyclones or COTS infestations. There has been no national reef monitoring and management in **Vanuatu**, with the only initiatives through NGOs and tourist resorts. Responsibility should be devolved to the user communities and linked with local enforcement of conservation areas.

Legislation and Regulation

These Pacific countries have minimal specific legislation to conserve coral reefs, but many fisheries laws do include coral reefs and some traditional marine tenure systems still exist. Most laws are spread across different government departments and often in conflict with customary systems. In **Fiji** and **Vanuatu**, indigenous system are still effective, while in **Samoa** and **Tuvalu**, traditional laws for fisheries management are being written into national legislation to manage marine resources. The conflict in the **Solomon Islands** has eroded much of the control over the environment. The pertinent laws for conservation are listed in the previous Status 2000 report.

Countries lack the staff needed to enforce the legislation for reef conservation, thus over-fishing and destructive practices still continue. There is a need to introduce less complex regulations and involve local communities in the policing of these, often through the imposition of traditional deterrents.

Recommendations

In the two years since the regional report of coral reefs for the Southwest Pacific in 2000, the pertinent needs of coral reefs in the Southwest Pacific region have not changed. Those recommendations are repeated:

- Capacity building is a priority for the region to establish coral reef monitoring in long-term National monitoring sites. This should be addressed at all levels, including stakeholders, NGOs, government and private sector. There is also a need to standardise sampling and surveying methods within scientific and monitoring groups;
- More attention needs to be focused on the more highly stressed coral reef areas in the region, particularly, around urban and coastal areas where anthropogenic pressures are concentrated;
- There is a growing interest in community-based MPAs throughout the region. Fiji, Samoa and New Caledonia have initiated community based MPAs, however there is still an urgent need for more comprehensive and enforced MPA programs;
- The development of appropriate national coastal zone management plans and policies are required for all countries of the region;
- All countries should incorporate coral reef issues into the national climate change strategies under the UN Framework Convention on Climate Change (UNFCCC);
- There is an urgent need to document the biodiversity of coral reefs in all the countries. This will require training of marine biologists (taxonomists, coral reef ecologists, fisheries and stock assessment specialists and oceanographers) and strengthening of the Marine Biodiversity Centre at the University of the South Pacific e.g. the biology of the important reef food fishes is poorly known, which impedes the introduction of sustainable fisheries management; training is also needed in the private sector and NGOs to supplement government programs;
- Regional and national strategies for the preservation of intellectual property rights on marine biodiversity must be developed;
- Legislation and regulations for the management of coral reefs need urgent upgrading, especially the incorporation of integrated coastal management, and sustainable fisheries;
- Coral reefs should be mapped using advanced technology such as the use of Remote Sensing and Geographical Information Systems.

The countries in this Node request the assistance and support from national, regional and the international communities to tackle these recommendations.

Reviewers

Michel Kulbiki IRD, Noumea; Posa Skelton IOI-Australia; Robin South IOI-Australia; Charles (Chuck) Birkeland, Hawai'i

Acknowledgements

The country coordinators and authors wish to express appreciation and gratitude to other IMR staff, and particularly to the Canada South Pacific Ocean Development Programme–Phase II (CSPODP-II) and the people of Canada for their financial support of coral reef monitoring in the Southwest Pacific GCRMN node. The following supplied their data freely: Greenforce Conservation Expedition (Fiji); Coral Cay Conservation Ltd; Cousteau Resort - Savusavu, Fiji; Tegan Churcher-Hoffmann; Foundation for the Peoples of the South Pacific International; and Worldwide Fund for Nature (South Pacific Programme)

Supporting Documentation

The national unpublished status reports for 2002 are available from the Institute of Marine Resources, University of the South Pacific, Suva, Fiji, and will be included on www.ReefBase.org. The reports are as follows:

Cumming R (2002). Status of Fiji coral reefs in 2002;

Jacob P (2000). The status of marine resources and coral reefs of Nauru – 2000;

Mulipola A, Lober M (2002). Status of Samoa coral reefs in 2002;

Pakoa K (2002). Status of Vanuatu coral reefs in 2002;

Sauni S, Poulasi T (2002). Status of marine resources in Tuvalu in 2002– a review;

Sulu R (2002). Status of coral reefs in Solomon Islands 2002; and

Wantiez L (2001). Observatoire des recifs corralliens de la Province Sud (ORC), Rapport 2001.

Authors and Contacts

The IMR Southwest Pacific Node coordinators are Cameron Hay (Hay_C@usp.ac.fj), Reuben Sulu (sulu_r@usp.ac.fj) and Lynette Kumar (Kumar_l@usp.ac.fj). For the countries: Cameron Hay and Ed Lovell (lovell@is.com.fj) coordinate Fiji; Peter Jacob (Peterjacob@mbox.com.au) coordinates Nauru; Laurent Wantiez (wantiez@univ-nc.nc) is the coordinator for New Caledonia; Antonio Mulipola (Fisheries@samoa.ws) coordinates Samoa; Peter Ramohia (sbfish@ffa.int or solfish@solomon.com.sb or sigrcgmn@solomon.com.sb) should be contacted for the Solomon Islands; Tupulaga Poulasi (tpoulasi@yahoo.com) is the principal contact for Tuvalu; and Kalo Pakoa (kmpakoa@hotmail.com or fishery@vanuatu.com.vu) coordinates Vanuatu.

ICRAN

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

The aquarium fish trade has a reputation for unethical methods of harvesting, particularly the use of cyanide and other chemicals to stun fish, which results in considerable death of corals and fish. 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.

Fiji is the major exporter of aquarium products in the Pacific. More than 500 village-level collectors are involved in the trade and it is the only source of income in some villages. There is little management of the harvest operations; all species of coral can be collected with no limit on size and numbers; and extraction methods are not regulated. Fiji is now seeking a balance between reef health, aquarium animal collection and community benefits. SPREP (South Pacific Regional Environmental Programme) has been working with the Government of Fiji to ensure the ecological sustainability of coral trade industry in Fiji. The expected outcome of this initiative, which began in 2001, is for coastal communities to get a fair share of the benefits of a flourishing industry without damaging their ecosystems. Moreover, the Fijian case study will provide a demonstration project for other Pacific Island Countries already in the trade, such as Vanuatu, Tonga and Solomon Islands.

Ecological Monitoring: 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.

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

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

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. The Samoan people are heavily dependent on reefs, but over- and destructive fishing and poor land management threaten the reefs and fish stocks. The Districts of Aleipata (11 villages) and Safata (9 villages) covering 10-15km of coastline on Upolu established district-level, community-based, multi-use MPAs under a World Bank-IUCN initiative (Samoa Marine Biodiversity Protection and Management Project).

Ecological monitoring: Intensive baseline data were recorded of parameters considered important by the local communities in all major reef habitats (lagoon, channels and outer slopes). This was augmented by information gathered from local communities. The reefs are in good health, considering the many natural and anthropogenic pressures that have affected these reefs over 20 years, including destructive cyclones in 1990 and 1991. There is low coral cover on the inner lagoons (10-20%), but very high cover on the outer slopes (80-100%) and outer lagoons (50–60%) adjacent to avas (reef channel breaks). Fish abundance is low and individuals small in most accessible areas of the lagoon and on some outer slopes, indicating strong fishing pressures. However, fish are more abundant and diverse in less frequented areas (e.g. exposed outer slopes), and a large numbers of juveniles in the outer lagoons was a good sign. Highly prized species like giant clams, sea cucumbers and edible molluscs are also very rare except in remote areas. The reefs have recovered well after the cyclones, but damage is still evident with some parts not functioning well. There are also residual effects of crown-of-thorns starfish (COTS) outbreaks 20 to 30 years ago, especially in the avas and bays where coralline algae have replaced corals. There are concerns that the COTS could re-emerge and destroy coral cover. Sea urchins are eroding the reef rock and preventing new coral recruits from growing. Recovery from past dynamite fishing is poor or non-existent, even 5 years after it was stopped.

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

Monitoring effectiveness: The communities developed draft MPA management plans after the surveys, and long-term monitoring sites were established to provide performance indicators of the plans. Village Fisheries Reserves have been established and incorporated into the MPA plans. Trials are under way for community based monitoring of selected indicators to provide more immediate feedback on how their MPAs are progressing. Contact: David Fisk, Apia Samoa; davefisk@ipasifika.net

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

ICRAN

CORAL GARDENS PROJECT, FIJI – ICRAN DEMONSTRATION SITE

The Coral Garden sites are along a stretch of coral reefs on the southwestern coast of Viti Levu, the main island of Fiji. These sites are representative of the major ecosystems of the Indo-Pacific region: atolls; fringing reefs; and barrier reefs, and sites will be managed under a variety of different zones, including 'tabu' or marine protected areas, coral reef restoration sites and experimental aquaculture. The area is under considerable threats from piggery wastes, sewage pollution, crown-of-thorns starfish (COTS) infestations, freshwater flooding and coral bleaching.

The Coral Gardens Project is centrally coordinated by a committee of landowners in the district of Cuvu and managed primarily by the Foundation for the People of the South Pacific (FSP- Fiji). These groups are developing comprehensive management plans for coral reef fisheries and land-based waste problems. Based on these pilot sites, international NGOs and FSP- Fiji will provide regional workshops to train people to replicate the Coral Gardens model throughout the Pacific and into the Caribbean.

Ecological Monitoring: Several experiments were initiated in Cuvu Bay to examine experimental 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 marine protected areas.

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

Urgency Of Sea Turtle Conservation In The South Pacific

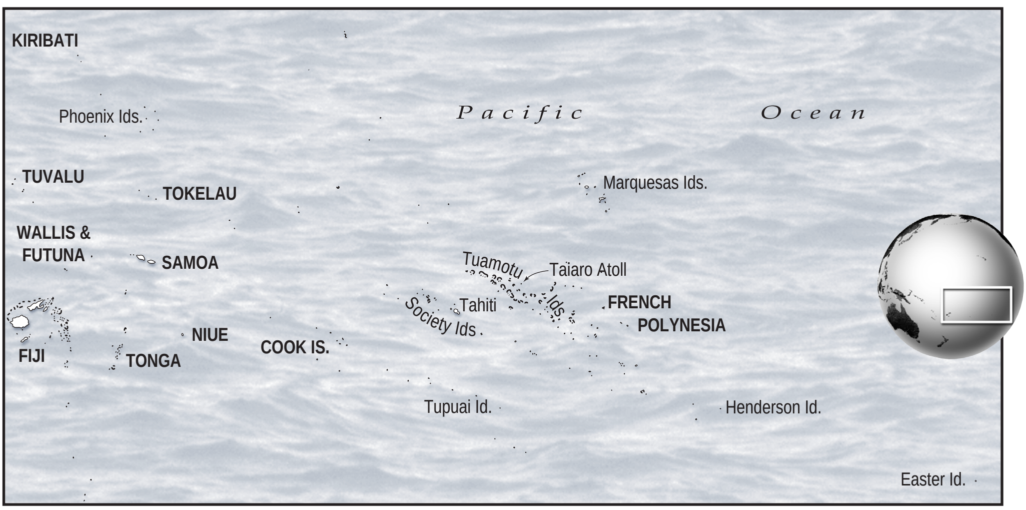
Hawksbill and green turtle populations in the South Pacific are in serious jeopardy; hawksbills are rapidly approaching extinction and greens should be classed as endangered. After nesting in American Samoa, these turtles migrate over 850km to feed on the higher diversity and biomass of seagrasses and algae in Fiji. Turtles were tagged with metal flipper tags and 7 were tracked by satellite transmitters. Six of the 7 migrated to Fiji at a rate of 1.8km per hour. The metal tagged turtles did the same with 96% travelling west after nesting, and 61% ended up in Fiji waters. Most returned to American Samoa to breed 4-5 years later. Thus Fiji is critical for turtle conservation and there is a need to identify and map the feeding sites. It is also critical to manage the water quality and rates of harvest in these feeding habitats. This action is urgently required. Contact: Peter Craig, National Park of American Samoa, Peter_Craig@nps.gov

11. Status of Southeast and Central Pacific Coral Reefs 'Polynesia Mana Node': Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga, Wallis and Futuna

Bernard Salvat

Abstract

These countries and states (Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga and Wallis and Futuna) contain 347 islands with coral reefs, an EEZ of more than 12 million km^2, and approximately 450,000 inhabitants (but 80% are concentrated in the major towns on 7 islands). The coral reef biodiversity is lower in the eastern Pacific than to the west, and cyclones are generally rare, occurring at approximately decadal intervals. Major outbreaks of the crown-of-thorns starfish occurred in the 1970s in French Polynesia, and coral bleaching with high mortality occurred in 1991, as well as other localities in the region during 1999 and 2000. Pollution from sewage and sediments only occurs near urban centres. There is a major lack of good information on the coral reef resources of most of the islands, even though these are important for subsistence and local commercial exploitation. French Polynesia, however, has reasonable data from an effective monitoring program. Tourism is the major industry, with much based around coral reef resources. More recently black pearl oyster culture has made major economic contributions in the Cook Islands and French Polynesia. Coral reef conservation is generally poorly developed, with poor enforcement and a lack of political will, although all



countries have considerable legislation. Improved funding for conservation is a major need, in order to build capacity and resources for conservation throughout the region. In addition, the existing or nascent traditional management systems should be used to raise public awareness of the true value of coral reefs to these Pacific islanders.

This chapter contains some new information on coral reef monitoring and Marine Protected Area (MPA) activities, but most of the other sections are edited versions from the chapter edited by Bernard Salvat and published in the 'Status of Coral Reefs of the World: 2000' report. Readers should consult this chapter for more details or consult the compilation of National reports published by Salvat in 2001.

Introduction

These countries (Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga and Wallis and Futuna) have vast areas of coral reefs, which remain in generally good condition with few anthropogenic impacts. Traditional management is still strong amongst these Polynesian countries which form the 'Polynesia Mana Node' of the GCRMN with assistance from the CRIOBE-EPHE Research Station on Moorea. The 'Mana' term symbolises the sense of stewardship that Pacific peoples have for their valuable reef resources. Some of the countries in this Node lack sufficient capacity to be fully involved in the reef monitoring and conservation aspects of the GCRMN, therefore the activities are closely linked with the Southwest Pacific Node coordinated through Fiji. Most countries produced national Coral Reef Status Reports in 2000, and these reports are summarised here; other national reports are available on www.reefbase.org.

Capacity building for monitoring is needed in these countries, however the small populations and large areas of resources to cover make implementation difficult. French authorities and the South Pacific Regional Environment Programme (SPREP) continue to assist by improving monitoring capacity and increasing coordination and collaboration across these countries.

Reefs, Peoples and Cultures in the South-East and Central Pacific

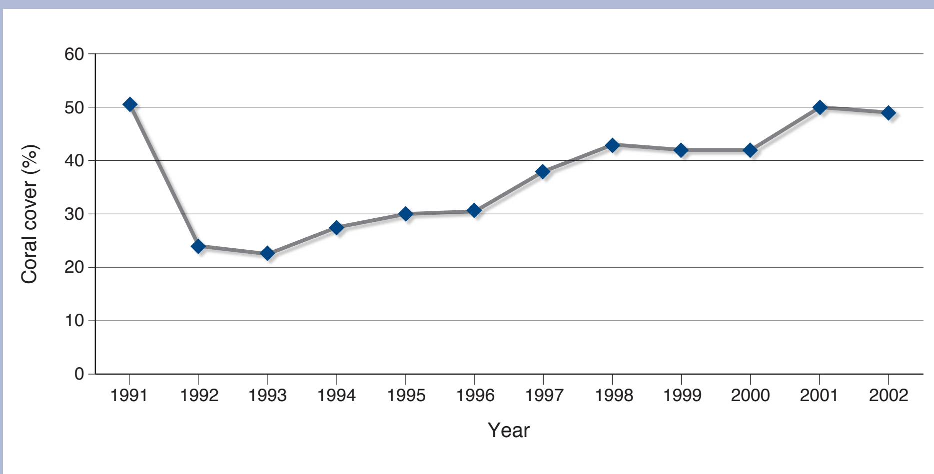
These countries lie across the International Dateline from the Equator to 25° South and contain 12 million km^2 of EEZ, but less than 6,000km^2 of land in 347 islands with 60,000km^2 of lagoons. There are many different island types, including 125 atolls, 8 uplifted atolls and many low coral islands on platforms. The coral reefs in the eastern Pacific have lower biodiversity than those on reefs to the west e.g. for hard coral species there are 115 on Kiribati, 192 on Tonga, but over 350 on the Great Barrier Reef. There are also few estuaries, which also limits species diversity. Soft corals, gorgonians, sponges, crinoids and mangroves are either absent or poorly represented. French Polynesian reefs however have over 800 fish species, about half that found in on the Great Barrier Reef of Australia.

There are about 470,000 people, varying from 230,000 in French Polynesia to 2,000 in Tokelau; however, there are often large non-resident populations in New Zealand, France etc. Population growth varies from 0.5% in Tonga to 2.3% in Kiribati. Most of the people live in capital cities or regional towns with few living traditional lifestyles on the outer islands, and more than half of 347 islands are uninhabited. Most people are of Polynesian origin, and can communicate using a common language base.

Kiribati, Niue, and Tonga are fully independent countries, whereas Tokelau and Cook Islands are associated with New Zealand, and French Polynesia, and Wallis and Futuna are part of the French Overseas Territories. Kiribati, Tonga, Niue, Tokelau, and Wallis and Futuna have smaller economies, whereas the GNP in the Cook Islands, and French Polynesia is higher, reflecting tourism and black pearl oyster incomes, plus considerable funds from expatriate workers and foreign assistance (up to 50% of GNP in some countries). Many Pacific islanders rely on reef resources for food security and cash incomes, especially on low populated atolls. Polynesian peoples maintain strong linkages to the reefs and have a valuable traditional knowledge of reef-based resources.

A Decade of Reef Monitoring on Moorea, French Polynesia

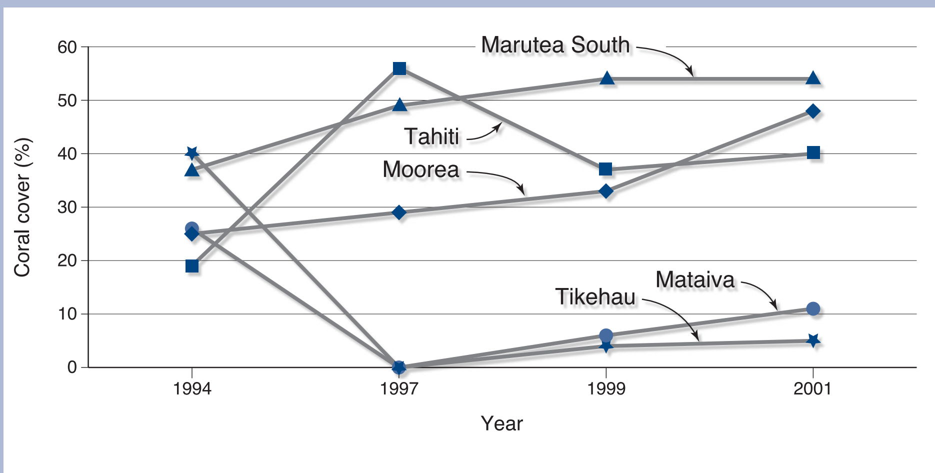
There has been annual monitoring of the barrier reef and outer slopes of the Tiahura (north west of Moorea) coral reef system since 1991. Along with collecting a lot of valuable data over a decade on an outer slope, many other lessons have been learnt. The maximum coral cover for a healthy reef at the monitoring site at 12-15m depth is about 50%, with coralline algal cover between 5 and 10%. This graph shows the variation in coral cover from 1991, just before the major bleaching event, after which it dropped to half of this, and has progressively recovered since then. In 1994, the corals bleached but there was little mortality. There have been major recruitment events in 1996 and 2000, which showed up as major boosts in coral cover in 1997 and 2001. These data clearly show the value of maintaining long-term monitoring studies.



Coral cover changes on the outer slope Moorea-Tiahura, French Polynesia with the effects of a major bleaching event clearly seen in the monitoring data for 2002.

Outer Slope Reef Monitoring in French Polynesia

A long-term monitoring programme has been launched to survey outer reef slopes on 15 of the 118 islands of French Polynesia to study the natural variability of the coral communities and the influences of cyclones and bleaching-mortality events. These outer slopes are remote from human impacts and the objective is to identify the impacts of global climatic change and follow the predicted increases in frequency and severity of such events. The results will be expressed in coral cover percentages to show how outer reef slopes are affected by these events and how long they take to recover. The results so far cover widely separated islands, some of which seem to have not faced the destructive events, indicate that: 1) a healthy outer reef slope coral community at 12-15m depth is about 50-55% coral cover; 2) cyclones are more catastrophic than bleaching-mortality events (but usually more localised) and 3) it takes about 10 years for reefs to recover from a major event.



Variability of coral cover on 5 French Polynesia islands surveyed between 1994 and 2001. A cyclone and bleaching dropped coral cover on Mataiva and Tikehau in 1994; and coral bleaching reduced coral cover on Tahiti after the monitoring of 1997.

Status of the Reefs

The major new information for this region is contained in the attached boxes. For most of the countries, the status of the coral reefs has changed little since the 2000 reports and there have been few surveys to assess coral cover data, fish populations and general coral reef health since then. Progress in monitoring, resource inventories, and management has been made in Wallis and Futuna since 2000, although French Polynesia has the only consistent program to assess reef health and trends.

Coral Reef Fisheries

Fish resources are important food for the Polynesian people, and have been the focus of many traditional management regimes. Most fish are eaten locally and there is little inter-island fisheries trade, except to large urban centres in the Cook Islands, Kiribati, and French Polynesia. There is a developing export industry for grouper and wrasses for the live reef fish trade from Kiribati to Asian markets. The tuna fishery remains a major economic interest for island peoples, especially via royalties for foreign harvest within Polynesian country EEZs.

Invertebrate and turtle resources are also important for atoll peoples e.g. harvest of octopus, clams and other molluscs, algae, worms, sea cucumbers and jellyfish. Sea cucumbers are exported from Wallis-Futuna, but export has been banned from Tonga. Lobsters are over-exploited and populations are now threatened. Black corals have been over-harvested, especially in Kiribati and Tonga although laws ban this exploitation.

Isolated Coral Reefs of the Phoenix Islands, Kiribati

These islands of Kiribati are just south of the equator in the Central Pacific, and comprise 3 atolls, 5 coral reef islands and 2 submerged reefs (total area $29km^2$). They are also some of the most remote reefs in the world, being 3 days steaming from the closest port, and also pounded by ocean swells on three sides, making them some of the most difficult to access. Two multi-disciplinary expeditions by the New England Aquarium (USA) and Nai'a Cruises Fiji in 2000 and 2002, documented the diversity and status of terrestrial and marine life on these remote coral reefs. The Phoenix Islands are virtually in pristine condition with minimal human impacts and a wealth of biological resources. Coral diversity was moderately high with about 120 species, comparable to the 115 species identified from the Gilbert and Line groups to the east and west. The health of the reefs was excellent, with no evidence of bleaching that has plagued reefs in other parts of the Pacific, no evidence of disease or predation, and large, prolific communities of *Acropora and Pocillopora.* Coral cover on leeward atolls ranged from 25-45% and in some instances exceeded 75% on shallow platforms, while windward sides ranged from 20-30% cover. Coral reef islands averaged 20-25% coral cover, although rocky platforms and spurs at Phoenix had >60% cover contributed by encrusting, submassive and plate colonies. Fish populations were incredibly abundant and diverse, and included pelagic fishes such as tuna and oceanic mackerel. There were large numbers and sizes of some fishes (such as the humphead or Maori wrasse – *Cheilinus undulatus*), which have been severely depleted in Asia and the Western Pacific. Shark populations were abundant on some islands indicating healthy coral reef ecosystems. However, in 2002 the expedition recorded a reduction in shark populations on Phoenix, Kanton and Manra islands, due to harvesting by a foreign shark-finning vessel. Similarly, sharks at Orona Atoll was severely depleted after a government project in 2001 to harvest sharks for their highly prized fins. The other islands (Nikumaroro, Birnie, McKean, Enderbury) are excellent examples of near pristine reefs because of the exclusion of human impacts. The Phoenix Island reefs are of global significance, and were suggested for World Heritage listing in early 2002.

From: Sangeeta Mangubhai, smangubhai@africaonline.co.ke

Green and hawksbill turtles are threatened throughout the Pacific; some nesting sites are protected, but enforcement is weak.

The aquarium trade has expanded recently in Kiribati, the Cook Islands and Tonga for corals, fish and invertebrates. There are projects to make the trade more sustainable e.g. harvesting larval fish at night in French Polynesia. Molluscs (*Trochus*, *Turbo* and *Tridacna*) have been introduced to some countries to develop export industries or replace over-exploited giant clam stocks.

Natural Disturbances and Impacts

Cyclones are more frequent in the western Pacific, such as in Kiribati, than in French Polynesia. Major cyclones occurred: in 1982, 1995, 1997, 1999, and 2000 in Tonga; 1958, 1960, 1968 and 1979 in Niue; and 1982-1983, 1991 and 1997 in French Polynesia. These cyclones result in less coral reef damage where such storms are relatively frequent; whereas major damage occurs to less-adapted reefs that develop fragile coral communities. In French Polynesia during the El Niño years of 1982-1983, there was major destruction of corals in lagoons and on outer slopes during 6 cyclones.

Crown-of-thorns Starfish outbreaks were reported in most Polynesian countries in the late 1970s and early 1980s, and populations now appear to be relatively stable.

Coral Bleaching Events appear to have been more frequent and severe during the last 20 years. About 80% of *Acropora* bleached in March 2000 in Rarotonga, Cook Islands. In February 2000, up to 90% of the *Goniastrea* and *Platygyra* colonies bleached in Tonga and Fiji, with mortality about 2-5% on the outer slope. Data on previous bleaching events are only available for French Polynesia e.g. there was 20% mortality on outer slopes in 1991; major bleaching but low mortality in 1994; and high bleaching and mortality, with great variability in location in 1999. Global climate change cannot be detected over the current low rates of human stresses. There are, however, many concerns in all countries about sea level rise causing destruction of low-lying coral reef islands e.g. a Climate Change Working Committee was launched in Kiribati. Models in French Polynesia indicate that a 1cm per year rise for 30 years could destroy all natural shorelines.

Anthropogenic Threats to Coral Reefs

The region experiences few of the anthropogenic impacts of other coral reef regions because human populations are relatively low and the islands are remote from continental influences. Most damage to lagoons and coral reefs occurs around urban centres, whereas the more remote areas and outer reef slopes remain healthy.

Over-fishing is becoming a major problem in most countries as populations grow or concentrate around urban areas and traditional fishing practices and laws are replaced and eroded. There is an increasing shift towards cash economies based on exploiting reef resources to buy boats, motors and fuel. Traditional fishing in village areas is now expanding to more remote reefs, and destructive fishing with poisons and dynamite has been reported in Tonga, Kiribati and Wallis and Futuna.

Bleaching Events in French Polynesia

There have been 7 bleaching events in French Polynesia over the last 2 decades, with most of them in the Society Islands. There are good data for 4 of these events: 1991, 1994, 1998 and 2002. All these bleaching events were correlated with warm ocean sea surface temperatures above 28°C, which is the normal summer maximum. Temperatures were at least 1 or 2°C higher for days, sometimes for weeks during months of warm waters. The most serious and best documented event occurred in 1991. It started in March, and by the end of the event in September 20% of coral colonies were dead. In 1994, the bleaching was equally severe at the time, but most of the colonies recovered and there was less than 5% mortality. These two events (1991 and 1994) were widespread throughout the Society and Tuamotu islands. The 1998 event was very patchy; one part of an island was bleached but not others, one island was affected but not the next one. On some outer reef slopes in Rangiroa, coral mortality was over 90% after a few weeks. The most recent event in December 2001 to January 2002 bleached corals on many Society barrier reefs and lagoons, and generalised bleaching of outer reef slope corals started in March and corals were still bleached in July (with about 10% mortality). The susceptibility of coral genera was similar in all events e.g. in 1991 for *Acropora,* 100% bleached and 51%; for *Montipora* it was 72% and 0%; for *Pocillopora,* 25% and 8%; and for *Porites,* 44% and 0%. The apparently increasing frequency of bleaching events (every 3 years on average) poses a major threat to the corals of this region, with the real risk that the more susceptible species may become rare in the coral community.

Coral, sand and mangrove extraction for construction is resulting in damage to lagoons and reef flat areas near urban centres, where there have also been major shoreline modifications e.g. building of wharves, roads, airports, and seawalls for shoreline protection. Coral and sand mining, although banned in Kiribati and French Polynesia, still continue and these activities have resulted in the disappearance of beaches near urban areas. In this way more than 50% of the coastline has been modified in the most populated areas of the Society islands, with similar problems on Rarotonga, Cook Islands.

Sediment and sewage pollution from poor land management on the populated high islands has damaged some reefs, but most impacts are local, and the sediments are readily dispersed into oceanic waters. Only a few of the tourist islands have major sewage treatment facilities, and human and animal wastes flow directly into reef lagoons. This results in eutrophication in lagoons around Moorea, Tahiti and Rarotonga. No oil pollution has been reported, except near the major harbours.

Tourism activities on some islands have resulted in major degradation to reefs during hotel construction, and the industry is developing rapidly with 250,000 tourists per year visiting French Polynesia, 60,000 to the Cook Islands and 25,000 to Tonga. Conflicts can arise between operators and communities over access to lagoon and reef resources, especially the fisheries, as well as well-recognised cultural impacts of too many tourists on islands with low populations.

The black pearl industry is developing rapidly in French Polynesia and the Cook Islands, and the holding lagoons have experienced eutrophication, algal blooms and mortality of pearl oysters, fish and invertebrates due to the large quantities of faecal pellets.

Coral Reef Protected Areas and Government Policies, Laws and Legislation

There are a few MPAs for coral reefs in this region and these include areas for fishery recruitment, shoreline stabilisation, and ecotourism. However, traditional measures used by local communities constitute *de facto* conservation areas. Legislation for reef protection is mostly ignored and enforcement is poor. The current emphasis is on developing community-based management as the bottom-up approach is more appropriate in Pacific communities; however top-down 'government' approaches are essential to start many of these processes.

Very few reefs have formal protection under international conventions e.g. Taiaro atoll, Tuamotu Archipelago which is a Man and Biosphere Reserve of UNESCO. There are no World Heritage or Ramsar sites with coral reefs, although some conservation projects are planned in the Cook Islands, French Polynesia, and Kiribati. Most countries have adequate legislation to establish MPAs, but political will is usually lacking. The Cook Islands have declared 5 unofficial coastal areas of Rarotonga (15% of the area) as temporary non-harvesting zones based on 'Ra'ui', a traditional Polynesian method of rotating protected zones. Two uninhabited atolls are nature reserves (Scilly and Bellinghausen, French Polynesia) and there are several seabird sanctuaries in Kiribati (e.g. Jarvis and Starbuck islands). There are some traditional conservation areas in Niue, and 'clam circles' protect giant clam resources in Tonga. There are no MPAs in Wallis and Futuna, but 3 zones have been selected and will be protected according to traditional law.

Most conservation laws are recent, and frequently based on fisheries management of key resources (regulated areas, fishing seasons and quotas). However, traditional management of coral reef resources is still strong throughout the region and often backed by legislation. Many countries have more recent legislation that could be used to conserve

Coral Reef MPAs in French Polynesia and Wallis and Futuna

Integrated Coastal Management is being attempted in 2 French overseas territories. In Moorea and Bora Bora, management plans will be adopted in late 2002 and 2003 respectively. These plans are being launched by the Municipal Councils which continue the dialogue until a consensus is reached between all stakeholders interested in the reefs and the lagoon habitats and their resources (fishing, tourism, local leisure, boating etc.). These Management plans include establishing protected areas where some activities will be prohibited or regulated. Many other Management Plans will be launched in the near future for Fangatau, Fakahina, Raiatea, Tahaa, Rangiroa, Makatea, Tikehau, Mataiva and Fakarava islands. In Wallis and Futuna, 3 coral reef protected areas covering 50ha devoted to protection and education have been nominated by traditional local authorities (a fringing reef, barrier reef and outer reef slope), and these will be managed by the local populations.

Coral Reefs of Rarotonga, Cook Islands

The coral reefs of Rarotonga provide food to the population and have a deep cultural and spiritual significance. These reefs are also essential for tourism, which is the foundation of the Cook Island economy. However, reefs in Rarotonga have a decades-long history of degradation. The decline of coral health results from several factors: bleaching from El Niño events; crown-of-thorns starfish (COTS) outbreaks; nutrient and freshwater runoff into the lagoons; and algal overgrowth. There is no central sewerage system on Rarotonga, and septic tanks overflow through the sands into the lagoons. Agricultural areas also drain directly into the sea, bringing sediments, nutrients and pesticides into the lagoons during heavy rains. There has been some bleaching of corals in Rarotonga, but many corals appear to be heat-tolerant and have survived several severe bleaching events.

The council of traditional leaders, the Koto Nui, and the Government have recently re-established the traditional system of reef management involving no-fishing areas known as 'Ra'ui'. Fish populations have recovered in the Ra'ui areas, however, the corals are still in very poor condition and filamentous algae dominate the lagoons. The coral reefs of Rarotonga will benefit greatly from continued fisheries management and the Ra'ui system, however, permanent no-fishing areas are also needed, where restocking of depleted shellfish and especially sea cucumbers can occur, serving as brood-stock for reseeding the wider reef system. COTS control is also needed. A coral transplantation and recovery program would also help accelerate coral reef recovery in the lagoons. Rarotonga desperately requires a tertiary treatment sewerage and storm drain system to lower nutrient runoff into the lagoons. A reduction of chemical inputs and runoff from agricultural land is also needed for long-term coral reef health. From: Austin Bowden-Kerby, Foundation for the Peoples of the South Pacific, bowdenkerby@connect.com.fj

coral reefs, but unfortunately, compliance is low and enforcement by governments is weak through a lack of resources and political will. French Polynesia has developed various types of 'marine management plans' using a bottom-up process, and most others are planning National Environment Management Strategies (NEMS) with local communities, usually with assistance from SPREP and other regional organisations. There are several regional conventions relevant to coral reef conservation, such as the Apia convention of 1976 to promote protected areas; and the Noumea convention of 1996 to protect marine resources from dumping at sea.

Monitoring

Coral reef monitoring is variable throughout the region. Well-developed programs only exist in French Polynesia where water quality is monitored in Tahiti and some of the Society islands, and the coral communities are monitored on the lagoon reefs of Tahiti, Moorea and the outer slope of 14 islands. These are measured for the impacts from cyclones, bleaching and minor anthropogenic pressures. A similar program was started in **Wallis and Futuna** in 1999 and has developed well. In the **Cook Islands**, water quality, coral cover and fish and invertebrate abundance are monitored in lagoons of 9 of the 15 islands. There is no monitoring in **Kiribati**, except surveying the abundance of the toxic alga responsible for ciguatera. Likewise, there is no monitoring in **Niue** and **Tokelau**. **Tonga** monitors the marine parks and reserves for nutrients, pesticides, metals, faecal pollution and the status of the benthos.

There is little information on changes to coral cover on most of the coral reefs, and the data are published only in national technical reports. Monitoring has started as surveys and some reefs were occasionally re-surveyed, but most programs have lapsed (with the exception of French Polynesia). Most outer reef slopes have low cover (between 16% and 71%), due to the exposure to oceanic waves, and not human damage. Wallis and Futuna has the lowest coral cover; Tonga and French Polynesia are intermediate; and Kiribati has the highest. Coral cover in the lagoons is highly variable.

Conclusions and Recommendations

Some progress has been accomplished since the last coral reef status report in 2000, but only in those countries which have the most advanced monitoring programs. Thus the gap is increasing between the different countries: French Polynesia is well advanced; Cook Islands, Kiribati, Tonga, and Wallis and Futuna are developing their capacity for coral reef monitoring and management; while there has been no reported progress in Niue and Tokelau. Most countries reported gaps and recommendations for improved management and conservation of their coral reefs and resources in 2000. The following recommendations are a summary of those:

Political Will

There is a widespread lack of political will for the conservation of coral reef resources. More political concern is shown for the larger economic components such as tuna concessions, than reef fisheries that are the basis for subsistence fisheries on remote islands. Insufficient attention is given to long-term environmental considerations although healthy lagoons and reefs are the basis for a flourishing tourist industry and traditional livelihoods. Most of the calls for conservation of the environment and the re-establishment of traditional management have come from communities and local NGOs.

Funding

The lack of sustainable funding is a major impediment for improving coral reef monitoring, conservation, economic assessment, education and awareness raising. These are all essential for developing the management capacity to maintain healthy coral reefs. The variation in funding is represented in the differences in monitoring and conservation between the wealthier states and the others. All countries depend on assistance from regional organisations, especially SPREP, which provides expertise, and organises exchanges and capacity building.

Capacity Building, Knowledge, Monitoring

Most countries have small populations and thus lack sufficient trained people for reef assessment, research and management. There are few research or tertiary training centres. Fisheries departments often have a dual role – to promote fisheries and as well as conserve the environment. This leads to confused roles and inaction. More education materials and programs on coral reefs are needed for schools, communities, stakeholders and decision-makers.

MPAs, Management Planning, Legislation and Policy

There has been some progress in developing MPAs and effective coastal management mechanisms in the more developed countries, but the others are lagging further behind. Developments often proceed without Environment Impact Assessments, or when they occur, they are largely ignored. All countries require assistance to harmonise legislation to avoid inter-sectoral disputes that are impeding sustainable management of coastal zones. However, there are still too few MPAs and applications of National and International laws and conventions to conserve the coral reef resources of the region. Importantly, most senior bureaucrats and politicians are unaware of the value of using protected areas to conserve resources for the future. All countries have requested assistance to prepare legislation, and introduce enforcement of existing legislation to conserve fisheries and maintain MPAs.

Traditional Use and Community Rights

The rights of communities to exploit resources have been eroded through the introduction of more open access policies contained in 'western governance'. Community based conservation areas have been established in some Pacific countries, with the emphasis on solving problems and disputes through a bottom-up process. This mirrors the traditional marine tenure system, however, these examples are too few and not used effectively to demonstrate these principles to other communities. There is a need for funding to spread the messages of success, and also show case studies that demonstrate failure with severe consequences.

Regional Cooperation and Coordination

There is a need to strengthen regional cooperation and coordination to reduce the gap in management capacity between the smaller countries and those that are more developed. Communication will be facilitated because the people are predominantly Polynesian and share languages and cultures. There is a need to develop common approaches and protocols for monitoring and management of coastal resources through cooperation within Polynesia and with other Pacific countries.

Author Contact

Bernard Salvat (bsalvat@univ-perp.fr) coordinates the Node from the Université de Perpignan, in France and the CRIOBE-EPHE, station on Moorea, in French Polynesia.

Suppporting Documents

Salvat B. 2000. Status of Southeast and Central Pacific Coral Reefs 'Polynesia Mana Node': Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga, Wallis and Futuna. In: Status of Coral Reefs of the World: 2000, Wilkinson C (Ed.). Australian Institute of Marine Science, Townsville, 363 pp.

Salvat B. Ed. (2001) 'Status of Coral Reefs 2000 in Southeast and Central Pacific 'Polynesia Mana' Network. Fondation Naturalia Polynesia, Papeete, 217 pp.

WHS

HENDERSON ISLAND, UNITED KINGDOM – WORLD HERITAGE SITE

Henderson Island is one of the few atolls in the world that is virtually unaltered by man. It has an area of $36km^2$ and is in one of the most remote island groups in the southeast Pacific, the Pitcairn Islands. There are fringing reefs around most of the island, although live coral cover is low, ranging from 5-30% on the fore-reef slope. There have been scientific missions to record species on Henderson's reefs, however many species remain unidentified. Green turtles occasionally nest on the island, and fish populations are sparse, with the Carangidae (Jack) species being the most common and obvious.

The island is uninhabited, but Pitcairn Islanders visit Henderson Island occasionally to collect wood for curio making. The only other visitors to Henderson Island are scientists. Its pristine state and isolated location is suited to the study of the dynamics of island biological evolution and natural selection. The Pitcairn Island group is a Dependent Territory of the United Kingdom and Henderson Island is Crown Land. Access to Henderson requires a license issued by the Governor, following approval by the Pitcairn Island Council. Henderson Island has not been declared a protected area as such, although it receives de facto protection from its isolation. The island was inscribed as a World Heritage Site under the World Heritage Convention in 1988, but no formal management of the site has yet been undertaken. The UK Joint Nature Conservation Committee has recently commissioned the production of a draft management plan for the World Heritage Site.

Ecological Monitoring: There has been no specific monitoring, however there have been scientific missions to assess the resources and examine the development of remote coral reef communities.

Socio-economic Monitoring: This has not occurred as the island in uninhabited, however an assessment of the impacts of visiting Pitcairn Islanders and the importance of Henderson to them is warranted.

Coral reefs are **20%** the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **not planned.**

		MAB	

ATOLL DE TAIARO, FRANCE – MAB SITE

Atoll de Taiaro is in the Tuamotu Archipelago, French Polynesia and was designated a biosphere reserve in 1977 to include 7 atolls. Taiaro Atoll is considered the core area of the reserve. The buffer zone includes 5 other atolls (Aratika, Kauehi, Niau, Raraka and Toau) that belong to the Fakarava community, as well as the sea bottom to 1,000m depth. Fakarava atoll and the ocean between the atolls is designated as a transition zone. Taiaro is almost circular and has an emergent coral reef rim that encloses a 5km wide sandy-bottomed lagoon, with a mean depth of 15m, whereas outside the depth drops very quickly to 500m within 700m off the shore. The outer reefs of Taiaro have a well-developed algal crest on the windward side and have much richer and more diverse coral and mollusc communities on the leeward sides. There are also whales, dolphins, and 3 turtle species (green, hawksbill and leatherback) in the reserve.

The earliest scientific work was in 1839 (U.S. Exploring Expedition). In 1972, the Museum National d'Histoire Naturelle (Paris) and the Ecole Pratique des Hautes Etudes assessed the ecology, geomorphology, and hydrology of the reef and lagoon. There have been more scientific expeditions in 1992, 1994 and 1996. There is close cooperation between the traditional owners, the administrative committee of the sanctuary, and the governor of French Polynesia for the protection of the atoll, lagoon, surrounding sea and buffer zone around the atoll. Access to the reserve is restricted to scientific researchers who have been granted permission by the committee. Catching turtles and collecting tritons, molluscs and black coral is prohibited. Cultivation of pearls is authorized by permission of the consultative commission of public affairs.

Ecological monitoring: Although Atoll De Taiaro continues to be a focal point for much biological and physical research, there is no long-term monitoring program in place.

Socio-economic monitoring: Fakarava atoll, in the buffer zone of the Biosphere reserve, has a small resident community, but the other 6 atolls are uninhabited. Thus, there has been little priority on establishing a socio-economic monitoring program.

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

Coral reefs are **80%** the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **not planned.**

12. Status of the Coral Reefs in Micronesia and American Samoa: US Affiliated and Freely Associated Islands in the Pacific

Robert Richmond, Ruth Kelty, Peter Craig, Carol Emaurois, Alison Green, Charles Birkeland, Gerry Davis, Ahser Edward, Yimnang Golbuu, Jay Gutierrez, Peter Houk, Noah Idechong, James Maragos, Gustav Paulay, John Starmer, Andrew Tafileichig, Michael Trianni and Nancy Vander Velde

Abstract

The coral reefs in this region are comparatively healthy, although there was extensive damage to the reefs in Palau during the coral bleaching event in 1998 and levels of human pressures are increasing, but not to the levels of reefs in nearby Asia. These countries and territories are affiliated with the USA and are currently included in many of the initiatives through the auspices of the US Coral Reef Task Force for improved mapping, monitoring and training to the eventual aims of strengthening coral reef conservation. Thus there has been a major expansion of all coral reef activities since the last report in 2000. In **American Samoa**, the reefs are recovering from crown-of-thorns starfish invasions, 3 typhoons, and warm water bleaching, as well as chronic human impacts around the towns and the aftermath of removing 10 shipwrecks. Fish populations, however, are not recovering at the same rate due to serious over-fishing on the populated islands. The local government has recently banned the export of 'live rock' and scuba fishing. In the **Commonwealth of the Northern Mariana Islands**, there was moderate coral bleaching during the summer of 2001 and the reefs continue to suffer from increased sedimentation from poor land use and over-fishing around the populated islands. There have been major advances in coral reef monitoring with considerable training and the establishment of permanent monitoring stations. Coral reefs on **Guam** vary from excellent to poor, depending on adjacent land activities. Those reefs under the influence of excess sedimentation from soil erosion have low coral cover. There is excellent monitoring and research capacity on Guam and the 5 MPAs established in 2000 show that corals and fish populations are recovering well, however enforcement is weak in other areas. The coral reefs of the **Federated States of Micronesia** are generally good to excellent, with some problems around developments on the high islands and some fishing impacts. Capacity to monitor and manage their reefs is improving, but more progress is needed before adequate areas are protected as no-take reserves. In general, the reefs of the **Marshall Islands** are in good condition, including those in the former nuclear test sites. The reefs near the urban areas of Majuro are stressed, but still have an abundance of fish and invertebrates. Capacity to monitor and manage their reefs previously lagged behind adjacent countries, however there has been significant recent progress in developing capacity and establishing monitoring. **Palau**'s coral diversity is among the highest in the

world and the remote reefs are generally in good condition. Reefs closer to population centres are degraded due to sediment flows and sewage pollution, and increasing fishing pressures. Bleaching severely affected most reefs in Palau in 1998, however, monitoring is showing strong recovery and recruitment at many sites. A growing problem is sediment and dredging resulting from road development around the main island. Since the last report in 2000, the Palau International Coral Reef Center has opened with active research and education programs and is coordinating coral reef monitoring in the region for the GCRMN.

INTRODUCTION

This region contains countries, states and territories that have traditional ties with the USA. They are all participants involved in the US Coral Reef Task Force directly and through the All Islands Committee, and are constituted into a Node of the GCRMN, called the MAREPAC node, made up of American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), the Federated States of Micronesia (FSM), Guam, the Republic of the Marshall Islands and Palau, which hosts the headquarters of the Node in the Palau International Coral Reef Center. FSM, the Marshall Islands and Palau are Freely-Associated States, whereas the others are US Flag islands.

American Samoa

The Territory is a group of 5 small volcanic islands and 2 atolls in the central South Pacific Ocean. The largest and most populated island is Tutuila (142km^2). The total reef area is 296km^2 with 85% fringing reefs, 12% of offshore banks, and 3% of atolls. The Samoan reefs have a diverse range of species: 890 fishes, 200 corals; and 80 algae, but less than reefs further west.

Commonwealth of the Northern Mariana Islands

The CNMI contains 15 islands in 2 sections, with large variations in the coral reefs between them. There are no reliable estimates of coral reef area, but there is a 417km shoreline that is potential coral habitat. The southern islands (Saipan the capital, Tinian, Agijuan, Rota, and Farallon de Medinilla) are mostly raised limestone, sloping platforms protected by barrier reefs and well-developed fringing reefs to the west. The largely uninhabited northern islands (Anantahan, Sariguan, Gugan, Alamagan, Pagan, Agrihan, Ascuncion, Maug, Uracas, and Farallon de Pajaros) are mostly volcanic, including some active volcanos, and have much less reef development.

Guam

This U.S. territory is the most southern of the Mariana Archipelago and the largest island in Micronesia (560km^2). Half the island is a relatively flat uplifted limestone plateau, while the rest is primarily volcanic, with large areas of highly erodible lateritic soils. There are fringing reefs, patch reefs, submerged reefs, offshore banks, and a barrier reef to the south. The reefs vary in width from a few meters to well over 100m. The combined area of coral reef and lagoon is 69km^2 in nearshore waters, and an additional 110km^2 offshore. Guam is near the centre of coral reef biodiversity with many species: 306 macroalgae; 403 hard corals; 77 soft corals; 1,019 fishes; 128 sponges; 1,673 molluscs; 3 sea turtles; and 13 marine mammals. The coral reefs are economically and culturally important to the cash and subsistence economies.

Federated States of Micronesia

The FSM consists of the states of Kosrae, Pohnpei, Chuuk, and Yap, with each island having its own language, customs, local government, and reef tenure system. Traditional leaders (Chiefs or their equivalent) and community groups are active in traditional governance as well as western-style democracy. There are high volcanic islands surrounded by barrier reefs (Pohnpei, Chuuk) or very broad fringing reefs that are nearly barrier reefs (Kosrae, Yap). All states (except Kosrae) also include remote clusters of atolls and low coral islands, with a total shallow-water coral reef area of about 5,440km^2.

Marshall Islands

There are 1,225 islands and islets with 29 atolls and 5 solitary low coral islands, with a total land area of 181km^2. However, the Exclusive Economic Zone adds another 1,942,000km^2 of ocean to the Republic of the Marshall Islands. There are also 11,670km^2 of atoll lagoons in the atolls, varying from Kwajalein, the world's largest atoll (2,174km^2) to Namdrik with only 8.4 km^2 of lagoon. Most of the atolls are large with many islets on the windward side, and around the deeper lagoon.

Palau

The Republic of Palau is a separate group at the end of the Caroline Islands, 741km east of Mindanao and 1,300km southwest of Guam. There are 20 larger islands and 500 small islands stretching over 700km. The biggest island, Babeldaob, is volcanic and contains the capital, Koror. The southwestern islands of Palau are 339-599km to southwest of the main archipelago. There is a 144km well-developed barrier reef with 86km on the western coast. Ngchesar and Airai islands also have barrier reefs. The total coral reef area of Palau is 1,661km^2. The Southern lagoon is the largest lagoon covering 500km^2 and has many islands including the famous 'rock islands' and marine lakes. The east coast barrier reef is less diverse with about 80% of the 150km coast having a fringing reef with limited barrier reefs, lagoons, and patch reefs to the south.

Status of the Coral Reefs

American Samoa

The reefs have experienced a series of natural disturbances over the past two decades including a crown-of-thorns starfish (COTS) outbreak (1979); three typhoons (1986, 1990, 1991); and warm water related mass coral bleaching (1994, 2002). These impacts were most severe on the main island of Tutuila, which also has moderate levels of fishing and chronic pollution, particularly Pago Pago Harbour. The reefs of American Samoa escaped the major bleaching events that struck Fiji and (Western) Samoa over the last 3 years. In 1995, a highly efficient commercial fishery (night-time scuba fishery) became established on Tutuila, which threatened the reef fish populations on the island. Fortunately, the scuba fishery was banned in 2001. By comparison, fishing and other pressures are much lower on the other islands of American Samoa (the Manu'a Islands and two remote atolls).

Coral reef surveys on all 7 islands in the Territory showed that the coral communities on Tutuila were recovering from the disturbances by the mid 1990s. Crustose coralline algal growth was abundant and new coral recruitment was high. Surveys in 2002 report dramatic recoveries of the coral communities at most sites on Tutuila, and even the reefs in Pago Pago Harbour are improving for the first time due to improved water quality, and the removal of 9 shipwrecks in the Harbour. However, reef fish populations on Tutuila are not recovering as well. Small coral associated fishes are recovering in parallel with the coral communities, however, the density and biomass of target fish species is very low on Tutuila compared to the Manu'a Islands, correlating with the over-fishing on Tutuila. The Manu'a Island reefs have experienced chronic pressures from COTS over many years, which has reduced coral cover, particularly on Ofu and Olosega. However, the reef fish populations are much larger than on Tutuila because fishing pressure is lower. Similarly, the corals and fishes on the two remote atolls (Rose and Swains) remain in good condition.

CNMI

There are 256 coral and 41 octocoral species, with higher diversity in the south on older, more developed reefs. Saipan's reefs are the best studied in the CNMI; the reef fronts and terraces have higher coral cover than inner reef areas, probably because lower water levels result in higher temperatures and salinity fluctuations. The coral reefs surrounding Tinian and Rota have lower coral diversity, with only 74 species of hard corals in localised coral communities. Seagrasses are found only in the extensive Saipan Lagoon and in a small area on Rota. COTS are found in low densities on most reefs in Saipan, Tinian, and Rota, and larger populations exist on the eastern side of Puntan Naftan near Boyscout Beach on Saipan and Unai Babui on the eastern side of Tinian. Green and hawksbill sea turtles occur in the CNMI, but details of their population size or feeding habitats are unknown, although green turtles nest on most of Tinian's beaches. There are also spinner, striped and bottlenose dolphins and numerous whale species.

Sewage pollution, dredging, and sedimentation from unpaved roads and development have reduced water quality in the CNMI and smothered nearshore corals, but these are not quantified. Deforestation by feral animals has increased sedimentation on the northern islands, and Farallon de Medinilla has been used as a Navy bombing target since 1981. The CNMI are adopting stringent nutrient standards for nearshore water quality and regular monitoring is occurring on beaches of Saipan, Tinian, Rota, and Managaha. Coral bleaching was observed around Saipan in 1994, 1995 and around both Saipan and Pagan in 1997, but there are no data. Most shallow water corals as deep as 18m on Saipan, Rota, and Tinian were affected by coral bleaching during the summer of 2001. Many encrusting *Montipora* and staghorn *Acropora* coral colonies died, and more detailed assessments are proceeding.

Guam

There are a mix of excellent to poor coral reefs on Guam. The condition is directly related to adjacent land-use patterns, accessibility, location of ocean outfalls and river discharges, recreational pressure and circulation patterns. The reefs off the northern limestone end of the island are generally in better condition, with higher coral cover and diversity than those affected by erosion and sedimentation in the south. There is also some eutrophication on the reef flats from nutrients percolating through the limestone. The eastern reefs are heavily affected by sedimentation and freshwater runoff during the rainy season, when sediments wash onto the reef flats and reef slope. Road developments have caused heavy sedimentation and massive coral mortality on a 10km section of fringing reef along the southern side, where the fringing reefs are generally in poor to fair condition.

The fringing and patch reefs near Apra Harbor are in relatively good condition, but corals in the harbour have been damaged by freshwater runoff, sediment and power plant discharges. The inner areas of Agana, Tumon, and Piti Bays are also in relatively poor condition, affected by land runoff and tourism activities e.g. jet ski operations and sewage treatment plant discharges. It is expected that water quality will improve after planned upgrades to the plants and restoration activities on the shore and reefs.

There is 35-70% coral cover on the good to excellent reefs, and less than 10% cover on the most damaged sites, where fleshy algae and sediment dominate the bottom. A comparison of data from the 1960s reported most reefs with over 50% coral cover, but only 7 of the same 113 transects had 50% live coral cover (and 88 had less than 25% live coral) when measured in the 1980s and 1990s. Few coral species remain near the Northern District sewer outfall and coral cover is less than 25%. Coral recruitment has declined around Guam since 1979, when 0.53 coral recruits per plate were found on 525 fouling plates, while in 1989 and 1992 only 0.004 and 0.009 recruits were found per plate respectively.

Coral diseases, the competitive sponge *Terpios*, and coralline algal lethal orange disease (CLOD) have all been observed on Guam's reefs, but none are critical now. However, a recent increase in abundance of COTS juveniles in the late 1990s is causing concern. Recent increases in blue-green algae are also a problem as these can overgrow corals. Sedimentation rates in Fouha Bay are sufficient to 'fill' the bay approximately 8 times per year, while the bay flushed on average 4 times per year. These sediments are re-suspended during strong swells and reduce light penetration and smother corals. The community in Umatac Village has been cooperating to control the activities responsible for accelerated erosion and runoff.

Coral bleaching has been documented during El Niño events, with both hard and soft corals affected, with some high mortality. However, Guam escaped the damage in the 1998 bleaching that affected reefs further south e.g. Palau. Other potential climate change impacts include inundation of low lying coastal areas, and increased sedimentation from drought followed by heavy rains.

Federated States of Micronesia

The condition of FSM coral reefs is generally good to excellent, and most of the reefs around the low islands are excellent. On the island of Pohnpei coral cover ranged from around 20% adjacent to Sokehs channel to 70% at selected sites on the barrier reef. In 1996, coral cover around Yap was about 29%. Crustose coralline algae are abundant on all reefs. In all FSM States, the greatest threats to the reefs come from land-based developments which cause increased sediment runoff, and pollution, along with sand-mining and dredging. Water quality is good on the uninhabited atolls and the coral cover in Chuuk Lagoon is indicative of good water quality. Dredging and filling for building roads, causeways, ports, and airfields over coral reefs have degraded water quality on Kosrae, and on some of the other high islands.

The potential for sea level rise from global warming to inundate the low lying areas is causing concern on the low islands and atolls of FSM. Likewise any increases in tropical storms are also a worrying issue. A typhoon in 1990 passed over remote reefs in Pohnpei State and picked up massive coral heads from the lagoon and threw them on the reef flat, crushing the corals. FSM reefs have experienced some bleaching, but information is limited. Efforts to reduced deforestation on Pohnpei, Kosrae and Yap are being made to control erosion and sedimentation.

Marshall Islands

The reefs are generally in good condition with those around Majuro showing signs of stress. RMI biodiversity consists of about 860 species of reef fishes, 362 hard and soft corals, 40 sponges, 1,655 molluscs, 728 crustaceans and 128 species of echinoderms. There are also 5 species of turtles and 27 marine mammals around the Marshall Islands. The reefs in the former nuclear test sites show remarkable recovery, although the larger bomb craters may not fill in for years.

Water quality has deteriorated due to coastal construction for ports, docks, airfields, causeways, and roads. Development projects often involve using fill material and expanding into adjacent reef areas, which all mobilise suspended sediments, increase turbidity, and can change the circulation patterns in lagoons.

The average sea temperature around the Marshall Islands in 2002 was about 29°C, near the upper limit for coral survival. A further increase of 1°C could trigger massive coral bleaching and die-off. A 2000 report on climate change in the Marshall Islands projected that air temperatures will continue to rise on all atolls with the highest increases in the northern areas.

Palau

The coral diversity is among the highest in the world with 425 species of hard corals and 120 species of octocorals, which is approximately 25% higher than on Guam. Four species of sea turtles use Palauan reefs. The Rock Islands once had large numbers of hawksbill nesting sites, but egg poaching and the killing of turtles for bekko jewelry have drastically reduced nesting activity. The species and the nesting habitats are protected within the Rock Island Reserve. The egg-laying banded sea snake and the yellowbellied sea snake are found in Palau, and the endangered dugong has been reported.

Coral cover on reefs in good condition, ranges from 50-70% with 45-95 species at a given site. For example, a comparison of the fringing reef at the southern tip of Malakal from 1976-1991 indicated no significant differences in coral cover and this is probably true for most areas. Before the 1998 bleaching event severely affected most reefs in Palau, the remote reefs were generally in good condition. Reefs closer to population centres or where there are developments show signs of degradation.

There was massive coral bleaching in 1998 when 30% of the reefs were heavily impacted. There was high levels of mortality of adult *Acropora* corals (30-50%), and 75-85% mortality of soft corals. Many juvenile colonies, however, survived. On many lagoon patch reefs, only a few blue corals (*Heliopora*) and brain corals (*Porites*) remain alive. Similar mortality was observed again in 1999 with *Acropora* corals showing the highest mortality. Corals in estuaries close to shore survived better, particularly in Ngiwal where coral survivorship was highest closer to land. Mortality of *Acropora* was nearly 100% at all depths on offshore reefs, like Short Drop-Off. Coral mortality approached 90% at 30m,

These summary data of coral cover on Palauan reefs by the Palau International Coral Reef Center clearly shows the impacts of the coral bleaching mortality in 1998 on those reefs marked with a *. Other reefs have very healthy coral cover.

Location	Average coral cover	Coral Species per site
Barrier reef lagoon slopes	60%	45
Northeast slopes *	10%	35
Protected bay south of Ngkesol*	25%	45
Western ocean-facing reef slopes	60-70%	35
Northwestern ocean-facing reefs *	10-20%	50
Kayangel Atoll	50-70%	126
Babeldaob lagoon patch reefs	50%	45-70
Ngermeduu Bay	50-70%	50-60

including *Favia*, *Porites*, *Fungia* and *Acropora*. Of 3,630 coral colonies from 52 genera surveyed in 1999 at several sites, 48% were living, 31% were dead and 21% suffered various degrees of mortality. The abundance of fish that are closely associated with corals (e.g. butterflyfish) decreased dramatically from 1992 levels.

Non-*Acropora* coral cover ranged from 6-25% at 95 of 217 sites surveyed around Palau. Only 22 sites had coral cover ranging from 50-100%. For *Acropora*, 189 sites had coral cover ranging from 0-5%, with only 2 sites having *Acropora* cover above 50%. Patch reefs had the best *Acropora* cover and fringing reefs had the best non-*Acropora* cover. These results show that recovery is occurring, but at a slow rate.

Between 1999 and early 2002, 11,991 COTS were removed from Palau reefs. The largest number collected was in 2001 with 9,862 taken from reefs that had been cleaned in previous years. This is evidence for a developing outbreak of COTS that could seriously damage the reefs, particularly as the COTS target the few *Acropora* corals that survived bleaching.

Status of Coral Reef Fish and Fisheries

American Samoa

Fish and invertebrate populations are not recovering at the same rate as the corals on Tutuila. Night time spear fishermen began using SCUBA in 1995, greatly increasing their catches, particularly of parrotfish. This led to a territorial ban on SCUBA-assisted fishing in April 2001. Surgeonfish, groupers, snappers, and giant clams are overfished. Data are insufficient on commercial and recreational catches for effective management, but communities report declining fish and target invertebrate numbers.

The illegal harvest of hawksbill turtles and destruction of nesting habitats threatens the species, which are approaching extinction in the Pacific. Green sea turtle populations have also declined and they may also be endangered. Conservation efforts are complicated by the complex migration patterns of turtles e.g. from American Samoa to Fiji and French Polynesia, such that their conserving will require international cooperation.

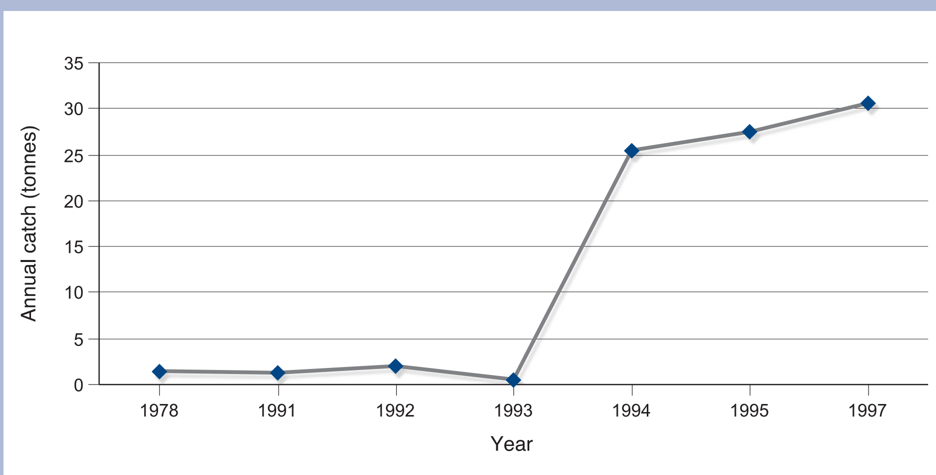
CNMI

There 1,019 fish species around the CNMI, but only the yellow-crowned butterflyfish (*Chaetodon flavocoronatus*) and 2 species of Guam reef damselfish (*Pomachromis*

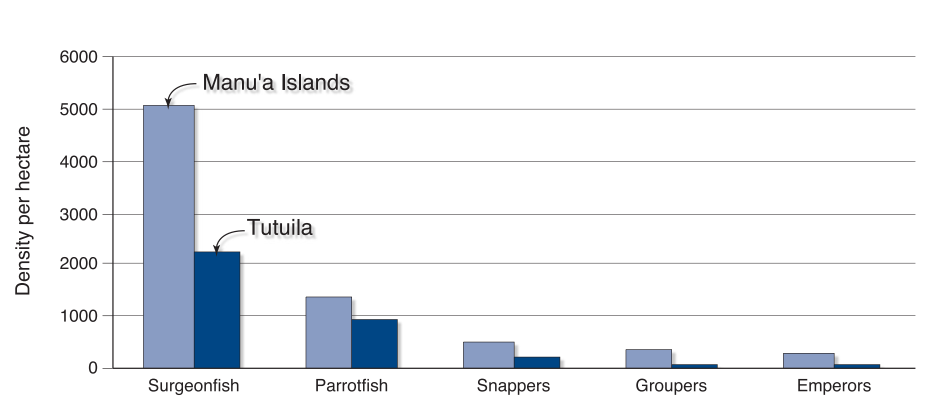
Banning of Scuba Fishing in American Samoa

Local resource managers can often be surprised by how rapidly fishers adopt new techniques to catch fish more efficiently, and then the managers have to react rapidly to prevent serious destruction of breeding stock. Here is one example from American Samoa where a high technology, commercial fishery became established the mid 1990s, which dramatically increased the catch of reef fishes on the main island of Tutuila. Teams of fishermen were working their way around the island at night using scuba to spear fish, particularly sleeping parrotfish. This was proving to be extremely efficient, such that local reef fish populations were being rapidly depleted and causing considerable concerns among the local subsistence fishers. The evidence was gathered by the Department of Marine and Wildlife Resources: there was a dramatic increase in reef fish catch after the fishery commenced (below); scientists and local managers reported that fish populations on Tutuila were showing signs of severe overfishing, based on long term monitoring data; and the local community were complaining that subsistence fishing had become more difficult since the scuba fishery started. Decisive action was needed to stop this destructive (and non-traditional) fishery, but it would require about 18 months to gather all the necessary scientific data to support the preliminary evidence, but by then the fish populations could be irreparably depleted.

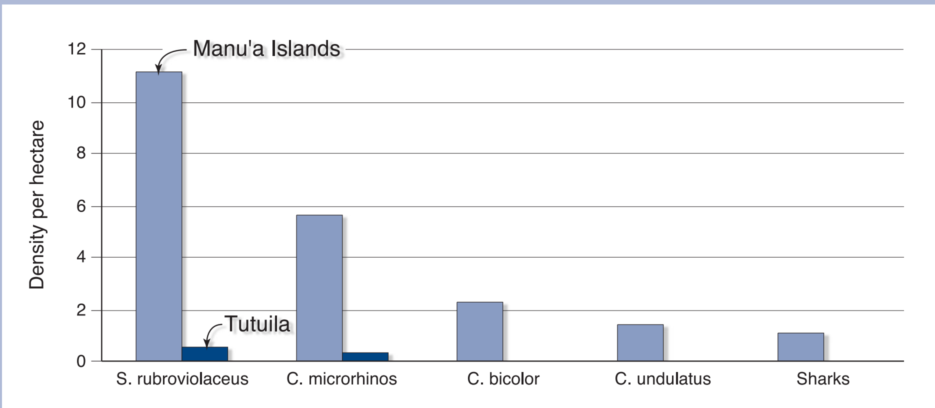
The resource managers put the position to Tauese Sunia, the Governor of American Samoa, who reacted immediately and banned the scuba fishery by Executive Order in April 2001, which was followed by banning regulation in January 2002. What helped the arguments were comparisons of fish populations of the major target reef fish around the heavily populated island of Tutuila and nearby Manu'a, where there are many fewer people and fishing pressure is lower. These clearly show the effects of fishing on the target species.



Annual harvest of parrotfish on Tutuila island from 1978 to the mid 90s when there was a 15 times increase in harvests.



Previous monitoring of the densities of the 5 major target fish families show much lower populations on Tutuila than nearby Manu'a Islands.



The resource managers could also present data on the target parrotfish (Cetoscarus bicolor, Chlorurus microrhinus, and Scarus rubroviolaceus), humphead or maori wrasse (Cheilinus undulatus) and sharks, showing the effects of strong fishing pressure on Tutuila.

This study demonstrates how managers should take the precautionary approach and use the best available information to protect their marine resources that are under threat. Sound scientific evidence is always preferable as a basis for management decisions, but if it is not available then action may be required using scientific and management judgement. In this case, the Governor acted decisively, because there was strong, coordinated support for the ban from local managers, scientists and the community. Since the bans were introduced, there seems to be little, if any, scuba fishing occurring on Tutuila, but the fishery has now been displaced to neighbouring Samoa, where the local government is also considering banning it. From Alison Green, GBRMPA, alison@gbrmpa.gov.au *gumaensis, Prealticus poptae*) are endemic. There are few data, but fish resources in the northern islands are considered to be healthier and have less fishing pressure than the more populated southern islands. Fish caught by scuba and spear-fishing around Saipan in 1993 and 1996 were generally smaller than those from Tinian. Destructive fishing methods are difficult to regulate, due to a lack of staff and funding for enforcement agencies. Fishing using poisons chlorine bleach and Derris roots does occur, but has not been documented. The use World War II bombs for blast fishing was prevalent in the past, but appears to be nonexistent today. Over-harvesting of topshell (*Trochus niloticus*) and edible sea cucumbers has resulted in moratoriums being placed on their collection.

Federated States of Micronesia

Most (873 of 1,125 species) of the fish on FSM are reef-associated, however, catch and export data are limited although scale of the fisheries operation may be substantial. The gross value of FSM fisheries in 1998 was estimated at US$86.4 million, and this is having the greatest impact on FSM fisheries, compounded by over-fishing by foreign vessels. FSM earns about US$18-24 million annually from licensing fees for foreign vessels fishing for tuna in its waters. Fish export from Yap and Kosrae is limited and mostly for personal and family use. Chuuk had the largest commercial export. Commercial export of fish and crab from Pohnpei occurred until a recent cholera outbreak shut it down. Destructive fishing practices, including the use of explosives taken from World War II wrecks, have caused localised reef damage, especially in Chuuk lagoon. A small sea cucumber fishery operating in Yap was closed down in the mid-1990s. Better quantitative assessments of fisheries resources within the FSM are needed.

Guam

The monitoring of the 5 MPAs established in 2000 has demonstrated an increase in both mean size and abundance of both herbivorous and carnivorous fishes, particularly in Tumon Bay, the main tourism centre on Guam. Large schools of grazing surgeonfishes and larger and conspicuous snappers are now seen. The rebound of fish populations within this easily accessible area is a good demonstration of MPA effectiveness. However, the granting of permits for the 'International Birdman Rally' in the protected area demonstrated that political will is weak, even following the objections of the regulatory agencies and most of the public. Elsewhere, fish populations have declined 70% over 15 years, and total fish catches have more than halved

Marshall Islands

Seven of the 860 species of reef fishes in the Marshall Islands are endemic, and the endemic three-banded anemonefish (*Amphiprion tricinctus*) is exported for aquariums. Live rock and molluscs are also exported for the aquarium trade and crafts respectively. There is no commercial food fishery in the Marshalls as a result of the 67 nuclear tests conducted between 1946-1958, although there has been no significant accumulation of heavy radioactive elements in fish muscle tissue. Some other radionuclides have been shown in fish from near the bomb tests on Bikini and Enewetak lagoons, however, the concentrations of these radionuclides are reducing and in some species it is below detection. The RMI reported a gross value of the fishing industry at US$19.2 million, but this was mostly for oceanic pelagic species.

Palau

The largest number of reef fish species occur on Palau (1,278 species). Commercial fisheries generate US$6.4 million in gross value output, however, foreign-based fishing activities are a problem, including poachers from Indonesia and the Philippines on Helen Reef. Fish populations in the main islands of Palau show signs of over-fishing compared to the Southwest islands where there is less fishing pressure. Highly desired species of fish are either absent or present in low numbers in the main islands of Palau.

ANTHROPOGENIC THREATS TO CORAL REEFS

Threats from fishing and climate change are addressed in previous sections. The major threats to reefs are directly attributed to increases in human activities such as development and more efficient exploitation of coral reef resources. For example in American Samoa, there has been an increase of 35% in the population during the last 10 years, and in the Northern Marianas, the increase has been over 300% in 15 years. These population increases result in over-fishing (and destructive fishing) of reef resources, and more coastal development and habitat destruction, which result in more sediment and wastewater runoff with increased loads of nutrients and eutrophication in reef waters. Major tourism growth in the Northern Marianas, Guam, Palau and FSM has resulted in the clearing of coastal lands for developments, harbour construction, golf courses and roads with major losses in habitat and water visibility on near-shore reefs and direct reef damage from tourists e.g. using jet skis.

American Samoa

In 1999, overfishing of reef resources, coastal development and habitat destruction, and oil and hazardous waste spills in Pago Pago Harbor were the top ranked human stresses in American Samoa. Sedimentation, dumping and improper waste disposal, and nutrient loading with eutrophication in Pago Harbor were identified as medium threats, and sedimentation, dumping and improper waste disposal, and nutrient loading and eutrophication in Pago Harbor, marine debris, alien species, coral disease, and aquarium trade were ranked as low threats.

CNMI

The reefs near towns on Saipan, Tinian, and Rota, and those surrounding Farallon de Medinilla receive most of the human impacts from coastal development, population growth, fishing, and tourism. Concerns over the potential impacts of marine recreational sports on the environment caused the authorities to limit the number of tourist boat permits. The Government and the local dive operators association are installing more mooring buoys at major dive sites using money through the Coral Conservation Act.

More than 20 ships have grounded on CNMI reefs over the past 20 years, usually during typhoons, and nearly half remain on the reefs. CNMI is working with NOAA to remove them before they disintegrate and cause more damage. There is a significant amount of war debris and unexploded ordnance in the nearshore waters. An unfortunate attempt in 1996 to clear some sunken bombs caused significant damage to the nearby Sasanhaya Fish Reserve, killing numerous fish, smashing coral, and killing a turtle. The resultant sediment plume blanketed an area around the Coral Garden site from months.

Guam

Sediment released from soil erosion in the Ugum River Watershed is 176,500 tons/km^2/year; with 46% from sloped roads, and 34% from cleared vegetation. Erosion rates in the Ugum Watershed doubled from 1975 to 1993 (from 1,547,250 to 3,039,750 tons/km^2/year), as a result of road construction and development projects. Guam's main power generation facilities are located on Cabras Island, in Apra Harbor. Elevated temperatures from the discharge of seawater used to cool the generators has resulted in coral mortality. The discharge of cleaning chemicals has also occurred, with subsequent impacts on local coral populations. Over 1 million tourists visit Guam each year, and damage to reefs is inevitable. In addition to impacts of scuba divers and snorkellers, underwater walking tours using surface-supplied equipment and a large number of personal watercraft (jet skis) have affected reefs and water quality. A coastal use zoning law called the Recreational Water Use Master Plan aims to address these problems but needs enforcement and should be updated to cover new activities and areas. Groundings of fishing vessels, recreational watercraft and ships carrying cargo and illegal immigrants have resulted in localised damage to reefs.

Federated States of Micronesia

As with the other high islands, road construction and development projects without adequate erosion control have been responsible for reef damage from sedimentation. Dredging projects associated with airport and harbour construction have localised impacts, and subsequent increases in freshwater runoff have limited recovery. Increasing populations are a concern for some islands as they must increase associated infrastructure, including sewage processing plants and outfalls. Ship groundings have been a problem for both the high and low islands. Foreign long-liners have been abandoned on numerous FSM reefs, with no funds available to clean up oil spills or remove ships. Larger shipping vessels have also run aground, most recently in Satawal and on Pohnpei. There has been an increase in deforestation and agriculture development for Sakau farming in Pohnpei, which has increased the amount of runoff into the reef lagoons. There is a low rate of connection to sewerage systems in the islands, therefore most human waste runs untreated or partially treated over coral reefs.

Marshall Islands

A general lifestyle change, loss of traditional conservation knowledge, and urbanisation are evident in increased dumping of wastes in reef lagoons and poaching of reef species. Ship groundings directly destroy reef habitat, and invasive species pose a more subtle, but potentially more permanent threat. Fouling marine invertebrates, algae and fishes have been introduced, but their impacts have not been studied. Harvest of live rock and molluscs is a growing concern. The most destructive events were nearly 50 years ago when nuclear bombs were detonated on Bikini Atoll. A huge crater resulted and large areas of reef were vaporised. The reefs are slowly recovering, but insufficient is known about the lasting impacts of the bombs, including long-lasting radioactive wastes. The reefs are still off limits to the original inhabitants.

Palau

The greatest immediate threat to Palau's reefs is a compact road project for Babeldaob as the associated erosion and sedimentation, and damaged upland habitats will result in sediments pouring onto the reefs. Additionally, the road will open large areas to development, increasing both land and reef use resulting in poorer water quality and reef health. Plans to dredge for fill materials needed to build the road base also have the potential for reef damage. The increased population will require additional sewage treatment and other support facilities. Ship groundings have also been occurring off the main islands as well as those in the south. Palau has done a great deal toward limiting the impacts of tourists on reef resources. 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 impact on some reef sites is the volume of divers, with varying levels of training.

In Palau, much new residential housing has been developed along one of the main rivers in Airai State, which flows directly into the bay on east coast. Corals in the bay are suffocating from the sediments and this is exacerbated by additional runoff from the 80km compact road. The Palau International Coral Reef Center have used data on watershed discharges and coastal water quality to support a moratorium on mangrove clearing and uncontrolled land clearing. Eutrophication in Malakal Harbor is linked to fishing vessels disposing of wastes directly into the water.

Current Conservation Management

American Samoa

Maps of Fagatele Bay National Marine Sanctuary and Pago Pago Harbor were made with multibeam technology in 2001 (see dusk.geo.orst.edu/djl/samoa.) by NOAA and will include habitat maps of the surrounding reefs. Corals, invertebrates, fish, and algae have been monitored by nearly 20 years in Fagatele Bay National Marine Sanctuary and at other Tutuila locations. In addition, coral monitoring from 1917 on a Pago Pago Harbor reef flat has been repeated several time since then. There are 4 Marine Protected Areas (MPAs) in American Samoa, only one of which is a ‘no-take’ area. Unfortunately, protection and enforcement in these areas is generally lacking and poaching in all the MPAs is an on-going problem e.g. 9% of the local commercial fishery occurs illegally within the National Park of American Samoa on Tutuila Island. Moreover, there are no ‘no-take’ MPAs on the main islands where over-fishing occurs.

Existing MPAs in American Samoa showing the proportion that has 'no-take' status. Unfortunately the largest MPA is on remote Rose Atoll.

MPA	Island	MPA Area (km^2)	Coral Reef Area (km^2)	No-take Status	Adequate enforcement
Rose Atoll National Wildlife Sanctuary	Rose Atoll	158.8	7	Yes	No
National Park of American Samoa	Tutuila, Ofu, Ta'u	9.1	9.1	No	No
Fagetele Bay National Marine Sanctuary	Tutuila	0.7	0.7	No	No
Vaoto Territorial Park	Ofu	0.2	0.2	No	No
Total		**168.8**	**17**		

CNMI

The first reef map for the CNMI was developed in 1959 and is still used for ecological comparisons. Now new maps of the coral reefs in Saipan's western lagoon are being made by the local authorities and NOAA. These will be expanded to all the coral reefs. The CNMI increased local monitoring capacity and hired a manager to coordinate the coral reef program using recent funds. Now 13 sites off Saipan Island, 8 sites off Rota, 7 sites off Tinian, and 1 site off Aguijan are monitored to provide the CNMI with a comprehensive baseline survey and track changes in coral reef health through time. The Fisheries Section has been collecting data on fish diversity and abundance primarily within existing and proposed conservation areas on Saipan, Tinian, and Rota since 1999. During fish surveys, data are also collected on reef topography (vertical relief) and estimated hard coral cover.

The CNMI have established 8 MPAs, which protect an area of 12.32km^2. The Sasanhaya Bay Fish Reserve in Rota, the Mañagaha Marine Conservation Area, Forbidden Island Sanctuary, and Bird Island Sanctuary are no-take zones for all marine resources. Enforcement remains a problem, but support from the NOAA Coral Conservation Program is helping. An MPA has been proposed for Tinian to protect approximately one-third of the western shoreline; this is currently under review by the government.

Guam

NOAA habitat mapping of Guam's coral reef ecosystems will begin in 2002. There is current water quality monitoring at 30 stations (10 fresh water, and 20 marine) as part of the National Coral Reef Monitoring Program. High risk stations are monitored intensively. The University of Guam Marine Laboratory has ongoing coral reef monitoring programs, in collaboration with government agencies. The university database dates back to 1970, and focuses on the marine biota. A joint educational outreach program exists as a collaboration among the stakeholders as part of the Guam Coastal Management Program. A NOAA Coastal Oceans Program awarded a Coral Reef Ecosystems grant to Guam, Palau and the FSM to study water quality and pollution and impacts on corals.

There are two federal (War in the Pacific National Historical Park and Guam National Wildlife Refuge) and 11 territorial MPAs, with 5 of the territorial MPAs being no-take reserves (Pati Point, Tumon Bay, Piti Bomb Holes, Sasa Bay, and Achang Reef Flat Preserves) representing approximately 12% of the coastline and 28% of the coral reefs. All 5 marine reserves are fully enforced and 2 more ecological no-take reserves were established in 1986, but they have not been enforced.

Federal States of Micronesia

Some FSM shallow-water coral reef and associated benthic habitats have been mapped but only off major towns. Coastal resource inventories and atlases have been prepared for Pohnpei, Yap, Kosrae, and Moen Island in Chuuk Lagoon. The College of Micronesia-FSM has staff trained in marine resource assessment and monitoring and works with the Environmental and Marine Resource agencies to monitor FSM reefs. There is regional cooperation under the Marine Resources Pacific Consortium (MAREPAC) and funded by the U.S. Dept. of the Interior to increase local and regional capacity for assessment and monitoring. The Nature Conservancy provides technical and financial assistance for monitoring programs, and Peace Corps volunteers also assist in monitoring. Coral reefs are protected by MPAs in the Trochus Sanctuaries Heritage Reserve and Kosrae Island Heritage Reserve. Other conservation areas are presently being negotiated in partnership with the FSM National Government. Chiefs and other traditional leaders usually control protection of specific areas. In Yap, the villages own the reefs, and have authority over resource use. A number of the islands have areas set aside for reef protection and limit resource extraction, but currently the FSM lacks the enforcement capacity to protect these MPAs.

Marshall Islands

Coastal resource atlases prepared for the region include mapping of coral reefs and uses for Arno, Majuro, and Kwajelein atolls, but better habitat mapping is needed. There were pioneering studies on coral reefs in several atolls before the bomb tests 1955 and a 1987 report on the resources of Enewetak Atoll is one of the most comprehensive reef assessments in the world. Coastal resource inventories and atlases of Arno, Kwajalein, and Majuro Atolls were conducted in 1998. In 2001, a systematic survey of coral reef resources was undertaken by the College of the Marshall Islands and the Marshall Islands Marine Resources Authority. More are planned for the northern atolls of Ailinginae and Rongelap and the southern atoll of Jaluit. The U.S. Army regularly monitors Kwajalein Atoll because it leases the area for ballistic missile testing.

Several agencies are involved in protecting coral reef ecosystems: Marshall Islands Marine Resources Agency; and the Environmental Protection Authority. A National Biodiversity plan addresses the need for conservation and management of the natural resources, and contains extensive lists of marine organisms. One recommendation is a strengthening of ‘mo’ a traditional system of taboo that identified certain areas as ‘pantries’ for periodic harvesting. Another is a need for sustainable fishing practices and a retention of local knowledge.

Palau

Palau’s coral reefs have not been mapped. The Palau International Coral Reef Center (PICRC) was created to enhance coral reef knowledge for more effective management and conservation. PICRC has established 14 permanent sites on shallow reefs to monitor corals, coral recruitment, and fish, and surveys close to 200 non-permanent sites. The Palau Conservation Society is active in conservation, and collaborates on monitoring and assessment programs with the Coral Reef Research Foundation, Palau Community College, the Environmental Quality Protection Board (EQPB) and the Marine Resources Division. The Nature Conservancy has an office on Palau, and works with the other agencies and organisations on coral reef conservation. Palau has substantial expertise and was recently supported by a monitoring grant from NOAA. PICRC functions as a Node of the GCRMN to assist other countries in the MAREPAC group, and an Education and Outreach Program has involved 3,030 students and about 14,000 visitors since the opening in January 2000.

Palau has a total of 13 established MPAs. In 1956, the Rock Island Management and Preservation Act designated certain areas of the Rock Islands as reserves and others as tourist activity areas. This was Palau’s first MPA. The total area of Palau’s coral reefs protected by no-take zones is 65.3 km^2 or 3.9% of the extent of the country’s coral reef area.

Conclusions and Recommendations

All countries and states are partners in MAREPAC, which aims to coordinate activities and avoid duplication of effort, fill gaps in areas of need and use time and financial resources efficiently and wisely. There is a need for a forum for states to present their priorities for monitoring and plan future directions. There is considerable expertise across the region and this needs to be harnessed in a coordinated manner to assist all states and raise the capacity in-country for more effective coral reef monitoring and conservation.

American Samoa

The coral reefs in American Samoa have been recovering from natural stresses, but the fisheries resources have not been recovering. The recovery of the corals will be enhanced if there are healthy populations of grazing and herbivorous fishes. These have been lost due to overfishing on Tutuila. Other major factors causing serious harm are reduced water quality near populated areas, and destruction of turtle nesting beaches.

- There is a need to expand coral reef monitoring efforts, but focus the objectives. Most monitoring efforts so far have been ecological in focus, but there is a need to address the questions faced by coral reef managers: 'Is overfishing occurring'; 'Is sediment from poor land-use practices harming the reef'. Consequently, monitoring programs must clearly identify the intended user of the data, and the parameters to measure to provide the information. A monitoring program in American Samoa should be: achievable with local staff, although off-island expertise may be needed; sustainable even with staff changes; comparable to other programs; and open to community input and management.
- Improved land-use practices are needed to slow the impacts that are currently damaging water quality. Some progress has been made in Pago Pago Harbor, but the coral reefs there have not fully recovered nor is swimming safe or fish uncontaminated. Fish and sediments in the harbour need to be tested for toxicity at regular intervals.
- A regional network of MPAs needs to be created to protect coral reef resources across the region. For example, tagging data show green sea turtles nest in American Samoa and migrate to both Fiji and Tahiti to feed.
- A recent ban on scuba-assisted fishing has been established, but there is a need for monitoring of its effects. The ban appears to have been enforced and the lack of large fishes indicates that time is required to show results. Village-based management and monitoring of reef fisheries resources should be encouraged.

CNMI

The CNMI has established a long-term marine monitoring program to provide data for conservation efforts.

- There is a need to ensure that agencies collaborate to collect and analyse monitoring data within a monitoring program that has sound objectives and establishes repeatable protocols for data collection, storage and analysis. An interagency team should be established to assess methods and design a workable monitoring program.

- Although there are adequate staff resources to start a long-term monitoring program, additional training is required to ensure continuity. Training is required in data collection, data analysis and quality control, as well as training in identification of marine flora and fauna.
- The CNMI should attempt to Rapid Ecological Assessments for the populated southern islands to identify long-term monitoring sites and implement the monitoring program. Data can then be used to recommend additional marine protected areas on Tinian and Rota.

Guam

The coral reefs of Guam continue to decline because of activities from the land. There are adequate monitoring and research data to identify the problems and suggest corrective measures. For example, there have been disturbing reductions in coral recruitment indicating that reef recovery is threatened in areas impacted by typhoons, COTS, and earthquakes. Community education initiatives have increased awareness and the political will to address reef decline. However, there is far more to be done in these areas. Overfishing is still a concern, but 5 Marine Reserves is a positive step.

- Enforcement of existing laws and environmental regulations is required.
- Improvements to erosion control programs are needed to reduce the land-based stresses on coastal reefs.
- Recovery of Guam's reefs will only occur with improvement in coastal water quality that allows natural recovery to occur. A balance needs to be found between continuing development of the traditional, urban, military and tourist sectors, and the conservation of the coral reefs, which are a key component of the local economy.

Federated States of Micronesia

The reefs within the FSM are in relatively good condition. However, land-use practices on the high islands are a concern and urban developments and agriculture have caused reef damage, which is expected to increase. Also reef fisheries on some islands have been over-exploited, and damaging fishing practices have been reported in Chuuk Lagoon.

- There is a need for integrated watershed management through improved coordination of management activities among the states. Currently some agencies have overlapping responsibilities.
- Improved monitoring of the coral reefs and assessments of fisheries resources are needed to counteract the over-optimism about developments, especially needed are data on how the fisheries respond to current levels of exploitation.
- Education and programs involving the community need to be expanded to increase awareness at all levels of the need and benefits of fisheries management and conservation via the establishment of MPAs.
- There is a need for improved enforcement of State fishery laws by police or conservation officers and patrols are required in MPAs to ensure that conservation objectives are attained.
- Mechanisms for the prevention of ship groundings and especially the timely removal of ships, with penalties applied for damage to the reefs, need to be applied state and national level.

Marshall Islands

At present, the coral reefs of the Marshall Islands are in good condition. While the two atolls used for the nuclear testing program experienced unique stresses, the reefs of the RMI as a whole have escaped the extensive damage seen in other parts of the world. The remoteness of many of the atolls and the fact that the country as a whole is relatively isolated has helped to keep down many potential impacts to the reefs. However, this isolation also leaves the reefs vulnerable to illegal or semi-legal exploitation. Moreover, increased globalisation and the pressures to change from traditional subsistence economy could easily alter the present situation and allow at least some of the stresses discussed before to become serious threats.

- There is need for further training in coral reef monitoring and management to bring the Marshall Islands to the same level as other 'countries' in the region.

Palau

- Regular assessment and monitoring of Palau coral reefs is required for effective coral reef management, so that problems can be detected earlier and effective remedial strategies can be developed. It is essential that results of monitoring programs be disseminated early and widely. It is essential that the community be informed as part of an awareness raising program. The Palau Community College is recommended as the repository for the data and the mechanism to involve the public.
- There is a need to develop school curricula from elementary to post secondary stages that incorporate environmental issues and concerns, especially on coral reefs, which are so important for Palau. This should be extended to community outreach programs targeted at policy makers, traditional and political leaders and villagers.
- There is a need to monitor reef fisheries catch levels and trends so that effective management of coral reef fish resources can be implemented. Currently, only two fish markets in Koror provide landings data to the Marine Resources Division. This needs to be expanded to include catch data from all fish markets, as well as gathering data on the type of fishing gear used, numbers of fishers and time spent fishing.
- A collaborative program should be established between all the agencies and organisations involved with coral reef monitoring and management. The first step is to form a strategic planning group, then set priorities and areas of focus for each group/area and focus on problems that can only be solved through cooperation.

AUTHORS CONTACTS

Robert H. Richmond University of Guam Marine Laboratory, Richmond@uog9.uog.edu; Ruth Kelty, NOAA's Ocean Service, ruth.kelty@noaa.gov; Peter Craig U.S. National Park Service, American Samoa, peter_craig@nps.gov; Carol O. Emaurois Node Coordinator-MAREPAC GCRMN NODE Palau International Coral Reef Center, Palau, cemaurois@picrc.org; Alison Green, Great Barrier Reef Marine Park Authority, alison@gbrmpa.gov.au; Charles E. Birkeland, USGS and University of Hawaii charlesb@hawaii.edu; Gerry Davis, Guam Division of Aquatic and Wildlife Resources, gdavis@mail.gov.gu; Ahser Edward, College of Micronesia, FSM, asher@comfsm.fm; Yimnang Golbuu, Palau International Coral Reef Center, ygolbuu@picrc.org; Jay Gutierrez, Guam Division of Aquatic and Wildlife Resources; Peter Houk, Florida Institute of Technology, p_houk@hotmail.com; Noah Idechong, Palau House of Representatives, noah.idechong@palaunet.com; James Maragos, U.S. Fish and Wildlife Service, jim_maragos@fws.gov; Gustav Paulay, University of Florida, Florida Museum of Natural History, paulay@flmnh.ufl.edu; John Starmer, CNMI Coastal Resource Management, crm.biology@saipan.com; Andrew Tafileichig, Yap Marine Resources Management Division, mrmdyap@mail.fm; Michael Trianni, CNMI Dept. of Fish and Wildlife, mstdfw@itecnmi.com; Nancy Vander Veldt, Majuro, vndvelde@ntamar.com.

Supporting Documents

Birkeland CE, Craig P, Davis G, Edward A, Golbuu Y, Higgins J, Gutierrez J, Idechong N, Maragos J, Miller K, Paulay G, Richmond R, Tafileichig A, Turgeon D (2000) Status of the Coral Reefs of American Samoa and Micronesia: U.S-Affiliated and Freely Associated Islands of the Pacific. In: Wilkinson C. Status of Coral Reefs of the World: 2000. Australian Institute of Marine Science and Global Coral Reef Monitoring Network, Townsville, p. 199-217

Houk P (2001). State of the Reef Report for Saipan Island, Commonwealth of the Northern Marianas Islands (CNMI). Saipan: Division of Environmental Quality. 60 pp.

Pultz S, O'Daniel D, Krueger S, McSharry H (1999). Marine turtle survey on Tinian, Mariana Islands. Micronesica 31: 85-94.

Trianni MS (2001). Evaluation of the resource following the sea cucumber fishery of Saipan, Northern Mariana Islands. Trochus Bulletin No. 9.

ICRAN

JALUIT ATOLL MARINE CONSERVATION AREA, MARSHALL ISLANDS – ICRAN DEMONSTRATION SITE

The atolls of the Marshall Islands run north and south in two parallel chains called Ratak, eastern chain, and Ralik, western chain. Jaluit Atoll lies in the southern end of the Ralik island chain and includes 91 islets with a total land area of only 11.4km^2. The islets form a ring around a shallow lagoon and 4 deep passes connect the lagoon to the open ocean. Over 250 species of reef fish and 4 species of mangroves inhabit the atoll along with several species of turtles, whales and dolphins.

Jaluit Atoll has a resident population of about 2,500 people, primarily on 6 of the 91 islets. Primary subsistence activities, including harvesting of giant clams, trochus, many finfish species, oysters and turtles, are considered unsustainable. In an effort to alleviate these problems, the Jaluit Atoll Conservation Area was established in 1999 under the Marshall Islands Environmental Protection Agency and in partnership with GEF and SPREP.

Ecological Monitoring: A survey of Jaluit's marine resources conducted in early 2000 showed that trochus and sea cucumber stocks were low due to unregulated harvesting. To allow their recovery, a ban on harvesting these species was recommended in 2000. For other locally used marine resources, a long-term monitoring system needs to be put in place and seasonal harvesting introduced to prevent overexploitation.

Socio-economic Monitoring: No details received.

Coral reefs are **80%** of the natural resources.
Ecological Monitoring is **planned.**
Socio-economic Monitoring is not **planned.**

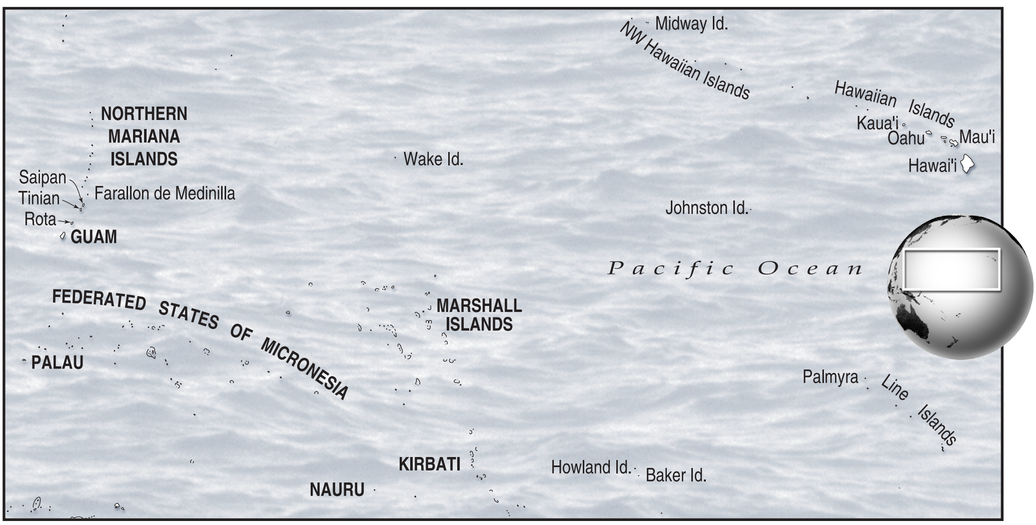
13. Status of Coral Reefs in the Hawaiian Archipelago

Russell Brainard, Alan Friedlander, David Gulko,
Cynthia Hunter, Ruth Kelty and James Maragos

Abstract

Coral reefs in the Hawaiian Archipelago stretch over 2,000km and comprise over 80% of U.S. coral reefs. The Main Hawaiian Islands (MHI) are populated, high, volcanic islands with non-structural reef communities and fringing reefs abutting the shore, and the Northwestern Hawaiian Islands (NWHI) with mostly uninhabited atolls and banks containing most (65%) of U.S. reefs. There are major differences in anthropogenic impacts: the MHI have extensive urban developments and associated runoff; over-fishing for food and marine ornamentals; invasions by alien species; and accumulation of marine debris. The NWHI coral reefs suffer minor damage from marine debris and the impacts from lobster and bottom fisheries, but concerns exist over current and proposed ecotourism activities and new fisheries.

Increased U.S. Federal funding in 2001 and 2002 supported mapping, monitoring, research, and management initiatives. Digital habitat maps were completed for 60% of the MHI and will be available in January 2003. The Hawaii Coral Reef Institute received over US$1 million in 2002 for coral reef research and monitoring to assist in the management of Hawaii's coral reefs. There have been surveys for the spread and control of invasive algae, assessments of the impact of stepping or anchoring on corals, and monitoring of



water quality and the harvest of aquarium fish on reefs in the NWHI. The National Coral Reef Monitoring program developed on-line databases for field data entry and tracking research progress. Monitoring data were published in the first National Report on the Status and Health of U.S. Coral Reef Ecosystems. Capacity in Hawaii to manage coral reefs and fisheries was expanded, and an economic evaluation of coral reefs completed in 2002. An Environmental Characterization of the Ahupua`a of Waianae, Hawaii, assembled information on terrestrial and marine resources, land-use patterns, traditional Hawaiian land and resource management concepts, and land cover data to identify potential stresses to coral reefs and how to mitigate them.

The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve was established to conserve the coral reefs and related marine resources. Progress is encouraging on: sanctuary designation and operations; research, mapping and monitoring; and marine debris removal. Draft benthic habitat maps were completed for 9 of 10 areas and bathymetry determined for all areas. A detailed atlas of the NWHI, will be available in January 2003. A database was developed of abandoned vessels on coral reefs, standardised protocols for managing vessel groundings, and a removal plan for problem vessels, along with a spill response guide focusing on oil and sea turtles.

Introduction

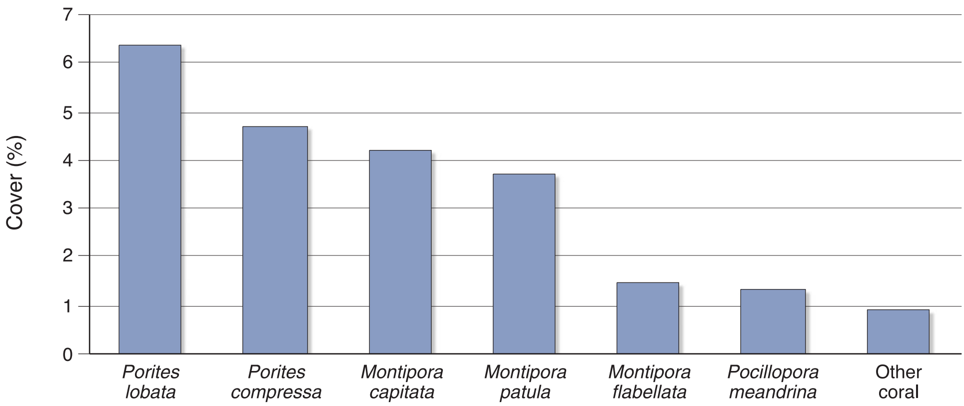
There are 2 distinct components in the Hawaiian Archipelagos: predominantly recent volcanic islands with fringing reefs and some associated patch and barrier reefs of the Main Hawaiian Islands (MHI); and the older atolls and bank reefs of the Northwestern Hawaiian Islands (NWHI). Most of these reefs are surrounded by deep oceanic waters and occur in tropical to sub-tropical climates (latitude range 19–28°N). Together they constitute 80% of the coral reefs under the jurisdiction of the USA, with 65% spread over about 2,000km of the NWHI. These 2 regions also differ markedly in the degree of human and land-based impacts. The NWHI are virtually uninhabited and have minimal impacts from the small amount of land near the reefs, whereas there are strong and increasing human pressures on the MHI with growing populations of residents and increasing numbers of tourists.

Most of the reefs, however, are in fair to excellent condition and the level of government, academic, community and NGO interest and management has increased considerably over the past few years. More intervention is required on MHI with greater protection needed for fish stocks and to reduce tourist impacts. The situation is more encouraging on the NWHI which is the focus of considerable government interest in coral reef conservation. The new Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, created by Executive Order 13178 in 2000, is 1200 nautical miles long and covers 3-50 nmi from the shoreline. It is expected that the Reserve will be designated a National Marine Sanctuary and managed by NOAA, and the Executive Order has established 15 Reserve Preservation Areas in which almost all extractive uses are prohibited.

Status of Coral Reefs

Main Hawaiian Islands

Average coral cover from Hawaii's Coral Reef Assessment and Monitoring Program (CRAMP) sites is 23%, overwhelmingly dominated by massive and encrusting *Porites lobata* and branched *Porites compressa*. There are also *Montipora* and *Pocillopora* species. The amount of coral cover is controlled by local variations in wave energy, depth, watershed influences, and bottom type. Coastal sites with high wave exposure (e.g. Pupukea, Hoai Bay) have the lowest cover (>10%), while bays and wave-protected coastal areas (e.g south Molokai) have the highest coral cover (70-80%). Hawaiian endemism is thought to be over 25% and the islands of O'ahu and Hawaii have the highest biodiversity.



The average % cover of the dominant coral species in all sites and all depths combined from surveys in 1999.

While local rises in water temperatures (or increased UV penetration) have caused occasional coral bleaching, the events that devastated reefs in many areas of the Pacific during the past decade have missed the Hawaiian reefs. Coral diseases and tumours have been documented in most major reef-building coral species in the area, especially in *Porites*, *Montipora* and *Pocillopora* species and a bacterial disease has been found in *Porites* from Hanauma Bay, O'ahu, similar to white-band disease from Florida. Like other areas, the incidence of coral disease in Hawai'i does not appear to be related to anthropogenic stress e.g. pollution, proximity to urban centres, and no major disease outbreaks have yet occurred in Hawai'i. However, necrotic coral tissues, whether caused by abrasion, predation, or pathogens, are rapidly invaded by fine filamentous algae and cyanobacteria.

There are 400+ species of marine algae in the Hawaiian Islands, with most of these being red algae (Class Rhodophyta), and many are endemic. There is one endemic species of seagrass (*Halophila hawaiiensis*). So far, more than 100 species of sponges, 1071 species of molluscs, 884 crustacean species, and 278 echinoderms have been identified, with a large number of endemics. Unlike elsewhere in the Pacific, there have been no major outbreaks of the crown-of-thorns starfish (*Acanthaster planci*) in Hawaii since the early

1970s. There has been speculation that the isolation of the islands and a lack of *Acropora* may explain the lack of major outbreaks since then.

Streams in developed areas have much higher levels of dissolved nutrients than streams from pristine areas and there is evidence of severe coral deaths from elevated nutrients, sediments and reduced salinity during heavy rain periods. In the MHI, nutrient enrichment encourages algal growth and causes phytoplankton blooms. Leaching of nutrients from cesspools, injection wells, or other non-point sources have allowed *Hypnea, Sargassum, Dictyota,* and *Cladophora* to dominate Maui's reef flat areas and may introduce bacteria and disease to corals. Government guidelines controlling point-source pollution are not standardised and are often based on non-coral reef impacts.

Sedimentation from runoff continues to be a chronic problem throughout the MHI as a result of poor land-use practices in the catchments. Sediment runoff is estimated at more than 1 million tons per year from agricultural, ranching, urban and industrial activities. 'Slash and burn' agriculture (sugar and pineapple) has decreased, and alternatives such as coffee, macadamia, cocoa and fruit trees may eventually result in long-term decreases in sedimentation. Considering that strong current and wave action will result in a relatively rapid removal of sediments along exposed coasts, the future scenario looks better for reef growth. Stream channeling, and paving of coastal and upland areas has also contributed to urban impacts on reefs. Two major freshwater kills of corals occurred in Kane'ohe Bay, O'ahu in 1965 and 1987 from '100 year storms'. Salinity within 1-2m of the surface was reduced to less than half (15ppt) for 2-3 days, causing mass mortality of corals and invertebrates on shallow reefs.

Oil spills and toxic chemicals are a growing problem. Ship traffic, proximity of reefs to harbour entrances, and increasing numbers of vessel groundings have resulted in a 200% increase in the number of oil spills from 1980 to 1990. Shore-based chemical spills from industrial or aquaculture sources have dumped sulfuric acid, PCBs, and refrigerants on near-shore reefs. The projected increase in large cruise ship visits throughout the MHI may be accompanied by increased 'gray water' discharges. Harbours and urbanized, enclosed bays concentrate heavy metals, oils, PCBs, tributyltin, pesticides, and herbicides. High concentrations of dieldrin and chlordane were found in oyster tissues sampled near stream mouths in Kane'ohe Bay in 1991, 5 years after their use was banned in Hawai'i. Lead, copper, chromium, and zinc concentrations were high in a number of samples, particularly near the southern, more urbanized, watersheds of the bay. A synergistic lethal effect of polycyclic aromatic hydrocarbons (PAHs) from municipal wastes and exposure to surface ultraviolet light form toxins that kill crustaceans, polychaetes and coral larvae. This is likely to increase as populations grow and more land is developed and may result in losses of corals and fishes.

NWHI

The Northwestern Hawaiian Islands Coral Reef Assessment and Monitoring Program (NOWRAMP) began in 2000 with the mapping and assessment of shallow reefs for their biodiversity, status, and management needs. Coral biodiversity was higher in the NWHI than the MHI, which was not expected as these reefs are in cooler, subtropical waters. There were 62 species of hard corals, including new reports for Hawaii, the NWHI, and science. In general, corals appeared healthy and free of disease. High numbers of very large, living corals of several species in protected waters of the atolls indicate that serious mortality events have not occurred on these reefs for decades to centuries. However, growth rates for corals in the northern portion of the chain are significantly slower than the same species found farther to the south, raising concerns about recovery rates from human effects at different locations in the Archipelago.

Coral cover for many areas of the NWHI is low overall (<10%), but high percentages (>80%) are found in many of the atolls, French Frigate Shoals (FFS), and Maro Reef. Rapid video surveys revealed high heterogeneity of coral cover within and among the different atolls, islands and banks. Common corals include the disk coral *Pavona duerdeni* (at Kure and Mario), table coral *Acropora cytherea* (FFS and Maro), finger coral *Porites compressa* (in the deep lagoons of Kure, FFS, Midway, and Pearl and Hermes), blue encrusting coral *Montipora turgescens* (in back reefs at Midway, Lisianski, and Kure), massive lobe corals *Porites lobata* and *P. evermanni* (on sheltered shallow reefs or back reefs at all atolls), and encrusting plate corals (*Montipora capitata* and *Porites* spp.) on deeper, semi-exposed reef slopes. Coral species diversity is highest at the protected atolls and Laysan.

Algal samples from the NOWRAMP cruise are still being analysed with data only available for French Frigate Shoals (FFS) where 126 species were reported, mostly reds, followed by greens and browns. Many of these are new species and the total number of species is expected to rise as samples from other islands are identified. The endemic seagrass *Halophila hawaiiensis* was found at Midway Atoll and Pearl and Hermes Atoll, and may exist elsewhere in the NWHI.

Similar trends were observed for invertebrates; over a third of the 600+ species recorded at FFS are new reports. Polychaete worms and molluscs are the most abundant animals in soft sediments. Some localised areas with a moderate abundance of *A. planci* were seen along the southern outer reef slope at Pearl and Hermes Atoll and along the eastern outer reef slope at Kure Atoll. These occurrences were associated with dead or dying *Pocillopora* colonies in areas of low coral cover.

While its remoteness and lack of human development prevents anthropogenic nutrient pollution, oil spills and toxic chemicals threaten reefs around the NWHI. Several fishing vessels carrying over 37,000 litres of oil have grounded on the isolated atolls. The October 1998 grounding of a 24m long-line fishing vessel at Kure Atoll released over half of its 41,640 litres of diesel onto the shallow reefs. Lead and PCBs were recently detected in the waters surrounding decaying seawalls on Tern Island at FFS and PCBs were found in monk seal blood and blubber. At 4 of 38 sites in near-shore waters of Midway and Kure, levels of PCBs, PAHs, DDT, Dieldrin, Chlordane, nickel, and copper were above the 85th percentile of concentrations measured in the coastal USA by the NOAA Status and Trends Program and contaminants on Laysan are being removed by the US Fish and Wildlife Service.

Fish	% of sites	% of numbers	% biomass
Brown surgeonfish (*Acanthurus nigrofuscus*)	74.9%	10.7%	7.4%
Black durgon (*Melichthys niger*)	36.6%	2.7%	11.6%
Goldring surgeonfish (*Ctenochaetus strigosus*)	55.4%	7.0%	7.4%
Saddle wrasse (*Thalassoma duperrey*)	95.4%	13.5%	4.0%
Orangespine surgeonfish (*Naso lituratus*)	41.1%	1.3%	4.1%
Whitebar surgeonfish (*Acanthurus leucopareius*)	26.9%	1.4%	4.4%
Sargent major (*Abudefduf abdominalis*)	21.7%	5.6%	5.2%
Convict tang (*Acanthurus triostegus*)	27.4%	2.9%	3.2%
Redlip parrotfish (*Scarus rubroviolaceus*)	21.7%	0.2%	3.4%
Pacific gregory (*Stegastes fasciolatus*)	69.7%	3.4%	0.9%

Above is a list of the top 10 reef fish species with the % seen at 44 locations, the % of the total population number and the % of the total fish biomass.

Status of Coral Reef Fisheries

Main Hawaiian Islands

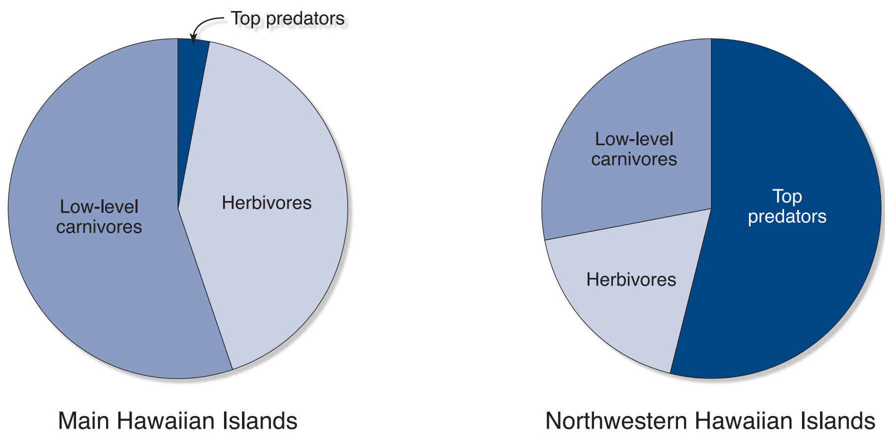
There are 557 species of reef and shore fishes, of which 24.3% are endemic. Surgeonfishes are the dominant fish group and herbivores in general accounted for over 70% of the total reef fish biomass in all locations, followed by invertebrate feeders (13%) and plankton feeders (9.7%). Predators were rare and accounted for only 3.8% of reef fish biomass.

The highest numbers and species of fish were seen in locations of moderate wave exposure, compared to the protected Kane'ohe Bay, which had the lowest fish richness and diversity. The lowest biomass was observed in areas exposed to north and south swells, whereas nearby areas protected from the direct swells, had higher stocks of reef fishes. There are more fish and more species in more complex habitats, which illustrates the importance of shelter as a refuge for some fishes to avoid predation. The only apparent exceptions were in a few places where there was high fish biomass in sites with low habitat complexity, but these were sites protected from fishing.

The results of years of chronic over-fishing around the more populated areas are seen with classic over-fishing indicators – mostly small fish that rarely reach breeding age. It is clear that in areas where fishing is prohibited, there are larger fish populations with distinctive fish assemblages. An example of the value of limiting fishing is in the Pupukea Marine Life Conservation District where lower standing stocks of fishes directly correlates with no restrictions on fishing. Thus the existing management regime which allows all types of fishing is not contributing to the conservation of these fish populations.

Fisheries catch statistics continue to be unreliable because of under-reporting by commercial fishers and the large resident recreational and subsistence fishing population. This is the only state in the USA where a saltwater recreational fishing license is not required. The pressures are particularly seen on the populations of predators, as can be seen in the pie diagrams below.

Another area where management is needed is in the trade of ornamental fish and invertebrates which are exported to the mainland USA. Evidence of this trade is seen in markedly reduced populations of the better aquarium species. There are 5 species of sea turtles and 24 marine mammal species on the coral reefs off the MHI. These include the threatened 'Hawaiian' green sea turtle (*Chelonia mydas*) that feeds in shallow waters of the MHI, as well as the Hawaiian hawksbill sea turtle (*Eretmochelys imbricata*). Turtle tumours (fibropapillomatosis) were rare prior to 1985, but are now common on turtles on Maui, Kaua'i, and O'ahu; with up to 60% of the turtles in Kane'ohe Bay infected. The endangered Hawaiian monk seal (*Monachus schauinslandi*) occasionally visits waters of the MHI.



The average total fish biomass in the NWHI is 260% higher than in the MHI with a far greater proportion of top predator ('target') species, whereas on the MHI, the predator species are a smaller proportion of a much smaller biomass, thereby showing indications of serious over-fishing.

NWHI

A total of 266 species of fishes are listed from Midway Atoll of which 258 are reef and shore fishes. Cooler water temperatures, lack of some high-island habitat types, and lower sampling effort may all contribute to the lower number of species compared to the main Hawaiian Islands. However, average fish biomass in the NWHI is nearly 3 times greater than in the MHI, with more than 54% of the total fish biomass consisting of top predators (there were fewer than 3% of these in the total fish biomass in the MHI). Jacks, sharks and groupers are the dominant species, while they are either rare or absent in the MHI and the target species that were present, regardless of trophic level, were nearly always larger in the NWHI. Mean weight of apex predators in the NWHI was 570% greater than in the MHI, and herbivores were 97% heavier in the NWHI. These differences represent both near-elimination of apex predators and heavy exploitation of lower trophic levels in the MHI compared to the largely un-fished NWHI. The only substantial fishing pressure comes from commercial vessels larger than 20m. The National Marine Fisheries Service, through the Western Pacific Regional Fisheries Management Council, is now managing the fishing industry, and the lobster fishery is closed.

Marine Debris Removal from the Northwestern Hawaiian Islands

The National Marine Fisheries Service (NMFS) recently completed a large marine debris clean-up in the Northwestern Hawaiian Islands (NWHI). Marine debris, mostly derelict fishing gear from northern Pacific fisheries, poses a significant threat to coral reefs, because the gear and entangled pieces of coral scour the reefs as they are dragged around by waves and currents. Marine debris also entangles animals that use coral reefs, including the endangered Hawaiian Monk seal. The clean-up effort was led by the NMFS Honolulu Laboratory and included NOAA's Ocean Service, the NWHI Coral Reef Ecological Reserve, U.S. Coast Guard, U.S. Navy, Hawaii Sea Grant, the U.S. Fish and Wildlife Service, State of Hawaii, universities and other local agencies, businesses and NGO partners. Two vessels were chartered to support rotating teams of trained NOAA divers for 6 months, who also conducted line transect surveys and recorded GPS coordinates of debris locations. Divers carefully cut the entangled gear away from the coral to minimise further damage, and airbags were used to bring balls of debris to the surface to be totally removed. By September 2002, divers had removed another 107 metric tonnes of debris, adding to the 100 tonnes collected since 1996. The divers were also able to disentangle a number of monk seals and green sea turtles. The NMFS is attempting to determine the primary sources of this derelict gear and locations in the NWHI where it is most likely to accumulate. From Scot Frew at NOAA.

Anthropogenic Threats to Coral Reef Biodiversity

There are far more human pressures on coral reefs of the MHI because they are close to large urban centres, whereas there are fewer pressures on the NWHI reefs. The major threats are: urbanisation; tourism and leisure; alien species; destructive fishing practices; marine debris; military impacts; and ship groundings.

The impacts of the growing resident population and increases in tourist numbers have resulted in considerable coastline modification and reclamation of reef flats, thereby destroying nursery wetland areas and fringing reefs. The expanding infrastructure also results in increased sedimentation and pollution. Tourism is the largest industry in Hawai'i, with marine tourism the focus. Although it brings in over US$800 million per year and employs over 7,000 people, there are also negative impacts. Coasts are continually being developed to cater for the tourists and the increased boating activities cause direct reef damage and pollution of oil and sewage from the boats. It was found that in heavily used areas of coral reefs (300,000 visitors annually), the coral cover is particularly low e.g. 2% cover; whereas in control areas it is much higher e.g. 34%. Tourist use results in pulverised corals that cannot survive continued exposure to trampling. However, if the trampling pressures are removed, the coral colonies can recover, particularly those species from high wave energy environments because they have much stronger skeletons. Damage to coral from anchors is being continually reduced with the installation of mooring buoys in collaborative activities of the government and dive industry. There is virtually no tourism activity in the NWHI, but this is being monitored, especially sports fishers who are encouraged to fish but adopt a catch-and-release policy.

Local Communities Combating Invasive Alien Algae

The coral reefs of Hawai'i have been invaded by alien marine algae, with at least two species swarming over and killing corals. Now researchers, State and Federal resource managers, and NGOs have joined forces to galvanise local community volunteer groups to combat the invaders. The first target was the alien red alga *Gracilaria salicornia* that now dominates reefs in front of the world famous Waikiki Beach. Because this alien species could damage the economy of the local tourism industry, as well as the ecosystem, the University of Hawai'i, the Waikiki Aquarium, the Hawai'i Department of Land & Natural Resources, the Hawai'i Coral Reef Initiative, NOAA, Reef Check and the Nature Conservancy have formed a combined force to control and reduce the impacts from *G. salicornia.* Two large-scale community clean-ups were held with an average of 80 community volunteers removing over 2.5 tonnes of the alien algae from the reefs during each 4 hour workday. Scuba divers stuffed burlap bags full of the aliens underwater, and swimmers then paddled the bags to shore on boogie boards. The beach volunteers then took over, drained the bags, weighed and sorted the algae. Their role was to help the researchers separate out and return native algae to the reef, while the remaining aliens were then donated to a composting company to end their days usefully on Hawaiian gardens. From: Jennifer Smith, jesmith@hawaii.edu

Many species have been introduced into the MHI, either deliberately for algal culture or to enhance fishing, or inadvertently with ships e.g. 4 of 19 introduced macroalgae are now prevalent throughout the MHI. *Kappaphycus alvarezii*, is killing corals in Kane'ohe Bay and over 5,000kg of *Gracilaria salicornia* were removed from an area near Waikiki. Key fishing target species (6 groupers, 4 snappers, and 1 emperor) were introduced with 3 being so successful that they are damaging native fish populations. There are reports of chlorine being used to capture lobster or fish, and illegal long gill nets are frequently used in Hawai'i causing depletion of fish stocks, and death of endangered bycatch species. The amount of marine debris continues to be a problem in MHI, and the major problems in NWHI are derelict fishing nets entangling coral reefs. Indeed US$3 million was spent to remove 50 tonnes of debris in 2001. NOAA is attempting to model currents to determine the sources and concentration points of such debris to be able to remove the material before it causes reef damage.

Reefs around Kaho'olawe have been damaged by military bombing and amphibious vessels have smashed reefs on O'ahu. There is also considerable military activity in the NWHI, and damage does not incur penalties. A major problem for the reefs of Hawai'i are the numerous small and large vessels passing through the islands. Groundings on coral reefs are a persistent problem, with direct damage as well as pollution from oil and toxic cargoes.

Current and Potential Climate Change Impacts

These reefs are remote and have not yet experienced major bleaching events, probably because of relatively strong currents and deep water around the islands. Some coral bleaching was observed in the NWHI in October 2002 after a period of sustained hot water and calm winds. NOAA satellite monitoring, showed warm waters in the NWHI, as far as Midway Atoll from early August to September 2002. With temperatures at Midway up to

Island	MPA	Estimated coral reef habitat (hectares)	% No-take zone
Hawaii	Haloko-Honokohau NHI	200	0
	Kealakekua MLCD	65	<50
	Kiholo FMA	40	0
	Lapakahi MLCD	60	<25
	Old Kona Airport MLCD	87	0
	Wailea Bay MCLD	14	0
	West Hawaii FRA	8,720	0
	Ahihi-Kinau NAR	323	100
	Honolua & Mokuleia MI	10	60
Kaho'olawe	Kaho'olawe	5734	0
	Molokini Shoals MLCD	31	39
	Hulopoe-Manele MLCD	10	100
	Kalupapa NHP	200	0
O'ahu	Hanauma Bay MLCD	40	100
	Hawaii Marine Lab Reserve	14	0
	Pupukea MLCD	10	0
	Waikiki MCLD	30	100
Northwestern Hawaiian Islands	Hawaiian Islands NWR	244,060	90
	NWHI FMA (proposed)	220, 120	
	Midway Atoll NWR	22,042	
	Kure Wildlife Refuge	0	0

28.9°C in August, which is 1°C above the bleaching threshold of 27.9°C; (http://orbit-net.nesdis.noaa.gov/orad/sub/sst_series_midway_cur.html). Similar extreme levels have only been seen in August 1987 and 1988.

Current MPAs, Monitoring and Conservation Management Capacity

The traditional practices by Hawaiians to conserve their resources by closing areas or having closed seasons for fishing have now largely been replaced by a range of 'western' approaches to conservation. These were detailed in the previous report in 2000.

MHI

There has been no increase in the no-take protected areas in the MHI (still only 0.3% of reefs). The current MPAs are summarised in the table.

NWHI

The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve was established in December 2000, and contains provisions for functional no-take areas distributed across the entire NWHI in Federal waters ranging from 50-200m. There are restrictions on anchoring, discharge, and non-extractive uses, and recreational and commercial fishing activities are prohibited in the 20-40m zone of most islands northwest of Kaua'i, owing to their status as a National Wildlife Refuge managed by the US Fish and Wildlife Service.

Coming Together in the Northwestern Hawaiian Islands

The President of the United States signed 2 Executive Orders in December 2000 and January 2001, establishing the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve (NWHICRER). This covers an area 1200 nautical miles long and 100 nautical miles wide and is the second largest marine protected area in the world after the Australian Great Barrier Reef. It is adjacent to areas administered by other Federal or State resource management agencies. Since 2000, a series of partnerships have developed among the various State and Federal resource trustees, the academic community and various NGOs to conduct large-scale, rapid ecological assessments of this immense area and better describe the various terrestrial and marine habitats. This has resulted in multi-agency expeditions in 2000, 2001 and 2002 involving many recognised experts and the discovery of new species, maps of the habitats, and a rethinking of what constitutes a natural coral reef ecosystem. Much of this will be used by managers to not only help reshape the future of the NWHICRER, but also to better manage both natural and impacted reef areas in the populated main Hawaiian Islands. The first such report from these expeditions: 'Coral Reef Ecosystems of the Northwestern Hawaiian Islands' is available on the web at www.hawaii.edu/ssri/hcri, or see www.hawaiireef.noaa.gov/. From: David Gulko, David_A_Gulko@exec.state.hi.us

Government Policies, Laws and Legislation

These were also detailed in the previous report in 2000 with the major recent activity being increased mapping, monitoring and research across the NWHI and the designation of agencies responsible for conservation of the reef resources.

Conclusions

The increased support over the past 2 years for improved understanding and management of Hawaii's coral reefs reflect their importance in Hawaiian culture. However, the coral reefs continue to be threatened by population growth, urbanisation, development and over-fishing. Ocean outfalls, urban and recreational coastal development (hotels, golf courses, etc.) are focal points for coral reef degradation, and new technologies for extraction, offshore aquaculture, and bioprospecting raise concerns about the ability of management agencies to keep ahead of these damages to coral reef resources. In the MHI, there is clear evidence of over-exploitation of most target food fish and invertebrates, and key marine aquarium trade species. Compounding these problems for resource managers is gross under-reporting of current levels of exploitation and the introduction of alien species that can change the structure and function of Hawaii's reefs and threaten endemic species.

Significant progress, however, has been made in mapping, monitoring, researching, and managing Hawaii's reefs. Digital habitat maps of the MHI and NWHI will help managers identify and protect the most critical areas to support biodiversity conservation and fisheries productivity. Research supported by the Hawaii Coral Reef Institute continues to improve the understanding of land-water interactions and how natural and human-induced stresses affect coral reef ecosystems. Monitoring programs provide feedback on the effectiveness of management strategies and document changes in ecosystem health and function. A socio-economic valuation of Hawaii's reefs raised awareness of their value and will facilitate damage assessments in ship grounding cases. Unprecedented amounts of marine debris and grounded vessels were removed from the MHI and NWHI, indicating that these could be ongoing problems.

Preliminary research indicates that MPAs are effective in increasing biodiversity and coral reef fish stocks and Hawaii needs to strengthen the political will to establish and enforce restricted-use zones where they will be most effective. While new partnerships have been formed by management agencies, academia, NGOs and user communities, there is a need for more financial and political support for the existing and proposed efforts at conserving the exceptionally wide variety of coral reef habitats and resources in the Hawaiian Archipelago.

Reviewers

Charles (Chuck) Birkeland, Hawai'i.

Author Contacts

Rusty Brainard, National Marine Fisheries Service in Honolulu, (Rusty.Brainard@noaa.gov); Alan Friedlander, Oceanic Institute, Waimanalo, (afriedlander@oceanicinstitute.org); Dave Gulko, Hawai'i Department of Land & Natural Resources, (david_a_gulko@exec.state.hi.us); Cynthia Hunter, Waikiki Aquarium Honolulu, (cindyh@hawaii.edu); Ruth Kelty, National Centers for Coastal Ocean Science, (ruth.kelty@noaa.gov); Jim Maragos, U. S. Fish & Wildlife Service in Hawai'I, (jim_maragos@fws.gov)

Supporting Documentation

Jokiel PL, Brown EK, Friedlander A, Rogers SK, Smith WR, (2001). Hawaii Coral Reef Initiative Coral Reef Assessment and Monitoring Program (CRAMP) Final Report 1999-2000. HCRI and NOAA Technical Report. Silver Spring, MD. 66pp.

US International Activities for Coral Reefs

The U.S.A. has strong political and economic interests in protecting international coral reef ecosystems. Healthy marine ecosystems are critical to US diplomatic and development strategies to promote economic and food security, social stability, democratic governance, improved human health, disaster and climate change mitigation, and biodiversity conservation in many countries. Coral reef ecosystems have great economic, social and cultural importance and constitute the economic base and future hope for sustained development in many countries.

The U.S. National Action Plan to Conserve Coral Reefs identifies reducing international threats to reefs as a goal and the National Strategy outlines the US approach to meeting that goal. In general, the US Government is forging and supporting strategic partnerships with international organizations and conventions, the International Coral Reef Initiative, other governments, NGOs, and the public and private sectors to address international threats and encourage broad stakeholder involvement. Domestic and international partners collaborate to conserve coral reefs, mangrove forests, seagrass meadows, and biodiversity around the world, while sustaining the human communities that depend on them. The primary agencies involved in international partnerships are US AID, the State Department, NOAA, FWS, and EPA.

Development and technical assistance efforts focus on building human and institutional capacity for integrated coastal management, marine park and protected area management, reduction of land-based sources of pollution, sustainable tourism, and sustainable fisheries in coral reef nations. In many cases, these capacity-building efforts will provide the foundation for a governance system based upon the principles of transparent, participatory governance and adaptive management.

The strategy includes six broad objectives to reduce threats to international reefs from human activities:

- Exercise global leadership in the international arena in shaping and developing environmentally sound and comprehensive ocean and coral reef policy;
- Build human and institutional capacity to manage and conserve reef ecosystems and coastal watersheds through integrated coastal management;
- Promote efforts to prevent, reduce and control land-based sources of pollution and their effects on coral reef ecosystems, including beaches, lagoons, seagrass beds, mangrove forests, shallow reefs, deep reefs and submerged bank reefs;
- Support the creation and effective management of coral reef marine protected areas, particularly those that contain substantial ecological (i.e. no-take) reserves;
- Address the impact of global change, coral bleaching, and coral health on reefs and people;
- Address unsustainable and destructive fishing practices and the US role in and impact on international trade in coral reef species.

To meet these objectives, US agencies are strengthening international partnership efforts to conserve coral reefs. A new International Coral Grants Program provides funding for international projects that study management effectiveness, make socio-economic assessments, develop regional action plans for no-take reserves, and monitor coral reef ecosystems. Another project establishes standardised socio-economic monitoring protocols for coral reef managers in the Caribbean and Southeast Asia. Others focus on improving effectiveness of existing and proposed international marine preserves. The following is a partial list of major accomplishments from 2000 - 2002 that contributed to reducing international threats to coral reef ecosystems.

- Promoted sound coral reef conservation and policy issues in various international and regional fora including the International Coral Reef Initiative (ICRI), Convention on International Trade in Endangered Species of Fauna and Flora (CITES), Convention on Biological Diversity (CBD), Ramsar, and the 9th International Coral Reef Symposium;
- Worked with the International Maritime Organization (IMO) to create a provision for nations to establish international no-anchoring areas under IMO authorities, and designated 6 US areas in National Marine Sanctuaries as IMO no-anchoring areas;
- Proposed universal coral and sensitive area symbols to the International Hydrographic Organization to more easily identify these areas on navigational charts.
- Improved international capacity for sustainable management and conservation in 25 countries within the Wider Caribbean, Central America, Southeast Asia, South Pacific, East Africa and Middle East regions;
- Strengthened efforts to reduce coastal pollution in at least 20 countries;
- Initiated the 'Ridge to Reef' project in Jamaica, which integrates land-based management practices for agriculture, forestry and urban planning with coastal activities, such as improving coastal water quality to protect the reefs;
- Held two international workshops to develop effectiveness guidelines for marine protected areas;
- Strengthened site-based and park management, including education and enforcement, in 15 parks of national and international importance;
- Promoted and supported the Global Coral Reef Monitoring Network and the publication of Status of Coral Reef of the World: 2000 and 2002 reports, and the Socioeconomic Manual for Coral Reef Managers;
- Continued providing data on sea surface temperatures and forecasting/tracking coral bleaching events worldwide through the Coral Watch Program (NOAA and partners);
- Established US-Australia bilateral partnership to develop improved tools for remote sensing of coral reef bleaching and other conditions;
- Addressed destructive fishing practices and adverse impacts of international trade in coral reef species through the East Asia and Pacific Environmental Initiative.
- Promoted the adoption of the APEC Destructive Fishing Resolution to address destructive fishing practices associated with the live reef fish trades.

Many of these activities are coordinated or assisted through the U.S. Coral Reef Task Force. Contact: Roger Griffis; Roger.B.Griffis@noaa.gov; www.coralreef.noaa.gov.

14. Status of Coral Reefs in the U.S. Caribbean and Gulf of Mexico: Florida, Texas, Puerto Rico, US Virgin Islands, Navassa

Billy Causey, Joanne Delaney, Ernesto Diaz, Dick Dodge, Jorge Garcia, Jamie Higgins, Brian Keller, Ruth Kelty, Walter Jaap, Cruz Matos, George Schmahl, Caroline Rogers, Margaret Miller and Donna Turgeon

Abstract

There has been a marked increase government funding for the U.S. Caribbean over the last 2 years. This has resulted in vastly improved regional mapping, monitoring, and management of coral reef ecosystems of Florida, Texas, Puerto Rico, U.S. Virgin Islands and Navassa. These improvements have resulted in significant advances in our understanding of the condition and functioning of these coral reefs. Digital maps of the U.S. Caribbean, including photo-moasics, individual aerial photographs, classified habitat maps, a mapping ArcView extension classification scheme, and methods manual, were completed and are available on CD-ROM and the web (www.biogeo.nos.noaa.gov). Maps of benthic habitats of the Florida Keys National Marine Sanctuary (FKNMS) were completed in 1998 and are also available. The NOAA (National Oceanic and Atmospheric Administration) National Coral Reef Monitoring Program has been expanded from US$0.6 to 0.9 million and now supports monitoring of water quality, reef fish populations, and the habitat in Florida as well as in Puerto Rico and the U.S. Virgin Islands. A comprehensive monitoring program in the FKNMS was expanded, and shows that fishes in no-take reserves are larger and more abundant than in fished reference areas. Databases have been improved to allow easier data entry from the field and many are now available on-line. Monitoring data are published in peer-reviewed literature and in the first National Report on the Status and Health of U.S. Coral Reef Ecosystems.

A major 5-year research program started in 2002 to examine the links between natural and human stresses, reef processes, socio-economic factors, and the use of MPAs as a management tool. Biological and physical data are being integrated into GIS programs to allow managers to visualise and predict the impacts of their decisions. The National Coral Reef Initiative (NCRI) received US$1M in 2001 and 2002 to support cooperative grants for coral reef research and monitoring. The research projects and collaborations include: innovative methods and programs to assess, monitor, and restore reefs; investigations of ecological, environmental, and genetic responses to coral reef restoration; mapping and biological inventories; and risk assessment and categorisation. A new Coral Reef Institute was established in Puerto Rico to strengthen monitoring and develop improved monitoring technologies. In response to increasing coral diseases in the Caribbean, the Coral Disease and Health Consortium has brought together many experts who have: identified information needs; prioritised strategic research; identified technology

requirements and risk management options; and determined prevention, mitigation or remediation strategies. Major needs identified are to: standardise the terms, procedures and protocols; clarify the basic research and technology developments; and improve the mechanisms for technology transfer, scientific training, and public education. The Coral Disease and Health: A National Research Plan is scheduled for release in late 2002.

Hopefully this improved attention to coral reef issues in this region will continue, and improve our understanding of how these ecosystems respond to anthropogenic stresses and how to develop management plans that protect the resources by minimising the stresses. It is recognised that a multi-disciplinary and cooperative approach is needed for better management of coral reef areas.

INTRODUCTION AND GEOGRAPHIC CONTEXT

This report on the status of U.S. Caribbean 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: 2002.' That report was authored by 38 recognised technical experts and supported by 79 contributors from government agencies and NGOs. The report is available at www.nccos.nos.noaa.gov.

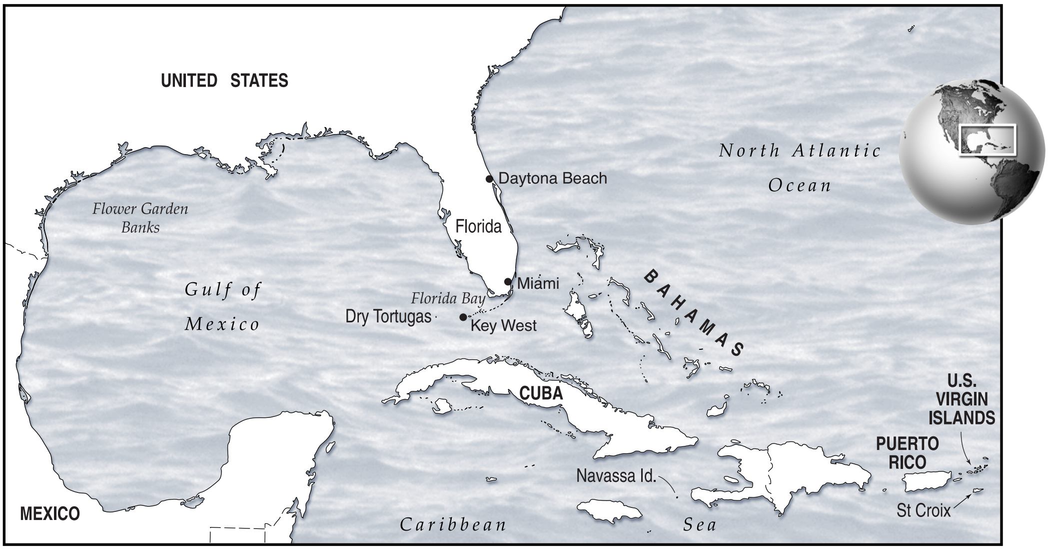
Florida East Coast

The reefs in northern Monroe County to Vero Beach are a series of 3 discontinuous reef rows parallel to the shore: First Reef rises to 3–5m of the surface with very low profile cover of algae and small octocorals; Second Reef at 6–8m depth has more complex relief that includes dissecting channels and conspicuous octocorals often in high density; and Third Reef is at 15-22m with the most diversity and abundant hard corals, that include *Diploria clivosa, Dichocoenia stokesii, Montastraea cavernosa*, and *Solenastrea bournoni*. There has been strong recruitment of *Acropora cervicornis* in the past 3 years and clumps of staghorn coral are common, especially in Broward County, along with large barrel sponges (*Xestospongia muta*). The hard corals are larger on the Third than the Second Reef and moderate sized colonies of *Montastraea annularis* are common. However, there has been no growth of the elkhorn coral (*Acropora palmata*) for more than 5,000 years.

Most reefs have been mapped and coral cover estimated for the first two rows, but less for the deeper Third Reef. These reefs are protected from some impacts by Florida State statutes and regulations e.g. fishing regulations, dredging permits, prohibition against harvest, sale, or destruction of corals etc. In addition, mooring buoys have been established.

Florida Keys

The Florida Keys coral reefs extend from just south of Miami to the Dry Tortugas and include the only emergent reefs off the continental USA. The Florida Keys National Marine Sanctuary (FKNMS) was designated in 1990 to protect and conserve the nationally significant biological and cultural marine resources of the area, including critical coral reef habitats. The Sanctuary covers 9850 km^2 with 1400km^2 of coral reef and hard bottom habitat (42% in Florida State territorial waters; and 58% in Federal waters i.e. more than 3 nautical miles offshore). The reefs comprise a bank reef system of almost continuous reef communities in lines that run parallel to each another. There are several distinct habitats



including offshore patch reefs, seagrass beds, back reefs and reef flats, bank or transitional reefs, intermediate reefs, deep reefs, outlier reefs, and sand and soft bottom areas.

Texas Flower Garden Banks

These are two prominent geological features on the edge of the continental shelf in the northwest Gulf of Mexico, approximately 190km southeast of Galveston, Texas. The Banks are uplifted Jurassic salt domes, rising from 100m depth to within 17m of the surface and have about 1.4km^2 of luxurious bank reefs on the shallowest portions of the East and West Flower Garden Banks. These are the most northerly coral reefs on the continental shelf of North America (27°52' to 27°56' North) and also some of the most isolated reefs of the Caribbean, being over 690km from the nearest reefs of Campeche Bank off Yucatan, Mexico.

The East Flower Garden Bank (27°54'N; 93°36'W) contains about 70% of the coral area, with the rest on West Flower Garden Bank (27°52'N; 93°49'W) about 22km away. These reefs have only 21 coral species probably because they are so isolated, but coral cover is high (~50%) with crustose, coralline and calcareous green algae also common. The Flower Garden Banks are composed of large, closely spaced coral heads up to 3m in diameter and height, which are hollow in places due to bioerosion and separated by sand patches and channels. These corals grow from the top near 17m down to about 50m.

The reefs were designated as the Flower Garden Banks National Marine Sanctuary (FGBNMS) in 1992, and Stetson Bank was added in 1996. The Sanctuary covers 143km^2 and includes all the coral reef areas. Regulations protect the corals with prohibitions on: oil and gas exploration; anchoring or mooring of vessels over 30m; anchoring of smaller vessels near mooring buoys; injuring or taking coral and other marine organisms; use of fishing gear other than hook and line; discharging or depositing any substances or materials; altering the seabed; building or abandoning any structures; and using explosives or electrical charges.

Puerto Rico

Along with the main island, there are 2 inhabited small islands off the east coast (Culebra and Vieques), and 3 uninhabited islands (Mona, Monito, Desecheo) off the west coast. Most coral reefs occur on the east, south and west coasts, with fringing reefs being the most common type. The western two-thirds of the north coast consists of mainly hard ground and reef rock with low to very low coral cover and some small, sparse, low coral colonies. Coral reefs cover approximately 3,370km^2 within 3 nautical miles of the coasts, which are about 3% of the total coral reef area under U.S. jurisdiction (Hawaiian Islands are first with 85%). The main islands of Puerto Rico, including Culebra and Vieques, are almost completely encircled by reefs, although coral reef abundance is highly variable, depending on the local conditions.

U.S. Virgin Islands (USVI)

Coral reefs occur around all the major islands of St. Croix, St. John, and St. Thomas, as well as the offshore cays. Fringing reefs, deep reefs (wall and shelf-edge), patch reefs, and spur and groove formations are present, although only St. Croix has barrier reefs. Bank reefs and scattered patch reefs with high coral diversity occur deeper offshore. The U.S. Departments of Interior, and Commerce, and the Virgin Islands Government have jurisdiction over submerged lands with coral reefs within the USVI. In 2001, NOAA completed maps of USVI coral reefs and associated ecosystems to a depth of 20m. Of the 485km^2, 61% consisted of coral reefs and hard-bottom habitats, 33% were seagrass beds; submerged and the rest was sand or rock.

Navassa

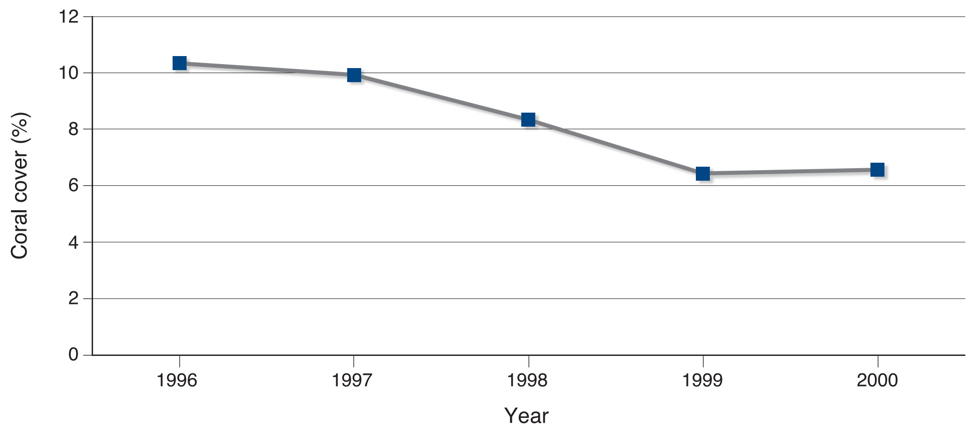
This tiny (5km^2) uninhabited U.S. protectorate between Jamaica and Haiti, is under the jurisdiction of the U.S. Fish and Wildlife Service. Knowledge about the status of the reefs is extremely limited and based on several expeditions over the past 2 years sponsored by The Ocean Conservancy.

Status of the Coral Reefs

Florida

The level of research and monitoring in the Florida Keys increased markedly after the declaration of the FKNMS. Seven years of data on water quality, seagrasses, and coral reef and hard bottom communities provided Sanctuary managers with trend information on the health of the coral reef ecosystem. In addition, there are 5 years of data on ecological changes associated with the implementation of the first network of marine reserves in the U.S. Those on the southeast coast of Florida and the Middle Grounds are not as well studied, but are being mapped and given some monitoring. Most of the information on these areas, however, continues to be anecdotal with some reefs appearing healthy although there was some bleaching similar to levels seen in the Florida Keys during the massive 1997-1998 event. There is little information on the status of benthic communities at the Florida Middle Grounds.

There are 64 hard coral species, 2 fire corals, and 55 species of octocoral on the Florida Keys. Coral cover is highly variable depending on the habitat type and previous history, with patch reef habitats showing the fewest losses and highest average cover over time.



The percent hard coral cover averaged from 160 stations along the length of the Florida Keys National Marine Sanctuary shows a steady decline in the corals over 5 years.

Hard coral cover in the FKNMS has decreased from an average of 10.3% in 1996 to 6.4% in 1999 at 160 stations, and species richness at first declined from 1996-1999, but rose slightly in 2000. The type, distribution, and frequency of coral diseases are increasing, and so far 3 pathogens have been identified. Coral bleaching also remains a problem, and has been responsible for some of the dramatic declines in coral cover in the Sanctuary since 1997, but fortunately there has been no repeat of that severity of bleaching.

Algae continue to dominate all sites, with average cover generally above 75% in the Keys and above 50% in the Dry Tortugas. Scientists have identified 90 species of marine macroalgae and 7 seagrasses, along with 3 species of mangroves in Florida. Seagrasses are present at over 80% of the FKNMS stations, and cover approximately 12,800km^2 in the 17,000km^2 study area. The algae and many invertebrates fluctuate widely between years e.g. algal cover increased between 1996 and 2000, while sponge and soft coral cover decreased. Similarly, algae dominate at deeper sites.

There is still considerable concern about water quality, with continued pollution by agricultural chemicals, sediments, and nutrients from agriculture and industry throughout Southeast Florida and the Keys. Total phosphorus concentrations are increasing as far as the Dry Tortugas, and the increases in nitrates appear to be mostly closer to shore on the shelf of the Lower and Upper Keys. By contrast, organic nitrogen is decreasing slightly at many sites around Florida. These trends may be driven by regional circulation of the Loop and Florida Currents.

Flower Garden Banks

These remain amongst the least disturbed coral reefs in the Caribbean and can be considered nearly pristine. The ocean water around the reefs is clear with visibility up to 30m, and no major variations in salinity and temperature. The coral communities have remained stable and healthy since they were first studied in the early 1970s. There has been some minor damage from anchors, illegal fishing gear, tow cables, and seismic arrays.

Coral cover has not significantly changed since 1972; it averaged 47% in 1995, and 52% in 1997. Coralline algae cover is 45.4%, algal cover is low at 2.7%, and there are some sponges (1.5%), and sand patches (<0.1%). The dominant coral species are *Montastrea annularis* and *Diploria strigosa*, but there are no branching *Acropora palmata* or *A. cervicornis*, and no sea whips or sea fans (gorgonians), which are common elsewhere in the Caribbean. Slight coral bleaching was observed when water temperatures exceeded 30°C, but there was no significant mortality. Coral disease is rare, with 23 only diseased colonies among 3700 observed. The most common algae were crustose coralline and calcareous greens among at least 44 species. Below 50m is the 'algal-sponge zone'. Fleshy algae are rare with cover usually below 5%, but increased to over 13% after the sea urchin die-off in 1983. They dropped again when herbivore populations picked up. There was an increase in turf algae in 1999 to 27.6% on the East Bank and 20.7% on the West Bank (usually 3 to 5% cover) which may signal a change to the benign conditions for corals.

There are no immediate concerns about water quality, however there are some warning signals. Dirty water at the Flower Garden Banks in mid-2002 was possibly associated with Mississippi and Atchafalaya River flood waters, and oxygen-depleted water masses seen in the northern Gulf of Mexico may be moving across the Continental Shelf towards the Banks. The direct threats include atmospheric pollution and effluent discharges from nearby oil and gas development, and transportation.

Puerto Rico

There are more coral species around Puerto Rico than further north. There are many 'coral' species, that include 117 hard corals, 99 soft corals and gorgonians, 13 corallimorphs, 3 fire corals, and 5 hydrocorals making the Puerto Rico reefs the richest in the U.S. Caribbean. It is now clear that reefs surrounding the main island are degraded, because of nearby coastal developments, whereas the reefs near Descheo Island are probably the best-developed and healthiest in Puerto Rico, with about 70% coral cover and very clean water; however there are few long-term monitoring data available. The main branching elkhorn and staghorn corals (*Acropora palmata* and *A. cervicornis*) have declined in most places over the last 25 years due to hurricane damage, white-band disease, and coral-eating molluscs. Hurricane Georges heavily damaged *A. palmata* on the outer reefs in 1998 such that only one thicket remains between Margarita and San Cristobel. *A. cervicornis* has recovered considerably since Hurricane Georges and flourishes in shallow back-reef sites off San Cristobel, despite the presence of white-band disease. However, up to 10% of the *A. palmata* near La Paguera is affected by white-band disease and has not recovered, nor have the *A. cervicornis* around Mona Island recovered after Hurricane Georges.

Most of the common coral diseases have been observed in Puerto Rico (yellow-blotch, black-band, white plagues I & II, and aspergillosis) and caused considerable damage down to 30m depth. White plague II struck after Hurricane Hortense (1996), and spread to more than 50% of the brain corals near La Parguera. Yellow-blotch disease was found on a few colonies in 1996, but by 1999, up to 50% of the *Montastrea annularis* off Mona Island were infected, as well as corals at almost all other sites. There was also massive coral bleaching and mortality in the late 1980s, however major coral bleaching in 1998, resulted in very little mortality.

Luis Peña Channel No-Take Marine Reserve, Puerto Rico

The Island of Culebra is 27km east of Puerto Rico and is only 11 by 5km. The surrounding waters sustain an extensive and varied coral reef that is healthier than most others in Puerto Rico. The Culebra Fisher's Association recognized that over-fishing was a problem in their areas and having serious consequences for their artisanal fishing livelihood. Through their own initiative and with the assistance of a volunteer fisheries scientist, the association catalyzed the conservation effort by petitioning the Department of Natural and Environmental Resources of the Puerto Rico Government to designate a 'no-take' zone on the west side of the island in 1999. The Biology Department of the University of Puerto Rico-Rio (Piedras) conducted scientific monitoring, both before and after the establishment of the reserve, and their results show that fish abundance has increased dramatically and species numbers have increased by 38%. Dramatic increases in the abundance (2,539%) and in the biomass (26,618%) of the yellowtail snapper *(Ocyurus chrysurus)* were noted as well as significant increases in the abundance (414%) and biomass (868%) of the schoolmaster *(Lutjanus apodus)*. The designation of the Luis Peña Channel No-Take Marine Reserve in Culebra, Puerto Rico is a clear demonstration of a grassroots effort to manage local fisheries resources.

There are extensive seagrass beds in the shallow water around Puerto Rico and mangroves fringe the southern coast. Massive macroalgal cover on the nearshore reefs, first observed in the 1970s, continues to kill corals. Such major cover by macroalgae is indicative of eutrophication from sewage and urban outfalls and low populations of algal grazing fishes.

There has been definite degradation of water quality around all reefs off the southern coast of Puerto Rico due to high sediment inputs and increased turbidity. There has been clear-cutting of the hillsides leading to increased sediment runoff during rainy periods, and sewage is discharged into the sea. Mangrove channels and reefs may be affected by sewage discharge from upstream sources (e.g. off Guayanilla, Guancia, and Ponce). Three rivers pour excessive sediments, sewage, and nutrients from agriculture and tuna canneries onto the near-shore reefs in the west. The fore-reefs off the Jobos Bay National Estuarine Research Reserve have been severely damaged by sediments from coastal erosion and long-shore transport from the towns of Guayama and Salinas.

The Environmental Quality Board reported that 97.7% of 88 sites around Puerto Rico can support aquatic life (e.g. 10% or less of the shore area violates health standards) and only 1.8% are more than 25% in violation of the standards, which measure turbidity, ammonia, dissolved oxygen problems linked to industrial and municipal, sewage disposal, urban runoff, land disposal, and marinas. The U.S. EPA cited the Bacardi Corporation for Clean Water Act Violations when in 2001 they discharged rum processing wastes that are toxic to mangroves and coral reefs.

U.S. Virgin Islands

Some of the best long-term datasets on Caribbean coral reefs come from St. John and Buck Island, St. Croix in the USVI. Live hard coral cover varies from a low of 5.8% on Buck Island, St. Croix to a high of 45.3% (Tektite, St. John), however 76% of randomly selected transects showed declines in coral cover between 1988 and 1991. For example, cover of the elkhorn coral (*Acropora palmata*) at Buck Island National Monument fell from 85% in 1976 to 5% in 1988 due to storms and disease. *A. palmata* is recovering and recruitment is increasing, however, the white-band disease that killed the corals is still occasionally observed. A similar plague appeared around St. John in 1997 affecting 14 coral species, and it is the most destructive of problems facing the corals in the USVI. Monthly surveys on one St. John reef have documented a new incidence of disease every month from 1997 to present, making this the most disease prone area on St. John. Some small patch reefs of *Porites porites* died from an unknown disease and have not recovered in 12 years. The large, dense seagrass beds observed in 1962 and 1983 on St. John no longer exist. The losses are most noticeable in areas within popular anchorages. Analysis of photographs shows a decrease in total seagrass area by 68,000m^2 from 1971 to 1991 in Great Lameshur Bay, and losses of 22,000m^2 in Little Lameshur Bay. Similarly in all the bays visited, seagrass area has fluctuated, but usually declined with direct correlations with the numbers of boats anchoring above.

There is more sewage treatment in the USVI than most parts of the Caribbean e.g. 8 facilities on St. Thomas; a new secondary treatment plant on St. John; 1 primary treatment plant on St. Croix. However, the plants are not all maintained correctly and inshore pollution still occurs. Untreated rum-effluent from a St. Croix distillery results in a 8km benthic 'dead zone' caused by the high toxin levels, and raised temperatures, but the distillery is granted an exemption every year.

Accelerating development, 56km of unpaved roads, and poor land management on St. John result in increased sediment runoff onto the reefs. When the 1998 bleaching event struck, there were more bleached corals in sedimented areas (38% bleached in 14 mg/cm^2/day) compared to cleaner zones (23% at 4-8 mg/cm^2/day).

Navassa

There is no regular reef monitoring, nor research at Navassa, but the reefs were assessed in 2000. The island is uninhabited with no development nearby, therefore the water is clean and the reefs are not heavily exploited. Average live coral cover was 20 to 26% at 11-23m, with sponges (7-27%) and fleshy brown algae (10-23%). The reef areas with more reef structural complexity had more fish than the smoother areas. The elkhorn coral (*Acropora palmata*) appeared healthy with no white band disease or predation scars. The staghorn coral (*A. cervicornis*) was healthy but less abundant. The only disease seen was some white plague on 3 colonies of *Agaricia*, but many *Montastraea* colonies had suffered partial mortality in the past. There was no observed bleaching in 1998.

Status of Coral Reef Fishes and Invertebrates

Florida Keys

There have been 517 fish species identified on the Keys, including 389 reef fish, however, the highest abundance and biomass came from 10 species: bluehead wrasse (*Thalassoma bifasciatum*); bicolor damselfish (*Stegastes partitus*); tomtate (*Haemulon aurolineatum*); sergeant major (*Abudefduf saxatilis*); striped parrotfish (*Scarus croicensis*); yellowtail snapper (*Ocyurus chysurus*); bluestriped grunt (*Haemulon sciurus*); white grunt (*Haemulon plumieri*); masked goby (*Coryphopterus personatus*); and French grunt (*Haemulon flavolineatum*). The target reef fish are highly exploited e.g. 13 of 16 species of groupers, 7 of 13 snappers, 1 wrasse, and 2 of 5 grunts are over-fished in the Florida Keys. A good sign for reef managers is that average densities of the gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyurus chrysurus*), and several grouper species are higher in the no-take zones than in fished reference sites.

The inventory of other animals includes: 117 sponge species; 89 polychaete worms; 1,400 mollusks; 371 crustaceans; and 82 echinoderms. 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 now underway to improve reproductive output. The large long-spined sea urchin (*Diadema antillarum*) populations seen before the massive die-off in 1983 are only showing poor recovery.

Texas Flower Garden Banks

Fish diversity is lower (266 species) than on other Caribbean region reefs, with plankton and invertebrate feeders the most abundant groups. However, these reefs may be important spawning areas for grouper. Other commercial species, like grunts and snappers are much less common. There has been a significant increase in queen and stoplight parrotfish (*Scarus vetula* and *Sparisoma viride*), possibly due to a greater availability of algae after the loss of the long-spined sea urchins in 1983. The Banks are year-round habitats for manta rays, whale sharks, tropical spotted and bottlenose dolphins, and the Banks serve as a winter habitat for hammerhead and silky sharks, and spotted eagle rays. Fishing pressure in the Sanctuary is not intense, but there has been longline fishing near banks since the late 1800s, and it appears that grouper, snapper, jewfish, and other target fish populations have declined.

Juvenile loggerhead sea turtles that live on the East and West Flower Garden Banks have a range of approximately 130km^2, centered on the Banks. Hawksbill and leatherback turtles have also been reported. There are not as many other animals identified as in the Florida Keys e.g. 27 sponge species; 20 polychaete worm species; 667 mollusks; 62 crustaceans; and 36 echinoderms, but figures are likely to increase as more taxonomists visit the Banks.

Puerto Rico

There are 242 reef fish species, but none are endemic to Puerto Rico. The number of fish species is directly related to the amount of live coral cover on shallow reefs, but reef fisheries have plummeted during the last 20 years as a result of over-fishing and reef decline (landings dropped 69% between 1979 and 1990). Total catch and catch per unit effort have declined, fish are now smaller, and there have been failures in recruitment. The loss of herbivores (i.e. parrotfishes) and large predatory fish has stimulated a proliferation of small fish like damselfish (*Stegastes planifrons*). This adds to the problems for the reefs, because these fish bite and kill coral polyps to promote algal growth for their young.

A NOAA fish monitoring program from 2000 has collected fish abundance, distribution, size-class structure, and micro-scale habitat data at more than 1000 sites throughout the US Caribbean (500 sites for St. Croix, 350 for PR, and 200 for St. John). Of particular concern is that among 50,000 fish counted and measured, only 0.6% of these were more than 30cm fork length. Even worse, of the 8,000 snappers, groupers, and grunts counted, less than 0.4% were larger than 30cm fork length. This means that most are below effective breeding size.

Spiny lobster populations are declining due to persistent and increasing fishing pressure, with an unwanted side effect. Coral-eating molluscs, which are a favourite food of the lobsters are increasing and causing more damage to the corals. Populations of the major grazing sea urchin (*Diadema antillarum)* remain at about 10% of their pre-1983 abundance.

U.S. Virgin Islands

There are no new fisheries data since the 2000 Status Report. Habitat losses on the coasts, clearing of mangroves, destruction of seagrass beds and losses of coral cover have all impacted on fish populations. However, the major problem continues to be over-fishing. Regulations exist to protect fish stocks, but these are not enforced and the populations of groupers and snappers continue to decline. Similar to elsewhere in the Caribbean, the excessive use of fish traps continues and many traps are lost and continue 'fishing'. Queen conchs and lobsters were once abundant, but over-fishing and loss of seagrass beds are causing major population declines. This will continue until management reduces fishing effort and prevents losses of critical habitats.

The prominent sea urchins (*Diadema antillarum*) are recovering very slowly around the USVI, but remain at less than 10% of their original levels. Conch populations are decreasing and there is no difference in conch density inside MPAs compared to areas outside. There has also been an apparent decrease in the size and abundance of lobsters e.g. 19.4 per hectare at 89 sites around St. John in 1970, compared to 5 per ha for 4 sites in 1996.

Navassa

Surveys counted 36 to 41 fish species per site around Navassa, with 97-140 fishes per 60m^2. Density of snapper + grouper was 2.5 fish per 60 m^2, whereas surgeonfishes + parrotfishes was 15.9 fish/60m^2. The sign of a reasonably healthy fish population was that 92% of snapper and 23% of parrotfishes were longer than 40cm. These fish, however are attracting more artisinal trap and hook and line fishers from Haiti, which is adding new stresses to Navassa reefs.

Anthopogenic Threats to Coral Reefs

Florida East Coast

There are varied and chronic stresses from this extremely urbanised coast. Dredging for beach renourishment, channel deepening and maintenance have significantly reduced water quality, smothered corals and other invertebrates and lowered productivity e.g. Boca Raton and Sunny Isles. Recreational usage can be extreme especially in warmer months, with clear evidence of fishing gear impact and anchor damage. Shipping from the large ports (Miami, Port Everglades, and Palm Beach) means that ships frequently run aground or anchor on reefs. Ocean outfalls pour large volumes of secondary treated sewage into the coastal waters.

Florida Keys

The major threats to the coral reefs stem from over 4 million annual visitors and 80,000 residents in the Florida Keys. Growth of the population in Monroe County is limited by a rate-of-growth ordinance, and was only 2% between the 1990 and 2000 censuses. Similarly, the number of registered private boats has increased 6 fold since 1965. Most visible damage in the last 20 years has been from direct human impacts such as grounding of boats in coral, seagrasses, or hard bottom areas, breaking and anchor damage, destructive fishing, and divers and snorkellers standing on corals. Boat propellers have permanently damaged over 12,000ha of seagrasses, and over 500 small boat groundings are reported annually in the Florida Keys National Marine Sanctuary. Large ships have been responsible for damaging or destroying over 10ha of coral reef habitat.

Indirect human impacts are significantly affecting the coral reefs with eutrophication in nearshore waters a major problem. Wastewater and stormwater treatment, and solid waste disposal facilities are inadequate in the Keys, but improvements are being made. In

IMO and Flower Gardens Bank

The International Maritime Organisation (IMO) took a historic step in 2000 by creating a new measure under international law for the establishment of 'No Anchoring Areas'. This measure allows any country to request the IMO to designate a 'no anchoring area' where anchoring is hazardous to a ship or could result in unacceptable damage to the marine environment. At the same time, the IMO approved the adoption of 3 mandatory no anchoring areas to protect the fragile coral reefs of Flower Garden Banks National Marine Sanctuary (FGBNMS) and later in the Tortugas. Coral reef communities such as those in the FGBNMS and the Tortugas may take thousands of years to develop, but an anchor can destabilise the reef structure and create loose rubble that causes further damage to sensitive species. Even if conditions for regeneration are optimal, it could take hundreds of years for the reef to return to its former condition. The shipping industry will also benefit from the IMO adoption of 'no anchoring areas', as this measure ensures that all countries produce charts for international navigation with such areas marked clearly. This informs the mariner of potentially hazardous areas, whilst also increasing compliance with the prohibition. 'No anchoring areas' focus on prevention, rather than enforcement and liability for damage to the resources.

The Value of Coral Reefs in the Economy of Florida, USA

Coral reefs in Florida are generating money, but greater conservation measures are required to keep them as major providers for the economy. From June 2000 to May 2001, Southeast Florida residents and visitors spent 18 million days fishing, diving and snorkelling on coral reefs. More time spent on the reef translates into more money spent in the area, as economists reported in a recent study. Fishers need bait and tackle, snorkellers need rental gear, and divers need tanks and pay to go out on boat trips. Reef-related sales like these generated US$2,706 million dollars in four southeast Florida counties (Broward, Miami-Dade, Monroe and Palm Beach). This means that:

- $2,706 million for 365 days – an average of $7.4million is spent each day;
- $2,706 million along 370km of reef – an value of $7.3 million per kilometre of reef;
- $2,706 million for 18 million person days – an average per person of $150.30 per day.

But the coral reef contribution to the local economy doesn't stop there. Local income increases and jobs are created as residents and visitors spend money to participate in reef-related recreation. In one year, a $1,214 million income was generated and 44,500 jobs were created as a result of reef-related sales and activities in the region.

Visitor and resident reef users in Florida are interested in keeping their reefs healthy. Researchers used a 'willingness to pay' study which indicated that locals and tourists in all 4 counties (Broward, Miami-Dade, Monroe and Palm Beach) are willing to pay $255 million per year to maintain reefs (natural and artificial) in southeast Florida in their current condition. Reef users were most concerned about maintaining water quality, limiting damage to reefs from anchoring and preventing the overuse of the reef. Furthermore, about 75 percent of reef-users endorse the idea of placing 'no-take' zones on local reefs. Most respondents suggested that they would support the placement of 'no-take' zones on 20 to 25% of existing coral reefs. From: Grace Johns, Florida USA

Florida Bay, reduced freshwater flow has resulted in plankton bloom increases, sponge and seagrass die-offs, fish kills, and the loss of critical nursery and juvenile habitat for reef species, which affects populations on the offshore coral reefs. Other indirect pressures on reef resources include serial over-fishing that has dramatically altered fish and other animal populations. Fiber optic cables deployed across reefs have smashed corals and sponges. Introduced, competitive species add additional stress e.g. at least 8 marine mollusk, 6 crab, 5 shrimp, 3 barnacle, 4 isopod, and 1 tanaid species have been introduced in the last decade through ship hull fouling or ballast water dumping. Fish introductions come from released aquarium fish; the Indo-Pacific lionfish (*Pterois volitans)* and the Pacific batfish (*Platax orbicularus*) have been observed off the Upper Keys.

Reducing these impacts is critical to sustaining the Florida Keys economy, which is largely based on the coral reefs. South Florida residents and visitors spent 18.2 million person-days fishing, diving, and viewing natural coral reefs from glass-bottom boats, yielding an annual non-market economic use value estimate of nearly US$228 million. This annual value yields an estimate of the asset value of the natural reefs at US$7.6 billion.

Texas Flower Garden Banks

Physical damage from vessel anchoring, potential water quality degradation, impacts of fishing and fishing related activities, and impacts from oil and gas exploration and development are the primary anthropogenic threats to the coral reefs. Anchors from large ships, including foreign-flagged cargo vessels unaware of anchoring restrictions, have caused devastating local impacts. In 2001, the International Maritime Organization designated the Flower Garden Banks as the world's first international no-anchor zone. Recreational scuba diving on the Banks is increasing and poses minor problems e.g. three live-aboard charter dive vessels brought 2,350 divers there in 1997. These divers spent over US$1.7 million in Texas, generating over US$708,000 in income and 35 jobs. There is also slight potential for pollution from the land to the north.

Puerto Rico

The present status of Puerto Rican coral reefs is amongst the most critical in the Caribbean, due to accelerated urban and industrial coastal development during the last 40 years, combined with a lack of effective management of these resources. 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 power plants all cause major stress to coral reefs. Other major anthropogenic activities include oil spills, anchoring of large oil cargo vessels, over-fishing, uncontrolled recreational activities, eutrophication, and military bombing activities (at Vieques and Culebra Islands). The landed value of Puerto Rico's fisheries declined from US$7.7 million in 1996 to US$6.4 million in 2000. The coastal waters are monitored and evaluated for direct human and indirect human health problems.

US Virgin Islands

Chronic stresses like over-fishing (commercial, hand-line, pot fishing, spear fishing, net, long-line, trolling, driftnet), point and non-point source water pollution, and sedimentation act together with natural disturbances to accelerate damage to reefs or slow their rate of recovery. Over-fishing throughout the USVI has had profound effects such that the fisheries are close to collapse. Even those ecosystems within the boundaries of 'marine protected areas' are deteriorating. Existing zoning, erosion control, and fishing regulations are not providing sufficient protection. The present combination of natural and human stresses and the magnitude of their effects may be unprecedented.

Destruction from boats running aground on reefs has been severe. Large vessels (greater than 20m) run aground with surprising regularity on USVI reefs (more than twice a year) and vessels abandoned after recent hurricanes still litter several harbor and reef areas. The worst was the cruise ship Windspirit, which destroyed 283m^2 of reef in 1988, with no recovery 10 years later. Small boats frequently run aground on shallow reefs, destroying corals, particularly elkhorn coral making them more susceptible to storm damage and white band disease. National park staff have installed 211 moorings and over 111 resource protection buoys around St. John to help prevent anchor damage to benthic habitats and the entire southern section of of the MPA is a no-anchor zone. The staff have been monitoring coral recovery around the moorings in several bays for the last 3 years.

While hurricanes break the most corals, chronic coral damage also occurs at areas of high recreational use by snorkellers and divers. Many popular snorkel and dive sites experience heavy visitor use (100-200 visitors/site) on St. Croix when cruise ships are in port e.g. Cane Bay, Davis Bay, Buck Island Reef, Carambola, Protestant Cay and Frederiksted beaches. The intensive use of the underwater trail at Buck Island Reef National Monument shows damage from snorkellers. A mooring system has been installed to limit boats and snorkellers.

Navassa

Fishing is the only anthropogenic threat to Navassa reefs and this is unlikely to change, and 1-4 Haitian boats per day with 3-5 men each were present at Navassa during a March 2000 cruise. They appeared to be non-selective regarding species or size. Increases in technology by these subsistence fishers (e.g. boat motors, ice chests), increasing population pressures, and poor fish resources in Haiti may lead to increased fishing pressure.

Current and Potential Climate Change Impacts

Florida

The principal natural environmental controls in this area are hurricanes, severe storms, winter cold fronts, cold-water upwelling, and ground water effects. The predicted climate change scenario is for warmer waters, rising sea levels, and more frequent and stronger hurricanes. This will probably cause significant changes to the reefs, including more bleaching. Rising sea levels will flood coastal areas and introduce water quality problems. Therefore, management strategies are focusing on alleviating the controllable, human impacts while working toward legislation and policy that will address global emissions in the long-term.

Texas Flower Garden Banks

There are no anticipated problems, as the location and depth of these reefs buffer them from the short-term effects of global warming and climate change. However, if summer water temperatures approach or exceed 30°C on a more consistent basis, the current minor incidences of bleaching will probably increase in severity.

Puerto Rico

Current levels of natural factors (hurricanes, coral bleaching, coral diseases) are resulting in considerable coral reef degradation which may mask any signals from climate change.

U.S. Virgin Islands

Hurricanes David (1979) and Hugo (1989) caused severe destruction on the reefs in the USVI, and recovery has been very slow due to subsequent hurricanes in 1995, 1998 and in late 1999. Any increases in these hurricane events (as predicted by many climate models) will inhibit the recovery of elkhorn coral at some places around St. John, St. Thomas and, St. Croix.

Navassa

There is very little ecological information on Navassa reefs, and hence no basis for assessing trends in current and potential climate change impacts.

Current MPAs and Management Capacity

Florida

The entire Florida Keys reef tract was given some level of protection when the FKNMS was designated in 1990, with oil exploration, mining, and large shipping traffic being excluded. Anchoring on or touching corals in shallow water is prohibited, as is collecting living or dead coral and harvesting 'live rock' for the aquarium trade. Potential pollution sources from outside the Sanctuary that can cause impacts within it can be controlled under existing legislation. After 6 years, a management plan was implemented with strategies for conserving, protecting and managing the significant natural and cultural resources of the Florida Keys environment based on a total ecosystem approach. There are several marine zones to protect specific reef areas more intensely e.g. 23 no-take zones were implemented in 1997, which cover less than 1% of the Sanctuary but protect 65% of shallow coral reef habitats. Most of the smaller zones (Sanctuary Preservation Areas) are on the offshore reef tract in heavily used spur and groove coral formations. The 31km^2 Western Sambo Ecological Reserve protects offshore reefs and mangrove fringes, seagrasses, productive hard bottom communities and patch reefs. The 518km^2 Tortugas Ecological Reserve (far west Florida Keys) was implemented in 2001 and increases the total protection of coral reefs within the Sanctuary to 10%.

Biscayne National Park encompasses an additional 291km^2 of the northern reef tract. Concerns about coastal development, intense use by recreational boaters, and growing fishing pressure prompted the Park managers to revise the General Management Plan. This new plan will include management zones that give greater protection to Park resources, including Natural Resource Reserve areas where fish nurseries and spawning habits will be protected from fishing. The Key West and Great White Heron National Wildlife Refuges, which overlap with portions of the FKNMS, contain over 1,610km^2 of coral reefs and associated habitats. Wildlife management zones in the Refuges direct human activities away from sensitive habitats.

Some protection is given to the reefs off the southeastern coast and the banks of the Middle Grounds through various MPAs, but neither region is comprehensively protected like the Florida Keys. An *Oculina* (a hard, but not 'coral reef' coral) MPA in the far north is managed by the National Marine Fisheries Service (NMFS) to protect these corals from dredging, trawling and long-line fishing gear damage. The Madison-Swanson and Steamboat Lumps Spawning Sites (offshore of the West Florida shelf) were declared in June 2000 to protect spawning aggregations of gag (*Mycteroperca microlepis*), and other reef and pelagic fish species, from fishing activities. Deepwater habitats are also protected from fishing impacts, and closed to all fishing for 4 years to evaluate the effects of fishing on spawning aggregations.

Texas Flower Garden Banks

The Sanctuary protects the fragile ecosystem from anchoring, oil and gas development and destructive fishing. Sanctuary staff direct resource protection, education, research, and enforcement efforts, and there is also a long-term monitoring program. Additional protection is provided by the Minerals Management Service through requirements imposed on industry operators such as the 'Topographic Features Stipulation' for the Flower Garden Banks.

Coral Disease and Health Consortium: Recommendations for Action

Coral diseases have dramatically increased in frequency and distribution over the last decade, leading to unprecedented decreases in live coral and changes to Caribbean coral reefs. The U.S. Coral Reef Task Force has a National Action Plan to Conserve Coral Reefs and formed a Coral Disease and Health Consortium (CDHC) to organise and coordinate scientists in the U.S. and its territories to meet the challenge of declining coral reefs. This Consortium: brings together coral health and disease researchers; identifies research priorities; and encourages a new generation of researchers through education and outreach. The goal is to develop new tools to identify and alleviate hidden stresses to corals before they become serious. The Consortium has 35 partners to tackle the coral reef disease issues within the Coral Conservation Program, which aims to 'to preserve and protect the health of coral reef ecosystems through an understanding of the effects of natural and anthropogenic stressors on reef-building communities'. The Consortium met in January 2002 with experts in coral diseases, biomedical and veterinary sciences, pathology, chemistry, biology, biotechnology, and marine management who determined the priority needs in information, research, and technology to assess diseases. They also aimed to assist managers with suggestions for risk management and strategies for prevention, mitigation, or remediation. The recommendations focussed on the following issues:

- a need for standardisation in terminology and protocols, mechanisms for technology transfer and training, and public education programs. There is no consensus on the names and status of coral diseases. Similarly, results often cannot be compared because there are no standard field and laboratory protocols in different countries. The Consortium recommended that standardised monitoring, assessment, and collection protocols be developed along with reporting standards, and agreed names of diseases. There is a need for standard sample collection procedures and means of transportation of specimens, while acknowledging the risks in shipping disease samples around the world;
- a need for research on the biological and environmental factors that may trigger diseases, and what are the causative agents e.g. viruses, bacteria or fungi. There is a need to examine the mechanisms of coral bleaching, as well as coral disease susceptibility, and defence and resistance mechanisms. Research scientists

Puerto Rico

The Department of Natural and Environmental Resources (DNER) has designated 8 Special Planning Areas (including all mangroves) and 24 coastal and marine natural reserves. No-take zones include the Luis Peña Channel (4.8km^2, est. 1999) and the Desecheo Marine Reserve (6.2km^2, est. 2000). In 2000, the Govenor approved the Jobos National Estuarine Research Reserve Management Plan, a Non-Point Source Implementation Plan, and revised regulations for the protection of coral reefs, fisheries, and related habitats. Benthic habitat maps resulting from monitoring and research activities were generated in 2001 to assist resource managers in planning, and planning of new MPAs. A major 5-year research program is examing the complex links between natural and human stresses and processes, socio-economic factors, and the use of MPAs in should work with resource managers to determine research priorities and how mechanisms for information and technology transfer;

- a need for training of more scientists to recognise and research diseases and also train managers in recognising diseases and in the correct methods of recording symptoms and collecting samples;
- a need to organise and integrate scientific information to guide management strategies when coral diseases break out e.g. it would assist if people used the same names, reporting methods, and field assessments. A centralised database would assist communication between scientists, managers, and divers. Rapid response teams of researchers, managers, dive masters, and recreational divers may be necessary to investigate bleaching and disease events;
- a need to bring all disciplines together e.g. pathology, microbiology, ecology, and toxicology to put the whole picture together, and then link with the public, policy makers, and resource managers to ensure that information is shared. This will require cross-disciplinary training programs and partnerships, and exchanges between experts.

Information on the Consortium is on the website:
www.coral.noaa.gov/coral_disease/cdhc.html

management strategies. Biological and physical data will be integrated into a unified GIS and visualization tool, allowing managers to see and even predict the impacts of their decisions.

U.S. Virgin Islands

Aspects of St. Croix's coral reefs are protected by 6 federal MPAs. Buck Island Reef National Monument (BINM) was established in 1961, expanded in 1975 and 2001, and now covers 71ha of land and 77.7km^2 of submerged lands. In 2001, the entire Monument was declared a no-fishing and no-anchoring zone. Until 2001, most of the BINM was open to extractive uses, including the use of fish traps, cast nets, hook and line, and hand collection of conch and lobster. The National Parks Service has had limited success in controlling illegal fishing due to a lack of law enforcement staff. The Salt River Bay National Historical Park and Ecological Preserve, which is also managed by the NPS, still allows fishing. The Park and Preserve has 160ha of land and 245ha of water to a depth of 91m, and includes the marine resources of the Salt River Bay, Triton and Sugar Bays. In the Mutton Snapper and Red Hind Spawning Aggregation Areas seasonal fishing closures are enforced by NOAA. Finally, 2 St. Croix Restricted Areas (0.01km^2, and 0.4km^2) prohibit anchoring of non-authorized vessels.

In 2001, the NPS established the Virgin Islands Coral Reef National Monument on St. John with most of the 51.4km^2 MPA being a no-take and no-anchor zone, however, the lack of published federal regulations make this MPA unenforceable. The Virgin Islands National Park occupies 56% of the 48km^2 island of St. John and 2,286ha of the surrounding waters. Traditional fishing with traps is allowed in the park, although illegal commercial fishing is occurring. Spear fishing is illegal in all Park waters and Trunk Bay, the site of an underwater trail, is a no-take zone. St. Thomas' Hind Bank Marine Conservation District was started in 1990 as a seasonal federal closure that protected the

Florida Keys Coral Reefs: in Decline, but not Beyond Hope

The coral reefs of the Florida Keys have declined in health and vitality at an incredible rate over the past 20 years. Even the declaration of the Florida Keys National Marine Sanctuary in 1990 as an American underwater treasure has apparently not reversed the decline, but now many government, academic and private partners are collaborating to tackle the complex range of problems. The evidence is clear: long-time residents report that the reefs are disappearing before their eyes; and scientists are documenting the decline and pointing fingers at the causes. The coral reefs of the Florida Keys grow at the northern limits for reef growth, often with severe fluctuations in water temperatures, but they also face an amazing range of human impacts. The evidence for decline comes from unparalleled research and monitoring efforts over these 20 years. The Coral Reef Monitoring Project has shown that 35% of living corals have died on most shallow reefs since 1996. These are not isolated examples, but come from over 120 stations at 43 fixed monitoring sites along the whole reef tract. The decline of the prominent elkhorn coral *(Acropora palmata),* is a stunning example. Elkhorn cover was once dominant on shallow reefs, but has declined by 86%, suggesting that it may be a candidate for endangered species status. The staghorn coral *(Acropora cervicornis)* has declined by more than 300% and the bladed fire coral *(Millepora complanata)* declined by more than 200%. The number of coral species has also declined, with two-thirds of sites reporting missing species, and much of the remaining coral is threatened by disease. The Sanctuary's long-term Water Quality Protection Program has shown that water quality at all sites continues to decline, with increases in nutrient pollution from sewage, agriculture and industry.

Local residents are concerned that their thriving tourism and commercial fishing industries are threatened; the Keys receive more than 3 million visitors each year, with most going snorkelling and scuba diving expecting to see clear water with flourishing, colourful corals and abundant fish populations. These visitors spend US$1.2 billion in Florida. Commercial fishermen land US$70 million worth of seafood every year, and 6 million people call South Florida 'home'. However, these same industries result in damage to the coral reefs. More than 7,000 cesspits, 900 shallow-injection wells and 25,000 septic tanks release nutrients that percolate through the porous rock out to the near-shore waters. Heavy rains also wash animal waste and petroleum pollutants from roads directly into the ocean. Careless tourists run boats aground, cut through seagrass beds or destroy fragile corals. Inexperienced snorkellers break corals by standing on or kicking them, and anchors still damage corals, despite an extensive system of mooring buoys. Key target fish, lobsters and conchs have been reduced below sustainable levels, which disrupt coral reef food chains and clean up mechanisms.

Reduced and channelised freshwater flows into Florida Bay has affected the quantity, quality, timing and distribution of water entering the Bay. Either the quantity of freshwater is limited during droughts, or catastrophic releases occur during storms. This has resulted in increased plankton blooms, and sponge, seagrass and fish kills. But the Bay is a critical nursery and juvenile habitat for many reef species. The Comprehensive Everglades Restoration Plan aims to return freshwater flows back to natural levels by managing activities upstream in the Everglades. A disturbing sign has been the increase in coral diseases, with more than 10 reported so far. Another worrying sign for managers is that increasing warm waters from global climate change is causing coral bleaching and may exacerbate diseases. Coral bleaching in the Florida Keys has increased in frequency and duration over these 20 years, with 1997 and 1998 being the worst on record.

These are the problems facing resource managers for the Florida Keys: to reduce the local, regional and global threats to the valuable resources; while at the same time permitting tourism and fishing industries to continue on or near the reefs, and without undue disruption of agriculture, industry or domestic activities. Wastewater and stormwater treatment must be accelerated and no-take ecological reserves implemented to conserve biodiversity and prevent the collapse of fish stocks. The Western Sambo and Tortugas Ecological Reserves are examples of how no-take areas can conserve and protect Sanctuary marine life. Above all, managers must involve all stakeholders and bring the public along through aggressive education programs and vigilant enforcement of protected areas. If the public support the Sanctuary management plans, including using mooring buoys and marked channels, some stresses can be minimised. In the wider region, it is essential that all people in the catchment understand that the health of the Florida Keys depends on what happens upstream in the Everglades, and in cities and towns. Restoration of natural freshwater flows and effective treatment of wastewaters is essential to reduce nutrient excesses on the reefs. The goals of the managers, and the whole community, are to give the Florida Keys reefs a fighting chance to survive and remains as a heritage for our children. From: Billy Causey and Cheva Heck, Florida Keys National Marine Sanctuary, Billy.Causey@noaa.gov

Red Hind spawning site. In November 1999 the closed area ($41km^2$) was designated a marine reserve with all fishing and anchoring prohibited. Average length of spawning red hind have increased from 29.5cm in 1988 to 38.8cm in 2000, and the number of spawning fish increased from 5 to 25 fish/$100m^2$. The USVI Government has also designated Marine Reserves and Wildlife Sanctuaries (Salt River, Cas Cay/Mangrove Lagoon and St. James) where fishing is allowed only with handlines or for baitfish with a permit (St. James).

Navassa

This island is part of the US Fish and Wildlife Service's Caribbean Islands National Wildlife Refuge. A Comprehensive Conservation Plan for the entire Caribbean Islands Refuge is being developed in 2002.

Government Policies and Legislation

Florida

Management strategies for the FKNMS are largely non-regulatory. Instead, they aim to educate citizens and visitors, use volunteers to build stewardship for marine resources, mark channels and waterways, install and maintain mooring buoys, survey submerged cultural resources, and protect water quality. Five types of marine zones reduce pressures in heavily used areas, protect critical habitats and species, and separate use conflicts. In addition, the International Maritime Organization is designating the FKNMS a Particularly Sensitive Sea Area in 2002. Florida's East coast is not as well served; policies on environmental impacts of dredging, fresh-water management, and nutrient input should receive attention. Vessel anchorages off Miami, Port Everglades and Palm Beach should be reviewed and changed to provide maximum protection for the reef system.

Texas Flower Garden Banks

Regulations governing the FGBNMS under the National Marine Sanctuaries Act, as amended, 16 U.S.C. 1431 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. In 2001 the International Maritime Organization designated the Flower Garden Banks as the world's first international no-anchor zone.

Puerto Rico

Land use policy and development control are proposed by the Planning Board and approved by the Governor. A general policy encourages avoidance of urban sprawl, concentration of industrial development, and agricultural practices that protect soils and avoid adverse impacts, including erosion, on water resources. 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 US EPA in 2000. A 5-year Coral Reef Action Plan written in 1999 guides management, research, and education efforts.

U.S. Virgin Islands

The U.S. Department of Interior, the U.S. Department of Commerce (including NOAA and the Caribbean Fishery Management Council), and the USVI Government all have policies, laws and legislation relating to coral reefs in that area. The Code of Federal Regulations Title 36 and the enabling legislation for Virgin Islands National Park and Buck Island Reef National Monument relate to reefs in the national parks. The Caribbean Fishery Management Council has Reef Fish and Coral Reef Management Plans with regulations pertaining to federal waters. Title 12 of the Virgin Islands Code presents environmental laws and regulations of the Virgin Islands. Several specific Acts relate to regulations on corals, fishing, etc. The Code of Federal Regulations states that commercial fishing is prohibited 'except where specifically authorized by Federal Statutory law'. However, commercial fishing is occurring in the waters of Virgin Islands National Park and Buck Island Reef National Monument.

Navassa

A 12-mile fringe of marine habitat around Navassa (estimated at 134,000ha) is under U.S. Fish and Wildlife management. Refuge policies allow subsistence fishing. A Comprehensive Conservation Plan is being developed.

Gaps in Current Monitoring and Conservation Capacity

In 2001, NOAA and U.S. State agencies developed a nationally coordinated, long-term program to assess species and conditions, monitor trends, and predict changes in U.S. coral reef and related habitats. This program was expanded to include Florida in 2002 and currently supports monitoring in all U.S. States and Territories with coral reefs.

Florida

There is no comprehensive and systematic monitoring program for the reefs of Florida's East Coast, but one is needed to provide a baseline. Site selection should ensure that representative habitats and unique sites are mapped and monitored. This will require that a selection committee of academic, county, state, conservation and fishing groups, and decisions rapidly disseminated for public discussion. The reef fish communities from seagrass and mangrove habitats of Port Everglades and the Intra-coastal Waterway also remain a mystery. Reefs along the southeast coast and Middle Grounds banks should also be mapped.

Current monitoring in the Sanctuary has focused largely on detecting changes in designated no-take zones and establishing the status and trends in corals, seagrasses, and water quality. Such monitoring must continue in the short-term until solid baseline data are obtained. This baseline will assist in detecting possible long-term changes in communities that may result from management practices (e.g. zoning) or from massive restoration efforts soon to be implemented in the south Florida Everglades.

Texas Flower Garden Banks

Recent observations of increased algal abundance highlight the need to improve water quality monitoring and assess currents and water circulation. The monitoring should include studies on algal populations, coral diseases, and extend to deeper coral reef communities. The great distance of the Sanctuary offshore makes surveillance and enforcement more difficult. Currently, the Sanctuary does not own a boat and relies on charter vessels to get to the area. Recent observations are that the Banks may be important spawning areas for several grouper species and this highlights the need to create a marine reserve to protect the biodiversity.

Puerto Rico

New research and monitoring programs in Puerto Rico are filling gaps and providing managers with information on status and trends of the coral reefs. The Coral Reef Ecosystem Study, a major 5-year research program lead by researchers at the University of Puerto Rico and supported by NOAA, started in 2002 to investigate causes of coral reef declines in the Caribbean. The project examines links between natural and human stresses and processes, socio-economic factors, and the use of marine protected areas in development of management strategies, and aims to integrate all data into a unified GIS tool that will help managers predict the outcomes of potential management actions. A cooperative agreement between the DNR and NOAA supports long-term monitoring and additional U.S. Federal grants support graduate student training in monitoring techniques and research on remote sensing of water quality and bottom cover.

U.S. Virgin Islands

Some of the longest data sets on coral reefs in the Caribbean come from a diverse array of ongoing monitoring activities. However, intensive, long-term monitoring has only been conducted at a few sites around St. Croix and St. John, with less information for St. Thomas. Coral reef monitoring needs to be extended to include a wider variety of coral habitats and more sites to provide managers with critical information to enable further protection and preservation of key reef areas. Very little is known of the deeper reefs around the USVI especially in the critical grouper and snapper spawning aggregation sites along the shelf edge. Some of these reefs have exceptionally high coral cover. Little is known about the interactions among reefs, mangroves and seagrass beds and how the losses of mangroves and seagrass beds contributes to the degradation of coral reefs. All agencies involved in coral reef monitoring suffer from a shortage of staff, and enforcement of regulations has been limited.

Navassa

There is no monitoring program nor planned for Navassa reefs, nor to assess the artisinal fisheries. This presents an important chance to assess the impacts of artisanal reef fisheries in the absence of other anthropogenic effects.

Conclusions

Florida

Advances in research and monitoring over the last 2 years reinforce the conclusion that immediate action is needed to curtail declines in coral reef condition throughout Florida. Local communities that are culturally and economically supported by coral reefs must employ management strategies that alleviate controllable human impacts. For example, in Southeastern Florida, the environmental impacts of fisheries, dredging, vessel anchorages, freshwater management, and nutrient input should receive attention to maximise protection to these reefs. Solutions to the wastewater and stormwater problems, habitat degradation, and over-fishing must be pursued in the Florida Keys. Elected officials and policy-makers at the regional level, should work to conserve and protect watersheds, reduce emissions, and decrease energy use. Citizens, elected officials, and MPA managers must work together to improve water quality, minimise physical impacts to corals and seagrasses, employ sustainable fishing practices, reduce pollution and save energy. Strict air pollution standards must be adopted, carbon dioxide emissions reduced, and renewable energy technologies employed to curb global warming trends. International policies on global climate change should be adopted and implemented. Comprehensive coral reef protection will ultimately require both proactive local steps and engaging leaders regionally and globally on climate change issues.

Texas and Flower Garden Banks

Recent data indicate that the Flower Garden Banks may be an important spawning area for several species of grouper. This highlights the importance of implementing no-take reserves to protect the biodiversity of this area.

Puerto Rico

Human pressures on Puerto Rican coral reefs are among the most extreme in the Caribbean. Many of Puerto Rico's near-shore reefs are degraded as a result of decades of accelerated urban and industrial coastal development, and poor implementation of policies designed to protect the reefs. Since the late 1990s, scientists and the Government have made a concerted effort to better understand, protect, and manage the reefs. Environmental Impact Statements are required by local law for development along the shoreline, and have generated quantitative and qualitative studies of reef communities. But these mostly relate to underwater outfalls from regional wastewater treatment plants and discharges from conventional electric power plants. In the last two years, significant progress has been made in mapping, monitoring, and researching the coral reefs of Puerto Rico. Continued U.S. Federal support for these programs should provide managers and policy-makers with the information they need to design and implement effective management plans aimed at reversing coral reef decline.

U.S. Virgin Islands

There is irrefutable evidence that additional regulations, and enhanced enforcement of existing regulations are necessary to reverse serious declines and degradation in the marine resources of the USVI. Resource managers from the local government and the NPS have requested additional marine reserves to protect functional reef ecosystems, to allow their recovery where damage has occurred, and to allow recovery of fish populations. The 2001 expansion of Buck Island sanctuary will close only 7% of the shelf area around St. Croix. Only 3% of the St. Thomas/St. John shelf area is closed and bait fish and line fishing is still allowed. This is less than the 20% goal for no-take protection of reef resources recommended by the U.S. Coral Reef Task Force. More effective enforcement of existing environmental regulations is also needed. Management plans should be developed for all territorially designated Areas of Particular Concern. Environmental education for residents and visitors should be expanded and improved.

Navassa

The presence of a relatively intact Caribbean reef could provide a unique opportunity for research on the ecology of Caribbean reefs to improve understanding and effective management and restoration of reefs in other areas of the Caribbean. Furthermore, it is predicted that fishing effort and reef impacts will escalate at Navassa, therefore the implementation of a rigorous reef and fishery monitoring program would provide critical information on the subsistence fishery and how this impacts on Caribbean reefs.

Author Contacts

Don Catanzaro, U.S. Geological Survey, U.S. Virgin Islands (don_catanzaro@usgs.gov); Billy Causey, Superintendent, FKNMS, (billy.causey@noaa.gov);Joanne Delaney, FKNMS Sanctuary, (Joanne.Delaney@noaa.gov);Ernesto Diaz, Puerto Rico Department of Natural and Environmental Resources (eldiaz@caribe.net);Richard E. Dodge, Director, NCRI, (dodge@ocean.nova.edu);Jorge R. Garcia, University of Puerto Rico, renigar@caribe.net; Walter Jaap, Florida Marine Research Institute (walt.jaap@fwc.state.fl.us);Brian D. Keller, Science Coordinator, FKNMS (brian.keller@noaa.gov);Ruth Kelty, National Centers for Coastal Ocean Science/NOAA (ruth.kelty@noaa.gov);Cruz A. Matos, Puerto RicoMargaret W. Miller, National Marine Fisheries Service Southeast Fisheries Center (margaret.w.miller@noaa.gov)Richard Nemeth, Eastern Caribbean Center, (rnemeth@uvi.edu)

Caroline Rogers, U.S. Geological Survey, U.S. Virgin Islands (caroline_rogers@usgs.gov) George P. Schmahl, Sanctuary Manager, Texas Flower Garden Banks NMS, (george.schmahl@noaa.gov); Richard Spieler, NCRI, (ncri@mako.ocean.nova.edu).; Zandy Hillis-Starr, Buck Island Reef National Monument (Zandy_Hillis-Starr@nps.gov); Marcia Taylor, University of Virgin Islands, (Marcia.Taylor@uvi.edu).

Supporting Documentation

Beets J 919960. The effects of fishing and fish traps on fish assemblages within Virgin Islands National Park and Buck Island Reef National Monument. U.S. National Park Service Technical Report. Washington, DC: U.S. Dept of the Interior. 44pp.

Beets J, Rogers CS (2001). Changes in fishery resources and reef fish assemblages in a marine protected area in the US Virgin Islands: The need for a no-take marine reserve. Proceedings of the 9th International Coral Reef Symposium, October 23-27, 2000. Bali, Indonesia: 281 pp.

Chiappone M, Miller SL, Swanson DW, Ault JS, Smith SG (2001). Comparatively high densities of the long-spined sea urchin in the Dry Tortugas, Florida. Coral Reefs 20: 137-138.

Chiappone M, Swanson DW, Miller SL, Smith SG (2002). Large-scale surveys on the Florida Reef Tract indicate poor recovery of the long-spined sea urchin Diadema antillarum. Coral Reefs 21: 155-159.

Miller SL, Swanson DW, Chiappone M. (2001). Multiple spatial scale assessment of coral reef and hard-bottom community structure in the Florida Keys National Marine Sanctuary. Proceedings of the 9th International Coral Reef Symposium, October 23-27, 2000. Bali, Indonesia.

WHA **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 585,867ha and the environment is characterized 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: National Oceanic and Atmospheric Administration (NOAA) is undertaking 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.

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

Monitoring Effectiveness: 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.

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. Most of the coral reefs around the islands are shallow fringing reefs that run parallel to the coastlines. The Virgin Islands National Park includes 3 individual areas, whereas the Biosphere Reserve, established in 1972, incorporates the entire area.

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. Direct damage by divers and snorkellers has been recorded at heavily used sites. 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.

The U.S. National Park Service supports management of the area as well as research work by the Virgin Islands Resource Management Co-operative (VIRMC). In cooperation with other local institutions and agencies, the Management Cooperative has completed studies within the reserve including ecological and social characterization of local fisheries, and description and mapping of near-shore marine communities. 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.

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 1991, other long-term sites were established around St. John in Newfound and Francis bays. These sites have provided detailed information about the effects of storms and the recovery of reefs from storms and anchor damage.

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

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

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

Dulcie Linton, Robbie Smith, Pedro Alcolado,
Carl Hanson, Peter Edwards, Reynaldo Estrada,
Tatum Fisher, Raul Gomez Fernandez, Francisco Geraldes,
Croy Mccoy, Duncan Vaughan, Vincent Voegeli,
George Warner and Jean Wiener

Abstract

The general pattern is one of continued decline of coral reef resources, although the rate of decline may have slowed. The decline is particularly acute where island shelves are narrow and easily accessible, and where reefs are relatively close to high population areas. Some of the more isolated reefs of the Bahamas, Turks and Caicos and Cuba are still considered relatively healthy. Reefs of the Cayman Islands and Bermuda are generally healthy, although impacts are increasing, while reef systems of the Dominican Republic, Haiti and Jamaica are highly impacted, with low coral cover on most shallow reefs. In most cases, the deterioration of the reefs is related to nutrient and sediment pollution from on-shore sources, such as sewage and agriculture (causing algae to over-grow reefs), disease, over-fishing, anchor damage, destructive fishing (dynamite and bleach) and high diving/snorkeling pressures. All of the countries are dependent on tourism to some extent to support their economies, but in countries such as the Dominican Republic, Haiti and Jamaica, where economic development is heavily dependent on the marine environment, the deterioration of the reef system is greater, due to rapid coastal development and resultant habitat destruction. The situation in these countries is exacerbated by high fishing pressure on coral reef fishes. Where legislation and effective management of marine resources are given fairly high priority (Bahamas, Bermuda, Cayman), some of the negative stresses have been removed and reef systems appear more stable. However, where MPAs have not been declared (Haiti) or where they remain little more than 'paper parks' (Cuba, Dominican Republic and Jamaica) coral reefs continue to be under stress.

Introduction

The Northern Caribbean and Atlantic region contains the 3 largest islands in the Caribbean; Cuba, (110,000 km^2), Hispaniola (divided into Dominican Republic and Haiti; 76,000 km^2) and Jamaica, (10,991 km^2), as well as the small, low islands of Bermuda and Cayman, and the archipelagic islands of the Bahamas and the Turks and Caicos with their extensive banks. Reef systems are well developed in all countries, mostly as fringing reefs along island shelves and offshore banks. The islanders are heavily dependent on coral reef systems for their livelihood, providing major sources of income and resources through tourism, fishing, and coastal protection. Most of the countries have limited opportunities for expanding their economies, therefore tourism has gained increased importance. More than 100 million tourists visit the entire Caribbean region each year, and generate approximately US$140 billion per annum. Fisheries associated with coral reefs also generate significant wealth as they are a major source of food and provide employment to large numbers of individuals.

Geographical Reef Coverage and Extent

The estimated reef extent ranges from the more southern reefs of Jamaica (17°N) in the Caribbean Sea to the most northern reefs of Bermuda (32°N) in the Atlantic Ocean. The reef area ranges from 188km^2 for Bermuda to 2,156km^2 for the Bahamas with its extensive offshore banks.

Bahamas

These comprise 2,750 low, carbonate islands, cays and rocks. This system sits on two large shallow bank systems and covers 11,400km^2, from about 80km off Florida and extending about 970km towards Haiti. The Little Bahama Bank is in the northern Bahamas, and the Great Bahama Bank extends from central to southwestern Bahamas. The remaining islands are small isolated platforms. These shallow seas give the Bahamas its name, from the Spanish 'Baja Mar.' A deep-water basin with depths up to 4,000m separates the bank systems from each other. Reefs cover 1,832km^2 (2.2%) of the Great Bahama Bank and 324km^2 of the Little Bahama Bank. Living coral reefs fringe most of the northern and eastern windward coasts and the bank edges.

Bermuda

There are 150 coral rocks, islets, and islands (with 20 being inhabited) in the Atlantic Ocean, about 920km off the coast of North Carolina. The islands form a narrow chain 35km in length, with a land area of 58km^2. The Bermuda coral reefs are the most northern in the world, with an area of 188km^2, including an off-shore reef (101km^2), a patch reef (70km^2) and 17km^2 of fringing reef. The reefs are divided into 5 major zones: North Terrace; North Rim; South Terrace; South Rim and Lagoon Reefs.

Cayman Islands

These consist of 3 islands: Grand Cayman, 197km^2 and the most populous; Little Cayman, 25km^2 and 145km to the ENE of Grand Cayman; and Cayman Brac 32km^2. The islands are composed of porous limestone rock with no rivers or streams which results in exceptional water visibility around the islands. The shelf surrounding Grand Cayman is narrow, ranging in width from 0.5-2.0km, and the fringing reefs have shallow reef crests, as well as mid-shelf and shelf-edge fore reefs, along with seagrass beds and mangrove fringes.

Cuba

The Cuban archipelago is made up of the Island of Cuba, the Isle of Youth and some 4,195 keys and islets totalling 110,860km^2. It is located at the entrance of the Gulf of Mexico, bathed by the Atlantic Ocean to the North and the Caribbean Sea to the South. It is 77km off Haiti across the Windward Passage; 140km off Jamaica across the Columbus Strait; 180km off the USA across the Florida Straits and 210km off Mexico across the Yucatan Straits. The coral reefs grow along virtually the entire border of the Cuban shelf (>98%)

and extend inshore across broad areas of the shelf. This shelf edge is 2150km long on the north coast and 1816km on the south. Inshore patch reefs are dispersed in the western Gulf of Guanahacabibes and Gulf of Batabanó, and the eastern Gulf of Ana María-Guacanayabo.

Dominican Republic

It has approximately 1,576km of coast including the islands of Saona, Catalina, Beata and the Cayos Siete Hermanos. The coast is characterized by a combination of coralline cliffs and escarpments, rivers, estuaries, beaches and marshlands often associated with lagoons. Reefs border approximately 166km of the coast and mangroves 268km. The continental shelf is generally narrow with a mean width of 7.5km and covers an area of 8,130km^2. The largest expanse of reef (64.2km) is along the north coast in the Montecristi region to the northwest. Most of the coral reefs are fringing reefs, but there are also two barrier reefs, numerous patch reefs, and four large offshore banks. In the eastern and northwestern coasts, broad coastal shallow platforms with barrier reefs are found, while in other places, terrigeneous sediments produce high turbidity that prevents reefs from forming.

Haiti
This is the western part of the island of Hispaniola, with a coastline of 1,500 km, including the offshore islands of La Gonave, La Tortue, Ile-à-Vache and the Cayemites. The north coast is extremely exposed and is bordered by a barrier reef separated from the mainland by a 30m deep channel.

Jamaica
Jamaica is roughly 230km long and 80km wide with an Exclusive Economic Zone 25 times the land area. The estimated length of the coastline is 891 km. The narrow northern shelf is fringed by a system of well-developed reefs, whereas reef development is discontinuous on the much broader southern shelf. Offshore are the Pedro and Morant Banks where there are also coral cays.

Turks and Caicos Islands
The islands consist of two archipelagos. There are 8 large islands and 40 small cays, covering 505km^2 (estimated coastline is 389km). These islands extend over 160km and are distributed across two limestone platforms with the margins ending in 'drop-off' plunging into abyssal depths. The Caicos Bank is the larger platform and covers approximately 8,000km^2. Water depth ranges from a few centimetres along the inland coasts of the Caicos Islands to 20–30m at the top of the drop-off, and clarity is typically good. A wide range of habitats occurs across the Caicos Bank. The margins are dominated by coral, algae and gorgonian communities that grow on hard substrate, while the middle of the bank is typically covered by sparse sea-grass, calcareous green algae and bare oolitic sand. Mangroves grow in fringes along the inland margins of the Caicos Islands, and there are substantial areas of hypersaline mud dominated by halophytic succulents. There are fringing reefs offshore, and shallow patch reefs around all islands and cays. Providenciales though not the largest, is the most developed and has the highest population.

Status of the Coral Reefs

Since the 2000 report, the coral reefs in most countries have not deteriorated any further. A notable exception is in Haiti where the general decline continues unabated as economic conditions worsen and the environment is exploited further. Some sites have reported stable coral reef cover, with values similar to or slightly higher than AGRRA surveys done 2-3 years ago. There are some reports that the urchin (*Diadema antillarum*) populations are slowly increasing and there are signs of increasing coral recruitment. Incidences of bleaching have been low in 2001-2002, with most corals recovering. While coral diseases have been observed at most sites, incidences have remained low and no major outbreaks have been reported.

Bahamas
Coral reefs have declined in waters of the more developed and populated islands, but are generally in good condition, especially on isolated offshore banks. Relatively isolated reefs of the less developed islands (Abacos, Andros, Bimini, Eleuthera, Cat Island, Long Island, the Exumas etc.) are still considered to be very healthy with high percent cover by hard corals as well as high densities of fish. Andros Island is the largest but one of the least populated islands of the Bahamas, with the third largest barrier reef system in the world (229 km). Surveys by the Atlantic and Gulf Rapid Reef Assessment (AGRRA) program and

the University of Miami, identified a total of 18 species of major reef building corals throughout all sites, with elkhorn coral *Acropora palmata* the most abundant in shallow areas (3m) and boulder star coral *Montastrea annularis* most abundant in deeper waters (10m). Coral colony frequency and coral cover was generally high at both depth zones surveyed and coral mortality was low to moderate. Sites in North and Central Andros seem to be healthiest based on lower coral mortality, lower abundance of macroalgae and higher abundance and diversity of fish. The reefs are considered to be in good condition overall, probably because of low levels of human impacts. Some areas to the south however, show obvious anthropogenic impacts, with high algal cover, a likely result of inadequate waste treatment and fertilizer runoff, and lower fish abundance and diversity probably due to greater fishing pressure. Coral disease, particularly white band disease of the main *Acropora* species, has been widespread. Coral reef decline is more pronounced where they are in close proximity to development, on the islands of New Providence and San Salvador. At San Salvador, monitoring by the Caribbean Coastal Marine Productivity Program (CARICOMP) since 1994 shows a change in coral cover at 10m depth of 9.6% to 4% in 2001, while macroalgae predominates (~40%).

Bermuda

There has been little change in reef status since 2000. Reefs are still fairly healthy with few declines in coral cover since the early 90s, and corals are relatively free from disease and bleaching. Average coral cover is 30-35% and as high as 50% on the outer terrace, but only about 9% on inshore reefs. Coral cover at the CARICOMP monitoring sites have remained relatively stable over 9 years, changing from 23% in 1993 to 18% in 2001.

Cayman Island

Coral reefs are generally in good condition, although the reefs of Little and Grand Cayman vary considerably. AGRRA surveys in 1999 showed coral cover ranges of 14.7 to 37.7% for Little Cayman, and 12.7 to 24.3% for Grand Cayman. Lower values are possibly due to increased impacts from coastal development and water pollution. Little Cayman is more remote and relatively undeveloped and less likely to be impacted. Data from the Department of Environment, Protection and Conservation Unit show coral cover on six reefs at 8 - 33 m in Little Cayman declining from an average of 22.2% in 1997 to an average of 19% in 1999 and 16% in 2001. On Grand Cayman average coral cover declined from 25.6% (ranges 13.8 to 35%) at 9 sites in 1997, to 15.7% in 2001. Coral cover on Cayman Brac averaged 15.6% in 2000. *Acropora* species have been severely damaged by white-band disease, although isolated healthy stands exist. Most reefs have recovered from the 1998 bleaching event, with corals that had partial mortality growing back over the dead surfaces, but in some cases corals have not recovered.

Cuba

These reefs are among the best in the Caribbean, probably due to minimal coastal development on the north and south coasts and the fact that many reefs are offshore and outside the influence of land-based sources of pollution. Southern Cuba's coral archipelagos including Los Canarreos Archipelago through Punta Guanahacabibes, and Archipélago Jardines de la Reina ('Gardens of the Queen') are healthy, and considered among the least damaged areas of the Caribbean. This area has high biodiversity (45 coral species, 23 gorgonians, 137 sponges, 212 polychaetes, 108 molluscs, 63 crabs, 28

Rackhams Cay, Jamaica – Dredging and Relocation of Corals

Port Bustamante, the main Trans-shipment Terminal for Kingston, Jamaica was expanded to take more and larger ships by dredging the turning basins, ship channel and approaches to the harbour. This was going to damage the corals on Rackhams Cay just outside the Harbour. The Cay consists of a semi submerged sand bar, extensive seagrass beds on the margins and corals growing on the steeper exposed slopes, before the muddy bottom at 20m depth. Fishermen collect bait (silversides or white fry, juvenile sprats and herring) for their major trolling and hook and line fishery from around Rackhams Cay. An Environmental Impact Assessment recommended that the Port Authority of Jamaica relocate many of the living corals and employed DiveTech, a local commercial diving company. They relocated 60,000 lumps of reef organisms, including corals, gorgonians and urchins to the western side of Rackhams Cay, in April 2002. Large and small coral colonies were moved underwater and cemented to existing patch reefs and seagrass beds. These included large intact colonies of elkhorn coral (Acropora palmata), which were cemented to the bottom or to concrete blocks. This was the largest relocation attempt in Jamaica, and the site is being monitored to evaluate the effectiveness of the methods and as a guide for similar restoration projects. Preliminary data show many relocated corals are apparently healthy, however others look less healthy, mainly because they are not stable in the relocated positions.

ascidians, 8 urchins, 278 fishes). It has the largest and most diverse shelf habitats in the insular Caribbean (barrier and patch reefs, islands, mangroves forests (extensive in Zapata Swamp) and extensive sea grass beds. It includes several reef fish spawning sites, and predatory fish such as the Nassau grouper and the Goliath grouper. However, there is some threat from unregulated fishing.

Coral cover data are sketchy, however signs of decline are evident near large population centres such as Havana where highly polluted waters are damaging about 3% of the shelf edge reefs. For example, the CARICOMP sites at 10m depth on Cayo Coco averages 6% coral cover. Reefs at Herradura (31% coral cover), west of Havana, and in the Archipelago de los Canarreos appear to be in good condition. Nutrient enrichment has caused overgrowth by algae and coral diseases (white band, yellow band and aspergillosis) have caused some coral mortality, and in late 2000 and early 2001, there was a massive outbreak of white plague disease on corals near Havana. There was intense coral bleaching in 1998, but recovery was widespread. Reefs of the southwest are more impacted but live coral cover is still moderate.

Dominican Republic

The situation has not improved since 2000. Near-shore reefs continue to be severely impacted by anthropogenic activities that include sedimentation from deforestation, coastal development and dredging, pollution from agricultural and industrial development and untreated wastewater discharge, and over-fishing. Data from the CARICOMP site at El Penõn in the Parque del Este (a MPA) at 10m depth indicate a decline from 20% average coral cover in 1996, to 11% in 2001. Generally, higher coral cover is found only on deep or offshore reefs that are less impacted by anthropogenic effects. These include the Montecristi barrier reef and the Silver Banks with mean coral cover approximating 40-50%.

Haiti

There is virtually no monitoring due to the political impasse between the Haitian government and the international community about funding activities, including environmental activities. Presumably the reefs have suffered from the recent Caribbean-wide mortalities from coral bleaching and disease, as well as the effects of extreme deforestation, over-fishing and local pollution. Over-fishing continues unchecked and the lack of herbivores means macroalgal growth is not controlled and smothers corals. There is obvious damage from urban runoff from Port-au-Prince.

Jamaica

The reefs continue to show symptoms of stress. Low coral cover and dominance by macroalgae is clearly evident, particularly on shallow reefs, where coral cover ranges from 2 - 20%. However, deeper reefs are in better condition. A CARICOMP monitoring site in Discovery Bay at 8m, shows a slight increase in coral cover from 9% to 12-14% in 10 years. Parallel ReefCheck surveys suggest slightly higher cover. Densities of the sea urchin (*Diadema antillarum*) increased until 1999, but have since declined. There are, however, encouraging signs of some recovery, with good coral recruitment on shallow reefs. In the Negril Marine Park, reefs have remained stable over the past 5 years and are generally in poor condition. Recovery is impeded by seasonal storms, constant fishing (including spear fishing, pot fishing and seine net fishing), heavy algal cover, frequent diving and snorkelling by tourists and locals, and sedimentation. The biggest problem is eutrophication and data from the Negril Coral Reef Preservation Society (NCRPS) confirm that macroalgal biomass on the reefs in Negril is at critical levels, particularly on reefs near the mouth of the South Negril River. Sewage and land run-off carrying agricultural fertilisers contribute to high nutrient loadings around Negril. Live coral cover remains low, between 5 and 12% in 2000 as does coral recruitment. There are, however, some reefs outside most of the coastal stresses that are in reasonably good condition. Reef Check surveys in Bloody Bay Negril suggest 30-40% coral cover, with many healthy gorgonians, but very few fish were seen confirming that over-fishing continues to be a major problem. Beach erosion in Negril continues without any immediate solution, and in future, the rapid deterioration of the reefs in the Negril Marine Park may reduce their ability to protect the shoreline from erosion.

South coast reefs, particularly those near high population centres, are similarly stressed e.g. coral cover near Kingston Harbour varied from 7.3% at South East Cay to 21.4% at Rackhams Cay (average 15%). Density of coral recruits ranged from 1 to 6.4 individuals per m^2, and the incidence of coral bleaching was 1.9 to 16.7%. There were signs of slow recovery of *Diadema antillarum* populations. Reefs around the offshore islands in the Portland Bight Protected Area are in better condition, though impacted by siltation and some algal overgrowth. Visual estimates of coral cover at Pigeon Island in 2001 and 2002 were >20% and coral recruits of different species e.g. *Agaricia, Siderastrea* and *Acropora (cervicornis)* were observed. There were low levels of disease (1.4%) and bleaching (1.4%). Again, fishes were small and scarce with no large predators. The offshore reefs at the Morant and Pedro Cays are relatively inaccessible and less impacted than inshore reefs, but there are no recent data.

Turks and Caicos Islands

These reefs are similar to those of the Bahamas with a deep fore-reef dominated by gorgonians and boulder coral *Montastrea annularis*. Green algae are abundant on the fore reef, especially *Laurencia, Microdictyon* and *Lobophora*. The majority of the coral reefs are still healthy, with diverse and abundant corals. Adverse human activity is slight with the major damage to fore-reef corals coming from intense dive tourism, especially near Providenciales, West Caicos and the western drop-off on Grand Turk. Massive construction on East and South Caicos with direct destruction of reef habitat, and increased sedimentation, is threatening the reefs. It is unlikely that conservation measures and enforcement will be able to keep up with the likely negative impacts of these activities, unless additional resources are diverted to the protection and enhancement of the marine resources.

There is intense fishing for lobster on the large patch reefs in the shallow, sheltered waters of the Turks and Caicos Banks, but the direct impacts are relatively limited, although chlorine bleach is sometimes used. Most of the Caicos Bank is covered by sand, algae, and sea-grasses, and is an important nursery ground for conch and lobster, but threats are minimal. The reefs have changed little since AGRRA surveys in 1999 and levels of coral mortality remain low, while coral diversity and cover remain relatively high (>30% at several locations). The School for Field Studies, Centre for Marine Resources Studies showed average coral cover of 18% (range 8-33%) on South Caicos in 1999 Coral disease and bleaching are rare, and a wide variety of target fish species, such as groupers is evident. There are low levels of bleaching in South Caicos.

Status of Coral Reef Fisheries

For many countries coral reef fisheries are extremely important in socio-economic terms, providing valuable employment and food for local consumption as well as to support the tourism industry. Exports of main species such as the spiny lobster and queen conch provide valuable foreign exchange for countries such as Jamaica, Bahamas and Turks and Caicos.

Many coral reef food fishes aggregate in large numbers at specific locations, seasons and moon phases in order to spawn. Such fishes include groupers, snappers, jacks, mullets, bonefish and others. A variety of such species will often spawn at common sites. These aggregations are prime targets for fishers, who often take large catches from them. In consequence, a number of them have been wiped out, along with the fisheries they supported. In the western Atlantic, grouper aggregations with a known history of heavy fishing pressure include Bermuda, Cayman and the Dominican Republic.

Bahamas

The fisheries sector contributed 2.3- 2.5% of GDP to the Bahamian economy between 1994 and 1996 (similar to insurance, and more than banking). Most are in New Providence, however the lobster fishery is particularly important in Eleuthera and Abaco. The 1995 Fisheries Census lists 4,050 Bahamian commercial fishing vessels employing 9,300 fishermen (6.8% of the workforce). The most valuable fisheries are lobster, conch, grouper, snapper, and jacks. Fisheries exports were US$74.1 million in 1999 (95% was lobster) and Bahamian landings of lobster are 4th in the world (after Australia, Brazil and

Cuba). There is an 8 month lobster season - August to March 31. Populations of grouper and conch show clear evidence of over-fishing, and action is essential to prevent the possible collapse of these populations, e.g. by establishing a closed season to prevent the depletion of Nassau grouper spawning aggregations. The Government of the Bahamas has developed a system of fisheries reserves, declaring 6 areas for the protection of lobster, conch and Nassau Grouper. The government has a commitment to the sustainable and profitable use of Bahamian marine resources, with a goal of promoting under-used seafood products. There are shrimp hatcheries in Nassau, and on Grand Bahama Island.

Bermuda
Surveys by the Bermuda Biological Station for Research (BBSR) indicate that reef fish populations are showing slow signs of increase, especially scarids, acanthurids and some serranids, such as the Black Grouper, suggesting that more time is required for recovery from over-fishing.

Cayman Islands
AGRRA and the Reef Environmental Education Foundation surveys from 1994 to 2001 showed relatively diverse and abundant fish populations on the Caymans. This richness probably results from high habitat diversity, a significant (34%) area of coastal reserves, and generally healthy reefs. There were 276 fish species recorded in these surveys. There is more fishing pressure on Grand Cayman than on Little Cayman, reflected by more and larger groupers, parrotfishes and snappers as well as more frequent sightings of large groupers on Little Cayman. The average abundance of most fishes was higher on Little Cayman, suggesting that coastal development and water pollution may effect fish communities on Grand Cayman. Five spawning aggregation sites of the Nassau grouper were heavily harvested during 2002 on Grand Cayman, and 4 have been depleted. Fish pots (Antillean Z-traps) represent the biggest threat to fish populations, and 500 locals hold licenses to use spear-guns with a snorkel.

Cuba
The coral reef fishery is probably in better condition than other Caribbean countries (higher species richness, biomass and average size), with about 40% of the total commercial catch coming from the reefs. The lobster export is worth US$100 million annually, however, recent declines in the catch of most species are attributed to over-fishing and the use of inappropriate fishing gear e.g. nets and heavy fishing of spawning aggregations. Commercial catches of the Nassau grouper have declined.

Dominican Republic
Artisanal over-fishing is one of the major problems affecting the recovery of the Dominican reefs, with all commercially important species depleted. There is also harvesting of black corals, hermit crabs, ornamental reef fishes, starfish, sea urchins etc. for the souvenir industry. In some cases chemical poisons such as bleach are used, which affect the corals and other non-target species.

Haiti
There is a complete disregard for fishing regulations, due to the extensive poverty. All areas are subject to strong fishing pressures from spear fishing, use of hookah, light

fishing at night, and the use of poisons (chlorine) to catch fish. All of these activities are illegal, but there is zero law enforcement capacity. Severe over-fishing of the queen conch has seriously threatened stocks, and aquarium fishing is also increasing.

Jamaica

Inshore fishery activity is carried out on the island shelf and the nine adjacent banks >64-km from the mainland. The south shelf has a maximum width of approximately 24km, while the north coastal shelf is much narrower and does not exceed 1.5km in width at any point. The island shelf is approximately 1,853km^2 in area.

Most of the fishery is artisanal. There were about 20,000 fishermen in 1997, with a total landing of 7,747 tonnes valued at US$43 million. Most of the catch comes from the south coast, and coral reef fishes form the highest proportion of the catch (4,476 tonnes in 1997). Most fish are caught in Z-shaped Antillean fish pots, along with gill and seine nets, hook and line and spear guns. There has been illegal, unregulated and unreported fishing by outsiders, particularly for conch, on the offshore fishing grounds such as the Pedro Bank. The Fisheries Division of the Ministry of Agriculture and the Jamaican coastguard, have seized vessels and arrested offending fishermen to deter this poaching.

Overfishing has been evident on Jamaican reefs for many years, with the target species like snappers and groupers being scarce and small. AGRRA surveys of the north coast in August 2000 showed that these species were found in densities from 0.1-0.3 per 100m^2 for snappers and 0.6-1.4 for groupers. These findings were confirmed in late 2001 by the Centre for Marine Sciences and the Coastal Water Improvement Project (CWIP - USAID/GOJ) in catches in the Ocho Rios Marine Park. Low-value species dominated the catch, with nearly half the catch made up of parrotfish (36%) and surgeonfish (12%), regarded elsewhere in the Caribbean as 'trash' fish. Most of the fish caught were well below maximum size (growth overfishing) and close to the size at maturity (risking recruitment overfishing: there are few large snapper and grouper on Jamaican reefs). Suggestions for better management of the fishery include phasing out of traps with small mesh sizes, reducing the total number of traps and enforcing 'no-take' zones in protected areas.

Turks and Caicos Islands

These reefs are presently in a relatively healthy state; there is low exploitation of reef fishes, fishing pressure on herbivores is almost non-existent, and nutrient pollution is low. Lobster and conch fisheries generate the only national exports with most of the product going to the USA. There were 6 processing plants for 727,000kg of conch and 410,000kg of lobster in 2001-2002. Conch is managed through a quota and a closed season, and all exports must have a CITES permit from the Department of Environment. Lobster is managed through a closed season. Annual Queen conch landings are quite variable and their size has decreased over time. Now most come from more distant and deeper waters, suggesting that stocks are declining. New fisheries legislation has been enacted to control harvest rates to conserve stocks by regulating size limits, equipment used, and closed seasons as well as issuing fishery licenses and export quotas. There are concerns over poaching by foreign (mostly from Haiti and Dominican Republic) fishermen using illegal methods. Declines in lobster and conch populations are causing some fishermen to turn to reef fish as an alternative resource, which may change the fishery situation. There are no minimum or maximum size limits or quotas for fishes, but landings are small and mostly consumed locally. There are 4 trap boats fishing for lobster and fishes, and only 2 boats operating in deep water; all other fishing is done by free diving from small boats. Hotels and restaurants are increasing the local demand, and AGRRA surveys show high fish diversity with no differences in population or abundance inside or outside the reserves. Grouper were abundant and relatively large in size. There is no evidence of over-fishing throughout the islands.

Anthropogenic Threats to Coral Reef Biodiversity

In the **Bahamas**, the predominant stresses to corals are sewage runoff and tourism impacts such as diver damage to corals and destruction of coastal habitats for hotel and marina development. San Salvador Island on the Great Bahama Bank is being damaged through sport diving, subsistence and sport fishing, and increased tourism and development. More than 4 million tourists visited the Bahamas in 2000 and tourism provides an estimated 60% of GDP and employs approximately 50% of the Bahamian workforce. Most of Bahamas' population of 350,000 is in Nassau, Marsh Harbour and Freeport, predominantly associated with the tourist industry. This has resulted in rapid degradation of these coastal waters and coastal habitat destruction e.g. mangroves are often cleared for development. There is also over-exploitation of fishes, lobsters, conch and other target species.

Bermuda has one of the highest population densities in the world e.g. 63,500 in 58km^2. Virtually all available land has been developed and the coral reefs are under threat from coastal development, contaminated run-off, sewage and industrial wastes. The inshore lagoons receive nutrients from agriculture and sewage run-off and groundwater seepage. Sewage pollution is limited, however, by good flushing rates. The tourism industry accounts for about 28% of GDP, with the reefs a focus for diving tourists. There is some damage through poor diving practices, and anchor damage in the best locations.

The resident population of the **Cayman Islands** is about 37,000, but total tourist arrivals exceed 1.4 million each year, accounting for about 70% of GDP. Rapid tourism growth is resulting in dredging of wetlands, but the 2 outer islands have escaped much of this, due to their remote location. Tourism-related developments have resulted in damage to the reefs including habitat destruction, increased suspended sediment loads from dredging and mangrove removal, sewage, oil pollution, and destruction by cruise ship anchors and anchor chains.

In **Cuba**, about half of the shelf edge reefs are separated from the land by broad shallow lagoons and this protects the reefs and cays from most of the anthropogenic pressures. Threats to reefs of the southern archipelagos are currently low, however, tourism is growing rapidly with 1.8 million visitors in 2001, generating $US1.9 billion in gross revenues. While tourism expenditures generate considerable foreign exchange, the associated development is causing environmental damage along the coast, including prime habitats for endangered species. In addition to habitat destruction, there is increased pollution from sewage, agricultural run-off and chemical contamination of reefs near high population centers (Cuba's resident population is approximately 11.2 million).

There is also relatively high fishing pressure on fish resources in most areas. Unregulated fishing has reduced reef fish populations, and illegal harvesting of black corals continues. Reef dive tourism is not well managed with considerable anchor and diver damage in the intensely visited locations.

The major problem in the **Dominican Republic** occurs through increasing human populations (estimated >9 million), economic development with associated sedimentation, sewage and other terrestrial pollution from agriculture, mining, industry, shipping and tourism. Large areas of the coast have been destroyed for tourism, including reconditioning of beaches, which causes more sediment damage. The development of transhipment ports will result in more reef destruction. Over-fishing of reef resources continues to be a major problem.

Similarly on **Haiti**, populations are growing (estimated 8.2 million) with few economic alternatives other than artisanal activities. There are increasing threats from road construction, sedimentation from deforestation and soil erosion, pollution and over-fishing, especially near Port-au-Prince. Illegal exploitation of corals for export under the guise of 'harvesting live rock' is increasing, with apparent indifference by government officials. Similarly officials ignore destruction of coral reefs for private boat access.

The population of **Jamaica** has been estimated at 2.6 million (2002). Where coastal development is concentrated due to tourism or high local populations, threats to reefs are highest. Continued threats to reefs include pollution from farming and sewage, sedimentation from soil erosion due to deforestation, and habitat destruction to accommodate development. The nearshore reefs on the north coast are all severely overfished and increasingly impacted by the activities of 1.5 million tourists per year. Rapid growth and new industrial development have resulted in more terrestrial runoff and dredging of reefs for ports outside of Kingston Harbour (See Box).

On the **Turks and Caicos** Islands, tourism development is increasing rapidly (120,898 in 1999 to 151,372 in 2000) threatening the relatively healthy reef system, particularly the remote cays where tourists dive. The major threats to the reefs around Providenciales are pollution from sewage and anti-fouling paints in marinas, coastal development, fish processing plants, conch aquaculture, coral breakage by divers and anchors, boat groundings and construction of tourism infrastructure. Several large developments and the likely introduction of cruise ships to Providenciales, Grand Turk, West Caicos, East Caicos and South Caicos threaten the viability of the National Parks, Nature Reserves and Sanctuaries adjacent to these areas. Fishing pressures are substantial in limited areas, in particular in the South Caicos, Grand Turk and Providenciales region.

Potential Climate Change Impacts and Responses

One of the major indications of climate change is the increase in sea surface temperatures and the increases in coral bleaching events throughout the world. The Caribbean region has experienced significant coral bleaching events in the past 2 decades and more are anticipated as sea surface temperatures continue to rise. Since the major coral bleaching event of 1998 there have been no significant bleaching events in the Caribbean, but predictions are for increases in the number and intensity of such events. With more intense bleaching events the possibility of permanent damage to reefs increases. Coral reefs protect coastlines from storm damage, erosion and flooding by reducing wave action approaching a coastline. The protection they offer also enables the formation of associated ecosystems (e.g. sea grass beds and mangroves) and allows the development of essential habitats, fisheries and livelihoods. The cost of losing coral reefs would run into the 100s of billions of dollars each year. The estimated cost of losing 58% of the world's coral reefs has been given at US$140 billion per annum in lost tourism alone. Predicted sea-level rises could cause severe erosion of beaches and losses of mangroves, particularly as populations of the major shallow-water reef building coral, *Acropora palmata*, have been markedly reduced due to diseases. Beach erosion is already a problem in the Negril area of Jamaica. Low coastal towns will suffer and damage to the predominantly coral islands of Bahamas and Turks and Caicos is likely. While the low island countries of Bahamas, Bermuda, Cayman Islands and Turks and Caicos are more vulnerable to the effects of rising sea level, the high islands will also be vulnerable, as most have very high levels of coastal development, with the majority of the population concentrated in the coastal zone.

Coral reefs that are in good condition and are suffering from fewer anthropogenic impacts (land-based sources of pollution, physical damage, overfishing etc.) are more likely to recover from coral bleaching. Conditions should be created to maximise the potential for resilience and recovery of coral reefs. Creating and managing MPAs effectively, reducing land-based sources of pollution, creating 'no-take' zones or fish sanctuaries and reducing physical damage to reefs from tourism-related activities are some measures that have been shown to improve coral reef condition.

Caribbean Planning for Adaptation to Climate Change (CPACC) is the regional organisation that has been responding to the issues of global climate change. As well, many national governments are exploring the issues associated with global climate change and are conducting vulnerability assessment, safety and security of water resources as well as planning for adaptation to these predicted changes.

Marine Protected Areas (MPAs) and Management Capacity

A survey by a UK resource management company (MRAG Ltd.), in association with the Natural Resource Management Programme of the University of the West Indies (Barbados) and the Caribbean Natural Resources Institute (CANARI) identified 75 MPAs in 17 island countries and territories of the Lesser Antillean and Central Caribbean, as well as Belize and the Turks and Caicos Islands. All countries and territories have at least one MPA with the exception of Haiti (one proposed in the 1990s but never established).

Management varies from reasonably strong in the Caymans, Bermuda and the Bahamas, to weak management in Cuba, The Dominican Republic, Jamaica and Turks and Caicos. Less than half of the region's MPAs have more than a low level of management and approximately 25% have no management at all. In most cases the level of management seems to be related directly to the availability of financial resources. Most of the MPAs cited as having high levels of management, functional user fee systems were used to cover all or most management costs (e.g. Cayman Islands marine park system). Importantly, user fee systems were found to be appropriate or effective only in areas where there is a high level of water-based tourism use. The issue of user fees continues to be a major issue delaying the start up and continuation of effective management in MPAs in Cuba, The Dominican Republic, Jamaica and Turks and Caicos, where management capacity is relatively high, but the critical limiting factor is funding. Thus most of the declared and proposed MPAs remain essentially 'paper parks'.

Bahamas

The Bahamas National Trust, established in 1959 as a statutory, non-governmental, self-funded organisation, manages the system of national parks and reserves in the Bahamas. Evidence that the reserves are working is seen in the Exuma Cays Land & Sea Park no-take fisheries replenishment area, which supports a 31 times greater concentration of conch than outside the park. Spillover effects have been shown with the park providing several million conchs per year to outside areas. Grouper tagged in the park have been caught as far as 240km away, and tagged lobsters replenish Cat Island, which is 110km away. These successes encouraged the Bahamas Government in 2000 to increase the size of protected areas by 20%, with the boundaries extending seaward to 200m. The Government also increased the number of no-take reserves to 6, covering roughly 4% (800 km^2) of the country's marine environment, with the creation of 5 new no-take areas (North Bimini, the Berry Islands, South Eleuthera, the Exuma Cays, and the Northern Abaco Cays). In April 2002, 10 new national parks (total 22) were established doubling the national park system and including large expanses of wetlands, barrier reefs, forests, critical breeding and nesting sites, and sites important to science and recreation.

Bermuda

Bermuda has some of the oldest MPAs (established since 1966), and protection and conservation of resources are relatively strong, particularly of coral reefs and fish resources. A study on the effect of MPAs on reef fish populations will conclude later this year. The establishment of 29 new protected areas (in open water) in 2000, along with the original MPAs, essentially encompasses the island chain. The following areas are included: Cristobal Colon, North East Breaker, Taunten, Aristo, Mills Breaker, Pelinaion & Rita Zovetto. A new Biodiversity initiative will hopefully result in further research on reefs; restructuring of the Ministry of the Environment will help drive this project forward. A large-scale digital reef map is being created by the Bermuda Aquarium Museum and Zoo that will form the basis of a reef GIS. New research on genomics in the reef and ecotoxicology of reef organisms is developing at the Bermuda Biological Station for Research.

Following concerns on the decline of fisheries, the government created 3 seasonally protected and 29 permanently protected fisheries reserves in the 1970s. In 1990, the government banned commercial fish traps, but by then the Nassau grouper was commercially extinct in their waters. All fish traps are now abolished and there is greater awareness of the consequences of over fishing, such that the reef fisheries have a good chance of recovery. The Ministry of the Environment sets minimum sizes for allowable species with the aim of preserving younger fish stocks. Some species have been added to the Protected Species Order and cannot be taken at all. They include the gag grouper (fine scale), Nassau grouper, red grouper, deer hamlet, green hamlet, mutton hamlet, and the tiger rockfish. Fishermen are allowed to take only one black or monkey rockfish a day and a daily bag limit of 30 fish a day has been set for silk snappers, for sport fishermen only. Changes to fish measurements restrict catches to larger, more mature fish which have had a chance to breed. These, with their minimum new sizes for allowable catches, are the black rockfish (30 inches); monkey rockfish (20 inches); red hind (14 inches); hog fish (14 inches); yellowtail snapper (12 inches); and silk snapper (10 inches).

Cayman Islands

Marine conservation laws are strict. The law designates four special areas for protection: marine park zones, replenishment zones, environmental zones, and no-diving zones.

In marine park zones it is illegal to take any marine life, alive or dead, except by line fishing from the shore or beyond the drop-off. Anchoring is permitted only at fixed moorings installed by the Department of Environment's Protection and Conservation unit. A comprehensive reef management program has been implemented and 257 permanent mooring buoys established throughout the 3 islands to prevent anchor damage and spread divers into less-frequented areas. Standards have been set for watersports operators, and snorkelling is now promoted more heavily to counter the negative effects of diving.

Reefs in marine park and replenishment zone areas are protected from fish traps, spearguns, anchoring, and line fishing although line fishing from shore and beyond the drop-off (shelf edge) is allowed. Lobster and conch are protected in the replenishment zones. Spear guns, pole spears, fish traps, and fish nets are also prohibited in these regions; only line fishing is allowed. Anchoring is permitted.

Environmental zones receive some of the strictest protection under the law. Here, no marine life may be taken or disturbed; anchoring is prohibited, as are all activities in the water. Part of the North Sound on Grand Cayman is covered by these stringent rules in order to protect breeding areas for fish and other marine life.

No-diving zones were created to protect the cultural heritage as well as the environment of the Cayman Islands. This designation marks a region as off-limits for scuba diving to protect the waters for traditional Cayman fishing. These special zones have been established off the north coast of Grand Cayman.

Cuba

There is increasing government will to protect, assess and monitor coral reefs despite current economic constraints. The Government passed a new decree establishing a legal framework for a National System of Protected Areas in 1999, including different protected area management categories, establishment and protection measures, and regulation of permissible activities. Extensive coral reef habitats are included in the new MPAs, fishery reserves, and no-take areas were declared and proposed. There is expertise for management and monitoring, but not enough funding for effective management and enforcement of legislation. Mooring buoys have been deployed at popular dive sites but many more are needed.

Dominican Republic
The most damaging activities are prohibited or regulated under existing Environmental Laws, but there is no financial support to implement these laws, educate the public, or enforce compliance. Therefore environmental protection and management is given low priority and intense fishing continues. Tourism may prove to be the best management mechanism and some coastal resorts have adopted reef areas close to their sites for conservation (e.g. installed fish attraction devices to assist the local fishermen). The Government, via the navy and drug enforcement agency, are attempting to enforce fishing gear regulations, but this protection is minimal.

Haiti
The outlook for the marine and coastal environment remains bleak, with only one organisation attempting to monitor, research, and protect the marine environment. The Fondation pour la Protection de la Biodiversite Marine is under-funded and overwhelmed.

Jamaica
More than 10% of the land area is legally protected and several important marine areas have been declared as MPAs. The National Environment Planning Agency (NEPA) in the Ministry of the Environment is responsible for the management of the MPAs under the main planning instrument for conservation and development, the Jamaica National Environmental Action Plan, 1999-2002. NEPA has been restructured with more emphasis on monitoring, education and enforcement. However, many MPAs do not have effective management, and funding for MPAs continues to be a major challenge, with NGOs playing a more important role in MPA management and attracting funds. Regulations to ensure that user fees support protected area management have not been enacted and this further delays effective management. There is a proposal to create a MPA in Port Antonio and include the offshore cays, which are protected through the 'Morant and Pedro Cays Act' of 1907, however, enforcement is very difficult on these remote cays.

Turks and Caicos
The government is taking steps to reduce the potential danger to coastal habitats from unregulated development. In 1992, a park system was approved to preserve critical natural areas, manage the harvest of renewable resources, and promote income-generating ecotourism. There are 33 National Parks on the islands (marine parks, land parks, nature reserves, historical sites and sanctuaries). Significant steps have been taken to build capacity within the government sector to increase enforcement of fisheries and national parks legislation, and improve maintenance of MPAs. Funding of the Department of Environment and Coastal Resources has increased and new patrol vessels have been purchased and staff hired. A new unit, the Protected Areas Unit is being established to oversee the management of protected areas. There is active management in the National Park in Grand Turk and the Fishery Reserve, 2 Nature Reserves and a National Park in South Caicos. Management plans are being developed for 2 MPAs in Providenciales and 1 in West Caicos. Most dive operators now install moorings to prevent anchor damage, and enforcement has improved dramatically since 2000 with regular prosecutions.

The benefits of MPA management have been demonstrated in increased fish stocks in the Admiral Cockburn Land and Sea National Park off South Caicos. The density of queen conch is nearly double in the East Harbor Lobster and Conch Reserve on South Caicos compared to a similar habitat outside. Adults dominated the queen conch population within the MPA, whereas juveniles dominated populations outside, and spawning within the reserve may support local queen conch populations outside.

Country	Protected Area	Year Established	Level of Management
Bahamas	Exuma Cays Land and Sea Park	1958	Moderate
	Inagua National Park	1965	Moderate
	Peterson Cays Land and Sea Park	1968	None
	Pelican Cays Land and Sea Park	1981	Low
	Central, Harrold & Wilson Ponds	2002	
	Bonefish Pond	2002	
	Little Inagua	2002	
	Moriah Harbour Cay	2002	
	Great Exuma	2002	
	Pasture and O'Brien Cays in the Exuma Cays Land & Sea Park	2002	
	Walker's Cay in Abacos	2002	
Bermuda	South Shore Coral Reef Preserve	1966	High
	North Shore Coral Reef Preserve	1966	High
	The Southwestern Area (Seasonal 'no-take' zone)	1990	High
	The Northeastern Area (Seasonal 'no-take' zone)	1990	High
	The Eastern Area (Seasonal 'no-take' zone)	1990	High
Cayman	Marine Park System	1986	Mod-High
Cuba	Parque Nacional Caguanes	1966	Low-mod
	Refugio de Fauna Cayos Cantiles-Avalos-Rosario	1986	None
	Refugio de Fauna Cayos de Ana Maria	1992	None
	Refugio de Fauna de Rio Maximo	1992	None
	Parque Nacional Punta Frances	1996	Moderate
	Reserva Ecologico Cayo Largo	1998	None
	Parque Nacional Guanacabibes	2001	Moderate
	Refugio de Fauna Lanzanillo	2001	Low
	Refugio de Fauna Las Picuas	2001	Low
	Parque Nacional Jardines de la Reina	Unsure	Low
	Reserva Ecological Maternillo-Tortugilla	Unsure	None
	Reserva Ecologico Varahicacos-Galindo	Unsure	Moderate
	Elemento Natural Destacado Ojo de Megano	Proposed	Low
	Parque Nacional Los Caimanes	Proposed	Low
	Parque Nacional San Felipe - Los Indios	Proposed	Low
Dominican Republic	Parque Nacional del Este	1975	Moderate
	Parque Nacional Los Haitises	1976	Moderate
	Santuario de Mamiferos Marinos de la Republic a Dominicana	1977	Mod-High
	Parque Nacional Jaragua	1986	Moderate
	Parque Nacional Montecristi	1986	None
	Parque Nacional Submarino La Caleta	1986	Moderate
	Monumento Natural Isla Catalina	1995	None

Country	Protected Area	Year Established	Level of Management
Dominican Republic	Area Nacional de Recreo Cayo Levantado	1996	None
	Area Nacional de Recreo Playa de Andres de Boca Chica	1996	None
	Parque Nacional Cabo Cabron	1996	None
	Reserva Biologica Humedales del Bajo Yuna, El Barracote y Gran Estero	1996	None
Jamaica	Montego Bay Marine Park	1992	Low-Moderate
	Negril Marine Park	1995	Moderate
	Ocho Rios Marine Park	1999	None
	Palisadoes and Port Royal Protected Area	1999	None
	Portland Bight Protected Area	1999	None
Turks and Caicos Ids	West Caicos Marine National Park ($4km^2$)	1992	Low
	Princess Alexander Land and Sea National Park ($26km^2$)	1992	Low
	Northwest Point Marine National Park ($10km^2$)	1992	Low
	Pigeon Pond and Frenchman's Creek Nature Reserve ($24km^2$)	1992	Low
	Chalk Sound National Park ($15km^2$)	1992	Low
	Fort George Land and Sea Park ($5km^2$)	1992	Low
	East Bay Islands National Park ($35km^2$)	1992	Low
	Three Mary's Cay Sanctuary ($13km^2$)	1992	Low
	North, Middle and East Caicos Nature Reserve ($540km^2$)	1992	Low
	Vine Point (Man 'O War Bush), Ocean Hole Nature Reserve ($8km^2$)	1992	Low
	Admiral Cockburn Land and Sea National Park ($5km^2$)	1992	Moderate
	Admiral Cockburn Nature Reserve ($4km^2$)	1992	Moderate
	East Harbour Lobster and Conch Reserve ($4km^2$)	1992	Moderate
	Bell Sound Nature Reserve ($11km^2$)	1992	Moderate
	French, Bush and Seal Cays Sanctuary ($0.2km^2$)	1992	Moderate
	Columbus Landfall National Park ($5km^2$)	1992	Low
	South Creek National Park ($0.75km^2$)	1992	Low
	Grand Turk Cays Land and Sea Park ($1.6km^2$)	1992	Low
	Long Cay Sanctuary ($0.8km^2$)	1992	Low
	Big Sand Cay Sanctuary ($1.5km^2$)	1992	Low

Government Legislation and Policy on Reef Conservation

Bahamas

Several organisations are responsible for conservation. The Bahamas National Trust (BNT), a statutory, non-governmental, self- funded organisation, has the authority to build and manage the national park system, and create by-laws to manage and protect resources within all national parks. The Bahamas Environment Science and Technology Commission coordinates the response to environmental, scientific, and technological matters referred to the Bahamas by international organisations. The Department of Fisheries of the Ministry of Agriculture and Fisheries administers the Fisheries Resources (Jurisdiction and Conservation) Act, which govern marine resources. The Conservation and Protection of the Physical Landscape of the Bahamas Act administers and regulates excavation and mining of coastal areas. Private organisations, such as the Bahamas Reef Environment and Educational Foundation assist in promoting protection.

Bermuda

Bermuda's marine life is protected by a number of laws and ordinances. Under the 1972 Fisheries Regulations, spear fishing is illegal in waters in or less than 1 mile from shore and offenders caught will be fined up to US$5,000.

Cayman Islands

The Cayman Islands have some of the strictest marine conservation laws in place in the Caribbean. The laws were first put into place in 1978 and were strengthened in 1993. The rules prohibit: damaging coral by anchor, chains or any other means anywhere in Cayman waters; the taking of any marine life while scuba diving; the taking of any coral, sponges, sea fans or other marine specimens; the use of a spear gun or seine net; fishing with gill nets or poison; dumping anything into the water; exporting any form of marine life. The Department of Environment and Protection administers parks and enforces existing regulations. Marine law also limits the amount of catch. Lobster can be caught only during the open season with a size and catch limit imposed. Similar controls are applied for conch catches and grouper are protected during the winter spawning season. The penalties for violation of these rules are severe, and include both financial penalties and time in jail e.g. the penalty for vessels illegally dumping waste is US$625,000.

Cuba

There is a National Program for the Environment and Sustainability and the Ministry of Science, Technology and Environment is the central agency in charge of proposing and directing environmental policies. Resolutions have been prepared for the management of coastal zones and a national System of Protected Areas. A National Program for the Integrated Management of the Coastal Area was prepared in 1999 with general guidelines for integrated Management Plans of the Coastal Area, development of the local and national ability to manage and protect coastal and marine resources and the promotion of an integrated management approach.

Dominican Republic

In 2000, the Dominican Republic passed a new environmental law creating a Department of Environment and Natural Resources and streamlining the environmental review process required for development. Despite the new law, environmental management is still inadequate and many coral reef systems continue to be threatened by anthropogenic impacts. Many MPAs continue to exist as 'paper parks' as the required management and funding are not in place.

Haiti

There is no enforcement of existing legislation. The outlook for the marine and coastal environment remains bleak with only one organisation attempting to monitor, research, and protect the marine environment. The Fondation pour la Protection de la Biodiversite Marine is under-funded and overwhelmed.

Jamaica

Jamaica has had a long history of protecting different areas using several discrete legal acts, e.g. Forest Act (1942) Wild Life Protection Act (1945), Beach Control Act (1956). A National Protected Areas system, an integrated system of parks and marine protected areas, was established through the joint effort of the Government of Jamaica and USAID through the Protected Areas Resource Conservation (PARC) project in 1989 and the National Resources Conservation Authority (NRCA) Act of 1991. The NRCA, renamed National Environmental Planning Agency (NEPA) in 2001, has responsibility for taking 'such steps as are necessary for the effective management of the physical environment of Jamaica so as to ensure the conservation, protection and proper use of its natural resources.' Unfortunately, the coral reefs around Jamaica continue to suffer from a lack of effective management.

Turks and Caicos

There is no specific marine conservation policy. However, some laws do refer to marine resources, although these are often conflicting. The government has developed an Environmental Charter that sets out government commitment to develop its natural resources in a sustainable manner to maximise the long-term benefit for the country. The Fisheries and the National Parks Ordinance (1975 and 1992) are currently undergoing revision.

Gaps in Current Monitoring and Conservation Capacity

Most countries have limited capacity to monitor their reefs to support effective management of these resources. Long-term monitoring is often dependent on overseas scientists and/or funding organisations and ceases when project funding terminates. Bermuda has a history of long-term monitoring. The Bermuda Biological Station has had an established program of coral reef research and monitoring for 80 years and reefs are well mapped and studied.

Funding for marine monitoring in the Cayman islands is relatively good, but laws are outdated for reef conservation which is being bypassed through a need for economic development. The Cuban reefs are probably the least damaged reefs in the region, but there is little monitoring and conservation capacity to handle the rapid tourism development. Conservation may depend on co-management with tourist operators and better environmental education for stakeholders, communities and decision-makers. In contrast, the coral reefs on the neighbouring island of Hispaniola (Dominican Republic and Haiti) are severely degraded and there is very little capacity for monitoring and conservation. Existing MPAs are not well managed and formal training in marine sciences and coastal management is limited. Major tourist centres have inadequate treatment of sewage and solid wastes. On the large island of Jamaica, the government lacks monitoring and enforcement capacity. Environmental education is critical to all levels of the community to avoid current conflicts between tourism and fishery interests, and to inform of the benefits of integrated coastal management. Similarly, conservation agencies on Turks and Caicos Islands are under-staffed. Staff in management agencies lack the experience and equipment to carry out daily operations. Inter-sectoral conflicts between agencies continue and there is a need for key stakeholders and users to be involved in monitoring and conservation.

Conclusions

Bahamas

Isolated reef systems are still relatively healthy, and new MPAs have been declared almost doubling the size of protected areas. Impacts from tourism-related and coastal development, however, still pose a threat to reefs, particularly where development is intensive and dive tourism is unregulated.

Bermuda

Coral reefs are relatively healthy, and fish populations are improving slowly as a result of the protected 'no-take' areas.

Cayman Islands

Coral reefs are generally in good condition, though there are some obvious signs of impacts, particularly on the more developed island of Grand Cayman. Reef fish populations are still healthy, though showing some signs of increasing fishing pressure.

Cuba

Offshore reefs are still comparatively healthy and are considered to be some of the best in the Caribbean. Northern reefs and those close to high population centres are more impacted. With the expected increase in tourism, effective management of the MPAs is critical to ensure that the negative effects of intensive coastal development do not damage reefs.

Dominican Republic

Deterioration of near-shore reefs continues particularly in areas where coastal development is high, and where reefs are very accessible. Over fishing remains widespread. Legislation exists to protect marine resources, but the required management is lacking.

Haiti

The outlook remains bleak for coral reefs in Haiti. Unregulated harvesting of resources continues to damage reefs, and there are still no MPAs. The political and economic situation in Haiti remains unchanged so there is unlikely to be any change in the environment in the near future.

Jamaica
Near-shore, shallow reefs continue to be dominated by fleshy algae, but the situation appears to have stabilised. Offshore, deeper reefs are less impacted. Over-fishing continues to be a problem, particularly on the north coast. Environmental education, improved monitoring capacity and effective management of MPAs are required to secure improvement of conditions of coral reefs.

Turks and Caicos Islands
Some reefs are still considered healthy with healthy fish stocks, but conditions are changing at near-shore reefs, particularly on more developed islands. All conservation agencies are understaffed, requisite training and experience is lacking, however, there have been improvements since 2000. There is little active monitoring of reef health within the existing MPAs which is a major requirement for the future especially as development continues.

General Conclusions

- Coral reefs have suffered declines in the past in all countries, particularly where development is high. Signs of slow recovery are few (e.g. Discovery Bay, Jamaica).
- Some reef systems are still impressive and include the isolated reefs of the Bahamas, Cuba and the Turks and Caicos Islands.
- Major anthropogenic impacts on reefs include pollution from sewage and agricultural discharge, sedimentation from deforestation and agricultural activities, coastal habitat destruction, physical damage to reefs from increased tourism activities and especially over-fishing.
- All countries are directly dependent on coral reefs to sustain their economies, through tourism and fisheries.
- All reefs have suffered some decline in reef fisheries resources, particularly of commercially important species such as conch and lobster and predatory species such as the Nassau grouper.
- Over-fishing is particularly acute in Dominican Republic, Haiti and Jamaica, where the loss of herbivores has exacerbated the problem of algae overgrowing reefs.
- The incidence of coral bleaching during 2001-2002 has been low and most corals affected seem to have recovered.
- Coral diseases seem to be widespread but disease incidence is relatively low.
- Coral reef monitoring is relatively extensive in Bermuda, Cayman Islands, and Jamaica, limited in Bahamas, Dominican Republic and Turks and Caicos and severely limited by lack of funds in Haiti and Cuba (which has adequate monitoring expertise).
- Management of MPAs is very high in Bermuda and Cayman Islands, moderate to low in Bahamas, Cuba, Dominican Republic, Jamaica and Turks and Caicos. No MPAs exist in Haiti.
- Funding and capacity for implementing and enforcing conservation measures are the main constraints to coral reef management in the Caribbean.

Recommendations to Improve Conservation of Coral Reef Resources

- Encourage Governments of countries to comply with the agreements to international conservation bodies such a CITES, Ramsar etc. Government involvement in legislation, implementation and enforcement is essential for effective conservation.
- Encourage Governments to adopt Integrated Coastal Management (ICM) to ensure that pollution and other impacts from land-based activities decrease. Thus sewage treatment, soil conservation, sustainable agriculture should be seen as part of coral reef conservation. Similarly, new coastal developments should be carefully planned to avoid negative impacts on coastal systems.
- Encourage international donor and environmental organisations to continue collaborative partnership with countries in the region to support sustainable development of marine resources. Increasingly, more governments have the political will, but lack the required funding.
- Establish more MPAs and no-take areas and improve the funding and level of management of MPAs, thus increasing their ability to protect resources.
- Implement, where necessary, appropriate user fees in MPAs to assist in their management.
- Promote continued research and monitoring to improve decision-making., especially in response to recent changes to coral reef systems.
- Protect important spawning aggregation sites. Spawning grounds could be closed or there could be a closed season for important species during the spawning season.
- Locate some marine reserves or no-fishing zones in near shore waters to protect important nursery areas.
- Educate residents and tourists on the value of coral reefs and on best practice to avoid damage and to achieve effective conservation.

Reviewers

John Ogden, Florida Institute of Oceanography, USA; Jeremy Woodley, Canada.

Addresses

Dulcie Linton, Caribbean Coastal Data Centre, Centre for Marine Sciences, Jamaica. (dmlinton@uwimona.edu.jm).

Pedro Alcolado, Instituto de Oceanología, Cuba. (alcolado@ama.cu)

Peter Edwards, Centre for Marine Sciences, Jamaica. (peedwards@uwimona.edu.jm).

Tatum Fisher, Caribbean Coastal Data Centre, Centre for Marine Sciences, Jamaica. (tfisher@uwimona.edu.jm).

Raul Gomez Fernandez, Centro de Investigaciones de Ecosistemas Costeros, Ministerio de Ciencia, Tecnología y Medio Ambiente, Cuba. (ciec@fica.inf.cu).

Francisco Geraldes, Centro de Investigaciones de Biología Marina (CIBIMA), Dominican Republic. (mamma@codetel.net.do).

Carl Hanson, Negril Coral Reef Preservation Society, Jamaica, Norman Manley Blvd., Negril, Jamaica. (chanson01@hotmail.com).

Croy McCoy, Dept. of the Environment, Cayman Islands Govt., Cayman. (Croy.McCoy@gov.ky).

Duncan Vaughan, Dept. of Environment and Coastal Resources, South Caicos, Turks and Caicos Islands, British West Indies (duncanvaughan@yahoo.co.uk).
Vincent Voegeli, Gerace Research Center, Bahamas. (grcss@juno.com)
George Warner, Centre for Marine Sciences, Jamaica. (gfwarner@uwimona.edu.jm).
Jean Wiener, Fondation pour la Protection de la Biodiversite Marine (FoProBiM), Haiti. (jwwiener@aol.com)

Supporting Documents

Status of coral reefs of Little Cayman and Grand Cayman, British West Indies, in 1999 (Part 2: Fishes). Christy, V., Pattengill-Semmens, and Brice X. Semmens. Atol Research Bulletin, 2002.

Murray A , Rudd W, Danylchuk AJ. Gore S, Tupper and MH. 2000. Are marine protected areas in the Turks and Caicos islands ecologically and economically valuable?. http://www.fisheries.ubc.ca/publications/reports/9-8p4.pdf or In Proceedings of an International Conference on the Economics of Marine Protected Areas (Alder J, Sumaila and Mark H, eds.). Fisheries Center for Research Reports. 9(8).

Inception Report R7976. Institutional Evaluation of Caribbean MPAs and opportunities for pro-poor management. http://www.mragltd.com/R7976inceptionrp.pdf.

Fisheries and marine protected areas. http://www.acmt.hr/classes/PDF/Enviro%20I/Fisheries%20and%20MPAs.PDF.

Protection of the marine resources of Central Andros, Bahamas (taken from a proposal prepared by the Central Andros Conservancy and Trust (CANCAT), a community organisation in Central Andros, with support from MEP and the Bahamas

Reef Environment Educational Foundation (BREEF)). file://C:\My%20Documents\Websites\MEP%20site%20design1\news\TMP1011646100.

Cuba The NCSD Sustainable Development Report: http://www.ncsdnetwork.org/global/reports/ncsd1999/cuba/english/cap1_4.htm

MAB

Man And The Biosphere Reserves of Buenavista; Península De Guanahacabibies; Ciénaga De Zapata, Cuba

There are 3 MAB sites in Cuba, which contain coral reefs but for which little information was provided.

The **Buenavista Biosphere Reserve** is 313,500ha on the northern coast with coral reefs, rocky and sandy beaches. The land part has evergreen coastal and mangrove forests. The species diversity of flora and fauna is high with more than 200 plant and over 200 animal species, including endemic and threatened species. The area is important for the conservation of traditional uses of natural resources by the 25,000 permanent inhabitants of Canario Canaray Islands origin. About 7,000 tourists visit annually and provide the community with income and purchase handicrafts. There are many research projects on traditional medicine and ecology, with support from UNESCO. **Coral reefs** are estimated at **30%** of the natural resources.

The **Guanahacabibes Biosphere Reserve** is on the western end of Cuba and was designated in 1987 to protect the vegetation and endemic plants, and also the important coastal areas with turtle nesting beaches and some of the healthiest coral reefs in Cuba. The core of the Reserve is a National Park with fishing and hunting largely controlled. Most research is focused on sustainable development, tourism impact and ecotourism, and environmental education and its influence on conservation and the management of biodiversity. **Coral reefs** are **40%** of the natural resources.

The 600,000ha **Cienaga de Zapata Biosphere Reserve** was designated by UNESCO in 2000 because of the diverse ecosystems and the sparse population of about 9,000 people in small villages. The western reaches are uninhabited. The people are mainly engaged in fishing, hunting, and, increasingly, in eco-tourism to the mangrove forests, coastal lagoons and coral reefs. The research conducted is multi-disciplinary on the ecology and reproduction of local crocodile species, fish and turtle ecology, impacts of tourism in areas with high conservation value, and socio-economic studies of the local communities. **Coral reefs** are **20%** of the natural resources.

For all three sites –
Ecological Monitoring: No information was provided - **unknown.**
Socio-economic Monitoring: No information was provided - **unknown.**

WHS

DESEMBARCO DEL GRANMA, CUBA – WORLD HERITAGE SITE

The Desembarco del Granma National Park, situated in southeastern Cuba, was designated as a World Heritage site in 1999. The site contains most of the key habitats found in the region, including the coral reefs of Cabo Cruz, seagrass beds and mangroves. In the western park of the park there are a series of sub-marine terraces up to 30m deep. Several species that live within park boundaries are of conservation concern including Caribbean manatee, species of marine turtles (loggerhead, green, olive ridley and hawksbill) and a colony of queen conch.

The first management plan for Desembarco del Granma National Park was approved in 1986. This plan is regularly updated and it is aimed at maintaining the conservation status of landscapes and species, promoting the recreational use by the public and restoring degraded ecosystems.

This area is not subjected to major threats or pressures. Desembarco del Granma National Park receives very little tourism; it has been estimated that no more than 1,000 tourists (both foreign and national) visit the site each year. Natural disasters such as hurricanes, sea floods and earthquakes are the most significant threats.

Ecological monitoring: No information received.

Socio-economic monitoring: No information received.

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

16. Status of Coral Reefs of Mesoamerica – Mexico, Belize, Guatemala, Honduras, Nicaragua and El Salvador

Patricia Almada-Villela, Melanie Mcfield, Philip Kramer, Patricia Richards Kramer and Ernesto Arias-Gonzalez

Abstract

The coral reefs of this region have changed considerably following a series of major natural disturbances and the impacts of human stresses. Reefs on the Atlantic side were battered by hurricanes in 2000, 2001 and 2002, which struck the reefs from the Mexican Yucatan Peninsula to Honduras, destroying corals with some losses up to 75% in Belize. These impacts follow closely on the heels of the extreme coral bleaching event and Hurricane Mitch in 1998, which also caused widespread damage to the region's reefs.

Throughout large parts of the region, there are intense fishing pressures and major threats to reefs from poor land-use practices and unregulated coastal development. A region-wide survey in 2001 found that coral cover had not increased since the 1998 disturbances and coral diseases were found throughout the region. The Mesoamerican Barrier Reef System (MBRS) Initiative has gathered considerable support for public and private conservation efforts in the region. This regional cooperation program between Belize, Guatemala, Honduras and Mexico is addressing: key aspects of marine protected areas (MPAs); environmental information systems; environmental monitoring of coral reefs and associated ecosystems; public awareness and formal and informal education. Capacity to monitor and manage coral reefs varies enormously in the region, from advanced to basic. The MBRS Initiative and the WWF Ecoregional Conservation Program are working with national, regional and international partners to improve management of the coral reefs and fisheries resources in these countries, and to understand and address land-based sources of marine pollution, and to resolve trans-boundary management issues.

Introduction

Coral reefs along the Caribbean coasts of Mesoamerica are well developed with relatively high biodiversity, whereas those on the Pacific side are usually smaller, less diverse, and with an isolated or patchy distribution. Most of the Pacific reefs are off central Mexico, and these are limited by frequent cold, nutrient-rich upwellings and El Niño events which result in localised extinctions. In addition, many rivers dump sediments on the coastal shelf from southern Mexico south to the Gulf of Fonseca, and Nicaragua. There is little reef development until further south in Costa Rica.

Reefs on the Caribbean side are well-developed and extensive, and include the Mesoamerican Barrier Reef System (MBRS) which is the second longest barrier reef system in the world, extending over 1000km through Yucatan, Mexico, Belize and east to the Bay Islands in Honduras. There are also many patch, fringing, and atoll-like reefs, which have high biodiversity of fishes, invertebrates, birds, plants, sea turtles, and mammals. There are several distinctive areas on the Caribbean coast: SW Gulf of Mexico; extensive fringing and barrier reefs along the Yucatan and Belize coast; 4 unique atolls (Banco Chinchorro, Turneffe Island, Lighthouse, and Glovers Reef); small coral communities along mainland Guatemala and Honduras, and the Bay Islands; and extensive reef complexes in Nicaragua. All reefs are influenced by pressures from the land including the direct human pressures of coastal development, over-fishing, agricultural and industrial run-off, deforestation, land-use, and sewage pollution. Two major climate events in 1998 (El Niño mass bleaching and Hurricane Mitch) caused severe damage to reefs along the Mesoamerican Corridor (Yucatan, Belize, Guatemala, Honduras).

Coastal activities have traditionally been relatively minor within national economies, which are mostly based on agriculture and small industries. However, the rapidly growing tourism industries, focused primarily on coastal centres and the emerging cruise industry, have recently become the major economic force in much of the region, particularly in Belize and Mexico.

There is little available information on the status of Central American reefs, except for those in Yucatan Mexico, Belize, and the Bay Islands. Little is known of the extensive reefs and coral communities of Nicaragua, along the mainland of Honduras and Guatemala, on offshore islands and banks like Swan Islands and the Mysteriosa banks in Honduras, parts of the Belize reef complex, and other reefs in the eastern Pacific coast. Some of these gaps will be filled during the development of the MBRS project, which is a regional conservation program involving Belize, Guatemala, Honduras, and Mexico. It is funded by the Global Environment Facility, implemented by the World Bank and executed by the Comisión Centroamericana de Ambiente y Desarrollo (CCAD) and headquartered in Belize. This has started the first 5 years of the planned 15 years. There are also significant NGO counter-part programs addressing regional conservation efforts, such as the World Wildlife Fund (WWF) MesoAmerican Caribbean Reef Ecoregional Conservation Program, which is focused on: supporting MPAs and forming a representative MPA network; developing sustainable tourism and fisheries management; improving watershed management; and creating a long-term and sustainable funding. These efforts are complemented by other international NGOs (The Nature Conservancy, Wildlife Conservation Society, and IUCN- The World Conservation Union) and numerous local NGOs. The capacity to monitor and manage coral reefs varies enormously in the region, and all of these efforts seek to increase this capacity.

Reef Descriptions

Mexico

There are three distinct coral reef areas in Mexico. The Pacific coast, Baja California and offshore islands, have 12 to 15 hard coral species on the coast and 18 species on the offshore Revillagigedo Islands. These reefs are not well developed and often restricted by cool temperatures. Reefs and coral communities are small and patchy with low abundance of soft corals, sponges, crustaceans, and echinoderms.

The Southwest Gulf of Mexico contains about 20 reefs off Veracruz, which are influenced by high turbidity from the coast. The coral diversity is low with only 45 species. The reefs on the Campeche Bank are better developed in the cleaner water, but suffer from over-fishing and oil exploration.

There is an extensive fringing reef along the Yucatan Peninsula from Isla Contoy south to Xcalak, including offshore islands and the Banco Chinchorro atoll. These reefs continue as the Belize barrier reef and have 56 hard coral species. Reefs in the north (Quintana Roo) have low coral cover (17%), but with prominent patches of dead and recovering *Acropora palmata*. There are better developed, shallow platform reefs in the central and southern areas, and Banco Chinchorro is a large (46km x 14km) atoll, surrounded by well-developed reefs. Tourism is a major activity in Quintana Roo, and is expanding rapidly, imposing new threats to these reefs.

Belize

It has the second longest barrier reef in the world (250km long) with a mix of lagoon patch reefs, fringing reefs, and offshore atolls. The northern reefs are well developed and continuous from Mexico to Caye Chapel, and then discontinuous and less developed south to St. Georges Caye. The central reefs are continuous and well developed, whereas the southern reefs are discontinuous and less well developed. The many patch reefs to the south of the central barrier are dominated by *Montastraea annularis*. Lighthouse, Turneffe, and Glovers are offshore atolls with different coral communities on leeward and windward slopes. Turneffe has extensive mangroves in a shallow lagoon, while the others have deep lagoons and many patch reefs. Belize is relatively sparsely populated and the coral reefs are important for commercial and artisanal fishing, and aquaculture. Tourism and the export of marine products are increasing rapidly, but the coastal populations are decreasing.

Guatemala

Most of the coastline is on the Pacific, where there are few reefs. The narrow coast in the Caribbean has many mangroves, seagrass beds and coastal lagoons. Major rivers limit reef development to isolated coral communities and small patch reefs in the Gulf of Honduras. Coastal communities use the reefs for food and transport and also rely on catching fish in Belize waters.

Honduras

Coral reefs on the Caribbean coast are restricted by sediment runoff from the mountains, with the best reefs around the 60 offshore Bay Island groups: Roatan, Utila, Guanaja, and Cayos Cochinos. These reefs grow to 9-12m depth before a deep wall to 75m. The dominant coral is *M. annularis*, with some *Acropora palmata* and *Agaricia tenuifolia* on the shallow fringing reefs. There are fringing reefs around the Swan Islands, and small fringing and patch reefs near the Mosquitia Cays and Banks. There are no reefs on the Pacific coast. The indigenous communities rely on subsistence fishing, and now tourism is developing on the Bay Islands.

Nicaragua

Little is recorded of the extensive reefs that grow on the broad carbonate banks (Miskito Bank, Man O'War Cays, Crawl, Taira, Pearl, and Set Net Cays and Little and Big Corn Islands) of the Caribbean coast, whereas near-shore reef growth is limited by high sedimentation with about 10% coral cover. The Miskito Cays are mangrove islands surrounded by fringing coral reefs, extensive seagrass beds, with abundant corals on the seaward slopes. There are also patch reefs, large pinnacles and fringing reefs, but these are poorly known. The Pearl Cays have thickets of *A. palmata*, and the large Corn Islands have three fringing reefs on the northeast side along with numerous patch reefs. *A. palmata* and *M. annularis* are the major reef building corals, averaging 25% coral cover. Reef development is limited on the leeward side of the islands. There are virtually no corals on the Pacific side, except isolated patches of *Pocillopora* corals and scattered gorgonians. Reefs are largely ignored in this mostly agricultural country with only 10% of the people living on the Caribbean coast where they harvest marine resources from their traditional land and sea territories. The Miskito Indians are mostly subsistence fishers within the Miskito Coast Marine Reserve.

El Salvador

There is a small rocky system at Los Cobanos, in Sonsonate, that has some coral communities on the Pacific coast, but little is known about these. This is the smallest country in Central America with 6 million people, mostly Mestizo Indians.

Status of the Coral Reefs

The coral reefs in this region clearly show the effects of severe recent disturbances; Hurricanes Keith (2000) and Iris (2001) damaged reefs along Belize and Hurricane Isidore hit the northern part of the Yucatan Peninsula in September 2002, affecting large areas inland. There have also been recurrent bouts of coral bleaching throughout the 1980s and 90s, which have resulted in major changes in the coral populations on both sides of

The Mesoamerican Caribbean Reef Ecoregion Expeditiion

The expedition was the first time regional scientists collaborated on coral reef surveys of the entire Mesoamerican Reef System, from Mexico to Honduras. The goal was to gather information to refine an Ecoregional Conservation Plan and assist local NGOs, government departments, policy makers and affiliated projects in the region with their conservation efforts. The expedition was organised by the WWF (World Wildlife Fund - USA) Mesoamerican Caribbean Reef Program in late 2001, along with researchers from Amigos de Sian Ka'an and SEMARNAP (Mexico), Coastal Zone Management Institute and Belize Audubon Society (Belize), Honduras Coral Reef Fund and DIGEPESCA (Honduras). The main goals were: to determine the ecological status of reefs throughout the region; monitor recovery from 1998 disturbances; and give local researchers ecoregional perspective and training. They examined 36 sites in 4 sub-regions and found that the reefs had an average live coral cover of 15.2% (range 2.6% to 39.7%). The density of recruits or juvenile corals was 7.5 per m^2 (range 1.0 to 14.6 per m^2). There were 26.7 (range 18 to 33) hard coral species on average per site, and 3.3% of 3,692 corals showed active disease infections (range 0-11.5%). The most common were 'white plague' and 'dark spot' diseases, with 'dark spot' and 'white band' more common in the 2 northern sub-regions, while 'black band' and 'white plague' were more common in the south. It is hoped that these disease data can help pinpoint specific impacts or conditions in these zones that may help explain the causes. Overall the average recent mortality (including parts of colonies that died in the last year) was 1.7% (range 0.2 to 4.4%). The expedition discovered some interesting trends e.g. coral diversity is highest in the south, while coral abundance (adults and juveniles) is higher in the north. Of particular concern was the relatively low coral cover in many sites, particularly in the Honduras and Belize sub-regions. Coral cover of 25-30% would be considered good for the Caribbean, and recent patterns of coral diseases and coral mortality are very complex. Diseases were highest in the North Honduran Coast subregion, and lowest in Belize, and the Sian-Ka'an / Ambergris region had high variability in disease levels, potentially indicating that some local stresses and not regional problems are the major influences e.g. possibly local development. Whereas in Honduras, widespread stresses like agricultural run-off may explain the consistently high disease levels. While Belize had the lowest average disease rate, there was relatively high recent mortality, suggesting other causes of mortality such as bleaching and hurricane damage. The participants welcomed the opportunity to study reefs of their ecoregion in a relatively short timeframe, which gave them invaluable insights and perspectives. These data will help WWF and partner organisations monitor the performance of conservation efforts. Contact: Melanie McField, mcfield@btl.net.

Central America. These climate related events have also resulted in major impacts to the agricultural and other food producing industries in the State of Yucatan, which was among the five main national producers of pork, chickens, eggs, etc. The losses in these agro-industries are estimated to be up to 80%. The full impact of hurricane Isidore on the marine resources has not been evaluated as yet. The combined effects of this event and the resulting flooding and sedimentation in the region, along with white band and bleaching events are expected to have long-term ecological consequences for the coral reefs.

The MBRS has a long-term monitoring program to assess the health of the coral reefs and associated ecosystems (mangroves, seagrass beds and other coastal wetlands). A reef expedition was organised by WWF to assess the reefs from Mexico to Honduras (see below). These fore-reefs (15-17m depth) still show the impacts of the severe disturbances of 1998, with little recovery apparent. Average live coral cover for the region was 15%, substantially lower than pre-1998 values. The region is divided into 6 sub-regions, with the 4 examined containing the majority of the reefs.

Summary of the 2001 Expedition averaging coral data from the 36 sites in 4 regions.

Sub-Region	Coral species	% Coral cover	Juveniles per m^2	% Coral disease	% Recent mortality
North Quintana Roo	24.5	24.5	12.2	3.0	2.7
Sian Kaan/Ambergris	26.4	20.3	7.0	3.7	1.1
Belize	26.5	12.9	7.6	2.3	1.9
North Honduras	27.6	10.1	6.9	4.4	1.8
Overall	26.7	15.2	7.5	3.4	1.6

Mexico

Reefs on the Pacific and the Atlantic coasts are under pressure from tourism activities, which include boat groundings, alteration to the coastal fringe, potential loss of mangrove and the resulting loss of protection from storms. Coral diseases continue to be present in the Yucatan area, including both some of the highest and lowest infection rates found in the region (ranging from 0%-11%). In general, coral cover and juvenile density is higher but species richness is lower than in other parts of the MBRS. Mexican reefs have received considerable attention and researchers from government and NGOs conduct coral reef research and monitoring in the country. Recently, the Comisión Nacional de Areas Naturales Protegidas (CONANP) organised a workshop to develop a Mexican Monitoring Protocol, which was presented to the MBRS Initiative as the Mexican contribution to the regional monitoring effort. These new activities should greatly enhance the existing knowledge of the reefs.

Belize

Coral reef monitoring has been conducted in several key areas by a combination of government agencies, NGOs and universities. Some monitoring activities have involved short and longer-term efforts, which have generated considerable information on the status of reefs and some of the key species in the area. Coral reef monitoring had been constrained by funding, logistics and manpower. New activities in 2000 included the pilot phase of a coral reef monitoring component of the Caribbean Planning for Adaptation to Global Climate Change Project (CPACC), which assessed the fore-reefs of the Hol Chan, South Water Caye and Glovers Reef Atoll marine reserves. These surveys showed low coral cover, less than 20% at all sites. Cover of macro algae was also low, which is encouraging. To ensure the recovery of coral cover, it will be necessary to implement sound management to improve water quality by controlling coastal developments. Maintenance of fish populations is also crucial to control macroalgal growth. A follow up project,

Conservation of Glovers Reef, Belize: A Remote Caribbean Atoll

Glovers Reef is one of 3 atolls off Belize and it has 6 sandy cays and some of the best developed reefs of high diversity in the Caribbean. The atoll has an emergent reef crest, with 3 channels that open into the 6-18m deep lagoon with 700 patch reefs. Outside the lagoon, the water drops to 1000m. Although it is 45km offshore, the reefs are subject to increasing direct and indirect human pressures, including over-fishing, coral bleaching, diseases, fleshy algal dominance, and increasing tourism damage. The Government of Belize declared the Glovers Reef Atoll as a Marine Reserve in 1993 and as part of the Belize Barrier Reef World Heritage site in 1996. The Reserve aims to conserve ecological processes, preserve genetic diversity and sustainable yields through informed management of species and their habitats, maintain natural areas for education and research, and provide social and economic benefits through ecologically sensitive tourism and recreation. There are 3 management zones: a small wilderness zone, where resource removal is prohibited; a larger no-take, conservation zone where non-extractive uses are permitted; and the general use zones, where fishing is allowed. The Wildlife Conservation Society (WCS) established the Glovers Reef Marine Research Station on Middle Cay in 1993 to promote the long-term conservation and management of the reefs through research, cooperative management, training and education. The research station also serves as the marine park headquarters for the Government of Belize. Monitoring has shown that key target fish species are more abundant and larger inside the reserve than outside e.g. the Nassau grouper *(Epinephelus striatus)* aggregates to spawn on the northern tip which has been temporarily closed by the Belize Fisheries Department. However, fishing has probably reduced the numbers of aggregating grouper by 90%. This indicates that continued protection of grouper aggregation sites is essential for long-term conservation. Another indication of over-fishing is higher grazing by the sea urchin *Echinometra viridis* in open areas where urchin predators have been over-fished. In the early 1970s, the patch reefs were dominated by hard coral *(Porites, Acropora and Montastrea)*, but algae are dominant now, probably due to white-band disease killing the *Acropora* corals, and to reduced populations of herbivores that allow the algae to overgrow the corals and prevent larvae settling. Hurricanes normally hit the Belize coast about every 10 years, and the major Hurricane Mitch passed near the atoll in 1998 and caused severe damage to the windward slopes, but little damage to the patch reefs and the leeward slopes. The major themes of the Station are research and capacity building with an internship program for students of the University College of Belize. From: Liz Lauck, The Wildlife Conservation Society, New York <llauck@wcs.org> and Tim McClanahan, The Wildlife Conservation Society, Mombasa, crcp@africaonline.co.ke; Glovers Reef Marine Research Station Manager, glover@btl.net.

Mainstream Adaptation to Climate Change (MACC), has recently started, and Belize will be a full participant.

The 50% reduction in live coral cover that occurred between 1997 and 1999 (mainly attributed to hurricane Mitch and the coral bleaching event) has remained relatively unchanged in 2001. The disease infection rate was the lowest in the region although some sites, particularly near Ambergris Caye, had up to 12% colonies infected. The density of juveniles (7.6 per m^2) for Belize sites was comparable to results in 1999. The coral cover and species richness were about average for the ecoregion, and the site with the highest species richness, Goffs Caye, is found in the central zone of the reef.

Guatemala

There have been no surveys of the distribution and condition of coral communities. The reefs were probably heavily impacted by Hurricane Mitch, especially from storm run-off and the 1998-bleaching event. Hurricane Iris in 2001 caused major flooding and sedimentation in the Rio Motagua area.

Honduras

The reefs of the Bay Islands and Cayos Cochinos had the highest coral species richness in the ecoregion, although the coral cover and juvenile density were lower than other areas of the MBRS. In addition, the coral disease infection rate ranged from 2.1%-8% with the highest mean for the region (4.4%). It appears that the impacts of Hurricane Iris in 2001 on the reefs north of Honduras were not as severe as those in Belize. Apparently no major direct damage was suffered by the reefs in the Bay Islands, however, there was major damage in the river areas of the Rios Chamelecon and Ulua by increased flooding and sediment release. The full effects of Iris on the reefs and coastal areas need to be evaluated.

Nicaragua

The Caribbean coastline is not highly developed nor studied in depth, however there has been considerable deforestation inland which has resulted in increased sediment loads that have degraded coastal reefs. There are also problems with excessive and damaging fishing and pollution from untreated sewage. Coral cover is generally low, around 25%, with 5% soft corals. Little is reported on the status of the more extensive reef of Pearl Cays, or the extent of damage from Hurricane Mitch. Damage, however, is likely to have been substantial as the hurricane passed over the Bay Islands and caused considerable flooding on land.

El Salvador

No new information has been received on the Los Cobanos coral reefs.

Status of Coral Reef Fishes and Fisheries

Coral reefs in Mesoamerica provide important animal protein foods for subsistence populations. Fishing pressures have intensified with increasing demand and better fishing gear. Spawning aggregations in the entire Mesoamerican region are particularly at risk since their location depends intimately on recognisable features of cayes and reefs. Fishing pressure has been particularly high on some of the spawning aggregations e.g. the Nassau Grouper, which is currently on the IUCN Red List of Threatened Animals.

Over-fishing, illegal fishing, destructive fishing and lack of enforcement of fisheries legislation have remained a problem in the region, although there are several initiatives to address this situation. Most of the reef fisheries rely on healthy reefs, however, coastal development has continued in the region, particularly on the northern part of the Yucatan Peninsula. Anthropogenic impacts to the coral reefs and associated ecosystems in the Mesoamerican Region are being monitored within the MBRS Project, and complemented by international and local NGOs, and universities researching in the region.

Mexico

There are 346 reef-associated fishes in Mexico, of which at least 245 reef fish are found on the Atlantic coast of Mexico: 68% of these in the Gulf of Mexico; and 92% along the Yucatan Peninsula. Herbivores are dominant on the Gulf of Mexico reefs, carnivores are more abundant in the Caribbean, and important families include Scaridae, Pomacentridae, Labridae, Acanthuridae, Lutjanidae, Haemulidae and Serranidae.

Belize

The highest fish diversity in the region occurs in Belize with more than 317 reef fish species with large numbers of surgeonfish and parrotfish. There is a small but expanding commercial fishery in Belize as well as considerable subsistence fishing. The Fisheries sector ranks third as a foreign exchange earner and earned over US$35 million in 2000. Farmed shrimp were the most valuable component (US$23million), but lobster exports ($9.5 million) and conch ($2.5 million) have both increased from 1999 to 2000, and have been relatively stable over the last two decades. The impacts of Hurricane Keith on the fishing industry were substantial, with the loss of revenue greater than US$6 million. Hurricane Iris further added to the stress in southern Belize. There is a good legislative basis for effective marine fisheries management, in particular the prohibition of fishing with scuba gear, or using nets along the reef or traps outside the reef, or breaking closed seasons and size limits for conch and lobster. The challenge is to enforce such regulations, reduce illegal fishing and maintain the infrastructure required to patrol the large reef area. A coalition of local and international NGOs has recently spearheaded an effort to enact legislation in Belize to protect the Nassau grouper spawning sites and declare a closed season or even protect the species. The government of Belize is expected to make the final decision before the 2002-2003 spawning season. The year-round closure of these spawning sites will help conserve a range of species, which use the spawning sites. This legislation will set an important precedent in the region and efforts will be made to replicate the strategy in other countries.

Guatemala

There are 218 reef fish species in Guatemala, and there is a minor commercial fishing sector. There are small-scale fisheries for fishes, sharks, rays and skates, and the yellowleg and *Penaeus* shrimps on the Pacific side. On the Caribbean side the main fish include manjua, shrimp, red snapper, mutton snapper, billfish, jack, tarpon, and snook. Little is reported on the fish resources and fishing levels, but there are indications of over-exploitation.

Honduras

There are at least 294 reef fish species in Honduras and 226 in Cayos Cochinos Biological Reserve, and there is some evidence of over-fishing by small-scale local fisherman and industrial fishing fleets. Around 78% of all households in the northern region have a family member involved in fishing, either industrial or artisanal; 29% of the households are involved in artisanal fishing and only 10% are completely dependent on industrial fishing for their livelihoods. Occasional fishing occurs continuously by many industrial fishers outside the main fishing seasons. A ban on lobster fishing using scuba gear was recently enacted within the Cayos Cochinos Natural Monument, after the fishermen participated in a WWF coordinated exchange program with the managed lobster fishery in the Banco Chinchorro Biosphere Reserve, Mexico. As in many other countries, it is difficult to separate fin fish and aquaculture catch statistics from the industrial catches.

Nicaragua

Much less is known about the reef fishes in Nicaragua, although the species composition is probably similar to reefs in adjacent Caribbean countries. Fish are important for local and domestic consumption, and fish stocks continue to be under serious pressure. Lobsters are the most valuable product, but there are also fisheries for fish, shrimp and aquarium species. Many turtles are harvested for local consumption and sale.

El Salvador

There are commercial and artisanal fisheries on the reefs, and the total annual landings registered between 1991 and 2000 were greater than 13,000 tons; 72% of which was from artisanal fishers. The net value of the fisheries production for 2000 was US$29 million. A marked increase in the exploitation of coastal resources out to 100m depth, has stimulated the development of a new legal framework to incorporate appropriate management measures for these resources. These include new models of participatory management and the establishment of conservation measures. There are 552 marine fish species in Salvadorian marine and coastal waters, of which 128 are reef associated species. However, the proportion of reef fish in the catch is unknown. The shrimp fishery continues to be the most important revenue earner, with most of them exported to the USA, and there are indications that the stocks are being over exploited.

Summary of the known status of the marine and reef-associated fish species in Mesoamerican countries from FishBase and IUCN sources.

Country	Marine	Reef Associated	Threatened	Threatened Marine	Under Treaties & Conventions
Mexico	1725	353	114	35	28
Belize	554	237	21	20	14
Guatemala	763	218	16	15	22
Honduras	924	286	14	14	15
Nicaragua	1013	260	19	19	18
El Salvador	552	128	4	4	15

Anthropogenic Threats to Coral Reef Biodiversity

The greatest threats to coral reef biodiversity are derived from human activities, compounded by natural disturbances. This was emphasised in 1998, when there was a mass climate change bleaching event and Hurricane Mitch, which severely damaged the reefs. The impacts of the Hurricane were exacerbated due to massive loads of sediment flowing into coastal waters from poor land-use practices. The long-term recovery of these reefs will depend predominantly on the ability of governments and managers to reduce the level of anthropogenic disturbances, otherwise there will be severe ecological and socioeconomic consequences.

The GEF/World Bank MBRS Initiative identified the main threats to the coral reefs of Belize, Guatemala, Honduras and Mexico as: 1) inappropriate coastal/island development and unsustainable tourism; 2) inappropriate inland resource and land use and industrial development; 3) over-fishing and inappropriate aquaculture; 4) inappropriate port management, shipping and navigation practices; and 5) natural oceanographic and climate meteorological phenomena. The process also identified locations of significant trans-boundary hot spots that threaten the shared reef resources of these countries, which is now a special focus for remediation.

The main threats along the Pacific coastlines are excessive sedimentation from deforestation, anchor and other diver-related damages, and illegal fishing. The remote Caribbean coast of Nicaragua has limited development, except by the indigenous communities, although there is some over-fishing, coral extraction, oil pollution, deforestation, soil erosion and sedimentation, and water pollution. Untreated sewage, fish processing and industrial activities have resulted in poor water quality around coastal communities and inhabited cays. Sedimentation and eutrophication from deforestation in Honduras are damaging the Miskito Coast Marine Reserve, and there is intense foreign fishing for lobster, fish and turtles, especially from nearby Honduras. There are similar threats in El Salvador e.g. deforestation and soil erosion, water pollution, soil and water contamination from toxic wastes, and frequent earthquake and volcanic activity.

Potential Climate Change Effects on Coral Reefs

The major signal of potential climate change threats occurred during the 1990s which was the warmest decade with a series of extreme El Niño events. These resulted in considerable coral bleaching and mortality in the region with major alterations to the composition and structure of the coral reefs. Added to this were several major Hurricanes, including Mitch, which was the most severe on recent record. The predictions for future increases in global temperatures, added to the additional anthropogenic stresses indicate that recovery from these acute disturbances may be delayed, and major shifts in community structure, including losses of live coral cover, can be anticipated.

Current MPAs, Monitoring Programs and Conservation Management Capacity

The awareness for conservation and sustainable use of coral reefs is increasing in the region and programs or regulations are being developed for improved land use and control of coastal development, sustainable fisheries exploitation, pollution control, and sustainable tourism. Mexico and Belize have developed conservation programs for coral

HURRICANE IRIS IMPACTS ON BELIZE REEFS

Belize lies right in the path of many late season hurricanes, with the largest, Hurricane Mitch, slamming into the barrier reef and Glovers Reef in 1998 with windspeeds approaching 300km per hour. Mitch battered the coastlines and degraded many shallow reefs. Just 2 years later in October 2001, Hurricane Iris hit the southern coast of Belize with maximum sustained winds of 220km per hour. This storm, however, moved along a narrow tract in a southwest direction and hit Monkey River Town. Hurricane force winds extended only 30km from the centre affecting southern Glovers Reef and South Water Caye Marine Reserves, patch reefs southeast and west of South Water Caye Marine Reserve, the barrier reef section north of Gladden Split, Gladden Split Marine Reserve, Laughing Bird Caye National Park and barrier reef section north of Sapodilla Cayes Marine Reserve. The Belize Coastal Zone Management Authority and Institute surveyed 3 MPAs and found that the greatest impact was to the fore-reef of Laughing Bird Caye with average mortality of 19.6% and 'mechanical' damage to 70.7% of coral colonies. The fore-reef of South West Caye, Glovers Reef showed 12.2% recent mortality and 52% mechanical damage, and there was much less impact on the back-reef of Laughing Bird Caye (6.2% mortality, 26.7% damage), Gladden Split (1.0% mortality, 6% damage), and patch reef near South West Caye (4% mortality, 28% damage). The greatest mechanical damage was to *Acropora cervicornis* (staghorn coral), and species of *Porites, Montastraea and Siderastrea* corals, particularly tumbling damage to colonies e.g. 53% of colonies were knocked over on the fore-reef of Laughing Bird Caye. Gorgonians were also damaged by the hurricane, especially near South West Caye, where many were toppled or completely detached. The damage from Hurricane Iris will have long-term consequences for the Laughing Bird Caye National Park, which is a main tourist destination for Placencia, because the fore-reef has been devastated. Further assessment and monitoring is planned by the Authority to distinguish damage from natural causes and those that management can control e.g. fishing and coastal development. From: Nadia Bood, Coastal Zone Management Authority and Institute, Belize, czmbze@btl.net.

reefs; while there is some progress in Honduras, Guatemala and Nicaragua. The Belize Coastal Zone Management Authority and Institute is a model of integrated coastal management for the region and the country's system of 13 MPAs is well-established, with almost all the parks now under active management.

Marine Protected Areas

There are over 100 MPAs in Mesoamerica, covering 45,000km^2 of marine resources, including coral reefs, with most of them designed to protect fishery resources or critical habitat from damaging human activities. Mexico and Belize have a mix of both government and NGO management of MPAs, whereas management in Guatemala and Honduras is mostly through NGOs. Management effectiveness is very variable, ranging from 'moderately satisfactory' in Belize and Mexico, with reasonable success in reducing human impacts on coral reefs, whereas most others in the region remain as 'paper parks', due to inadequate funds to manage the resources. These issues remain the two greatest challenges for the region's MPAs. An investigation is currently being conducted in El Salvador to review the System of Protected Areas.

Regional initiatives are fostering a broader perspective of the importance of a functional network of marine protected areas. Support is being developed for planning, management and monitoring of the effectiveness of the MPAs; institutional strengthening and financial sustainability mechanisms. The MBRS Initiative is working with 15 priority MPAs in the 4 participating countries, and there is major training of MPA personnel on several key issues under its objectives, including co-management of MPAs and preparation of management plans. WWF has identified 9 highest priority biodiversity areas in the ecoregion, which often encompass several protected areas. A regional initiative is currently under development to increase funding mechanisms and building human capacity, in order to tackle both in-country problems and trans-boundary threats.

Coral Reef Monitoring

Until recently, the capacity to monitor reefs varied considerably across the region. Most monitoring and research was done through a combination of local NGOs, MPA biologists, GCRMN, AGRRA, REEF, Reef Keeper and Reef Check, CARICOMP and numerous local and national programs, many of them short-lived. There has been recent monitoring in Belize and Mexico, and Honduras with a mix of government, NGO or academic involvement, but virtually none in Guatemala and Nicaragua. There had been poor coordination and data sharing among monitoring programs, with few successes in using the data for conservation decision-making. Most government agencies lack the funds and capacity for extensive monitoring programs.

COMMUNITY CONSERVATION EFFORTS IN XCALAK, MEXICO

The Meso-American Barrier Reef system is a focus for many agencies seeking to conserve some of the best coral reefs in the Caribbean. The U.S. Agency for International Development (USAID) has provided funds to the Coastal Resources Center at the University of Rhode Island to work in the State of Quintana Roo, near the Belize border. This is a small-scale success story that can be used as a model in the region. The community of Xcalak became greatly concerned in mid-1990s, about the decline in fish catches along their coast. Fishermen were spending more time on the water to catch the same amount of fish that they had caught a few years earlier in much less time. Then the community was informed about a government sponsored tourism development. The Xcalakeños participated throughout the process of designating the 17,000 hectares around the barrier coral reef as a National Park. The Xcalak Marine Park was officially declared in June 2000, making it one of the first locally initiated marine parks in Mexico. Community members are now implementing some of the components, including water zoning to separate fisheries and tourism activities, fisheries monitoring, and training to help local people engage in the ecotourism industry. The combined promotion of low-impact tourism development, linked to protection and conservation of the barrier reef through the marine park, has made Xcalak a learning example in coastal management for its neighbours on the Mesoamerican Reef system. Contacts: Lynne Hale, lzhale@gso.uri.edu; Richard Volk, rvolk@USAID.gov

A summary of marine and coastal protected areas in North Central America, with an assessment of their state of management (where information was available).

Country	No. of MPAs	Status of MPAs	Progress Since 2000
Belize	13 (marine) 7 (coastal)	11 of the 13 MPAs have active management, most through agreements with local NGOs.	Increasing support for MPAs Swallow Caye Wildlife Sanctuary established (2002) Many MPAs newly under active management
El Salvador	2	A System of Natural Protected Areas is under consideration for legislation by Government & the President.	Inclusion of Areas de Reserva Acuática (Aquatic Reserve Areas) in Sistema de Areas Naturales Protegidas is being considered
Guatemala	4	Established the first Manatee Protected Area, which has a management plan & staff administered by Universidad de San Carlos.	Increasing support for MPAs
Honduras	25	Some of the existing management plans need updating.	Increasing support for MPAs
Mexico	44 (marine & coastal)	Most MPAs have a management plan. Enforcement of legislation is improving & monitoring being developed.	Increasing support for MPAs National coral reef monitoring protocol developed
Nicaragua	4	Miskito Cay Marine Reserve is community managed.	No details available
TOTAL	**91**		

Monitoring programs in Mexico have included CARICOMP, AGRRA, REEF, Reef Keeper and Reef Check, and conducted by a range of institutions (academic, government and NGO). Similarly in Belize, monitoring activities have involved CARICOMP, AGRRA, CPACC and REEF methodologies and been conducted by MPA staff. Guatemala has few coral reef resources, and most monitoring is of land impacts or via a tourism perspective. NGOs have done virtually all the monitoring in Honduras and Nicaragua. The first region-wide reef survey was sponsored by the GEF MBRS Initiative in 1999 to assess damage following hurricane Mitch and coral bleaching. A second region-wide survey was coordinated by WWF in 2001 to determine the extent of recovery and any subsequent impacts.

Monitoring in Belize, Guatemala, Honduras and Mexico will increase within the MBRS Project, which has substantial funding and established harmonised and standardised monitoring methodologies for the region. Monitoring will focus on three core areas: coral reef ecology and associated ecosystems; marine pollution (from land-based and marine sources); and physical oceanography and models. The MBRS Initiative will develop a 3-D oceanographic model for the entire region to assist management understand current patterns in the region, interconnectivity between reefs, transport of eggs and larvae and dispersion of pollutants. The monitoring will involve the active participation of many partners from government agencies, NGOs, academia and coastal communities. The data and meta-data will be included in an environmental information system.

Government Policies, Laws and Legislation

While most governments have signed major international agreements pertinent for coral reef biodiversity conservation, the most significant have been regional plans for government cooperation, especially the Declaration of Tulum and the Cartagena Convention. The Tulum Declaration was signed by the leaders of Belize, Guatemala, Honduras and Mexico to protect and conserve the fragile ecosystems of the Mesoamerican Barrier Reef, as a precursor to a large Global Environment Facility project to conserve these resources across national boundaries. Capacity within each country varies considerably, but generally there is insufficient infrastructure and institutional ability to implement international agreements and enforce national environmental laws. Funding of conservation policies and MPAs is an ongoing issue that is being addressed by the creation of a regional Mesoamerican Reef Environmental Fund which will establish a long-term endowment to support these activities.

Mexico has extensive legislation and is developing capacity to manage natural resources, with an effective protected areas program containing numerous ecological zoning programs responsible for regulating coastal activities. **Belize** has the legal and institutional policy framework to manage coral reefs, but may lack the long-term funding for enforcement and monitoring of the extensive system of MPAs. There is considerable reliance on international government and NGO support. There are few laws or regulations for coral reefs in **Guatemala**, but this is being remedied through the Declaration of Tulum and follow-on activities. Similarly in **Honduras** there are few laws and regulations on coral reef resources, and enforcement of these is weak. **Nicaragua** has no national legislation or institutional framework to conserve coral reefs. There are a few small MPAs, which are managed as partnerships between public and private sectors. In **El Salvador**, there is no legislation for coral reefs as there are few reef resources.

Information Gaps, Monitoring and Research Needs

Although significant efforts have been made to address the lack of information on key issues to manage coral reefs and minimise human impacts, there are still large gaps in capacity and political will. The MBRS Initiative recommended 5 target areas that require further focus.

Conclusions

- The best developed reefs are on the Atlantic coast; Pacific reefs are poorly developed. Major information gaps remain for Nicaragua, Honduras and Guatemala, and offshore areas like Swan Islands, Mysteriosa banks and offshore Pacific reefs. Future monitoring programs should adopt the regional methodology being developed to aid in data analysis and comparison of results.
- Human threats to regional reefs continue: inappropriate and unsustainable land use; expanding tourism (especially in Mexico and Nicaragua), and industrial development; over-fishing and impacts from aquaculture; pollution from poor sewage treatment, waste disposal, agricultural runoff, and other land-based sources; poor port management, shipping and navigation practices; as well as global climate change and coral bleaching.

Gaps Identified In 2000	Activities Since 2000
1) Sustaining Fishery Resources • Fishing activity (effort, catch) • Status of fisheries resources (population, life history data) • Location, size and exploitation of nursery and spawning areas • Economic alternatives to fishing	MBRS is conducting a regional assessment of spawning aggregations with training and will launch an environmental awareness campaign on sustainable fishing in Nov 2002; WWF is promoting the 'value of fully protected marine reserves as a fishery management tool in the Mesoamerican reef' and training in alternative livelihoods Dec 2002-Oct 2003.
2) Conserving Coral Reefs • Status, distribution and connectivity of coral reefs • Water temperature trends and patterns	MBRS monitoring will assess health of the reef and associated ecosystems, and larval flows. WWF will repeat 2001 reef survey.
3) Sustainable Development • Current and projected land use • Tourism levels and potential sustainable expansion • Agricultural development and impacts	Belize is the focal point for studies; Mexico completed land development plan for Quintana Roo WWF has sustainable tourism project in Costa Maya & studies in Hol Chan, Belize, Banco Chinchorro and Xcalac, Mexico; MBRS Initiative developing tourism certification and Tourism Forum; WWF developing best practices in watershed management in Honduras & Guatemala
4) Improving Water Quality • Status of water quality & sources of contamination • Water discharges and flows, minimize water pollution	Belize has a comprehensive water quality program; to extend to all countries; flow rates have been modelled & continuing.
5) Environmental Awareness and Public Education	The MBRS Initiative developing an environmental awareness campaign to focus on issues above. WWF has sponsored regional journalists workshops.

- Fishing pressures are increasing for most target species (conch, lobster, grouper) and over-exploitation is evident throughout the region, although data are patchy. Fishery regulations are not enforced, management is fragmented, and communities are being provided with few alternatives to fishing. The countries are seeking trans-boundary solutions.
- Coral reefs in the region declined in the 1980s and 1990s due to coral diseases and mortality of the sea urchin *Diadema antillarum*; mass coral bleaching, and hurricanes. There has been some recovery since then, but not to former levels of cover, diversity and health.
- The long-term recovery after the damage will depend on the ability of corals to recruit, adapt, and persist, and whether there are repetitions of similar disturbance events. Human pressures (inappropriate coastal development, land-use etc.) are impeding recovery from natural stresses.
- Monitoring and research capacity is improving via the MBRS Initiative and an environmental information system will be developed 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; other countries have neither.
- The Tulum Declaration (1997) has enhanced the prospects for conservation and the injection of funds into the MBRS Initiative by the Global Environmental Facility and collaborative NGO ecoregional conservation programs have greatly accelerated prospects for improved conservation of the coral reefs.

Recommendations

Coral Reefs and Adjacent Ecosystems (to complement current activities)

- A regional comparable monitoring program needs to be strengthened to better identify, characterise, and monitor the extent and condition of coral reef habitat and associated organisms.
- An extension of surveying and monitoring is needed to cover less known areas and countries not assisted by the MBRS Initiative such as Nicaragua, offshore islands and banks like Swan Islands and Mysteriosa banks, and reefs in the eastern Pacific.
- Further studies are required on coral reef recovery, reef vulnerability, and resiliency, especially in response to coral bleaching and climate change associations, and hurricane impacts.
- There is a need to gather information on coastal and oceanic currents and circulation patterns and water temperature trends and patterns to track larval flows.
- It is essential to identify areas that warrant immediate protection, in particular those with high biological productivity; sources of larval corals, fishes, and other important reef organisms; biodiversity hot spots; nursery and breeding areas; and areas at high risk of human impacts.
- Improved information is required on the distribution and status of adjacent ecosystems (mangroves, seagrasses, lagoons, bays, and wetlands). Some of this information can be gathered using remote sensing techniques, although there are limitations, which will have to be rectified by direct field observations.

Critical and Endangered Species

- Further assessments and monitoring are required on the populations of the West Indian manatee and American crocodile, especially feeding habitats of the manatee and crocodile nesting sites. There are large data gaps on dispersal and survival of juveniles, interactions with humans, and current deliberate or accidental catch rates.
- Information on sea turtle populations, migration patterns, nesting beaches and hatching success rates, feeding habitats and ranges, illegal fishing, and impacts of coastal development is a priority requirement.

Fisheries and Fishers

- 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, larval transport pathways, and migration corridors.
- Current fishery statistics are inadequate across the ecoregion, although some countries do have statistics on key species. There is a need for uniform reporting standards and yearly updates of fishery statistics.
- Specific data are required on: fishing activity (number of fishing boats, effort, catch volume); major fishing areas; types of gear used; artisanal, sport, and destructive or illegal fishing practices.
- The enforcement of existing fishery regulations is essential and education to improve compliance is needed. There is a need to design new regulations to

reflect an ecosystem approach to management, and ensure that regulations are harmonised throughout the region.

- There is a need to designate more and larger no-take marine reserves and develop financial mechanisms to plan and manage these protected areas.
- Economic alternatives to fishing need to be developed to reduce effort and eliminate unsustainable fishing practices. Involving fishers in conservation and research efforts is an essential mechanism to reduce effort and increase compliance.

Socio-economic Data and Coral Reef Users

- Improved understanding and better regulation of and local participation in control of planning of coastal development is required, including current and projected land use of forests, wetlands, coastal areas, shrimp aquaculture, land tenure, tourism and industrial and agricultural activities.
- Another specific need is an understanding of water use and the effects on water quality, especially point and non-point sources of contamination, discharge and flow rates and trans-boundary pollution.
- Information on tourism is lacking in some countries, thus surveys should focus on the number of tourist rooms, location of diving sites, and cruise operators in the area.
- Information is patchy on how local communities interact with coral reefs and the economic benefits from goods and services the reef provides. Specific assessments should include how human are affected culturally and economically by natural disturbances like hurricanes that damage ecosystems. Analyses of short-term losses and long-term gains in the designation of 'exclusion' and 'no-take' areas are required.
- Improved documentation and planning is required on the impacts of the oil industry and pipelines, and shipping and port activities.
- There is a need to develop mechanisms for gathering, archiving and transmitting critical data on coral reefs and related ecosystems to all stakeholders, including user communities. This will require the construction of national databases and mechanisms of interpreting these data for general use.
- There is a need to assess the vulnerability of communities and governments to global climate change and mechanisms for adaptation.
- Investigations are required on how to improve institutional infrastructure and financial sustainability to implement effective conservation and maintain MPAs, such as the Mesoamerican reef fund being developed.
- Environmental awareness campaigns are needed to inform communities and the public of the need for and value of conservation of natural resources, especially their coral reefs.
- Finally there is a need for frank assessments of the effectiveness, roles, capacity and willingness of governments, training institutes and NGOs to implement natural resource conservation and management and ability to continue into the future.

Reviewer

Marea Hatziolos, World Bank, Washington USA.

Acknowledgements

The Mesoamerican Barrier Reef Systems Initiative is funded by the Global Environmental Facility, and implemented by the World Bank and executed through the Comisión Centroamericana de Ambiente y Desarrollo. It has official support from Belize, Guatemala, Honduras and Mexico. Helpful information has been provided by Oscar Lara (MBRS Initiative Natural Resources Specialist), Demetrio Martínez (MBRS Initiative Sociologist), Nadia Bood (Head, Coral Reef Monitoring Unit for Coastal Zone Management Authority and Institute). Ramon Carcamo from the Fisheries Department in Belize provided useful information on national fish catches. Margarita Salazar de Jurado provided valuable information for El Salvador. Melanie Mcfield is supported by the World Wildlife Fund's Mesoamerican Reef Ecoregional Program.

Author Contacts

Patricia C. Almada-Villela is the MBRS Project Environmental Monitoring Specialist and leader of the MBRS Regional Synoptic Monitoring Program, which is the Regional Node for the GCRMN, palmadav@mbrs.org.bz; Melanie McField is the Reef Scientist and Senior Program Officer for Belize for WWF's Mesoamerican Reef Program, mcfield@bt.,net; Philip A. Kramer and Patricia Richards Kramer are at University of Miami/RSMAS.USA, pkramer@rsmas.miami.edu, and kramer_p@bellsouth.net; Ernesto Arias-Gonzalez, CINVESTAV-Univ. Merida, Mexico, earias@mda.cinvestav.mx

Supporting Documentation

Belize Fisheries Department 2001. Capture Fisheries Statistical Report 2001. 27 pp.

Bood ND 2001. Coral Reef Monitoring Status Report - Belize. Carribbean Planning for Adaptation to Global climate Change: Component 5. Coastal Zone Management Authority and Institute. Revised Version. 52 pp.

Froese R, Pauly D (Eds). 2002. FishBase. World Wide Web electronic publication. www.fishbase.org, http://www.fishbase.org/search.cfm

IUCN 2002. The IUCN Red List of Threatened Species. World wide Web electronic publication. http://www.redlist.org/search/search-expert.php?kingname=ANIMALIA

MBRS 2002. Mesoamerican Barrier Reef Systems Project. Annual Work Plan for the Period: 2002-2003. Belize City, Belize. 26 June 2002. 54 pp.

McField M 2002. Mesoamerican Reef Expedition: 2001. World Wildlife Fund. www.worldwildlife.org.

World Bank 2001. Conservation and Sustainable Use of the Mesoamerican Barrier Reef System (MBRS) Project Appraisal Document. World Bank Latin American and the Caribbean Regional Office (Washington) and the Central American Commission on Environment and Development (El Salvador). 182 pp.

ICRAN | WHS | MAB

SIAN KA'AN BIOSPHERE RESERVE, MEXICO – ICRAN DEMONSTRATION SITE

Sian Ka'an, a 5,300km^2 Biosphere Reserve on the Caribbean coast of the Yucatan Peninsula, was designated a World Heritage area in 1987. The area contains saltwater, brackish and freshwater lagoons and limestone sinkholes fed by underground rivers and springs. Sian Ka'an also includes one of Mexico's largest protected coastal wetlands for thousands of species of plants and animals, many of them endangered. There is also a MPA with approximately 150,000ha of coral reefs, which are renowned for their sportfish populations of tarpon, bonefish, snook and permit. It is in the 2nd largest barrier reef in the world and contains considerable biodiversity.Fishing is the major activity and many of the people are involved in fishing, with spiny lobster the main catch (75%) that sells for about US$15 per kilo for a total yearly catch of 80 tons over the last 11 years. Most is exported to the USA and Japan. Long-term conservation plans for the Reserve focus on fisheries and tourism in the coastal zone. Uncontrolled growth of tourism is a major threat, but the local management agencies and stakeholders believe that the future of Sian Ka'an lies in small scale tourism such as sport fishing, snorkelling, kayaking, nature walks, camping and wildlife observation. The paramount management goals of the area include: preserving the physical integrity of the area; promoting reasonable use of the natural resources; fostering social integration; spearheading research and education; and securing financing for the operation of the area.

Zoning: The reserve is divided into: a *Core Zone,* containing the best preserved areas for conservation and limited scientific research; *Buffer Zone,* where low-impact human activities and sustainable use of natural resources are permitted within reserve boundaries; and *Cooperation Zone,* which includes those lands and human settlements located adjacent to the boundaries of the reserve, where natural resource management measures are also applied.

Ecological Monitoring: During the last decade of reef monitoring in Sian Ka'an, changes in the number of species, coral cover, algae and fish, have been noted in every monitoring station, but these changes are not statistically significant. This variation is attributed to hurricanes, El Niño, and bleaching.

Socio-economic Monitoring: A socio-economic assessment is being implemented to elucidate the changes in the coastal communities of the Reserve. This ICRAN project aims to demonstrate the value of community-based management along the coast line. This project will also provide baseline data to contribute to the implementation of a long term socio-economic monitoring program.

Monitoring Effectiveness: Long-term ecological monitoring of Sian Ka'an has contributed valuable scientific data that has been crucial for decision making and the development of management measures. It has provided information on the ecosystems and resource conservation status, as well as on the trends related to human impacts.

Contact: Oscar Álvarez, Cancún, México, oalvarez@conanp.gob.mx

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 Reserve is on Ambergris Caye, about 6km south of San Pedro Town in northern Belize, and contains coral reefs, seagrass beds, and mangrove forests. The main feature is a natural break in the reef, the Hol Chan Cut. The Hol Chan Marine Reserve was established in 1987 with protected areas designated for no-fishing, no dredging of seagrasses, and no cutting of mangrove forests, and aimed at protecting the reefs and habitats for commercially important species. The Reserve is multi-use and divided into 4 zones: A - includes the barrier reef and is a no-take zone; B - consists of seagrass meadows where traditional fishing is allowed, but spear fishing and nets are prohibited; C - includes the southern tip of Ambergris Caye and 7 mangrove islands, where the cutting of mangroves and disturbing wildlife is prohibited; and D - Shark and Ray Alley, with 2 'Exclusive Recreational Areas' where diving and snorkelling are allowed. Tourism has become the major income activity in Belize, however, environmental pressures are increasing and damaging the resources that attract tourists. Over-fishing of lobster and conch result from an increased demand for seafood. Tourism developments have involved dredging, cutting of mangroves, and pollution.

Ecological Monitoring: The monitoring program of the Reserve staff is not fully effective or consistent due to a lack of finance and manpower. Funding from Caribbean office of UNEP and the ICRAN project, is upgrading monitoring by training park staff to dive instructor level so that they will train volunteers from San Pedro town to form the core monitoring group and undertake public education campaigns. Lobster and conch populations are monitored, and fish populations assessed with a visual census technique. Corals are monitored using a line intercept technique and the CARICOMP methods. Some data are available e.g. there was 25% live coral cover at Tackle Box, Ambergris Caye in 1994, and 20% cover at Gallows Reef in 1992. The shallow Mexico Rocks patch reef off Ambergris Cay had 84% coral cover in 1993, but this dropped to 66% in 1995, due to the 1995 coral bleaching even, and coral cover in Hol Chan was estimated at 39.6%.

Socio-economic Monitoring: Visitor impacts are assessed by observing recreational divers for half an hour.

Monitoring Effectiveness: The Hol Chan MPA was established in 1987 as a response to the decline in fish stocks. An assessment program selected the preferred area with good coral reefs, mangroves and seagrass beds. Since the establishment, there has been an improvement in fish stocks, and monitoring enables the management to demonstrate that the MPA is fulfilling its objectives compared with adjacent areas. The current monitoring program aims is to show fishers any spill-over effect with increased fish, lobster and conch populations being available in nearby fishing areas. Monitoring results are used to stimulate interest among stakeholders and to convince visitors and locals of the benefits of the MPA. Plans are underway to extend the Hol Chan MPA, and create additional reserves, with support from the Tour Guide Association and local fishermen, largely stimulated by monitoring data that demonstrate benefits from the MPA.

Contact: Miguel Alamilla, San Pedro Town, Belize, hcmr@btl.net

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

Reefs at Risk in the Caribbean

The project aims to raise awareness about threats to coral reefs by compiling and analysing information similar to the process for Southeast Asia. The goal is to guide management interventions at national and international levels using data on location, status and protection of coral reefs across the Wider Caribbean, coupled with estimates of threats from human activities. The analysis collates different threats, and combines them into a region-wide indicator of human pressures on coral reefs. This is a project of the World Resources Institute, the UNEP Caribbean Environment Program (UNEP-CEP) and other partners, including the International Coral Reef Action Network (ICRAN). The following threats are being analysed:

Coastal Development: Poorly managed coastal development can threaten coral reefs both through direct impacts (dredging and land-filling) and indirect impacts (sewage discharge, and runoff from constructions). This threat is evaluated via population and infrastructure development along coasts;
Sediment and Pollution form Inland Sources: Land-use change and agriculture far inland can damage coral reefs. A region-wide watershed-based analysis will incorporate information on slope, precipitation, land cover and soil type to estimate relative erosion rates (for all areas in each watershed) and sediment delivery by watershed;
Marine-based Sources of Pollution: Pollution threatens coral reefs from ports and oil spills, ballast and bilge discharge, dumping of garbage, and direct damage by groundings and anchor damage. These threats are assessed by location of oil infrastructure and size of ports, and shipping patterns;
Overfishing: Over-fishing results in reductions in fish size, abundance and species composition, and alters the ecology of reefs. Information is integrated from fisheries agencies of over-fishing indicators developed by the Atlantic and Gulf Rapid Reef Assessment (AGRRA) and coastal population density;
Coral Bleaching: This is an increasing threat to coral reefs as global temperatures rise, and the relative resistance to coral bleaching will be evaluated based on proximity to deep water, degree of enclosure, water movement, cloudiness, and turbidity;
Coral Disease: The incidence and patterns of the many coral diseases attacking Caribbean coral reefs will be assessed.

The analysis will explore the natural vulnerability of coral reefs to pollution and sedimentation, based on the physical oceanography, particularly the degree of flushing. A revised coral reef map for the Wider Caribbean is being developed by UNEP - World Conservation Monitoring Centre. Additional components include: **Management Effectiveness** – revised maps of MPAs in the region with indicators of management effectiveness, in collaboration with UNEP-WCMC and UNEP-CEP; **Economic Valuation** - information on the sustainable economic value of healthy coral reefs and losses that follow damage will be assessed in collaboration with the WorldFish Center. Production is scheduled for early 2004; contact Lauretta Burke, World Resources Institute, LAURETTA@wri.org or www.wri.org\reefsatrisk

17. Status of Coral Reefs in the Eastern Caribbean: the OECS, Trinidad and Tobago, Barbados and the Netherlands Antilles

Paul Hoetjes, Amoy Lum Kong, R. Juman, Andre Miller, Malden Miller, Kalli De Meyer and Allan Smith

Abstract

The islands of the eastern Caribbean continue to face the same threats to their coral reefs that were described in 2000. These threats include: sedimentation and pollution from coastal development; anchor and diver damage from tourism; overfishing due to increased demand; and coral bleaching and increasingly frequent and severe storms as a result of climate change. The effects of climate change have resulted in the degradation of shallow reefs throughout the eastern Caribbean, whereas deeper reefs have generally been less affected. Some islands have established effective management institutions and monitoring programs that are either well supported or are capable of generating their own revenues. However, others are hampered by inadequate legislation or lack of enforcement of existing legislation, and insufficient human and financial resources. The use of volunteer Reef Check teams for coral reef monitoring has increased management capacity in many areas. There is a need to expand upon these efforts and demonstrate the benefits derived from monitoring programs and protected areas in order to increase support from local governments.

Introduction

This region includes the islands of the Organisation of Eastern Caribbean States (OECS) plus Trinidad and Tobago, Barbados, and the Netherlands Antilles. Coral reefs are critical to the economies of these islands for tourism and fisheries, but little is known about the status and trends of these reefs and management is often rudimentary and inconsistent.

The reefs of **Antigua and Barbuda** cover about 25km^2, with large bank reefs, patch reefs and fringing reefs around both islands. **Dominica** is a steep high island with little reef development, whereas on **St. Lucia** there are extensive coral reefs off the south and east coasts. Those on the west coast grow mainly as veneers on volcanic rock, but this is the side favoured by the tourists. In **Grenada** there are patch and fringing reefs on the east and south coasts, and around the islands of the Grenadines. Reefs around **Montserrat** are exposed to high-energy waves and also have been damaged by volcanic eruptions. The **Barbados** coral reefs cover 16.4km^2 with an additional 7.2km^2 of coral rubble, which is being consolidated by encrusting algae. The west and south coast has an almost continuous bank reef, which has recently shown signs of recovery from human impacts and bleaching. The northeast and southeast coasts have the most reefs and are the least impacted.

The **British Virgin Islands** consist of 60 small islands, just over 150km^2 in area on a 3,000km^2 shelf of the Puerto Rican Bank. These reefs are very popular for tourists, particularly those on ships and yachts. The island of **Barbados** differs from the other islands by being an uplifted reef surrounded by a narrow 2-3km wide shelf with several bands of fringing reefs. These are better developed on the relatively calm west coast which is the basis for a large tourist industry. **The French Caribbean** has reefs on **Guadeloupe** and **Martinique**, which are similar to others in the Eastern Caribbean States growing on narrow shelves around high islands. There are a mix of fringing and barrier reefs, which are better developed on the western protected coasts.

The Netherlands Antilles

There are 2 distinct island groupings in Netherlands Antilles. **Bonaire** and **Curaçao** are small oceanic islands 70km north of Venezuela that are exposed to persistent trade winds. Continuous fringing reefs surround the islands, particularly on the leeward sides. The islands of **St. Maarten**, **Saba** and **St. Eustatius** are in the northern part of the Lesser Antilles Arc and similar to other islands in that area. The **Saba Bank** is a submerged bank in Netherlands Antillean waters that is considered to be a submerged atoll with actively growing reefs on its eastern and south-eastern edges.

Trinidad and Tobago are on the edge of the South American continental shelf, and under the direct influence of the Orinoco River. Thus, there are comparatively fewer coral reefs in Trinidad than Tobago. There is a single fringing reef on the northeast coast of Trinidad, and many patch reefs near the offshore islands, and particularly around Tobago. These reefs are heavily used for fishing and tourism with up to 200 tourists visiting Buccoo reef per day. In southwest Tobago, there are 1,654 hotels, and another 1,372 rooms are approved for construction.

Status of Coral Reef Benthos

For many of the islands in the Eastern Caribbean, there has been no new information provided for this 2002 report. For more details, see the Status report published in 2000.

Dominica

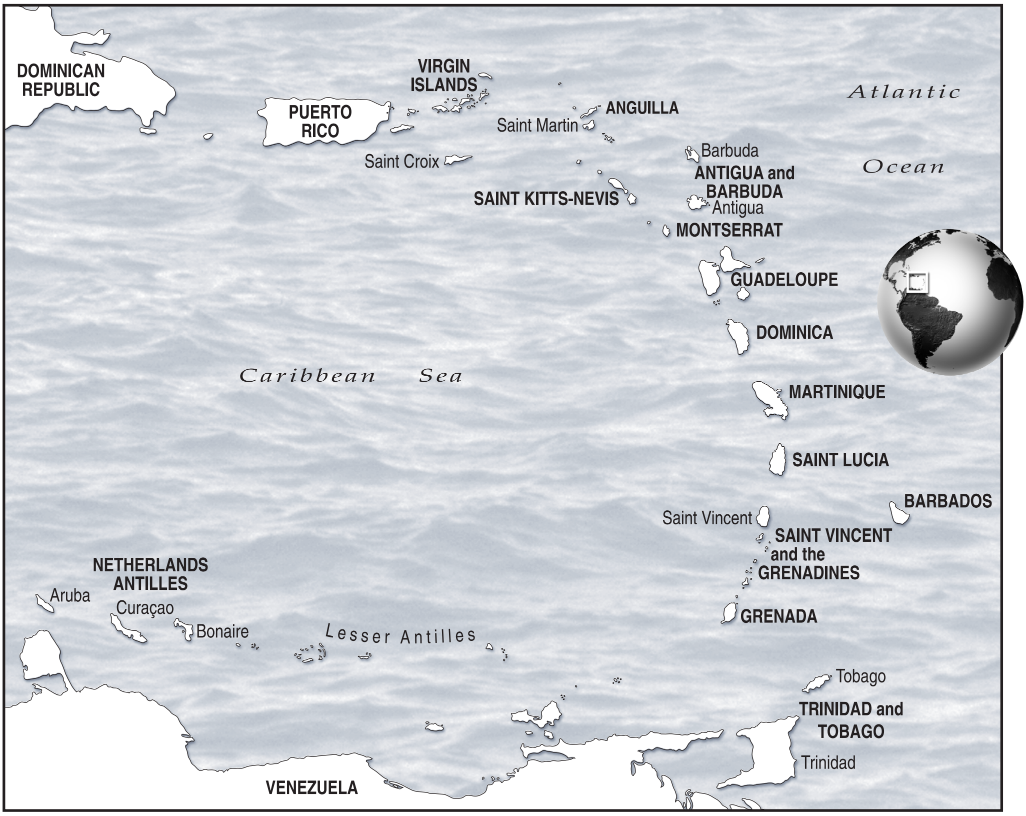
Most of the reefs are considered very healthy.

Anguilla

In late 2002, Reef Check surveys of an exposed reef 5m deep and 100m off the north of Blackgarden showed 15% live coral cover, 4% macroalgal cover, 46% rock and low numbers of key fish species and black spined sea urchin. Coral cover is considered to be comparatively high for the island.

St. Lucia

Reef Check surveys in St. Lucia (Maria Island Nature Reserve, Anse Chastanet, Coral Gardens, Malgretoute and Turtle Reef) in 2001 show that the shallow reefs (3m) continue to be under stress with further declines since the 1999 surveys. The shallow sites were dominated by standing dead *Acropora palmata*, which contributed to more than 50% of the total benthic cover. Live coral cover averaged 6.9%, ranging from 2-10.6% and fleshy algal cover averaged 15.8%, ranging from 12-19.4%. The deeper reefs (10m) appeared healthier than the shallow reefs with 17% cover, although this is still a decline from 1999. Algal cover averaged 22.2%.



Barbados

The west coast fringing reefs continue to be in poor condition, although some early signs of recovery are evident. The patch reefs to the southwest have also deteriorated significantly over the last 20 years. Reefs on the Atlantic coast are in better condition with high diversity but low coral cover, due to exposure to oceanic waves. Anthropogenic impacts on this coast are slowly increasing, but the implementation of an integrated management plan is starting to have a positive effect with most stakeholders cooperating. The last extensive surveys were in 1997/8 on the east, southeast and north coasts and the results indicated 10 distinct habitat types down to the 5m depth contour.

There has been no specific bleaching monitoring, but there was 65–90% bleaching in 1998 around the island with *Diploria* sp and *Siderastera siderea* the most affected. At one site, monitoring showed that approximately 20% of bleached corals did not survive, but this site was also impacted by effluent from the rum refinery. Reef Check surveys in April 2001 showed 10-42.5% (mean 28%) hard coral cover, and fleshy algal cover of 0-20% (mean 6.3%) along the west and southwest coast.

Coral Disease in Bellairs Barbados

2,439 coral colonies were surveyed for diseases in December 2001 and in March 2002 at the Bellairs North & South Reef sites at 4-5m depth. At Bellairs North, 93.5% of colonies were healthy, 2.6% were bleached, 1.2% had dark-spot disease, 0.5% of colonies had yellow band disease, 0.2% had white plague and 1.7% showed some injury.

At the Bellairs South, 97.9% of colonies were healthy, 0.2% had dark-spot disease and 1.9% showed signs of injury. The corals most affected were *Siderastrea siderea* and *Porites asteroides,* however these were not the most abundant (see % relative abundance below). The incidence of disease was low at only 1.2% over both sites, with Dark Spot disease the most abundant. The incidence of bleaching was 1.5% at both sites. These Bellairs reefs are relatively free of diseases.

Species	Bellairs North	Bellairs South
Agaricia humilis	33.7%	17.5%
Agaricia agaricites	19.1%	26.0%
Porites astreoides	17.6%	31.5%
Porites porites	8.5%	0.9%
Millepora squarrosa	6.9%	10.6%
Montastrea annularis	5.2%	1.1%
Siderastraea siderea	3.1%	1.3%
Madracis mirabilis	2.4%	0.8%
Millepora complanata	1.2%	5.4%
Millepora alcicornis	0.8%	—

The Netherlands Antilles
Bonaire and Curaçao

The coral reefs on the leeward (western) side have a 30-150m long shallow terrace to a 10-15m drop-off. The terrace has predominantly *Acropora palmata*, *A. cervicornis* and *Montastrea annularis* hard corals and a variety of gorgonians. *A. cervicornis* has largely disappeared since 1983 due to white-band disease, and *A. palmata* stands have also declined on **Curaçao** and **Bonaire**, except for a few small locations. After the drop-off, the fore reef slopes downwards at 30-60 degrees to a sediment bottom at 50m. The dominant corals are *M. annularis*, *M. faveolata*, and *Agaricia agaricites,* with *M. cavernosa* and *Stephanocoenia* in deeper waters. About 55 coral species occur on the reefs, along with 250 species of fish. An average of 19 coral species occurred per 200m^2 at 6m on **Curaçao** and 23 species at 12m depth. Coral cover on most monitored sites has declined by 10% from 1997 to 2002, with a greater decline at 6m than at 12m. Coral cover in 2002 at 6m on the leeward side of **Curaçao** was 30 to 50%, and 30 to 70% at 12m.

Reefs on **Bonaire** have unusual shallow water spur and groove formations on the north at Boca Bartol and Playa Benge. The western (leeward shore) has continuous shallow fringing reefs including large coral heads, several meters in diameter. The reefs slope gently from the shore to approximately 12m with maximum diversity in this zone. Beyond the drop-off, the reef slopes at approximately 45 degrees to a sandy bottom between 30m and 60m. The southern facing shore contains buttresses, which slope steeply to the sediment platform at 100m. The reefs on **Klein Bonaire** are very mixed and some drop steeply only a few metres from the shore to the first sediment platform at 25-30m. Over 50 species of coral and 350 species of fish have been recorded on Bonaire's reefs.

Reef structures in **Curaçao** are similar to those in **Bonaire**, except that along the eastern half of the island vertical drop-offs are common, starting at 6 to 10m with a vertical face down to about 35m where the gently sloping sediment platform starts. As in Bonaire, the north-western part of the leeward coast is characterized by very large coral heads several meters in diameter and high, mostly *M. faveolata*, at 8-20m depth.

On the windward (eastern in Bonaire, north-eastern in Curaçao) shore the terrace extends generally 100-200m off shore to a depth of 12m. It is covered primarily with crustose coralline algae and *Sargassum,* and also some gorgonians. The reef slope is generally far less steep than on the leeward shore with less coral cover and abundant brown algae.

Saba is a volcanic island with steep slopes above and below water, which reflect past volcanic activity, with underwater lava flows and hot springs. The sheer walls are covered with sponges and the only 'true' coral reefs are on the east side of the island. Human pressures on the reefs have always been slight, even while the island population has increased, and there has been limited coastal development.

The dominant hard corals are *Montastrea anularis, M. cavernosa, and Diploria strigosa* as well as 35 other hard coral species and several species of gorgonians. Coral cover at 0-7m is low due to the rough seas. Densities of *Acropora palmata* are very low in relatively calm shallow areas because of storms in 1998 and 1999. Coral cover does not exceed 20% because of high sediment loads and frequent benthic algal blooms. Bioeroding sponges overgrow large areas of star and brain corals. Saba Bank is a shallow submarine plateau, 3-5km southwest of Saba and 25km west of St. Eustatius. It is a submerged but living atoll, with corals growing on the eastern and south-eastern windward edges covering approximately 20-40km^2. Surveys in 1996 concluded that reefs on the eastern edge have rich coral cover (60-90%) and diversity (28 hard coral species). AGRRA surveys in December 1999 found only 24% live coral cover with the highest coral cover at 21m depth. The average of 27.5% dead coral cover suggests that these shallower reefs have deteriorated badly, possibly due to disease and bleaching.

St. Eustatius is on the same submerged volcanic platform as St. Kitts and Nevis. Corals form true reefs as well as grow on volcanic rocks. The coastline is relatively undeveloped, except for an oil terminal on the north-western coast, and some developments on the mid-leeward coast. The leeward side is mostly a sandy plateau with large populations of Queen Conch extending to 17m depth. The offshore coral reefs begin at approximately 25m with complex spur and groove formations that extend to about 60m. There are steep buttresses on the northern part with coral cover of approximately 80% with 35 different species. The northern complex has a labyrinth of encrusted ridges, sand channels and huge encrusted rocks. There is a fringing reef on the exposed Atlantic side.

St. Maarten is the Netherlands part at the southern end of the island of St. Martin with the remainder being under French administration. This island is on the shallow submarine Anguilla Bank, together with Anguilla and St. Barth. Patch reefs with spur and groove structures are concentrated at the east and south-eastern part of the island from 8-18m depth. In 1999, average hard coral cover was about 30% with bleaching and some diseased corals evident.

Trinidad and Tobago
CARICOMP data for Eastern Reef, Tobago shows virtually unchanged cover of hard and soft corals, or algae over 5 years. There are occasional elevated values of ammonia, nitrates and petroleum hydrocarbons on some of the reefs with discharges from land being the likely cause. The most common problems are coral bleaching and diseases, but these have been much less than elsewhere in the Caribbean. There was a major fish kill around on Trinidad and Tobago reefs in 1999 that correlated with flooding of the major South American rivers.

Live coral cover for Eastern Reef, Tobago has changed little between 1996 and 2000.

Reef Component	Total Percent Cover			
	1996	1997	1998	2000
Algae (fleshy & turf)	44.9	37.3	32.9	42.8
Hard Coral	29.4	29.9	33.6	30.6
Soft Coral	3.1	4.7	5.0	4.8

Status of Coral Reef Fishes

Most reef fisheries are artisanal in most of the English-speaking islands, but few data are available. The pelagic fishery includes 40-55 species, most of which appear to be overfished.

Barbados
Fisheries are an important tradition in Barbados contributing 1% of GDP in 1995 and employing 2,000 people. The objective of the Fisheries Management Plan of 1997 was to ensure the optimum utilisation of the fisheries resources in waters of Barbados. The principal fisheries in the plan are: shallow reef fishes; deep reef slope fishes; coastal pelagics; large pelagics; flying fish; lobsters; and sea urchins (*Tripneustes ventricosus*). However, all targeted reef fish species have been over-fished, particularly the parrotfishes (algal grazers), which are caught on lines, in traps and are speared by divers.

The Netherlands Antilles
There are hundreds of artisanal fishermen in the coastal areas of **Curaçao**, and the major target fishes are pelagic species. Fish traps and gill nets are used and spear-fishing is illegal, but still practiced. Fish populations have been severely reduced and few large fishes, lobsters or conchs are seen on the reefs due to heavy fishing pressures. Large groupers and full-size parrotfish are very rare, however, snappers and small parrotfish are still fairly frequent. Turtles are protected, but are occasionally caught as by-catch and sometimes slaughtered. Similarly on **Bonaire** there are hundreds of fishermen who fish for recreation, as well as 20-30 commercial fishermen who fish exclusively for pelagic

Coral Disease in Eastern Buccoo Reef, Tobago

Coral diseases have severely damaged Caribbean reefs since the 1980s but frequently there is insufficient information to determine causes and possible management actions. Surveys of 1269 colonies of 32 species for coral diseases at 2 sites on Buccoo Reef during October 2001 showed that 89.2% of the colonies were free of coral disease at Eastern Buccoo Reef I, but 10.1% of colonies were diseased, 0.4% were bleached and 0.2% showed signs of injury. On Eastern Buccoo Reef II, 84% of colonies were healthy, 10.4% diseased, 3.3% bleached and 2.3% showed injury. The predominant diseases were Dark Spot (affecting 4.3% of colonies at Reef I and 7.3% at Reef II), Yellow Band (3.5% and 3.1% respectively), White Pox, and White band Type I. Dark Spot occurred on 0.5% of *M. annularis* and 46.6% of *Siderastrea sp.* colonies, while yellow band disease occurred only in *M. annularis,* affecting 10.8% of colonies. Disease at Buccoo Reef averaged 10.2%, which is higher than in other locations in the Caribbean e.g. less than 2% in Jamaica and Barbados. The higher incidence in Tobago may be due to the nearby Orinoco River, which carries large sediment and fresh water loads during the rainy season (June-December).

The dominant species at both sites as % relative abundance of colonies.

Species	Eastern Buccoo I	Eastern Buccoo II
Montastrea annularis	34.0%	27.4%
Agaricia sp.	18.8%	5.3%
Briareum asbestinum	16.6%	10.4%
Siderastrea sp.	13.0%	12.7%
Mycetophyllia lamarckiana	4.3%	0.1%
Millepora sp.	3.9%	1.1%
Diploria sp.	3.3%	-
Colpophyllia natans	1.7%	7.8%
Pseudopterogorgia sp.	1.4%	0.3%
Montastrea cavernosa	0.8%	0.9%

fishes. There are no data on the number of artisanal fishermen or catch data. Whilst they primarily target pelagic fish, some of Bonaire's reefs are suffering from over-fishing as shown by an absence of grouper, conch and lobster, and reductions in snapper populations. Parrotfish are still plentiful and are not commonly targeted by fishermen. Spear-fishing, which is illegal, constitutes a small but persistent problem. Turtles are completely protected although some illegal poaching continues.

St. Eustatius has only 5 full-time fishermen, and 10 others who fish to supplement income. Fish traps are used to capture lobster and fish, and lobster are sold to local restaurants and to **St. Maarten.** Spear-fishing with scuba is illegal, but is still practiced. No fishing is allowed in the two marine reserves. Yellowtail snapper and grouper are prized fish, but locals eat almost any reef fish. The conch fishery was substantial until 2001, until the regulations started being enforced. They are currently fished illegally, although much lower than before 2001 and the populations appear healthy. Turtles are protected, although some poaching of eggs still occurs and 1-2 adults are taken annually for traditional purposes.

St. Maarten has 30 fishermen who mostly use fish traps and other artisanal practices. Fish populations are still reasonable although big groupers are not common and conch populations have been depleted.

There is limited fishing around **Saba**. Over 200 species of fish have been observed in the Saba National Marine Park and populations are considered healthy, but still recovering from historical over-fishing. Grouper and snapper biomass continues to increase after the establishment of the Marine Park.

The **Saba Bank** is fished by about 50 fishermen (mostly from Saba) who concentrate on the lobster trap and red snapper fishery. Data suggest that the lobster fishery is still sustainable. By-catch includes Queen triggerfish, small groupers (predominantly Graysbies and Red Hinds) and larger grunts. The red snapper fishery uses lines and fish traps in deep water. There was an intensive grouper fishery until the populations were depleted. Large numbers of conchs were taken from the Bank until 1995 when fishery regulations were effectively enforced and the fishery ceased to exist. The present status of the population is unknown.

Trinidad and Tobago

Fishing is the mainstay of many coastal villages in Tobago and there are 840 registered fishermen in Tobago operating 275 fishing vessels. These are mostly small, open-deck vessels, operating inshore. Fishing activities on some reefs are increasing.

Anthropogenic Threats to Coral Reef Biodiversity

There is a similar set of anthropogenic threats and impacts on most of the islands. These threats include: increased sedimentation from poorly planned development, especially construction of tourist resorts, roads and ports and through the clearance of mangroves and upland forests as well as over-grazing by feral goats; eutrophication from agricultural fertilizers and sewage, which is one of the biggest problems in Barbados; physical damage from yacht anchors and divers, although many mooring buoys have been installed; over-fishing; and climate change, which has resulted in more frequent and intense storms, high sea surface temperatures and coral bleaching.

Current and Potential Climate Change Impacts

Many countries are involved in the 'Planning for Adaptation to Global Climate Change (CPACC)' program to assist in developing policies to cope with issues like sea level rise. Specific activities include establishing a sea level and climate monitoring network and databases, resource inventories, vulnerability and risk assessments, and policy formulation.

Current MPAs and Monitoring/Conservation Management Capacity

Dominica

Photographic quadrat monitoring was implemented between 1994-1996, but has since stopped. However, water temperature monitoring continues, and the Fisheries Division conducts diver surveys as part of their monitoring process.

St. Kitts and Nevis

There is no current monitoring of the reefs. The legal framework for reef management is contained in the Fisheries Act and Environmental Protection Act but no MPAs have been declared.

Anguilla

The Government is installing 'Manta' permanent boat moorings to reduce anchor damage.

Barbados

All park naturalists have been trained to scuba dive and to conduct several forms of reef monitoring, and maintenance. The Barbados Permanent Mooring Project is underway with the aim of declaring Barbados 'anchor free' through the installation of the Manta Anchoring system for permanent moorings. Another large shipwreck has been sunk in Carlisle Bay, to increase the artificial reefs and divert diver pressures off natural reefs. In addition, an artificial reef dive area is being established on the west coast, the Folkestone MPA is being expanded and management is being improved through staff training. The Coastal Zone Management Unit has started quarterly coral reef monitoring and water quality sampling to fill in temporal or spatial gaps in available data. There were 8 permanent monitoring sites established on the Atlantic coast in 1997 to track reef health at 5 year intervals, with the next monitoring scheduled for July 2003.

No other new other MPAs have been established in the region since the last report in 2000. The Soufriere Marine Management Area on St Lucia has been chosen as an ICRAN Demonstration Site and this MPA will be provided with additional resources to ensure that valuable learning lessons are transmitted to the other island states in the Eastern Caribbean.

Trinidad and Tobago

Buccoo Reef was declared a restricted area in 1973 under the Marine Areas (Preservation and Enhancement) Act, and remains the only marine park in Trinidad and Tobago. Management plans have been formulated for Buccoo Reef Marine Park (1995), and Speyside Marine Area (Draft Plan, 2000), but they have not been implemented by the Tobago House of Assembly. Pot and spear fishing are not encouraged on the reefs, but there has been no attempt to reduce fishing.

Government Policies, Laws and Legislation

The islands of Dominica, Antigua and Barbuda, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Grenada have collaborated in the development of similar Fisheries Acts and Regulations. In general, all damaging practices are prohibited and there is adequate legislation to enable the establishment of Marine Reserves and Local Fisheries Management Authorities. Barbados has enacted comprehensive statutory laws for the management of all coastal areas that incorporates existing fragmented laws. Similar laws have been passed to control land based pollution.

The French Caribbean

There is existing legislation to regulate fishing and collecting of marine organisms and to ban collecting using scuba. Minimum mesh size for fish traps has been enacted as well as controls on the harvest of sea urchin, queen conch, and lobsters. There are also specific laws to protect turtles and attempt to control ciguatera. These laws are well accepted in **Guadeloupe** and **Saint-Barthélémy**, but not on **Saint-Martin**.

The Netherlands Antilles

Bonaire

The Bonaire National Marine Park was established in 1979 and has been under continuous active management since 1991. The park includes 2,700ha of coral reef, seagrass and mangrove ecosystems and management activities include maintenance of Park infrastructure and public moorings, provision of outreach and education, research, monitoring and law enforcement. The Bonaire Marine Park also acts formally and informally as an Advisory Body and the Marine Park is protected under the Marine Environment Ordinance. In 1999 it was declared a National Park and is managed by the Bonaire National Parks Foundation, a local NGO, which also manages the island of Klein Bonaire and the Washington Slagbaai Terrestrial Park. The Marine Park successfully supports its manager and 4 rangers from diver admission fees. Monitoring is conducted by visiting scientists, park staff and volunteers. Bonaire is a CARICOMP site, implements Reef Check annually and has also set up AGRRA monitoring stations.

Curaçao

The Curaçao Marine Park encompasses 20km of coastline from Oostpunt to Willemstad. Despite being established by the island government in 1983 there is no legislative support. Only the collection of coral and spear-fishing are banned, but enforcement is insufficient. Management of the Marine Park has been delegated by the government to the Carmabi Foundation, an NGO that also manages terrestrial parks and is active in ecological research. Since the Marine Park has no income and receives only a relatively small subsidy from the island government, management has been restricted with only a part-time manager and no other staff. Curaçao has had a CARICOMP site since 1994, but this has not been monitored since 2000. Since 1997 a volunteer NGO, Reef Care Curaçao has run regular Reef Check monitoring.

Saba

The Saba National Marine Park (SMP) was established in 1987 under the Marine Environment Ordinance of Saba. It circles the entire island from the high-water mark to

60m and is managed using a multiple-use zoning plan with mooring buoys in place to prevent anchor damage. The park is financially self-supporting through visitor fees, souvenir sales, and donations. Management administration is under the Saba Conservation Foundation, a local NGO, which employs a marine park manager, an assistant manager and a visitors centre attendant.

St. Eustatius

The St. Eustatius Marine Park was established in 1996 under the Marine Environment Ordinance of St. Eustatius and encompasses all the waters surrounding St. Eustatius from the high water mark to 30m. The park contains two 'no take zones' to help replenish the fish populations. The park has been actively managed since 1998 by the local NGO, St. Eustatius National Parks Foundation. The number of visitors is insufficient for the park to be financially self supporting from diver levies, and it is a constant struggle to maintain funds for management. Donations and subsidies from WWF and island and national governments have kept it going. A new levy on tankers visiting the island oil terminal is expected to provide sufficient funds for management. The Marine Park has a manager, an assistant manager and an office/visitor centre manager and successfully recruits volunteers to supplement the workforce.

St. Maarten

It is expected that a Marine Park will be designated in 2002. A local NGO (St. Maarten Nature Foundation), with funds from WWF, is being formed to manage the reefs. This NGO employs a part time director and a park manager and assistant manager who are already placing moorings and implementing monitoring, as well as educational and outreach activities.

Trinidad and Tobago

Environmental issues have relatively low priority on the National Agenda. There are a range of problems: inadequate financial and human resources for proper management; inadequate law enforcement; unsustainable coastal development and activities; and inadequate coral reef research and monitoring programs.

Gaps in Current Monitoring and Conservation Capacity

There is wide variability in the capacity for coral reef monitoring and management in governments and NGOs in the eastern Caribbean islands, therefore it is clear that improved capacity across the board is needed. Those islands that have marine research institutions or have participated in the CARICOMP program have greater capacity, whereas most government fisheries departments have few trained staff. The use of Reef Check protocols has permitted some governments and NGOs to start monitoring the corals and fishes, in parallel with creel surveys at landing sites. This has been particularly evident in the BVI.

There are no or few baseline monitoring data in **Antigua and Barbuda**, **Dominica**, **Montserrat** and the other Eastern Caribbean islands. In **Barbados** and **BVI**, some data have been collected on corals, fishes and water quality, but there are both gaps in time and over large areas. Most monitoring in the French Caribbean is centred on Guadeloupe, with recent monitoring started on Martinique and Saint-Barthélémy.

The Netherlands Antilles

Bonaire, **Saba** and **St. Eustatius** all have well managed Marine Parks that are protected under island legislation. The **Curaçao** Marine Park, although established by island decree, still lacks legal protection. A draft island marine ordinance is ready and waiting to be passed by the island council. **St. Maarten** has no marine park (although one is planned), and there is no monitoring. Park management on all islands has been delegated by the respective island governments to local NGOs. National Park status for protected areas on all islands is regulated by national legislation. Fishery on the **Saba Bank** is regulated by the National Fishery Ordinance and the Saba Fishery Ordinance.

In 2000, the Netherlands Antilles Coral Reef Initiative (NACRI) was established to involve all coral reef stakeholders, both government, non-government, private sector and fishermen in coral reef conservation. NACRI is supported by the central government and aims to provide support for MPAs, to promote public awareness and support for coral reef conservation, and to stimulate monitoring and research. There is active management of the **Bonaire** Marine Park in the Netherlands Antilles using visitor fees drawn from tourist divers. The same success is not evident in Curaçao because there is a lack of legal protection.

Trinidad and Tobago

The only reef monitoring is through the Institute of Marine Affairs applying CARICOMP methodology annually on the Buccoo Reef Complex. An NGO, the Buccoo Reef Trust plans to build the Tobago Marine Research Centre as an international institution for research and education on tropical reef ecosystems and sustainable aquaculture. Funding is being sought from many sectors. There are major gaps in capacity and funding for effective ecological and socio-economic monitoring

Conclusions and Recommendations for Coral Reef Conservation

The following recommendations were made in addition to those outlined in the 2000 report:

- To establish one common and transferable coral reef and fish monitoring methodology and implement this at specified sites throughout the region;
- To establish a roving team of marine scientists from various Government agencies to establish monitoring sites and conduct the first round of monitoring while training local stakeholders (as proposed by CPACC);
- To establish a Reef Check roving team to train stakeholders in methodology and data analysis throughout the Eastern Caribbean;
- To ensure that there are follow up visits and training until project monitoring is demonstrably sustainable. It is envisaged that it will be necessary to demonstrate the benefits derived from coral reef monitoring before Governments in the region provide the necessary support.

Author Contacts

Paul Hoetjes, Department of Environment and Nature Conservation, Curaçao, Netherlands Antilles, paul@mina.vomil.an; Lum Kong Amoy, R. Juman, Institute of Marine Affairs, Trinidad, alumkong@ima.gov.tt; Andre Miller, Coastal Zone Management Unit, Barbados, wetrootz@yahoo.com; Malden Miller, ICRAN-Caribbean Project Manager, UNEP-CAR/RCU, Kingston, Jamaica, mwm.uneprcuja@cwjamaica.com; Kalli De Meyer, Coral Reef Alliance, Bonaire, kdm@bonairelive.com; Allan Smith, Caribbean Natural Resources Institute, St Lucia, ahsmith@candw.lc

Supporting Documents

Bak RPM, Nieuwland G. (1995). Long-term change in coral communities along depth gradients over leeward reefs in the Netherlands Antilles. Bull.Mar.Sc. 56: 609-619.

Siung-Chang A, Lum Kong A. (2001). Possible link between reef-fish mortalities in the southeast Caribbean and South American river discharge (July-October 1999). Bulletin of Marine Science 68: 343-349.

Smith AH, Archibald M, Bailey T, Bouchon C, Brathwaite A, Comacho R, George S, Guiste H, Hastings M, James P, Jeffrey-Appleton C, De Meyer K, Miller K, Nurse L, Petrovic C, Phillip P. (2000). Status of Coral Reefs in the Eastern Caribbean: the OECS, Trinidad and Tobago, Barbados, the Netherlands Antilles and the French Caribbean. In: Wilkinson C. (Ed.), Status of Coral Reefs of the World: 2000. Australian Institute of Marine Science. P. 315-330.

Van Moorsel, G. W. N. M. (1989). Settlement of stony corals (Scleractinia) on artificial substrata on a Caribbean reef. PhD thesis 31-65.

French Caribbean Islands

Corals and fishes have been monitored on permanent transects in 7 stations on the coral reefs in Martinique, Guadeloupe and Saint-Barthelemy. Coral cover varies between 22 and 43%, and the density of juvenile corals is 2 to 9 individuals per m^2. The level of coral disease was alarmingly high in some places with between 9 and 62% of corals showing disease; the amount being related to the degree of human impacts. Brown Algae *(Dictyota, Sargassum)* are the main coral competitors and algal cover varies between 2.4 and 31%. Fish abundance fluctuates between 187 and 513 individuals per $100m^2$ and fish biomass between 261 and 829 kg per hectare. These study sites reflect the coral reef status in the French Caribbean Islands and the problems that affect them. The reefs are stressed by eutrophication and overgrowth by macroalgae, which result in reductions in juvenile coral recruitment and injury to adult coral tissues. The level of stress is more marked closer to cities or bays receiving significant pollution runoff. Coral communities on Saint-Barthelemy have remained in good health as human pressures are less pronounced. From Yolande and Claude Bouchon, Yolande Bouchon, yolande.bouchon@univ-ag.fr

ICRAN | | | RAMSAR

BONAIRE NATIONAL MARINE PARK, NETHERLANDS ANTILLES – ICRAN DEMONSTRATION SITE

Bonaire is in the southern Caribbean about 100km north of Venezuela, and one of the islands in the Netherlands Antilles. The island is approximately 40km by 11km with a land area of 288km^2, and includes the small uninhabited island of Klein Bonaire, 750m off the western coast. The Marine Park was established in 1979, but not actively managed from 1984 until 1991, when dedicated Dutch Government funds were provided. There is comprehensive legislation for the Marine Park area, which is enforced over the 2,700 hectares of extensive coral reefs and seagrass beds, and mangrove-lined bays, from high water to 60m depth around Bonaire and Klein Bonaire. There are 5 Ramsar sites on Bonaire, 3 of which are Salinas (salt lakes), the semi-enclosed bay of Lac on the windward shore and the island of Klein Bonaire is also a Ramsar site, with 690ha of limestone platform and the vegetation. After the success of the Saba National Marine Park, the Bonaire MPA followed as one of the first in the world to introduce a diver user fee, raising enough funds to become self-sufficient. In 1999 the MPA was given National Park status, having complied with the requirements of the Netherlands Antilles Nature Policy Plan i.e. legal protection, sufficiently large, representative of local nature, and with effective and sustainable management in place.

Ecological Monitoring: There has been regular coral reef monitoring since the first baseline study in 1983 of the leeward slopes of Bonaire and Klein Bonaire. Since 1974 a series of photographic quadrats (3 x 3m2) has been monitored annually at 4 sites at Karpata to study coral cover and diversity. These show a steady decline in coral cover and diversity at all depths except 40m. The greatest loss of total coral cover has been at 20m where coral cover declined from over 70% in 1974 to approximately 7% in 2001. Causes of coral loss are related to: increases in the alga *Lobophora* sp. which is out-competing corals in the deep reef environment; overgrowth by the colonial ascidian *Trididemnum solidum*; effects of repeated bleaching events; and coral disease. The most significant loss of coral cover occurred in the early 1990s during a major bleaching event in September 1991, but also correlated with substantial increases in tourism within the coastal zone. The Bonaire reefs are still amongst the best in the Caribbean and coral losses on Bonaire are less than elsewhere. Marine Park staff began to monitor photo-quadrats at 15 sites along the leeward shore in 1994 (36 photos each 1 x 0.7m) at 10m and 20m. Preliminary results indicate that the reefs are in good condition.

Data on fish populations were collected in 1972 and again in 1994. The 1994 study compared heavily-dived and little-dived reefs and results indicate that fish biomass was high, with a good balance of herbivores and carnivores. More recent anecdotal evidence suggests that carnivore populations are declining with few grouper present on Bonaire's reefs, although parrotfish are especially abundant. Local volunteer divers, directed by the Marine Park, have conducted annual Reef Check monitoring since 1997 within the Marine Reserve north of Karpata. This has generated considerable local publicity for the annual event.

Bonaire has actively participated in CARICOMP monitoring since 1995 with a permanent coral reef study site located at Barcadera (10 permanent 10m transect lines).

Mangrove and seagrass study sites are located in Lac, a semi-enclosed bay on the windward shore. The results show a slow decline in coral cover coupled with an increase is turf and fleshy algae cover. The AGRRA (Atlantic and Gulf Rapid Reef Assessment protocol) was implemented on Bonaire in 1999 along with training in AGRRA techniques to build local and regional capacity. Results indicate that these reefs are amongst the 'healthiest' in the Caribbean. Volunteers trained by REEF, local expert fish spotters and REEF staff have collected species lists and abundance, with 391 species of fish recorded on Bonaire reefs since 1994 (the highest number for a single location in the Caribbean). Surveys in and after 1996 of possible coral diseases around Bonaire showed the presence of yellow band, black band, white band and white plague. Additionally, losses were documented due to parrotfish bites which are believed to be a form of territorial marking.

Marine Park staff and local volunteers monitored the colonial ascidian *(Trididemnum solidum)* on Bonaire's reefs in 1994 and in 2000. Cover of this ascidian, has increased dramatically in density at some sites, but not changed much in the overall area covered. The highest densities are found at 15-30m and they easily overgrow living corals, but the ascidian suffers little predation, has a high reproductive rate, and spawns daily.

Socio-economic Monitoring: A study of the carrying capacity of the reefs and the economic impact of the MPA in 1991 reported that visitor numbers were at or near the Park carrying capacity. The Marine Park also monitors the number of arriving yachts and use of the Park by dive operators and fishermen. Information of dive site visitation is collected from dive operators on a monthly basis. Studies are also assessing the reasons for success of the Marine Park and diver willingness to pay for conservation.

Monitoring Effectiveness: The data from monitoring are vital for effective management in the Bonaire MPA. The principle value has been in outreach activities with the local community, tourism and especially diver operators, and government decision-makers. Park managers have been able to use data to distinguish between natural and human damage to the reefs and change management accordingly. A particularly valuable assessment is the economic value of the Marine Park coupled with determination of sustainable carrying capacity for particular dive sites and also the whole island. The Marine Park staff are strong supporters of frequent and constant monitoring of the largest possible number of components on the coral reefs. Contact: Fernando Simal, Washington Slagbaai National Park, Bonaire, manager@washintonparkbonaire.org

Coral reefs are **85%** of the natural resources.
Ecological Monitoring is **effective.**
Socio-economic Monitoring is **occasional.**

ICRAN

SOUFRIERE MARINE MANAGEMENT AREA, ST. LUCIA –ICRAN DEMONSTRATION SITE

Soufriere is a picturesque rural town, on the southwest coast of Saint Lucia, in the Eastern Caribbean. The area has rich landscapes including active volcanoes and coral reefs. The Soufriere Marine Management Area (SMMA) extends along 12km of coast, comprising beaches and cliffs, with Soufriere Bay at the centre. The SMMA is managed by the Soufriere Marine Management Association, a not-for-profit-company that includes most stakeholders. Their mission is to 'manage the Soufriere coastal zone based on principles of sustainable use, cooperation among resource users, institutional collaboration, active and enlightened participation, and equitable sharing of benefits and responsibilities among stakeholders'. There has been rapid growth of coastal tourism with several new hotels, resorts, guesthouses and restaurants, catering for diving, yachting, day boat charters and water taxis. This has led to competition for limited space and resources, especially in relation to more traditional activities, such as fishing. There are about 150 registered fishers, with two-thirds of these fishing full-time using nets, lines and traps.

Environmental and Social Problems: The main problems before the SMMA were: degradation of coastal water quality; depletion of near-shore fisheries; loss of the economic, scientific and recreational potential of the coral reefs, especially dive tourism; degradation on land, notably on the beaches; pollution by solid waste in ravines and the sea; and poor resource management with growing conflicts among resource users. The conflicts were between: commercial dive operators and fishermen over who was damaging the coral reefs; yachtsmen and fishermen because of anchoring in fishing areas; the local community and hoteliers over access to beaches; fishermen and local and national authorities over locating a jetty in a fishing priority area; and fishermen and hoteliers over the use of beaches for either commercial fishing or tourism recreation. Thus conflict resolution was implemented in 1992, which resulted in designated zones that address the needs of users. The fishermen, hoteliers, divers, yacht operators, government agencies, and community groups agreed on the formation of the SMMA in 1994.

Zoning Arrangements: There are 5 zones: **Marine Reserves** for areas of high ecological value to protect all marine flora and fauna, allow scientific research, and for divers and snorkellers; **Fishing Priority Areas** where this takes precedence over all other activities; **Recreational Areas** for important public recreation sites; **Multiple Use Areas** for fishing, diving, snorkelling provided the general rules of the area are observed; and **Mooring Areas** for visiting yachts and recreational boats.

Ecological Monitoring: The SMMA staff collaborate with other organisations to monitor the coral reefs and fish landings and assess levels of sedimentation, salinity, turbidity. Sediment measuring is particularly important as recent storms e.g. tropical storm Debbie in 1994 and Hurricane Lenny in 1999, have resulted in up to 50% death of corals after being smothered by sediments. The problem was exacerbated because the river was straightened and retaining walls constructed to prevent flooding of the town. There are now attempts to manage the catchment areas to prevent rapid runoff of sediments.

Two major studies were carried out on the role of marine reserves in reef fishery sustainability: a cooperative venture entitled 'Soufriere Experiment in Reef Fisheries Sustainability'and annual reef fish stock assessment. Scientists assessed the net export of adult fishes from the marine reserves into fished areas, and the mean distance of fish dispersal was 50m. It is unknown how net export will change as fish densities increase inside the SMMA. Fish stock surveys from 1994 to 2000, in both marine reserve and fished areas, show increases in stocks of commercially important species in both areas. Furthermore, fish catch is also increasing to almost double. The number of fish species has also increased, which may indicate benefit of marine reserves to local reef fish communities.

Socio-economic Monitoring: The increased fish stocks outside the SMMA is reflected in improved catches, which is significant to the fishers who depend on this for their livelihood and who lost prime fishing grounds after the establishment of the SMMA. The increased fish stocks also benefit tourism.

Monitoring Effectiveness: The SMMA management team recognizes the value of constant monitoring for informed decision making, for the benefit of tourism, fisheries and local recreation. Monitoring has demonstrated the impacts on resources in the area of external influences, which cannot be managed in isolation. There is need for more collaborative management.

Contact: Glenda Allain, Soufriere Marine Management Area, smma@candw.lc

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 both a Man and the Biosphere reserve and a Ramsar wetland site. The coastal areas have rich mangrove forests, wetlands and coral reefs, while inland there are dense tropical, humid forests. 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 reefs, GIS mapping of biosphere reserve zones, distinguishing human effects from natural fluctuation and reintroduction or rehabilitation of species. The Guadeloupe National Park Authority is responsible for managing the Grand Cul-de-Sac Marin nature reserve and it also initiates and funds various scientific studies within its management area. There are several unions for sea-going fishermen in Guadeloupe, which act as their main representatives in dealing with any problems concerning the use and management of marine resources.

Ecological Monitoring: No details were provided, however it is assumed that ecological monitoring is adequate as there is a university campus on the island and relatively strong commitment to conservation of the marine resources.

Socio-economic Monitoring: No details were provided.

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

18. Status of Coral Reefs in Southern Tropical America in 2000-2002: Brazil, Colombia, Costa Rica, Panama and Venezuela

Jaime Garzón-Ferreira, Jorge Cortés, Aldo Croquer,
Héctor Guzmán, Zelinda Leao and Alberto Rodríguez-Ramírez

Abstract

The 5 countries continue collaborating to consolidate the Node of the GCRMN for Southern Tropical America (STA), covering coral reef areas of the Eastern Pacific and the Western Atlantic. The coral reefs have been limited in their growth because of the strong influence of the major continental rivers, but the biodiversity is comparable to large parts of the Caribbean and they are economically important for supplying food and a strongly developing tourism industry. The coral reefs, however, have changed radically in the last 35 years, in particular during the 1980s, due mostly to anthropogenic stresses compounded by natural disturbances. Live coral cover has dropped dramatically on many of the reefs and frequently these are now dominated by algae. There are however, still some reefs that retain high coral cover between 20-40% in the Caribbean and above 40% in the Pacific. The 1997-98 strong El Niño event in the Pacific generated only moderate bleaching and low coral mortality throughout the STA. Reef monitoring in the STA has expanded over the last 3 years but geographic coverage is still insufficient in most

countries to adequately assess reef status for effective resource management. Monitoring has commenced in Brazil since the last report. The rate of coral reef decline will not be reversed until there is more effective government intervention and the recognition that policies and laws need to be implemented and enforced. This will require the establishment of more marine natural parks and reserves with adequate funds to develop sustainable management backed up with coral reef research and monitoring. These funds must be sourced from national governments and international agencies, and supported by stable government infrastructure that recognises the economic and heritage value of coral reefs throughout the STA.

Introduction and Biogeography

The Southern Tropical America (STA) Node of the GCRMN includes Costa Rica, Panama, Colombia, Venezuela and Brazil, with reefs in Pacific, Caribbean and Atlantic waters. The Node is coordinated by the 'Instituto de Investigaciones Marinas y Costeras' (INVEMAR) in Colombia and is also supported by UNEP-CAR/RCU in Jamaica. The STA Node has been operating since late 1999, has carried out two workshops in Costa Rica and Colombia, and has supported the expansion of monitoring activities in several countries. Letters of agreement have already been signed between INVEMAR and other institutions from Costa Rica (Universidad de Costa Rica-CIMAR), Panamá (Smithsonian Tropical Research Institute) and Venezuela (Universidad Simón Bolívar-INTECMAR) to continue collaboration for Node development.

Most of the reefs in the STA region are strongly influenced by continental runoff, with large amounts of sediments and often high concentrations of nutrients flowing out of some of the largest rivers in the world - the Amazon, Orinoco and Magdalena rivers. This high turbidity and sedimentation reduces coral growth in most coastal areas and also occasionally impacts on offshore reefs. 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 large proportion of endemic species. Special emphasis is given in this report to Brazil, as they have only recently started monitoring. The best developed coral reefs are on the Caribbean coasts of Panama, and on islands off Colombia and Venezuela. Corals are less developed and diverse on the Pacific side, with the best reefs on the Costa Rica-Panama coast.

Brazil

There are sparse, discontinuous coral reefs and with low species diversity (18 hard coral species, with 6 endemics) along the Atlantic coastline in 5 five major areas: Touros-Natal with extensive coastal knoll and patch reefs; Pirangi-Maceió with linear coastal reefs and higher species diversity; and Bahia de Todos os Santos-Camamu, Porto Seguro-Cabrália, and Abrolhos Region to the east and south. The National Marine Park of Abrolhos of 900km^2 contains the richest coral reefs of Brazil with the Timbebas Reefs (isolated coastal bank reefs), and fringing reefs on offshore volcanic islands of the Abrolhos Archipelago, and the 'chapeirões' (giant mushroom-shaped coral pinnacles 70km offshore).

Colombia
Coral reefs are present along both Caribbean and Pacific coasts. There are more than 1,000km^2 of Caribbean reefs scattered over 21 areas in 3 groupings: fringing reefs on rocky shores of the mainland coast (e.g. Santa Marta and Urabá); continental shelf reefs around offshore islands (e.g. Rosario and San Bernardo archipelagos); and the San Andrés Archipelago oceanic reef complexes in the Western Caribbean. These complexes include atolls, banks, barrier reefs, fringing reefs and patch reefs. In contrast, Pacific reefs are poorly developed, with only Gorgona Island having large coral formations.

Costa Rica
There are less than 50km^2 of coral reefs on the Caribbean (with 40 hard coral species) and Pacific (18 species) coasts. Along most of the Caribbean coast there are high energy sandy beaches, but the southern section of the coast has coral reefs growing over fossil reefs. There are fringing reefs: Moin-Limón, which has a large port; Cahuita Natural Park with the largest and best studied fringing reef; and Puerto Viejo-Punta Mona. The Pacific reefs are found almost all along the 1160km coast, but are relatively small and have low coral diversity, e.g. near Santa Elena, Bahía Culebra, Isla del Caño and Golfo Dulce, and around Isla del Coco, 500km offshore.

Panamá
There are 290km^2 of reefs along both Caribbean and Pacific coasts, with much higher diversity (68 hard coral species) reefs in the Caribbean, and lower in the Pacific (25 species). The major Caribbean areas are: Bocas del Toro on the western coast with the highest average coral cover; Colón-Isla Grande on the central coast where the corals are degraded because of major industrial activities and runoff; and San Blas or Kuna-Yala territory on the eastern coast, with the most extensive and diverse reefs. The Pacific reefs are mostly on islands near the coast, notably the Gulf of Chiriqui, with the best fringing reefs, and the Gulf of Panamá, including Las Perlas archipelago, Taboga and Isla Iguana.

Venezuela
Venezuela has 2875km of coastline; approximately 67% are in the Caribbean Sea and 33% in the Atlantic Ocean. Despite this, the area covered by coral reefs has not been determined accurately, and it is known that the best reef development occurs around the oceanic islands, specifically at Archipelago de Aves, Archipelago Los Roques, La Orchila and La Blanquilla. Coral communities are common on the Venezuelan continental shelf, but development is limited by high sedimentation, terrestrial runoff and upwelling. Major changes in coral reef structure have been reported along the continental shelf, where coral reefs have declined in the last decade (e.g. Morrocoy National Park).

Status of the Coral Reefs

There has been major damage to coral reefs of this region in the last 35 years. The damage has been caused by a mix of 'natural agents' (coral disease outbreaks, bleaching, El Niño events), and direct human impacts. This is evident as considerable losses of live coral cover, poor recovery of damaged areas, significant increases in the cover of marine algae, reduced fish populations, and the incidence of disease in corals, gorgonians and sea urchins appears to have increased dramatically. The appearance of some reefs has changed considerably, with much lower populations of the branching, and previously dominant, species (e.g. *Acropora* spp.), which are now replaced by other corals and benthic organisms.

Brazil

Coral reef monitoring programs started in 2000 using the AGRRA protocols, in the Abrolhos National Marine Park on the fringing reefs and offshore 'chapeirões'. Corals, algae and fishes were assessed on 13 reef sites. This monitoring program was extended in 2001 and 2002 to the coastal arc in the Abrolhos region adding 22 more sites, including measuring sediment inputs on the nearshore reefs. The reefs are in rather good condition on the offshore 'chapeirões', but there were signs of degradation in parts of the Abrolhos Islands where tourism diving and snorkelling is allowed. Nearshore reefs are most affected, particularly by exposure of reef tops during low tides, re-suspension of muddy sediments during winter storms, and overfishing. There was extensive coral bleaching in 1998 in North Bahia and the Abrolhos region, with levels of 80% reported in important species such us *Agaricia agaricites*, *Mussismilia hispida*, and *Porites astreoides*, but all corals recovered after 6 months. AGRRA monitoring in 2000 to 2002 showed the offshore chapeirões had consistently more coral recruits (34.0-38.8 recruits per m^2) with coral cover around 20%, comparable with the fringing reefs on the North coast of Santa Barbara Island. The South Santa Barbara fringing reefs, however, had lower coral cover (6.0-12.7%) and fewer recruits (10.0–16.5 per m^2), probably as a result of strong storm waves in winter and intense recreational use of these reefs in summer. No major disease and mass mortalities have been seen on these reefs. Similarly, reef fish species were more common on the chapeirões (39-40 per site) than on the Santa Barbara fringing reefs (13-37 per site). Future monitoring will assess tourism impacts by comparing open with restricted areas in the Abrolhos Park.

ITACOLOMIS MONITORING

Monitoring of the Itacolomis Reefs (South of Porto Seguro) began in 2001 and indicated stressful levels of sedimentation. The average coral cover of between 2.2 and 22.5% was similar to the Abrolhos coastal reefs and cover of coralline algae was between 3.4 and 43.5%. Sediment inputs in other areas that are perceived as 'normal' for coral reefs are up to 10mg/cm^2/day, those that have resulted in moderate to severe stress range from 10 to 50mg/cm^2/day and those above 50mg/cm^2/day tend to result in severe to catastrophic impacts. These data illustrate sediment inputs of 34.5mg/cm^2/day in the protected area but 78.4mg/cm^2/day in areas open to fishers. According to these data, the Itacolomis Reefs exist in relatively stressful conditions. The continuation of this monitoring program will provide insight into whether Brazilian corals are adapted to high sedimentation rates or become degraded as a result. From Emiliano Calderon, Bárbara Segal and Clovis Barreira e Castro, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; encalderon@imagelink.com.br, bsegal@acd.ufrj.br, cbcastro@pobox.com.

Reef Check Monitoring in Brazil

Until recently there has been a gap in our knowledge about the coral reefs of Brazil because they have not gained government attention. On Earth Day 2001, 65 volunteer divers, students, researchers, fishermen, and community members conducted Reef Check surveys at 5 reefs in the Coral Coast MPA, as well as cleaning the beaches. In 2002, the Ministry of Environment assisted with the establishment of a National Monitoring Program for Brazil. This time surveys were conducted at popular tourist destinations inside MPAs: Maracajaú reef in the northern Touros-Natal area; the Coral Coast reefs in the Pirangi-Maceió area; Fernando de Noronha, an archipelago located 225 nautical miles off the NE coast of Brazil; and the Abrolhos reefs in eastern Brazil. These surveys were designed to provide a baseline of information and compare reefs in Marine Parks and adjacent reefs where there is no protection. All these activities involved scientists who trained dive operators, park rangers, and environmental managers to gather data for the Government and funding agencies. Reef Check in Brazil is coordinated by Beatrice Padovani Ferreira, from the Universidade Federal de Pernambuco, Recife, beatrice@ibama.gov.br or www.reefcheck.org

Coral condition of selected sites of the Abrolhos National Marine Park in 2000-2002 based on AGRRA monitoring.

SECTOR	Variables	2000	2001	2002
North Santa Barbara	Coral Cover	9.5%	25.9%	26.0%
	Species #	7	7	6
	Recruits m^{-2}	16.4	31.0	16.5
South Santa Barbara	Coral Cover	6.0%	12.7%	7.6%
	Species #	8	6	5
	Recruits m^{-2}	10.0	13.0	16.5
Offshore chapeirões	Coral Cover	20.4%	20.8%	19.0%
	Species #	11	8	13
	Recruits m^{-2}	38.1	38.5	34.0

Costa Rica

Coral reef monitoring has continued only in Bahía Culebra, and not at other sites, due to funding and personnel constraints. The last assessment in Cahuita (September-October 2000) showed coral cover at 13-15% and algae at 53-63%, while coral disease incidence was around 6%. Isla del Coco was visited and data collected in 2002, which will be compared to data collected in the late 1980s and early 1990s. Monitoring will recommence at Cahuita and Manzanillo in the Caribbean, and at Bahía Culebra and Isla del Caño in the Pacific if new funds are received in 2002. There was low coral mortality (5-6%) in Isla del Caño, Culebra Bay, Murciélagos Island and Golfo Dulce in the Pacific during the 1997-98 El Niño warming, indicating that the remaining populations of massive and branching corals may have been more tolerant to thermal stress than during previous events. There are signs of recovery at Isla del Coco after the strong El Niño events of the 1980s and late 1990s.

Colombia

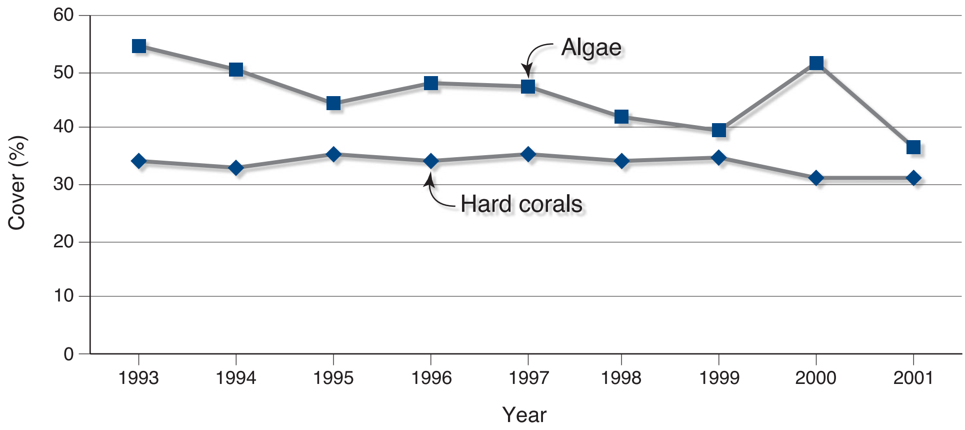
No clear signs of either decline or recovery have been observed in Colombian Caribbean reefs following major degradation of the 1980s. Coral cover has fluctuated during the last 4 years (1998-2001) within small ranges of 31-35% in Chengue Bay, 28-32% in Rosario Islands, and 22-28% in San Andrés island. Algae continue to be the dominant component of the reef surface (36-39% in 2001). Coral communities in Chengue were damaged in late 1999 during Hurricane Lenny, which reduced coral cover from 35% to 31%. The 1997-98 El Niño event had little effect on Colombian Caribbean reefs. Coral bleaching between 1998-2001 was lower than 5% in the monitored localities, except in Chengue where it was 10%, but related coral mortality was insignificant. The incidence of coral disease has been below 5% in 1998-2001, except in San Andrés in 1999 (9.1%) and 2001 (6.3%). Dark spots and white plague continue as the most frequent diseases. Coral cover at Gorgona Island on the Pacific coast has remained high (67% in 1998, 74% in 2001), while algae are a minor component (10% in 2001). The 1997-98 El Niño caused 21-24% coral bleaching in Gorgona, but mortality was very low. Bleaching at other localities of the Colombian Pacific in 1998 (Utría, Tebada and Malpelo) was much lower (about 1%). No more bleaching, nor coral diseases, have been observed in Gorgona since 1997-98.

Panamá

As reported previously, coral cover has declined on Caribbean coast reefs in the central and eastern areas, whereas coral cover may be as high as 75% on western reefs, and there is an average above 25% on Bocas del Toro archipelago. There has been a general decline in cover (6-10%) at Bocas del Toro associated with tourist development, and central coast reefs have less than 6% coral cover at Bahía Las Minas and 13% at the Parque Nacional Portobelo due to industrial and urban development. Recruitment has increased in these areas since 1998, mostly *Siderastrea siderea* and *Agaricia* spp. Coral cover dropped from 40% to 15% in 1997 at San Blas (eastern coast) following coral mining and natural causes. Average coral cover on 56 reefs in the Kuna-Yala Reserve is now 23%. Many reefs in the

Advances of 'SIMAC' Monitoring in Colombia

The National Monitoring System for the Coral Reefs of Colombia (SIMAC) has continued monitoring activities since 2000, despite a low budget. Most coral reef areas established in 1998 were monitored in 2000 and 2001, with support from UNEP-RCU/CAR and several Colombian institutions (INVEMAR, UAESPNN, CORALINA, CEINER, U. del VALLE). A new phase began in 2001 sponsored by the Colombian Ministry of the Environment ('Convenio Programa Ambiental'-BID-774OC/CO) to consolidate and expand SIMAC. Data were collected at the established SIMAC areas (San Andrés, Chengue, Rosario, and Gorgona) plus 3 new areas (San Bernardo Islands and Urabá Chocoano in the Caribbean, and Ensenada de Utría in the Pacific). Thus SIMAC covers 7 of the 30 principal coral reef areas of Colombia, with several different stations in each area. Monitoring data are particularly important for the management of some sites that show clear trends. However, the monitoring cannot provide a reliable picture of the status of all Colombian reefs. This GCRMN Regional Node has received additional funds from UNEP-RCU/CAR to continue SIMAC activities during 2003, which is particularly valuable considering the economic and political problems in Colombia.



Chengue Bay

Pacific lost up to 90% of corals in the 1982-83 El Niño event, and signs of recovery have been seen since 2000. Mortality was 50 to 100% in the Gulf of Panamá, such that some reefs in Las Perlas archipelago have less than 2% coral cover, while the highest (30%) on the Pacific coast is at Isla Iguana (west from Las Perlas). Coral mortality after the 1997-98 El Niño was minimal in the Gulf of Panamá, but reached 13% in the Gulf of Chiriquí.

Venezuela

There have been new efforts during 2000–2002 to assess the status of coral reefs, with most surveys conducted in the Los Roques National Park. The reefs continue to be almost pristine compared with other Caribbean reefs monitored by CARICOMP. Live coral cover ranges from 18-44%, dead coral cover from 31-64%, and algal cover between 0.1-11%. Coral diseases (yellow blotch, dark spots, white plague and white band) are rare (below 6%), although in some places, white plague disease has affected up to 24% of the major reef builders. The only reef being monitored regularly on the continental coast is Sombrero Key (Morrocoy Natural Park) with coral cover dropping from 40% in 1997 to less than 30% in 2000; this trend might be attributed to increasing sedimentation, tourism pressures, and coral diseases.

Status of Coral Reef Fishes

Information on reef fish populations continues to be extremely scarce in the STA region. The SIMAC program in Colombia has monitored densities of important reef fishes during 1998-2001 in several Caribbean and one Pacific location. At Chengue Bay, Rosario Islands and San Andrés Island (Caribbean) the abundance of snappers, groupers, jacks or other target fish in 2001 continued to be very low (absent or less than 3 fish per 60m^2), with comparable surveys at Gorgona Island in the Pacific showing densities greater than 10 fishes per 60m^2. Damselfishes are still very abundant on Caribbean reefs (7-31 fish per 60m^2), particularly the three spot damselfish (*Stegastes planifrons*) with densities of 26 fish per 60m^2 at Islas del Rosario. AGRRA surveys performed in 2000 at Caribbean localities (Cahuita and Gandoca-Manzanillo) in Costa Rica, also showed low densities of snappers or groupers on the coral reefs (usually less than 2 fish per 60m^2). Reef fish monitoring in Brazil started recently at the Abrolhos area (2000) and the Itacolomis reefs (2001) using the AGRRA and Reef Check protocols.

Anthropogenic Threats to Coral Reef Biodiversity

The coral reefs of the southern tropical America region are suffering from the same range of threats that is damaging reefs around the world. The most significant threats to the reefs in these countries are sedimentation, sewage pollution, resource extraction, tourism, oil pollution, mining and coastal development. The most serious threat comes from increased sediment runoff from logging, land clearing and agriculture, particularly in the inland forests and on mountain slopes. This has resulted in losses in coral cover, and reduced reproduction and growth on the Caribbean and Pacific coasts of Costa Rica, in the Santa Marta area in Colombia, and Morrocoy Natural Park in Venezuela. These threats to reefs are predicted to continue. Untreated sewage from high population growth is adding excess nutrients to most coastal ecosystems with anecdotal evidence of reef damage. However, coral and fish exploitation is causing direct and observable damage to many coastal reefs, in some cases through the use of damaging methods such as dynamite. Most commercial species are clearly over-exploited, with increasing reef tourism adding to the pressures. Tourism is bringing huge economic benefits with massive increases in some marine parks, but most of this is uncontrolled with increases in coral collection, over-fishing, direct damage to corals by divers, anchors and boats, sewage pollution and sedimentation. This is currently being seen in Bocas del Toro, Panama. In Venezuela, diving and snorkelling are resulting in localised impacts on the reefs at Los Roques National Park, but damages are not enough to cause reef decline. Oil pollution has caused major impacts at Bahía Las Minas on the Caribbean coast of Panamá with coral cover is now down to 4%. Coral has traditionally been used for construction and landfill in several countries (e.g. at San Blas, Panama), and this is continuing during the construction of tourists resorts in Brazil. There have been major river modifications and building of canals in Colombia, which have resulted in considerable degradation of some coral reefs. Unfortunately, there are insufficient baseline studies to fully document these damaging impacts. Major anthropogenic impacts on Venezuelan coral reefs seem to be localised near the mainland, where industrialisation, urban development and populations have increased recently. Oceanic areas appear to remain relatively pristine compared to reefs on the continental shelf; nevertheless, it is difficult to draw accurate conclusions because there are few data for many of these islands.

Current and Potential Climate Change Impacts

The impacts have been poorly assessed in the region, with the most serious damage now associated with coral bleaching and mortality from the early 1980s. Bleaching appears to have increased in frequency, but not in severity throughout the 1990s. The most bleaching was along the Pacific coast during the severe El Niño of 1982/83 with 50-100% coral mortality on most reefs, and coral bleaching was moderate, with low mortality during the strong 1997/98 El Niño. In the Caribbean, the most severe bleaching with high coral mortality was also in 1982/83, but this was poorly documented. There was mild bleaching (less than 10%) in 1997/98 in the Caribbean and on the Brazilian coast, but mortality was insignificant. The predictions of increased global warming suggests that

The status of MPAs in Southern Tropical America showing progress in some countries, particularly in Brazil.

COUNTRY	NO. OF MPAs	STATUS OF MPAs	PROGRESS SINCE 2000
Brazil	8 MPAs	All have management plans, but enforcement is still weak in most MPAs	AGRRA monitoring in Abrolhos National Marine Park in 2000 at 13 sites; 2001 at 30 sites; 2002 at 35 sites; corals, fishes, sediment rates monitored in 2001 in Corumbau. Reef Check in 2002, northeastern Brazil & Abrolhos.
Colombia	4 on Caribbean side; 3 on Pacific side	Many have management plans; poorly implemented; Pacific MPAs fewer problems, better managed; Caribbean MPAs poorly enforced, some blast fishing; SIMAC & Reef Check monitoring in 5; others none.	New monitoring in Utría Natural Park in 2002. Coral reefs of San Andrés & Providencia archipelago included in Seaflower Biosphere Reserve.
Costa Rica	2 on Caribbean side; 7 on Pacific side	Some active management, artisanal fishing permitted; Tourism in some MPAs; 2 on the Caribbean & one on Pacific have monitoring.	CARICOMP monitoring in 2002 at Gandoca-Manzanillo Refuge.
Panama	5 on Caribbean side, mostly Indian reserves; 5 on Pacific side	4 on Caribbean side & 3 on Pacific were monitored. Management plans either ineffective or don't exist.	Monitoring implemented in 2000-2001 at 3 MPAs on Pacific coast.
Venezuela	4 on Caribbean	Only Morrocoy monitored by CARICOMP; management Instituto Nacional de Parques INPARQUES.	Several assessments of reef status at Los Roques national park, Turiamo Bay, Mochima & Margarita in 2000-2002.

coral bleaching will become a more frequent event, although the level of bleaching and related mortality will probably be low during the next decade.

Current MPAs and Management Capacity

The 23 MPAs in the Caribbean-Atlantic and 15 in the Pacific were designated for a variety of reasons under several protected categories, however, most are 'paper parks' with little management planning, operational capacity, and enforcement. Most are managed by government agencies and lack reef monitoring programs, usually due to the poor economic status of governments and communities. There is a need for education and awareness raising to reduce conflicts between traditional users and governments over fisheries and tourism activities. In Brazil, the Itacolomis Reefs south of Porto Seguro have recently been included in the Corumbau Marine Fisheries Reserve, where parts are closed for fisheries, and the rest is only for artisanal fishermen. Open and closed areas have been monitored in a program that includes coral cover, sediment deposition, fish populations, and socio-economic aspects.

Coral Coast MPA Management Initiative – NE Brazil

The MPA was set up to implement local integrated coastal management and ensure sustainable economic benefits from the reefs. This was set up in 1997 as the first national conservation area for coastal coral reefs of Northeastern Brazil, between the cities of Recife and Maceió. The Tamandare-Paripueira reef system is an Area of Environmental Protection in the 'Costa dos Corais', and covers 413,563ha from 33m on land to 33km offshore. The local communities of 130,000 people rely on sporadic work in tourism and agriculture, and exploitation of reef resources. The traditional and subsistence fishery is intense, targeting a large variety of fishes, lobsters and octopuses with an average daily catch of 2.18kg. Their initial tasks involved environmental assessments to characterise the coral reefs through mapping, biodiversity evaluation, fisheries assessment, population assessments of important species, as well as socio-economic assessment. In addition to subsistence fishing, there is the commercial capture of prawns, lobster and reef and pelagic fishes. However, the reefs have been damaged through poor land use practices that increase sedimentation, domestic and agricultural pollution, overexploitation of reef resources, uncontrolled tourism and urban development. Coral mining had been intense until the 1980s, when it was banned throughout Brazil. Collection of all ornamental marine life has been banned at the 'Costa dos Corais' MPA as well. This is a multiple use MPA that permits subsistence and commercial activities, however Fully Protected Zones were included in 1998, and preliminary results indicate significant increases in exploitable resources, and spill over effects, with increased catches in adjacent areas. These are being monitored with the help of fishers, and hopefully will encourage the communities to support the protected area as a management tool, both for tourism and fisheries. The Project has been funded by the Inter-American Development Bank from 1998 to 2003. From: Beatrice Padovani Ferreira and Mauro Maida, Universidade Federal de Pernambuco, Recife, Brazil, beatrice@ibama.gov.br or www.recifescosteiros.org.br

Government Policies and Legislation

These countries have enacted few specific government laws to promote the study, sustainable use and conservation of their coral reef resources. Many of the 'protected' reef areas are within natural parks and reserves, but few are achieving their objectives of sustainability. Colombia and Panamá have developed specific regulations prohibiting the harvesting of hard corals and reef fishes for the aquarium trade. However, those regulations are not enforced and there has been an increasing demand in Panama for 'live rock' to be exported to Florida. Brazil has a specific local law to declare permanent protection for the coral reefs of Bahia. Important environmental conventions (CITES, FCCC, and CBD) have been ratified by most of the countries, and other region-specific treaties such us the Convention for the Protection of the Marine Environment in the Southeastern Pacific Coastal Zone the Convention for Protection and Management of the Marine Environment in the Wider Caribbean Region have also been ratified. Colombia, Panama and Venezuela have attempted to organise national systems and legislation for the management and conservation of the environment and biodiversity.

Mapping Reef Monitoring in Tropical America

A major problem in attempting summaries of reef status in a region is knowing where monitoring has occurred and who has the data. Thus, the Instituto de Investigaciones Marinas y Costeras (INVEMAR) in Colombia was requested to assemble all the known information on coral reef monitoring in the Wider Caribbean but also in the far Eastern Pacific and the Western Atlantic. The goal was to produce maps of all such coral reef activities and make these available to reef managers and decision-makers. The principal support came as a grant from the National Oceanic and Atmospheric Administration (NOAA) of USA, with additional assistance from the Colombian Ministry of the Environment and the GCRMN. A short electronic questionnaire was sent to persons in charge of monitoring activities in all localities in tropical America.

Respondents provided information on locality, geographic coordinates, type of reef, reef zones, depth, years of monitoring, MPAs, variables measured, methods, periodicity, monitoring program and contact information. The preliminary GIS maps were displayed at the ICRI Regional Workshop for Tropical America in June in Cancun, Mexico in order to gather more information and correct errors. The results of this project were produced as a CD, which includes the complete database, the final GIS maps (in shape and coverage formats), graphic outputs of the maps (in ARC and PDF formats), summary tables and graphics. Maps were drawn for the whole region, but also in more detail for each GCRMN Node. There were 25 monitoring programs in 562 localities, distributed along the coasts of 27 countries in tropical America. About 50% of the localities have been monitored for less than 5 years, and only 3% for more than 10 years; in more than 40%, there are only evaluations of biological variables and 50% are restricted to depths of 0-10m. MPAs are being covered by 87% of the monitored localities. There is ongoing analysis and a more comprehensive report will be published in late 2002. From: Jaime Garzón-Ferreira and Sonia Bejarano, INVEMAR, Santa Marta, Colombia, jgarzon@invemar.org.co or simac@invemar.org.co.

Gaps in Current Monitoring and Conservation Capacity

Although there has been reef monitoring for 30 years and all countries recognize the need for national monitoring programs, the level and coverage of monitoring is very limited and high quality monitoring is restricted to a few sites. Lack of funding and poor infrastructure are major impediments for an effective control and conservation of marine resources in the region. CARICOMP has stimulated considerable monitoring in the Wider Caribbean, but usually in only 1 or 2 sites per country. The Reef Check program has contributed to some expansion of volunteer, non-professional monitoring in Colombia, Panamá and Brazil. All countries have well trained professional scientists and reasonable logistics to implement monitoring, but few have allocated sufficient funding to maintain national monitoring programs. INVEMAR in Colombia has been developing an integrated national reef monitoring program (SIMAC) since 1998 but the current economic and political problems pose threats to its continuity and expansion. The Smithsonian Tropical Research Institute in Panama has supported the implementation of the Panamanian Coral Reef Monitoring Network (PCRMN) using minimal funds to cover over 15 reef sites. A workshop is planned for early 2003 in Costa Rica, to establish a National Coral Reef Monitoring Program with the participation and funding of the government, private enterprise, local communities and academics.

CONCLUSIONS

- Five countries continue collaborating to consolidate the Southern Tropical America Node of the GCRMN and institutions from Colombia, Costa Rica, Panamá and Venezuela have signed letters of agreement.
- Most coral reefs in the region have undergone major changes during the last 30 years, but particularly during the 1980s, with considerable losses of live coral cover. Nevertheless, significant coral cover can still be found at several reef locations of both Caribbean (averages of 20-40%) and Pacific (averages above 40%) coasts.
- The coral reefs of this region are suffering from the same range of threats that is damaging reefs around the world. The most significant threats in these countries are sedimentation, sewage pollution, resource extraction, over-fishing, tourism, oil pollution, mining and coastal development.
- The second strong El Niño event of 1997/98 caused only moderate bleaching and low coral mortality on the Pacific side. Mild bleaching (extensive in some locations of Brazil), but insignificant coral mortality, occurred also in 1997/98 in several Caribbean and Atlantic localities.
- There are about 40 protected areas and reserves that include coral reefs in the region, but most remain as 'paper parks' because of limited funding to implement management plans and enforce regulations.
- Despite the importance of coral reefs in the region and their accelerating degradation, there are few specific government policies and laws to promote conservation of these ecosystems. Most protection is intended through the inclusion of reef areas within national parks and other reserves, however, law enforcement is not working properly in most of the countries.
- Reef monitoring in the region has been carried out for 30 years. Although considerable expansion has occurred over the last two years, geographic coverage is still low in most countries. The current level of monitoring and a modest expansion cannot be supported without continuous funding.

RECOMMENDATIONS

- It is necessary to complete the baseline characterisation of coral reefs in the region, including: mapping; biodiversity evaluations; population assessments of important species or groups of species; coral health and socio-economic assessments.
- Reef monitoring in this region must be maintained in the long term and significantly expanded through the development of national monitoring programs in each country, including the integration of these into the regional and global initiatives. National programmes need to address both protected and non-protected reef areas.
- Extraction of all reef organisms, including so-called 'live rock' must be completely prohibited within the protected areas.

- Tourism in coral reef areas needs to be regulated, including the designation of dive sites based on scientific criteria to establish carrying capacity limits.
- New reef conservation programmes must include the surrounding areas, in particular adjacent and upstream large watersheds in order to minimise the input of sediments and pollutants into reef areas.
- Specific government policies and laws for coral reef sustainable management need to be developed during the next few years, as well as effective protection of natural parks and reserves through implementation of management plans and law enforcement.
- National governments need to increase regular budgets for institutions that have responsibilities for monitoring and conserving coral reefs, but also the funding for scientific research on these ecosystems. At the same time, international programmes and funding agencies must provide important matching support for developing countries and for regional cooperative initiatives.

Reviewers

Marion Howard, CORALINA, San Andres Island, Colombia; Rodrigo Leao de Moura, Caravelas, Brazil

Acknowledgements

GCRMN Node activities for Southern Tropical America have been supported through agreements (CR/0401/94-15-2218 and MT/1010-01-03-312-2234) between the 'Instituto de Investigaciones Marinas y Costeras' (INVEMAR) and the Regional Coordinating Unit for the Caribbean of the United Nations Environment Program (UNEP-RCU/CAR). Additional support has been received from COLCIENCIAS-BID (PROJECT 2105-09-327-97) and the Colombian Ministry of the Environment ('Programa Ambiental' BID-774 OC/CO). The Smithsonian Tropical Research Institute and the Smithsonian Institution Environmental Science Program have supported reef monitoring in Panamá. The Brazilian monitoring programs are supported by the Brazilian Ministry of Environment (Reef Check), Brazilian National Science Foundation – CNPq (AGRRA), Conservation International of Brazil, Federal University of Rio de Janeiro, the Abrolhos National Marine Park, and the Corumbau Marine Fisheries Reserve. Valuable information and collaboration has been provided by R. Kikuchi (Abrolhos data) from Brazil; S. Bejarano, M. Chiquillo, J. M. Díaz, , A.M. González, D. L. Gil, S. Lozano, C. McCormick, J.C. Martínez, R. Navas, M. C. Reyes, J. A. Rojas, N. Santodomingo and F. Zapata from Colombia; A. Fonseca from Costa Rica; C. Guevara and A. Castillo from Panamá; D. Bone, A. García, F. Losada, S.M. Pauls, J. Posada, E. Villamizar, A. Zubillaga from Venezuela.

Author Contacts

Jaime Garzón-Ferreira (jgarzon@invemar.org.co) and Alberto Rodríguez-Ramírez (betorod@invemar.org.co) are the Regional and Colombian Coordinators respectively of the Southern Tropical America Node at the Instituto de Investigaciones Marinas y Costeras (INVEMAR) in Colombia; Jorge Cortés (jcortes@cariari.ucr.ac.cr) is the Costa Rica Coordinator at the CIMAR-University; Aldo Croquer (croquer@telcel.net.ve) is the Venezuelan Coordinator at the INTECMAR-Univ. Simón Bolívar; Héctor Guzmán (guzmanh@naos.si.edu) coordinates Panamá from the Smithsonian Tropical Research Institute; and Zelinda Leao (zelinda@ufba.br) is the Brazil National Coordinator at the Instituto de Geociencias-Univ. Federal da Bahia.

Supporting Documentation

Bone D, Croquer A, Klein E, Pérez D, Losada F, Rada M, Cruz JJ, Galindo L, Penchaszadeh P. (2001). Programa Caricomp: monitoreo continuo del Parque nacional Morrocoy. Interciencias 26(10): 457-461.

García A. (2001). Enfermedades y otras anomalías que afectan a los corales escleractínidos en algunas localidades del Parque Nacional Los Roques. Trabajo especial de grado, Universidad Central de Venezuela, Caracas. 300 p.

Garzón-Ferreira J, Rodríguez-Ramírez A, Bejarano-Chavarro S, Navas-Camacho R, Reyes-Nivia C. (2002). Estado de los arrecifes coralinos en Colombia, año 2001. En: Informe del estado de los recursos marinos y costeros en Colombia, año 2001. INVEMAR, Santa Marta, Ser. Documentos Generales: in press.

Glynn P, Maté JL, Baker AC, Calderón MO. (2001). Coral bleaching and mortality in Panamá and Ecuador during the 1997-1998 El Niño-Southern Oscillation event: spatial/temporal patterns and comparisons with the 1982-1983 event. Bull. Mar. Sci. 69(1): 79-109.

Guzmán HM, Cortés J. (2001). Changes in reef community structure after fifteen years of natural disturbances in the Eastern Pacific (Costa Rica). Bull. Mar. Sci. 69(1): 133-149.

Jiménez C, Cortés J, León A, Ruiz E. (2001). Coral bleaching and mortality associated with the 1997-98 El Niño in an upwelling environment in the Eastern Pacific (Gulf of Papagayo, Costa Rica). Bull. Mar. Sci. 69(1): 151-169.

Laboy-Nieves EN, Klein E, Conde JE, Losada F, Cruz JJ, Bone D. (2001). Mass mortality of tropical marine communities in Morrocoy, Venezuela. Bull. Mar. Sci. 68(2): 163-179.

Vargas-Angel B, Zapata FA, Hernández H, Jiménez JM.. (2001). Coral and coral reef responses to the 1997-98 El Niño event on the Pacific coast of Colombia. Bull. Mar. Sci. 69(1): 111-132.

WHS

COCOS ISLAND NATIONAL PARK, COSTA RICA – WORLD HERITAGE SITE

Situated 535km off the southwest coast of Costa Rica, Cocos Island provides critical habitat for marine wildlife, particularly large pelagic fish and sharks. The park includes the main island and 10 nearby offshore islets. Underwater habitat consists of a shallow coral reef with almost no intertidal zone, culminating in sand and rubble at the edge of the several hundred meter deep trench. Studies of the coral fauna organisms have resulted in the identification of 32 species, 9 of them in deep water. The diversity of coral organisms places Cocos Island as one of the areas of major biodiversity in the Tropical Eastern Pacific. The coral fauna group has similarities to that of the Indo-Pacific.

Cocos Island National Park was declared a National Park in 1978, but this status alone was not adequate in protecting the marine resources. There have been numerous reports of illegal shark-fin collection. 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. In October 2001 the marine reserve surrounding Cocos Island was officially extended from 15km to 22 km in order to increase the protection of the marine resources. This was also accepted as an extension to the World Heritage site in 2001. A partnership is being negotiated with the National Coast Guard Service and Sea Shepherd Conservation Society for patrolling the marine area and prosecution of illegal fishing boat owners.

Ecological Monitoring: The coral reefs of Cocos Island suffered declines as a result of the 1982-83 and 1997-1998 El Niño disturbances. There are no data from area after the El Niños between 1992 and 1995. The reefs will be evaluated again in late 2002.

Socio-economic Monitoring: No information reported.

Coral reefs are **40%** the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **not planned.**

WHS

THE GALAPAGOS ISLANDS, EQUADOR – WORLD HERITAGE SITE

The Galapagos were made famous by Charles Darwin who visited these remote and apparently inhospitable volcanic islands in 1835. The islands were granted World Heritage status in 1978 in recognition of their unique wildlife on land, but only recently has the marine biodiversity received attention. There are over a million sea birds of 19 different species, thousands of coastal birds, 100,000 sea lions, hammerhead and Galapagos sharks, and the flightless cormorant, penguin, and the Galapagos albatross. Green and hawksbill turtles are common and nearly 300 fish species have been recorded, with 23% being endemic. The Galapagos are far from Ecuador in the eastern Pacific. Resource access disputes are causing increasing problems for management as most of the 15,000 people live on 3% of the land and are either fishers, farmers or tourism operators. The 70,000 tourists generate over US$55 million per year, but the impacts are minimised because they live on large cruise ships, or arrive by air and use smaller boats. Tourist scuba diving is increasing. The local population expanded dramatically in the 1970s and 80s due to tourism and to exploit the fishing resources of sea cucumber, shark, tuna and lobster. Biologists and conservationists agree that the Galapagos over-fished and that marine biodiversity is under threat.

The first management plan for the Galapagos Marine Reserve in 1992 was largely ignored and social unrest increased over attempts to ban fishing for sea cucumbers. New legal, administrative and community participation structures are being designed to improve conservation of marine ecosystems. The Charles Darwin Research Station was established in 1959 and advises the National Park Service of the Galapagos on protective programs for the marine ecosystem, tourism policies and environmental education programs.

Ecological Monitoring: The first surveys of the coral reefs were in 1983 after there was 97% mortality of the corals during the severe El Niño of 1982/3. It was considered that the event may have resulted in localised extinctions of *Pocillopora* species of hard coral. After re-growth, the 1997/1998 bleaching event devastated the *Porites* and *Pavona* species down to 30m, with extensive bleaching in 10 to 15 m depth. The re-growth of *Pocillopora* seemed to be largely resistant during the 1998 event.

Socio-economic Monitoring: The Charles Darwin Research Station has participatory fisheries monitoring of catch, by-catch, consumption, market prices etc. to use in adaptive management of the Galapagos Islands.

Coral reefs are **5%** the natural resources.
Ecological Monitoring is **occasional.**
Socio-economic Monitoring is **occasional.**

MAB

SEAFLOWER, COLOMBIA – MAN AND THE BIOSPHERE RESERVE

The Seaflower Biosphere Reserve is in the Southwest Caribbean, about 1000km northwest of Colombia. It is a large reserve, covering about 300,000km^2 of island and sea territory. It contains the archipelagoes of San Andrés, Providencia and Santa Catalina, with 3 small populated islands (only 57km^2 but 60,000 inhabitants), several sand cays and numerous banks, atolls and complex coral reef areas.

The reserve is principally oceanic; however, it includes at least 2,200 km^2 of reef environments, with 826 km^2 of coral reefs. The three major islands also have large mangrove forests and seagrass beds. The oceanic reefs of the archipelago are mostly bank-reef type with wide fore-reefs; almost continuous peripheral reefs on the windward side; and poorly developed reef tracts and lagoons on the leeward side. There is high biodiversity of hard corals (57 species), gorgonians (40), sponges (118), algae (163), and fishes (273).

Ecological Monitoring: There has been long-term coral reef monitoring by CORALINA and INVEMAR under the CARICOMP and SIMAC programs since 1998 in San Andrés island (5 stations), and more recently in Providencia island (4 stations). There has also been some monitoring of the mangroves, seagrasses and beaches of these major islands and the potential impacts of global climate change on these ecosystems.

Socio-economic Monitoring: There have been socio-economic studies of the interactions of fishing and other communities with the biosphere reserve.

Contact: June Marie Mow, Corporación CORALINA, San Andrés, Colombia; coralsai@col1.telecom.com.co

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

WHS MAB

LA AMISTAD, PANAMA /COSTA RICA – MAN AND THE BIOSPHERE RESERVE

The La Amistad Biosphere Reserve and International Peace Park spans the Talamanca Mountains from southern Costa Rica to western Panama. The Costa Rican part of La Amistad, which forms most of the core area of the Reserve, was designated in 1982 and the Panamanian side was inscribed in 2000. They are also jointly inscribed on the World Heritage List. UNESCO/MAB is considering proposing a further trans-border biosphere reserve consisting of the two coastal/marine elements on the Atlantic side, possibly together with adjacent terrestrial and/or marine areas.

La Amistad includes lowland rainforest, cloud forest, and montane forest to extensive Caribbean and Pacific ecosystems, and also includes coral reefs, seagrass beds and some of Central America's most extensive mangroves. Coral reefs in La Amistad contain 25 species of soft corals and 54 species of hard corals. Habitat destruction is possibly the greatest threat to the diverse terrestrial and aquatic flora and fauna in this biosphere reserve. To control this threat, management plans for the reserve are currently being developed and updated. In collaboration with the Costa Rican government, the Organization of American States (OAS), and several local groups, Conservation International helped produce the official management strategy for La Amistad that was adopted by the Costa Rican government in 1990. Since then, efforts have been undertaken by the Panamanian government, OAS, and grassroots organizations to draft a similar strategy for the portion of La Amistad that lies in Panama. There is a need to further strengthen logistic function of the Reserve and facilitate cooperation between Costa Rican and Panamanian management authorities.

Ecological Monitoring: It is understood that substantial monitoring and resource assessment has been undertaken but the information was not available.

Socio-economic Monitoring: No information was available

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

19. Sponsoring Organisations, Coral Reef Programs and Monitoring Networks

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, macroalgal index, sea urchin density, abundance and size of key fish families. Consistency between observers is ensured through training workshops. AGRRA assessments have been on 500 reefs throughout the Caribbean (including Bahamas, Belize, Bonaire, Cayman Ids, Costa Rica, Cuba, Curacao, Honduras, Jamaica, Mexico, Puerto Rico, St. Vincent, Turks and Caicos, US Virgin Islands, US Florida Keys and Flower Gardens, and Venezuela) since 1998. There are extensive regional databases on Caribbean coral reef condition and the information will soon be available on the Internet. Regional comparisons can be made by examining many reefs, but cause and effect relationships are pending further analysis. Contact: Robert Ginsburg or Phil Kramer, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Rickenbacker Cswy, Miami, USA; agrra@rsmas.miami.edu or rginsburg@rsmas.miami.edu; www.coral.noaa.gov/agra/

AIMS – Australian Institute of Marine Science

AIMS is one of Australia's key research agencies and particularly committed 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 regional network of 25 marine laboratories, parks, and reserves established by IOC-UNESCO in 1986 that has been monitoring long-term variation in ecosystem structure and functioning 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 it available. CARICOMP contributes data to ReefBase and has 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. More details: www.uwimona.edu.jm/centres/cms/caricomp/ ; contacts John Ogden, jogden@seas.marine.usf.edu; Dulcie Linton, Caribbean Coastal Data Centre, Jamaica, dmlinton@uwimona.edu.jm

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 organizes 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 works with the dive community, coral park managers and others to promote coral reef conservation around the world. CORAL provides tools, resources and training to dive operators and resource managers to help them build capacity to sustainably manage their reefs. CORAL supports community-based organisations by providing financial and technical support for coral reef conservation in communities throughout the world. In addition, CORAL builds public awareness about coral reefs through various outreach programs, including the International Coral Reef Information Network (ICRIN). CORAL's mission is to keep coral reefs alive. E-mail: info@coral.org; www.coral.org

CORDIO – Coral Reef Degradation in the Indian Ocean

CORDIO 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 Indian Ocean. CORDIO is an operational unit within ICRI. The objectives are 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 participating countries are: Kenya, Tanzania, Mozambique, Madagascar, Seychelles, India, Maldives, Sri Lanka, Reunion, Comores, Mauritius and Chagos. Program co-ordination contacts: Olof Lindén, Dept. of Zoology, University of Kalmar, Sweden, olof@timmermon.se; In South Asia: Dan Wilhelmsson, c/o SACEP, 10 Anderson Road, Colombo 5, Sri Lanka; E-mail: dan.wilhelmsson@cordio.org; In East Africa: David Obura, WIOMSA, P.O. Box 10135, Bamburi, Kenya, E-mail: dobura@africaonline.co.ke; In Island States: Jean Pascal Qoud, CloeCoop, Cellule Locale pour l´Environment, 16, rue Jean Chatel, 97400 Saint Denis, Reunion, cloecoop@runtel.fr

CRC Reef – Cooperative Research Centre for the Great Barrier Reef

The 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. The 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), 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; E-mail: info@crcreef.com; or www.reef.crc.org.au

GBRRF – Great Barrier Reef Research Foundation

The Foundation was established to build on world-class science and encourage the application of research to ensure the sustainability, conservation, protection and responsible use and management of the world's coral reefs. The GBRRF is a non-government, not-for-profit body that is independent of research providers and focussed on funding research that supports long-term practical solutions to the threats facing coral reefs. The GBRRF raises funds for research and ensures that the information is disseminated widely to assist in policy formulation for environmental conservation and community benefit. The Foundation aims to strengthen understanding of the human threats of coral reefs, mechanisms of reef restoration, developing alternative livelihoods and building partnerships in education, research and knowledge for the benefit of reefs worldwide. The GBRRF is advised by an International Scientific Advisory Committee. Contact: David Windsor, GBRRF, 320 Adelaide St. Brisbane 4000 Australia, david.windsor@barrierreef.org, 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 and Reef Check, which constitute the central direction. The GCRMN is sponsored by IOC-UNESCO, UNEP, IUCN, CBD, the World Bank, AIMS, WorldFish Center and 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 IOC-UNESCO and UNEP. IUCN currently Chairs the Management Group of the GCRMN, and the Global Coordinator is hosted at AIMS. 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 Report, 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 Programme:
Middle East – Nodes are assisted by the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) and the Regional Organisation for the Protection of the Marine Environment (ROPME), Contact: Abdullah Alsuhaibany, abdullah.alsuhaibany@persga.org; or Hassan Mohammadi, ropme@qualitynet.net
Eastern Africa – assisting Kenya, Mozambique, South Africa and Tanzania operating through the CORDIO network in Mombasa, in association with the Kenya Wildlife Service. Contact: David Obura in Mombasa, dobura@africaonline.co.ke; and Nyawira Muthiga, nmuthiga@AfricaOnline.Co.Ke
South-west Indian Ocean Island States - coordinating Comoros, Madagascar, Mauritius, Reunion and Seychelles with assistance from the Global Environment Facility and Indian Ocean Commission. Contact: Lionel Bigot, ARVAM La Reunion, lbigot.arvam@wanadoo.fr
South Asia - for India, Maldives and Sri Lanka with support from the UK Department for International Development (DFID) and coordination through IOC-UNESCO. Contact: the Regional Coordinator in Colombo, Ben Cattermoul, reefmonitor@eureka.lk
South East Asia - for the ASEAN countries with assistance from the WorldFish Center, Penang Malaysia. Contact: Jamie Oliver, j.oliver@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 in Japan. Contact: Kei Osada, KEI_OSADA@env.go.jp, Tadashi Kimura, BXQ02107@nifty.ne.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: Cameron Hay, hay_c@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);
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, Carol Emaurois, emaurois2000@yahoo.com
Hawaiian Islands – for US islands in the Pacific. Contact: Ruth Kelty, Ruth.Kelty@noaa.gov, or Mark Monaco, mark.monaco@noaa.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: Dulcie Linton, dmlinton@uwimona.edu.jm; George Warner, gfwarner@uwimona.edu.jm
Mesoamerican Barrier Reef System for Mexico, Belize, Guatemala, Honduras. Contact: Patricia Almada-Villela MBRS Project office, Belize, palmadav@mbrs.org.bz; 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, 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 protect 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 current scientific, economic and social information. The ICRAN partners are: CORAL, GCRMN, ICLARM, ICRI, Reef Check, SPREP, UNEP, UNEP-WCMC, UNF, WRI and WWF.
E-mail: Kristian Teleki, kteleki@icran.org; www.icran.org

ICRI – International Coral Reef Initiative

ICRI was developed to reverse the declining status of the world's coral reefs. It is a partnership of countries, international organisations, NGOs and regional seas programmes created in 1994 following calls at the 1992 UNCED Rio Earth Summit and by the Small Island Developing States. ICRI was initiated by Australia, France, Jamaica, Japan, Philippines, Sweden, UK and USA, along with CORAL, IOC-UNESCO, IUCN, UNDP, UNEP, and the World Bank. ICRI seeks to mobilise global support for coral reefs and catalyse sustainable management through representation in diplomatic and international fora, such as UNEP and IOC governing councils, Conventions on Sustainable Development, Biological Diversity, Climate Change; Global Meetings of Regional Seas Conventions and Action Plans, Global Plan of Action to Protect the Marine Environment from Land-based Activities, Global Conference on Sustainable Development in Small Island Developing States and CITES. The first ICRI international workshop in Dumaguete City, Philippines in 1995 developed the ICRI Call to Action and a Framework for Action. These were refined into the ICRI Renewed Call to Action at the International Tropical Marine Ecosystems Management Symposium (ITMEMS) in Townsville, Australia in 1998. The ICRI Coordination and Planning Committee makes decisions by consensus. The Secretariat, which seeks to implement the ICRI agenda, has been hosted in rotation since 1995 by the Governments of USA, Australia, France and presently by Sweden and the Philippines. The GCRMN was the first operational unit of ICRI, followed by the establishment of ICRIN - the Information Network; and ICRAN - the Action Network. Contacts: Robert Jara (secretariat@icriforum.org, icri_secretariat@hotmail.com) and Olof Linden (olof@timmermon.se) / Dan Wilhelmsson (dan.wilhelmsson@telia.com); 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 sponsoring local events and activities. ICRIN is the outreach component of ICRAN and ICRI. Contact: icrin@coral.org; or www.coralreef.org

IOC – UNESCO

The Intergovernmental Oceanographic Commission (IOC) in Paris has promoted marine scientific investigations and related ocean services for more than 30 years, with a view to learning more about ocean resources, their nature and sustainability. IOC, with UNEP, IUCN and the World Meteorological Organization formed the Global Task Team on Coral Reefs in 1991 to select methods and develop plans to monitor the world's coral reefs. This Task Team was the immediate precursor to the GCRMN, and after the ICRI Dumaguete meeting in 1995, the IOC, UNEP and IUCN were invited to co-sponsor the GCRMN, with the World Bank and the CBD joining later. The GCRMN was coordinated and administered through the IOC as part of the Global Ocean Observing System, to which it contributes data on coral reef health and resources. Contact: Ole Vestergaard, o.vestergaard@unesco.org; www.ioc.unesco.org

IUCN – The World Conservation Union

IUCN was founded in 1948 to bring together States, government agencies and NGOs in a unique world partnership. As a Union of 980 members across 140 countries, the IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. The IUCN represents the views of members on the world stage and provides the strategies, services, scientific knowledge and technical support to achieve their goals. IUCN has 6 Commissions with 10,000 experts in project teams and action groups, focused on particular species, biodiversity conservation and the management of habitats and natural resources. IUNC assists countries prepare National Conservation Strategies, and leads or assists in field projects. Operations are decentralised to regional and country offices, mostly in developing countries. IUCN is built on its members' strengths, networks and partners to enhance capacity and support global alliances to safeguard natural resources at local, regional and global levels. IUCN is a founding member of GCRMN and currently chairs the Management Group. Contact for the Global Marine Program: Carl Gustaf Lundin, IUCN - The World Conservation Union, Rue Mauverney 28, CH-1196 Gland, Switzerland, Marine@iucn.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 over 1000 from 60 countries. The Society promotes the production and dissemination of scientific knowledge and understanding of coral reefs, both living and fossil. It prints and distributes the journal *Coral Reefs* and the magazine *Reef Encounter*, and offers major research awards and travel support for students and 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.uncwil.edu/isrs/.

MAC – Marine Aquarium Council

This is an international, multi-stakeholder, not-for-profit, NGO created to ensure the global trade in marine aquarium organisms is sustainable by creating standards and certification for those engaged in the collection and care of ornamental marine life from reef to aquarium. MAC brings together the aquarium industry, hobbyists, conservation organisations, government agencies, public aquariums, international organisations and others to ensure the health and sustainability of the organisms, their habitat and the marine ornamental trade. MAC certification creates market incentives that encourage and support responsible and sustainable practices by encouraging consumer demand and confidence for certified organisms, practices and industry participants. This results in reef conservation and management by requiring certified reef areas to be managed, including fish reserves, and by ensuring certified aquarium fishers use non-destructive methods. The certified marine aquarium trade also supports sustainable livelihoods, poverty alleviation and other community benefits by ensuring healthy reefs support a sustainable fishery and by ensuring fishers earn a good return and subscribe to occupational health standards. MAC launched the Certification in November 2001 with 3 Standards covering the ‘reef to retail’ supply chain: Ecosystem and Fishery Management Standard; Collection, Fishing and Holding Standard; Handling, Husbandry and Transport Standard. Collectors and exporters in the Philippines and elsewhere, and importers and retailers in the USA and Europe are being certified in late 2002. MAC has offices in Hawaii, Washington D.C., the Philippines, Solomon Islands, and Indonesia. Contact: Paul Holthus, Marine Aquarium Council, 923 Nu’uanu Ave, Honolulu, HI 96816, USA; www.aquariumcouncil.org, info@aquariumcouncil.org

Packard Foundation

The David and Lucile Packard Foundation is a private Foundation based in California that established the Western Pacific Conservation Program in 1998. The goals are the long-term conservation and responsible stewardship of critical coastal marine habitats and resources, especially coral reefs and seagrasses in 8 countries in the Western Pacific: Palau; Federated States of Micronesia; the Philippines; Papua New Guinea; Solomon Islands; Fiji; and eastern Indonesia and Malaysia. The Program’s funding strategy focuses on: improving individual technical skills for effective conservation and resource management; supporting a network of site-specific marine protected areas; and developing a range of targeted, applied research and analysis initiatives to get useful information e.g. on new technologies, small business development opportunities, policy reform, into the hands of practitioners, policy-makers and local community members. Contact: www.packard.org

Reef Check

Reef Check is a university-based environmental organisation established to facilitate community monitoring and management of coral reefs on a global scale. Reef Check is active in over 60 countries and territories throughout the tropics where it seeks to: *educate* the public about the coral reef crisis and how to stop 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 academia, 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 presently coordinates training for the GCRMN. Training programs in ecological and socio-economic monitoring and coral reef management are regularly offered throughout the world. Contact: Kelly McGee, Institute of the Environment, Mailcode 149607, University of California at Los Angeles, CA 90095 USA; rcheck@ucla.edu, www.ReefCheck.org

UNEP – United Nations Environment Programme

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 partnerships and enhance the participation of civil society – the private sector, scientific community, NGOs and youth – in working 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.
Contacts: PO Box 30552, Nairobi Kenya; cpiino@unep.org; www.unep.org

UNEP – Coral Reef Unit

UNEP is implementing a comprehensive work program on coral reefs, aiming to prevent further degradation while involving all stakeholders and addressing their social and economic needs. Coral reef activities of the Unit are carried out through UNEP divisions, the UNEP World Conservation Monitoring Center, Regional Seas Programmes, and in collaboration with multilateral environmental agreements such as the Convention on Biological Diversity and the International Coral Reef Initiative of which UNEP has been a member since 1994. ICRI and its operational networks, in particular the International Coral Reef Action Network (ICRAN), where UNEP is a partner, and the GCRMN, which is co-sponsored by UNEP, are at the centre of a global effort to protect coral reefs and form partnerships for sustainable development. Coral reef conservation has a firm commitment from UNEP. Contact: Agneta Nilsson, Agneta.Nilsson@unep.org

UNEP – World Conservation Monitoring Centre

UNEP-WCMC has a major coral reef focus, including mapping, a global database on marine protected areas, monitoring trade in corals and marine ornamentals, and the global distribution of threats, including coral disease and bleaching. The World Atlas of Coral Reefs (2001) was a major product. UNEP-WCMC maintains a as 'marine ornamentals' database of the global trade in live coral reef species, with the Marine Aquarium Council and members of the industry. This aims to improve understanding of the trade and measure the impacts to foster a regulated and sustainable trade operating via certification schemes. There is also a global database on marine protected areas, with 680 coral reef sites within 3600 listings. UNEP-WCMC is committed to making coral reef information accessible, through its partners (WorldFish Center, WRI, GCRMN) and the Internet. 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

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 emerging 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 Depatment, contact: Marea Hatziolos, Environment Department, The World Bank, 1818 H St. NW, Washington, DC 20433 USA, Mhatziolos@worldbank.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-centered policies for sustainable development. WorldFish Center is an autonomous, non-governmental, non-profit organisation, established as an international center in 1977, with new headquarters in Penang, Malaysiam 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 implementing a series of regional projects examining threats to coral reefs to provide resource managers with specific information and tools for more effective management. These projects are being implemented in close collaboration with regional partners, and are a more-detailed follow-on to the global *Reefs at Risk* analysis, released in 1998. The first, *Reefs at Risk in Southeast Asia*, was released in February 2002. The current project, *Reefs at Risk in the Caribbean*, is planned for release in February 2004. The projects have these goals: 1) Improve the base of information available on threats to and status, value, and protection of coral reefs within a region, through collecting, improving, and integrating information; 2) Model threats to coral reefs based upon population and development patterns, land use change, and the location and intensity of specific activities known to degrade coral reefs; 3) Develop of a geographic information system (GIS)-based tool for more local-level evaluation of development scenarios and related implications for coral reef health and economic value; 4) Raise awareness of human threats to coral reefs through wide dissemination of project results. All data (including GIS data sets) are on the Internet at www.wri.org/reefsatrisk Contact: Lauretta Burke, World Resources Institute, Washington, DC 20002, USA: lauretta@wri.org

WWF – World Wild Fund for Nature or World Wildlife Fund

WWF is the world's largest and most experienced independent conservation organisation, with over 4.7 million supporters and a global network in 96 countries. WWF is in its 4^{th} decade, with a mission to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by: conserving the world's biological diversity; ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption. The WWF Ocean Rescue initiative is working to conserve coral reefs throughout the world, as well as safeguarding cold water corals. In the next 10 years, WWF has the goal of creating or strengthening management in 100 marine protected areas, and creating networks of MPAs that safeguard the ecological integrity of larger reef systems. WWF will also continue landmark efforts to protect whales and other ocean wildlife, end destructive fishing practices, stop illegal trade in marine species, and reduce pollution on land and sea.

Suggested Reading

The following are some useful references in addition to the Chapters above, although most Chapters include source references for material in those chapters:

Birkeland C (1997). Life and Death of Coral Reefs. Chapman & Hall, New York, 536pp.

Birkeland C (1997). Symbiosis, fisheries and economic development on coral reefs. Trends in Ecology and Evolution 12:364-367.

Brown BE (1997). Integrated Coastal Management: South Asia. Department of Marine Sciences and Coastal Management, University of Newcastle, Newcastle upon Tyne, United Kingdom

Bryant D, Burke L, McManus J, Spalding, M (1998). Reefs at Risk: A Map-Based Indicator of Potential Threats to the World's Coral Reefs. World Resources Institute, Washington D.C, 56pp.

Cesar HSJ (Ed.) (2000). Collected Essays on the Economics of Coral Reefs. CORDIO, Kalmar University, Sweden, 244pp.

Bak RPM, Nieuwland G (1995). Long-term change in coral communities along depth gradients over leeward reefs in the Netherlands Antilles. Bull.Mar.Sc. 56: 609-619.

Bunce L, Townsley P, Pomeroy R, Pollnac R (2000). Socioeconomic Manual for Coral Reef Management. Australian Institute of Marine Science and GCRMN, Townsville 183 pp.

Burke L, Selig E, Spalding, M (2002). Reefs at Risk in Southeast Asia. World Resources Institute, Washington D.C, 72pp.

Davidson OG (1998). The Enchanted Braid: Coming to Terms with Nature on a Coral Reef. John Wiley New York, USA, 269 pp.

English S, Wilkinson C, Baker V (1997). Survey Manual for Tropical Marine Resources. 2nd Edition. Australian Institute of Marine Science, Townsville, 390pp.

Froese R, Pauly D (Eds) (2002). FishBase. World Wide Web electronic publication. www.fishbase.org, http://www.fishbase.org/search.cfm

Ginsburg RN (ed) (1993). Global Aspects of Coral Reefs: Health Hazards and History, 7-11 June 1993. University of Miami, Miami, 420pp. (This volume has a valuable series of papers on problems facing reefs around the world).

Glynn P, Maté JL, Baker AC, Calderón MO (2001). Coral bleaching and mortality in Panamá and Ecuador during the 1997-1998 El Niño-Southern Oscillation event: spatial/temporal patterns and comparisons with the 1982-1983 event. Bull. Mar. Sci. 69: 79-109.

Guzmán HM, Cortés J (2001). Changes in reef community structure after fifteen years of natural disturbances in the Eastern Pacific (Costa Rica). Bull. Mar. Sci. 69: 133-149.

Hatziolos M, Lundin CG, and Alm A (1996). Africa: A Framework for Integrated Coastal Zone Management. World Bank, Washington D.C., 150 pp.

Hatziolos ME, Hooten AJ, and Fodor F (1998). Coral Reefs: Challenges and Opportunities for Sustainable Management. In Proceedings of an associated event of the fifth annual World Bank Conference on Environmentally and Socially Sustainable Development. World Bank, Washington D.C., 224pp.

Henrichsen D (1998). Coastal Waters of the World: Trends, Threats, and Strategies. Island Press, Washington D.C. 275pp.

IUCN (2002). The IUCN Red List of Threatened Species. World wide Web electronic publication. www.redlist.org/search/search-expert.php

Jiménez C, Cortés J, León A, Ruiz E (2001). Coral bleaching and mortality associated with the 1997-98 El Niño in an upwelling environment in the Eastern Pacific (Gulf of Papagayo, Costa Rica). Bull. Mar. Sci. 69: 151-169.

Johannes RE (1981). Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. University of California Press, 320pp.

Johannes RE (1998). The case for data-less marine resource management: examples from tropical nearshore finfisheries. Trends in Ecology and Evolution 13:243-246.

Kelleher G (1999). Guidelines for Marine Protected Areas. World Conservation Union, Washington D.C., 107pp.

Kelleher G, Bleakley C, Wells S (1995). The Global Representative System of Marine Protected Areas. Volume II Wider Caribbean, West Africa and South Atlantic. Great Barrier Reef Marine Park Authority, Townsville ; World Bank, Washington D.C. ; World Conservation Union, Washington D.C., 93pp.

Kelleher G, Bleakley C, Wells S (1995). The Global Representative System of Marine Protected Areas. Volume III Central Indian Ocean, Arabian Seas, East Africa and East Asia Seas. Great Barrier Reef Marine Park Authority, Townsville ; World Bank, Washington D.C. ; World Conservation Union, Washington D.C., 147pp.

Kelleher G, Bleakley C, Wells S. (1995). The Global Representative System of Marine Protected Areas. Volume IV South Pacific, Northeast Pacific, Southeast Pacific and Australia/New Zealand. Great Barrier Reef Marine Park Authority, Townsville ; World Bank, Washington D.C. ; World Conservation Union, Washington D.C., 212pp.

Knowlton N (1998). Hard decisions and hard science: research needs for coral reef management. In: Coral Reefs: Challenges and Opportunities for Sustainable Management. Proceedings of an associated event of the Fifth Annual World Bank Conference on Environmentally and Socially Sustainable Development. October 9-11, 1997)

Laboy-Nieves EN, Klein E, Conde JE, Losada F, Cruz JJ, Bone D (2001). Mass mortality of tropical marine communities in Morrocoy, Venezuela. Bull. Mar. Sci. 68: 163-179.

Lessios HA, Macintyre IE (eds) (1997). Proceedings of the 8th International Coral Reef Symposium, Panama, June 24-29 1996, Volume 1. Smithsonian Tropical Research Institute, Balboa, Panama.

Maragos JE, Crosby MP, McManus JW (1996) Coral reefs and biodiversity: a critical and threatened relationship. Oceanography 9:83-99.

McClanahan TR, Sheppard CR, Obura DO (eds) 2000. Coral reefs of the Indian Ocean: Their ecology and conservation. Oxford University Press, N.Y.

Norse EA (1993). Global Marine Biological Diversity: a strategy for building conservation into decision making. Island Press, Washington D.C. 383pp.

Obura D (ed) (2002). Proceedings of the International Coral Reef Initiative (ICRI) Regional Workshop for the Indian Ocean, 2001. ICRI/UNEP/ICRAN/CORDIO.

Richmond, MD (1997). A Guide to the Seashores of Eastern Africa. SIDA Department for Research Cooperation, Stockholm, Sweden, 448 pp.

Salm RV, Clark JR, Siirila E (2000). Marine and Coastal Protected Areas: A Guide for Planners and Managers. IUCN Washington DC 371 pp.

Salvat B (2001). Status of Coral Reefs of the World 2000 in the Southeast and Central Pacific 'Polynesia Mana' Network. Fondation Naturalia Polynesia, Moorea, French Polynesia. 217 pp.

Salvat B, Haapkyla J, Schrimm M (2002). Title : Coral Reef Protected Areas in international instruments: World Heritage Convention, World Network of Biosphere Reserves, Ramsar Convention. Criobe-EPHE, Moorea, French Polynesia. 210 pp.

Sapp J (1999). What is Natural? Coral Reef Crisis. Oxford University Press, New York USA, 275 pp.

Sheppard CRC, Sheppard ALS (1991). Corals and Coral Communities of Arabia. Fauna of Saudi Arabia 12.

Spalding M, Ravilious C, Green E (2001). World Atlas of Coral Reefs. UNEP World Conservation Monitoring Centre and University of California Press, Berkeley USA 424 pp.

Talbot F, Wilkinson C (2001). Coral Reefs, Mangroves and Seagrasses: A Sourcebook for Managers. Global Coral Reef Monitoring Network & Australian Institute of Marine Science, Townsville, 193 pp.

Turgeon DD, Asch RG, Causey BD, Dodge RE, Jaap W, Banks K, Delaney J, Keller BD, Speiler R, Matos, CA, Garcia JR, Diaz, E, Catanzano, D, Rogers, CS, Hillis-Starr Z, Nemeth R, Taylor M, Schmahl GP, Miller MW, Gulko DA, Maragos JE, Friedlander AM, Hunter CL, Brainard RS, Craig P, Richmond, RH, Davis G, Starmer J, Trianni M, Houk P, Birkeland CE, Edward A, Golbuu Y, Gutierrez J, Idechong N, Paulay G, Tafileichig A, Vander Velde N (2002). The State of Coral Reef Ecosystems of the United States and the Pacific Freely Associated States: 2002. National Oceanic and Atmospheric Administration/ National Ocean Service/ National Centers for Coastal and Ocean Science, Silver Spring, MD. 265 pp.

Vargas-Angel B, Zapata FA, Hernández H, Jiménez JM (2001). Coral and coral reef responses to the 1997-98 El Niño event on the Pacific coast of Colombia. Bull. Mar. Sci. 69: 111-132.

Veron JEN, Stafford-Smith M (2000). Corals of the World. Australian Institute of Marine Science, Townsville, Australia 363pp. Volume 1 463 pp., Volume 2 429 pp., Volume 3 490 pp.

Wallace C. (1999). Staghorn Corals of the World. CSIRO Publishing, Collingwood Australia 421 pp.

Wells S, Hanna N (1992). The Greenpeace Book of Coral Reefs. Sterling Publishing Co., New York, 160pp.

Wells SM (ed) (1988). Coral Reefs of the World. Volume 1: Atlantic and Eastern Pacific. UNEP, Nairobi ; International Union for Conservation of Nature and Natural Resources, Switzerland.

Wells SM (ed) (1988). Coral Reefs of the World. Volume 2: Indian Ocean, Red Sea, and Gulf. UNEP, Nairobi ; International Union for Conservation of Nature and Natural Resources, Switzerland.

Wells SM (ed) (1988). Coral Reefs of the World. Volume 3: Central and western Pacific. UNEP, Nairobi; International Union for Conservation of Nature and Natural Resources, Switzerland.

Wilkinson CR (1998). Status of Coral Reefs of the World: 1998. Global Coral Reef Monitoring Network and Australian Institute of Marine Science, Townsville, Australia 184pp.

Wilkinson CR (2000). Status of Coral Reefs of the World: 2000. Global Coral Reef Monitoring Network and Australian Institute of Marine Science, Townsville, Australia 363pp.

Wilkinson CR, Buddemeier RW (1994). Global Climate Change and Coral Reefs: Implications for People and Reefs. Report of the UNEP-IOC-ASPEI-IUCN Global Task Team on Coral Reefs. IUCN, Gland, 124pp.

List of Acronyms

AGRRA	Atlantic and Gulf Reef Assessment
AIMS	Australian Institute of Marine Science
ASEAN	Association of South East Asian Nations
AusAID	Australian Agency for International Development
BAPPEDA	Council for Provincial Planning and Development
CATIE	Centro Agronomico Tropical de Investigacion y Ensenanza
CFC	Chlorofluorocarbon
CI	Conservation International
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CORAL	The Coral Reef Alliance
CORDIO	Coral Reef Degradation in the Indian Ocean
COTS	Crown-of-thorns starfish (*Acanthaster planci*)
CSD	Convention for Sustainable Development
DFID	Department for International Development (of UK)
DNA	Deoxyribonucleic Acid
EIA	Environmental Impact Assessment
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRRF	Great Barrier Reef Research Foundation
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GIS	Geographical Information System
ICAM	Integrated Coastal Area Management
ICM	Integrated Coastal Management
ICRAN	International Coral Reef Action Network
ICRI	International Coral Reef Initiative
ICRI	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
IOC	Intergovernmental Oceanographic Commission of UNESCO
IOI	International Ocean Institute
IUCN	The World Conservation Union

MAB	Man and the Biosphere site of UNESCO
MARPOL	International Convention of the Prevention of Pollution from Ships
MPA	Marine Protected Area
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration (of USA)
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
ROPME	Regional Organisation for the Protection of the Marine Environment
SACEP	South Asia Cooperative Environment Programme
SAREC	Sida Department for Research Cooperation
SCUBA	Self-contained underwater breathing apparatus
SIDA	Swedish International Development Agency
SIDS	Small Island Developing States
SPREP	South Pacific Regional Environment Programme
TNC	The Nature Conservancy
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNF	United Nations Foundation
USAID	US Agency for International Development
UV	Ultraviolet radiation
WCMC	World Conservation Monitoring Centre
WHA	World Heritage Area
WHS	World Heritage Site
WRI	World Resources Institute
WWF	World Wildlife Fund (USA)
WWF	World Wide Fund for Nature (elsewhere)
WWF	World Wrestling Federation