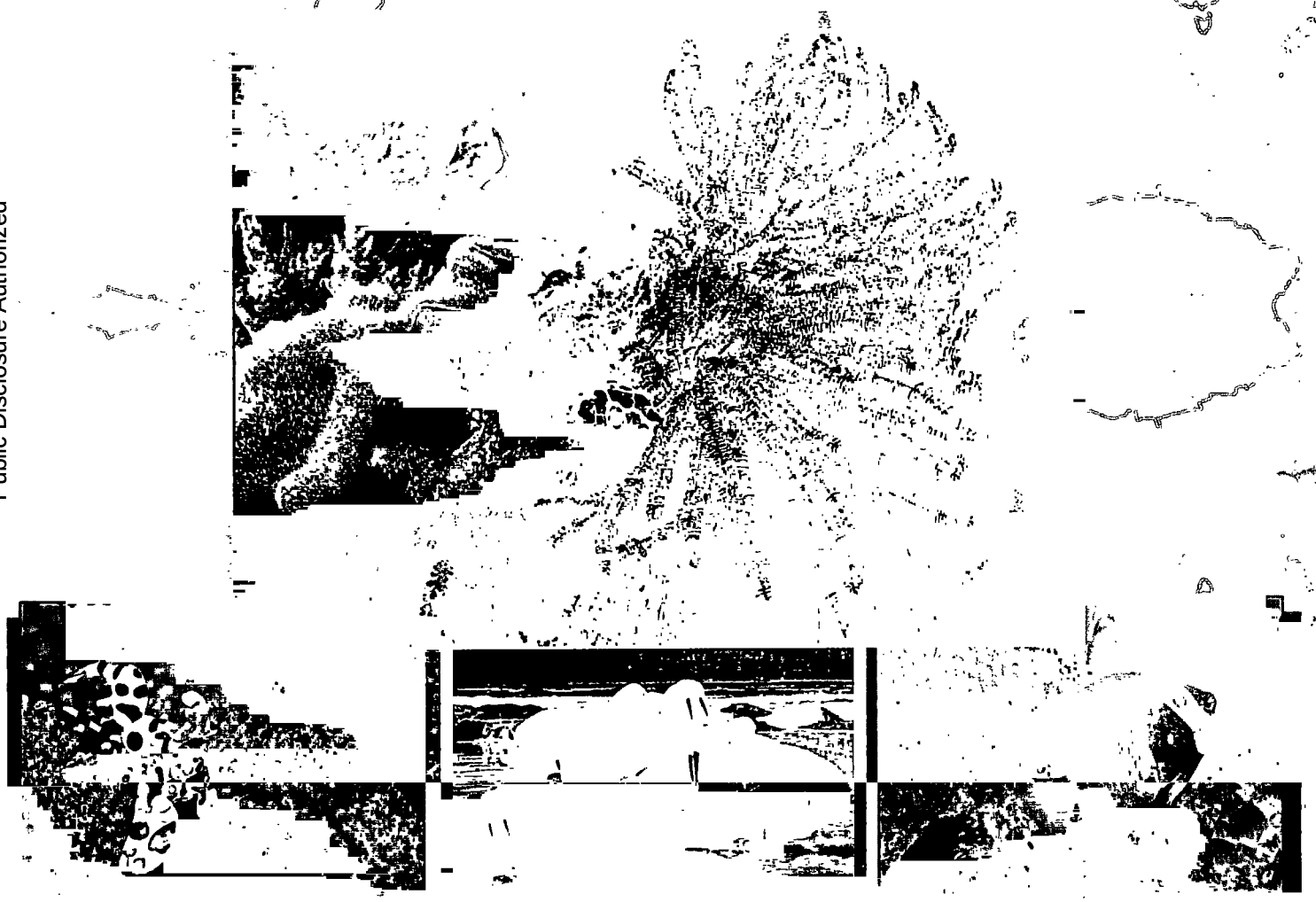
A GLOBAL REPRESENTATIVE SYSTEM OF MARINE PROTECTED AREAS

Volume III

Central Indian Ocean, Arabian Seas, East Africa and East Asian Seas



Great Barrier Reef Marine Park Authority
The World Bank
The World Conservation Union (IUCN)

A Global Representative System of Marine Protected Areas

Principal Editors
Graeme Kelleher, Chris Bleakley, and Sue Wells

Volume III

The Great Barrier Reef Marine Park Authority
The World Bank
The World Conservation Union (IUCN)

The International Bank for Reconstruction
and Development/THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

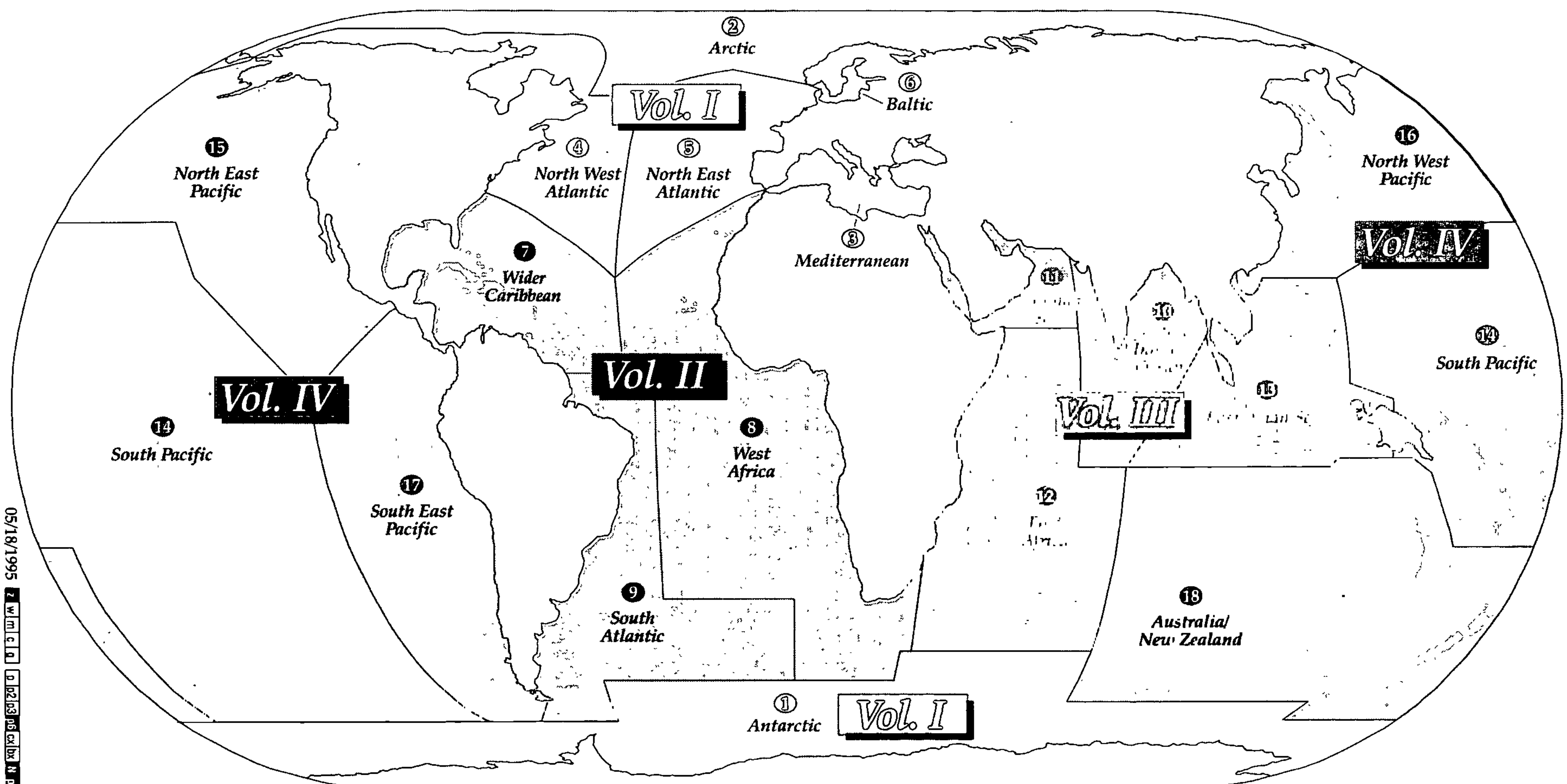
Manufactured in the United States of America
First printing May 1995

This publication was printed with the generous financial support of the Government of The Netherlands.

Copies of this publication may be requested by writing to:
Environment Department
The World Bank
Room S 5-143
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

WORLD
CNPPA MARINE REGIONS

5 CNPPA MARINE REGION NUMBERS
—— CNPPA MARINE REGION BOUNDARIES



05/18/1995

IBRD 26261

The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries

Contents

Acronyms

AIMS
Australian Institute of Marine Science

CITES
Convention on International Trade in Endangered Species of Wild Fauna and Flora

CNPPA
Commission on National Parks and Protected Areas (IUCN)

GBRMPA
Great Barrier Reef Marine Park Authority

GEF
Global Environment Facility

GIS
Geographic Information System

HDU
Habitats Data Unit

ICLARM
International Center for Living Aquatic Resource Management

IMO
International Maritime Organization

IUCN
The World Conservation Union

LME
Large Marine Ecosystems

MPA
Marine Protected Area

MAB
Man and the Biosphere Programme

MARPOL
International Convention for the Prevention of Pollution from Ships

NGO
Nongovernmental Organization

PADU
Protected Areas Data Unit

SSC
Species Survival Commission

TNC
The Nature Conservancy

UNDP
United Nations Development Programme

UNCED
United Nations Conference on Environment and Development

UNEP
United Nations Environment Programme

UNESCO
United Nations Educational, Scientific, and Cultural Organization

WCMC
World Conservation Monitoring Centre

WWF
World Wildlife Fund

Data Note
Billion is a thousand million; *trillion* is a million million.

Introduction

This introduction is a summary of the comprehensive introductory chapter in Volume I. It provides a summary of the background, methodology, results, major conclusions and recommendations of the four volumes of this publication. An abbreviated summary of the major results of the 18 regional reports is also included. The full descriptions and full summaries of the results are included in the introductory chapter in Volume I.

The marine environment is critical to the natural and cultural heritage of the world. Not only do many marine areas support a great diversity of plants, animals, and natural habitats, but the oceans play an essential role in climatic cycles and other global processes. Marine ecosystems and resources are fundamental to the sustainable development of coastal countries, providing food, minerals, pharmaceuticals, construction materials, and a vast range of other products.

They often support growing tourism and recreation industries and play a vital role in transport and in the culture and lifestyle of coastal people. However, marine ecosystems throughout the world face increasingly serious threats from pollution, overexploitation, conflicting uses of resources, damage and destruction of habitat, and other harmful consequences of human development. Biodiversity is especially at risk. Conserving marine biodiversity is therefore a priority.

Since 1986 the IUCN Commission on National Parks and Protected Areas (CNPPA) has been promoting the establishment and management of a global representative system of marine protected areas (MPAs). The four volumes of this publication represent the conclusion of the latest phase of CNPPA's program and have been prepared through the collaboration of IUCN-CNPPA, the Great Barrier Reef Marine Park Authority (GBRMPA), the World Bank, and many other organizations and individuals (acknowledged in the contributors' section of each volume). This publication documents the biogeographic and ecological characteristics in each of 18 Marine Regions of the world and summarizes the range of marine biodiversity within each region and the major threats to its conservation. Based on a comprehensive set of selection criteria, including ecological, social and economic factors, marine protected area sites of national and re-

gional priority for the conservation of marine biodiversity are proposed in each region. These sites include existing MPAs in need of improved management as well as new areas proposed to fill in the gaps in biogeographic representation within the existing marine protected area system.

The following definition has been adopted by IUCN for the term "marine protected area" (IUCN 1988):

Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.

OBJECTIVE

The aim of the report is to identify priority areas for the establishment and management of a global representative system of MPAs. It provides strategic guidance to governments, aid agencies, and others working to conserve marine biodiversity conservation and achieve sustainable use of the marine environment. The report also offers recommendations that address priority issues for the establishment and effective management of MPAs.

One of the prime objectives of this report was to produce maps of the 18 biogeographic regions into which the CNPPA has divided the world, showing the locations of:

- Existing MPAs
- Existing MPAs characterized as to national and regional priority for management strengthening
- Proposed new MPAs of national priority or regional priority.

Both existing and proposed MPAs are depicted on the accompanying maps as a point representing the center of an area. For proposed MPAs, this may be a well-defined location or a general focal area for biodiversity conservation requiring further investigation.

Supporting information will be provided for each of the regions, including:

- An overview of the marine biodiversity and biogeography in each region, particularly as they relate to MPAs
- Available data on existing MPAs in each region, including assessments of their representativeness and management effectiveness
- Justification for the selection of priority areas
- Identification of further information required for completing a network of MPAs to cover each region's marine biological and geographic diversity.

METHODOLOGY

The CNPPA has divided the marine areas of the world into 18 marine regions, largely on the basis of biogeographic criteria, but for practical reasons also considering political boundaries. In 1990, working groups were established in each region, consisting wherever possible of both marine resource managers and marine scientists. The aims of the working groups have been to:

- Summarize the main physical and biological characteristics of the marine environment
- Divide each marine region into its constituent biogeographic zones
- Make an inventory of existing MPAs
- Identify gaps in the representation of the biogeographic zones in MPAs
- Identify areas of national or regional priority for the establishment of new MPAs or for management strengthening and support to existing MPAs
- Determine other recommendations for establishing or improving the management of MPAs in each marine region.

Workshops were held in the East Asian Seas (February 1993), the Baltic (June 1993), North West Pacific (September 1993), the South Pacific (October 1993) and Latin Amer-

ica (January 1994) regions to allow marine resource managers and marine scientists to cooperate in the identification of priorities. In some regions this was the first time that these two groups had cooperated in this way for any purpose.

Information from the Protected Areas Data Unit and Habitats Data Unit at the World Conservation Monitoring Centre has been made available to GBRMPA and the World Bank for this project, and these organizations now maintain an identical computerized database on MPAs. This database, which has been substantially edited and updated for the purpose of this report by the Bank and GBRMPA, has been used to generate maps showing the location of MPAs worldwide, each region's biogeographic classification scheme, and the location of priority areas for the conservation of marine biodiversity of global significance.

SELECTION OF PRIORITY AREAS

The criteria used to identify priority areas in this report were developed by Kelleher and Kenchington (1992) and have been adopted by the International Maritime Organization for use in the identification of Particularly Sensitive Sea Areas and by the parties to the Helsinki Convention for identification of a system of marine protected areas for the Baltic Sea.

Priorities were identified primarily on the basis of ecological and biogeographic criteria using available data. Other, equally important, criteria were used to provide additional justification for or against the selection of a particular area and to help decide the feasibility of establishing and successfully managing a marine protected area. All priority areas were therefore assessed as having a reasonable chance of success as a marine protected area.

Within these guidelines, each working group applied the specific criteria shown in Box 1 for the selection of priority areas.

PRIORITIES FOR CONSERVATION

Priorities in this report have been identified for regional and national areas using available data. Only limited information has been available on some subjects in some regions and countries, and the report reflects this variability in data. Recommendations on the management of individual MPAs require detailed assessment of these sites. Unfortunately, the limitations of time and resources meant that such assessments were beyond the scope of this report.

The report concentrates on the subtidal marine environment in coastal areas and does not attempt to assess intertidal, estuarine, and wetland areas. In some instances, a lack of available information on the boundaries of protected areas that appear to have marine components made it difficult to determine the extent of any marine environment. It was therefore decided to identify only those areas that include a significant subtidal marine component.

Whenever possible national priority areas were identified by national representatives and regional priority areas were identified by the regional working group leader. This process of identification stretched over three years and every effort was made to incorporate contributions from marine resource managers and marine scientists in each country.

The selection of sites was to some extent subjective, and the lack of information and a well-tested and accepted global biogeographical classification system makes the determination of priorities between regions difficult. However, priorities in each region have been identified within the framework of a biogeographic classification system considered appropriate for that region.

Many nations are carrying out programs for conservation and development of the marine environment. As far as possible, the priorities identified in this report are consistent with expressed national priorities, as identified by national representatives or in documents such as National Environmental

Box 1. Criteria for Selection of Priority Areas

Biogeographic criteria
- presence of rare biogeographic qualities or representative of a biogeographic "type" or types
- unique or unusual geological features.

Ecological criteria
- an essential part of ecological processes or life-support systems (for example, is a source for larvae for downstream areas)
- area's integrity, or the degree to which the area either by itself or in association with other protected areas, encompasses a complete ecosystem
- the variety of habitats
- presence of habitat for rare or endangered species
- nursery or juvenile areas
- feeding, breeding or rest areas
- rare or unique habitat for any species
- genetic diversity (is diverse or abundant in species terms).

Naturalness
- extent to which the area has been protected from, or has not been subject to, human-induced change.

Economic importance
- existing or potential contribution to economic value by virtue of its protection (for example, protection of an area for recreation, subsistence, use by traditional inhabitants, appreciation by tourists and others or as a refuge nursery area or source of economically important species).

Social importance
- existing or potential value to the local, national or international communities because of its heritage, historical, cultural, traditional aesthetic, educational or recreational qualities.

Scientific importance
- value for research and monitoring.

International or national significance
- potential to be listed on the World (or national) Heritage List, declared a Biosphere Reserve, or included on a list of areas of international or national importance, or is the subject of an international or national conservation agreement.

Practicality/or feasibility
- degree of insulation from external destructive influences
- social and political acceptability, degree of community support
- accessibility for education, tourism, recreation
- compatibility with existing uses, particularly by locals
- ease of management or compatibility with existing management regimes.

Action Plans or National Conservation Strategies.

Priorities for marine biodiversity conservation will change in the future as further information becomes available, as experience and education increase the awareness of communities and decisionmakers about the role and importance of marine environments and ecosystems, and as the priorities identified in this report are acted upon. This new information from management experience, community education, research and monitoring should be taken into account in making decisions and taking action. Regular review and updating of the priorities identified in this report is therefore to be welcomed.

It its beyond the scope of this report to deal with issues relating to broader coastal zone management. However, the close interaction between marine environments and be-

Table 1. Number of Subtidal MPAs, by Marine Region

	Marine Region	*Number of MPAs*	*Percentage of Total*
1	Antarctic	17	1.3
2	Arctic	16	1.2
3	Mediterranean	53	4.0
4	Northwest Atlantic	89	6.8
5	Northeast Atlantic	41	3.1
6	Baltic	43	3.2
7	Wider Caribbean	104	7.9
8	West Africa	42	3.2
9	South Atlantic	19	1.4
10	Central Indian Ocean	15	1.1
11	Arabian Seas	19	1.4
12	East Africa	54	4.1
13	East Asian Seas	92	7.0
14	South Pacific	66	5.0
15	Northeast Pacific	168	12.8
16	Northwest Pacific	190	14.5
17	Southeast Pacific	18	1.3
18	Australia/New Zealand	260	19.9
	Total	1,306	

tween the land and sea imposes an urgent need for the integration of protected area management and an overall conservation strategy in the coastal zone. This is a central challenge to governments and organizations working in coastal areas. MPAs are successful only if they are managed as part of broader programs that provide for management of all uses of the sea and adjacent land. Large, multiple-use MPAs covering complete ecosystems are a major step toward this goal. They can be examples of effectively protected Large Marine Ecosystems (LMEs). Smaller reserves, which are often community-based, also need to incorporate management of land-based activities that affect the viability of the MPA.

Although this report is concerned with sites of regional importance for marine biodiversity, it recommends that all countries within a region should attempt to conserve a biogeographically representative set of sites at the national level in accordance with Resolution 17.38 of the IUCN General Assembly.

SUMMARY OF RESULTS

In terms of the number of MPAs, there are significant disparities between marine regions (Table 1).

There is also wide variation in the size of MPAs. The mean size of the MPAs inventoried is over 100,000 hectares. However, this number is greatly skewed by a relatively small number of very large MPAs; a truer reflection may be given by the median size, which is 1,584 hectares. Table 2 shows the distribution of MPAs according to size classes.

Biogeographic classification systems have been adopted for use in 17 of the 18 marine regions, the exception being the Antarctic region, for which there is no general agreement on an appropriate classification system). These systems have been used in assessing the degree to which existing MPAs represent the major biogeographic types in each marine region. Table 3 lists the number of zones in each region that have at least

Table 2. Distribution of MPAs by Size Class

Size	*Number of MPAs*
1–10	41
11–100	175
101–1,000	226
1,001–10,000	242
10,001–100,000	206
100,001–1,000,000	79
> 1,000,000	22
unknown	315
Total	1,306

one MPA and the number that have no MPAs.

Across all marine regions 118 out of 150 zones (about 79 percent) have at least one MPA, while 32 (about 21 percent) zones have no MPAs. Two marine regions (Northwest Atlantic and East Asian Seas) have MPAs in every zone. All the remaining sixteen marine regions have at least one zone with no MPAs.

For the zones that have MPAs the mean number of MPAs per zone is approximately eleven. This number is skewed by a large number of MPAs in relatively few zones. The median number of MPAs per biogeographic zone is four.

Table 4 shows the number of biogeographic zones in relation to number of MPAs, according to frequency classes ranging from 0 to 26 or more.

The recommendations of the IVth World Congress on National Parks and Protected Areas (IUCN 1993) call for 10 percent of each biome of the world to be included in protected areas. Although the lack of an accepted global classification system makes comparison between marine regions difficult, broad conclusions may be drawn about the extent to which MPAs achieve this objective.

In the great majority of cases the area of each marine biogeographic zone that is included in MPAs is much less than 1 percent of its total area. Furthermore, most of the biogeographic zones are large areas that in-

Table 3. Representation of Biogeographic Zones

Marine Region		*Number of Biogeographic Zones with at least one MPA*	*Number of Biogeographic Zones with no MPAs*
1	Antarctic		
2	Arctic	4	1
3	Mediterranean	8	2
4	Northwest Atlantic	10	0
5	Northeast Atlantic	5	1
6	Baltic	8	1
7	Wider Caribbean	5	1
8	West Africa	4	1
9	South Atlantic	4	1
10	Central Indian Ocean	4	2
11	Arabian Seas	8	5
12	East Africa	3	2
13	East Asian Seas	8	0
14	South Pacific	12	8
15	Northeast Pacific	8	1
16	Northwest Pacific	7	1
17	Southeast Pacific	3	3
18	Australia/New Zealand	17	2
	Total	118	32

Table 4. Frequency of MPAs in Biogeographic Zones

MPAs per Zone	*Number of Zones*
0	32
1–5	60
6–10	22
11–15	9
16–20	6
21–25	9
26+	12
Total	150

clude a range of different ecosystem types. More detailed information on the range of ecosystem types present in each zone and in each MPA would be required to determine the extent to which the biodiversity of each zone is "represented." However, there must be doubts about the extent to which MPAs of a median size of 1,500 hectares can protect a representative sample of the biodiversity of a large zone, particularly given the interconnectedness of the sea and the degree to which material (pollutants, larvae, and so on) and impacts are transferred.

From the available information on the size, number and distribution of MPAs according to biogeographic type, it is clear that the coverage of existing MPAs falls well below a target figure of 10 percent of all marine biomes. About one-fifth of the marine biogeographic types identified have no MPAs. Although there is sure to be a degree of commonality of biogeographic types between some marine regions, these gaps would appear to be significant at the regional scale.

There are a few very large MPAs, but most are relatively small areas of less than a few thousand hectares. Many are threatened by activities beyond their boundaries that are beyond the scope of existing management control.

Questions about the degree of protection provided to marine biodiversity cannot be answered without information on the extent to which MPAs are achieving their conservation objectives. However, data on management effectiveness are sketchy. The difficulty of obtaining such information points to the general absence of evaluation of management effectiveness. Although field surveys could not be carried out to supplement available existing data, it has been possible to assess the management of 383 out of 1,306 MPAs (29 percent). The management level has been classified according to the following scheme:

- High: Generally achieve management objectives
- Moderate: Partially achieve management objectives
- Low: Generally fail to achieve management objectives

Table 5. Management Level of MPAs

Management Level	*Number of MPAs*
High	117
Moderate	155
Low	111
Unknown	923
Total	1,306

Table 5 shows the numbers of MPAs assessed as having high, moderate or low management level.

About 31 percent of those MPAs for which data were available were assessed as having a high management level and generally achieving their management objectives.

The reasons for MPAs failing to achieve their management objectives vary between marine regions. However, there are some commonly recurring themes that can be summarized as:

- Insufficient financial and technical resources to develop and implement management plans
- Lack of trained staff
- Lack of data on which to base management decisions including information on

the impacts of resource use and the status of biological resources
- Lack of public support and unwillingness of users to follow management rules, often because users have not been meaningfully involved in establishing these rules
- Inadequate commitment to enforcing management
- Unsustainable use of resources within MPAs
- Impacts from activities in land and sea areas outside the boundaries of MPAs, including pollution and overexploitation, lack of clear organizational responsibilities for management, and absence of coordination between agencies with responsibilities relevant to MPAs
- Lack of clear organizational responsibilities for management and absence of coordination between agencies with responsibilities relevant to MPAs.

Achieving effective management of existing MPAs is of equal priority to the establishment of new areas. In most regions a significant number of MPAs exist only on paper with no management plan and no management activity of any sort.

Priorities for Marine Biodiversity Conservation

A listing of regional priority areas for all regions covered in a volume is included in a table at the end of each volume. This is followed by a serious of regional maps with digitized information on the location of each of these sites. National and regional priority areas for each Marine Region are included in the relevant regional report.

In all, 640 MPA sites have been identified as being of national priority for marine biodiversity conservation. Of these, 232 (36 percent) are existing areas that require support for improved management and 408 (64 percent) are proposed new MPAs. In total, 155 MPAs sites have been identified as being of regional priority for the conservation of marine biodiversity. Of these, 73 (47 percent) are existing areas that require support for improved management and 82 (53 percent) are proposed new MPAs.

General Recommendations

The recommendations in this publication specifically address priority issues for the establishment and effective management of a global representative system of marine protected areas for the protection and sustainable management of the world's marine biodiversity.

Key recommendations are outlined below, with the full text provided in the introductory chapter of Volume 1. The recommendations are based on an analysis of the 18 regional reports and a synthesis of the recommendations contained in these reports.

1. Achieving Integrated Management of the Marine Environment

The establishment and management of MPAs should occur within regimes that provide for integrated management of all uses of the adjacent land and sea areas. Thus, wherever possible, management of MPAs should be coordinated with the management of adjacent land areas.

Management responsibilities for MPAs must be clearly defined to avoid duplication and competition between agencies. These responsibilities must be accompanied by institutional and administrative mechanisms to ensure coordination of agencies with responsibilities relevant to the marine environment.

Achievement of ecological sustainability should be the overriding goal of MPA management.

The Large Marine Ecosystem and UNESCO Biosphere Reserve models should be applied where practicable in establishing and managing MPAs. In particular, a large multi-

ple-use MPA may provide the basis for integrated and sustainable management of a complete marine ecosystem, with the advantage that coordination of regulating different human activities can be automatically achieved when management responsibility rests with one agency.

2. Ensuring the Application of Science to Management

Increased research and monitoring are required to assist in making MPA management decisions. Available funds should be directed toward those areas of research that have a high likelihood of answering management questions.

The development of long-term monitoring program for all MPAs should be a priority. A fairly broad sweep will be needed for monitoring the changes brought about by the varied human activities and for providing enough information to develop appropriate management responses. This will require developing techniques that can be easily understood and widely applied.

Research is needed on the existing and planned uses of the marine environment and their likely effects. Such basic information is essential to keeping these activities compatible with the overriding goal of ecological sustainability.

There are two fundamental principles in ensuring effective application of science to management:

- Managers and scientists must work together in the identifying the environmental problems to be addressed by the scientific methods.
- Managers and scientists must work together in designing the research programs for addressing such problems and in interpreting and applying the results.

Any further developments in biogeographic classification resulting from this research or monitoring can proceed in parallel with the implementation of immediate MPA management priorities. Providing information of practical use to managers for the protection and management of marine biodiversity should be a primary objective of all these systems.

3. Securing Community Support

Where there is continuing use or custody of marine resources by local people, whether an effective MPA can be established will depend largely on the voluntary acceptance of management measures locally. MPA managers should therefore devolve some responsibility to local users, including involvement in planning and participation in management programs. the establishing of an effective MPA will depend very largely on voluntary acceptance of management measures, including involvement in planning and participation in management programs. The use of traditional knowledge and skills in the management of MPAs should be encouraged.

MPAs must provide for the continued welfare of people affected by their creation. Community support will depend on the development of management plans that are, to the extent feasible, compatible with traditional or customary practices for the use and conservation of marine resources. MPAs should be used for the economic well-being of coastal communities by providing a sustainable flow of benefits as well as achieving conservation objectives. Where appropriate to management objectives and within the limits of ecological sustainability, tourism and fisheries should be encouraged to provide sustainable financial benefits to local communities.

Ongoing consultation with local communities is required to determine economic, social, cultural and conservation priorities and to determine how MPAs can help achieve these priorities. MPAs should be integrated and compatible with ecological, social, and economic objectives at both the national and local levels. Local communities must be convinced of the importance of using marine re-

sources sustainably and of the need and benefits of taking action to protect marine biodiversity. This will require conducting information campaigns to raise the profile of MPAs and marine biodiversity conservation and incorporation of a strong marine component in environmental education.

4. Developing the Human Capacity to Manage

International and other support for capacity development in marine management should emphasize the development of training capacity within regions and countries. Such an approach involves "training the trainers" and the establishment of regional and national training centers that can undertake further training to produce a multiplier effect.

Training should extend to all levels, from field staff to senior managers with the aim of equipping MPA managers with the skills required for their job. Training is required to increase the political awareness of the benefits of effective MPA systems.

There is a demand for a network in which managers of MPAs can share and learn from each other's experience and discuss and review management priorities.

5. Achieving a Balance Between Planning, Implementation and Evaluation

In total, 1,306 MPAs have been identified as established in all of the marine regions. Available data suggest that the number of MPAs that fail to achieve their management objectives is high. One reason for this is that the resources and emphasis on planning MPAs typically exceeds that given to implementation of management. There is even less attention given to evaluation of the success of management.

Effective implementation, monitoring and review are essential for MPAs to achieve their management goals, and should be part of all MPA management programs. MPA agencies should commence a coordinated scientific and administrative effort to ensure that existing MPAs meet their management objectives.

Programs that aim to support MPAs must provide sufficient financial and technical resources over a time frame long enough to allow for effective implementation, monitoring, and review of management plans.

6. Identifying Sources of Funding

Sufficient resources need to be mobilized for the development and implementation of management plans, for regulatory statutory review processes, interpretation, education, training, volunteer programs, research, monitoring, surveillance and enforcement programs. It is unlikely that governments alone can provide these resources now or in the future.

Sustainable financing for MPAs, therefore, must be developed if they are to function well in the long term. This will require innovative approaches and partnerships. Examples include revenue generation from taxes or "rent" from resource uses such as fisheries or tourism, as well as taxes on development projects that result in losses of marine or coastal biodiversity. In some countries the establishment of trust funds has proved to be a useful tool. Partnerships with NGOs and the private sector, which leverage management skills and investment capital for income generating enterprises consistent with conservation objectives should also be explored.

Research should be carried out to evaluate and publicize the economic benefits of MPAs and the feasibility of integrated conservation and development. (CNPPA is carrying out such research.)

In cooperation with local communities and other groups, management agencies should identify and establish facilities to promote ecotourism in MPAs and make use of MPAs as a tool for fisheries management.

Many developing countries will require financial assistance to establish national MPA systems, and there is a clear role for the international community to provide such support. However, in some cases the most effective use of resources might be made through the use of a regional fund or system of national environmental funds, particularly where there is a diversity of small governmental and nongovernmental organizations managing MPAs.

THE WAY FORWARD

This report recommends priority areas and actions for the creation of a global representative system of MPAs. It is intended to provide strategic guidance to the Global Environment Facility (GEF), World Bank, and other organizations for investment in marine biodiversity conservation. The next phase must focus on the development and implementation of specific proposals for the creation of new MPAs and for improved management arrangements for inadequately managed existing MPAs. Sites of highest priority in each region are identified in this report. At the same time, in some regions or countries additional investigation is required to refine priorities or to begin filling in the gaps in knowledge that will make it possible to set priorities.

It can be expected that developed countries will take the initiatives and provide the funding for further developing their national MPA systems, using funds and resources of their own. By identifying priorities, this report will help such countries make the most efficient use of their resources.

Few developing countries have the human or financial resources that are required to create and effectively manage new MPAs. These countries will require assistance internationally in terms of both expertise and the provision of funds. Possible sources of those funds include international financing institutions such as the GEF, World Bank, United Nations Development Programme (UNDP), regional banks, bilateral organizations, and nongovernmental sources.

Many of these agencies provide funding primarily on a national basis. It follows that the development of proposals for priority MPAs in developing countries should have a strong national focus and that all such proposals must be developed and implemented with the full involvement and support of the relevant national government authorities and other appropriate organizations and individuals. The importance of this principle has been recognized in this report, which has been developed with very wide participation of national representatives. Although in the majority of cases proposals probably will be country specific, in some instances they may be developed using regional institutions that have national support, such as the South Pacific Regional Environment Programme (SPREP) and the Coordinating Body for the Seas of East Asia (COBSEA). This pragmatic approach has advantages in promoting coordination between country efforts and in some cases may be more efficient in terms of administrative effort.

International organizations such as IUCN and CNPPA that already have a broad constituency of both governmental and nongovernmental organizations can also be used effectively. This report proposes that IUCN and CNPPA mobilize this constituency to consult with the governments of the developing countries where the priority areas identified in this study occur. It will be necessary to establish national working groups of scientists and managers to ensure coordination and cooperation between the management and scientific communities. NGOs and community groups should also be represented in the process. The purpose of the consultations will be to develop proposals for implementing the priorities that meet the criteria of funding organizations and that are compatible with national social and eco-

Box 2. Priority Actions for the Establishment of a Global Representative System of Marine Protected Areas

1. Develop and implement projects to address the priority areas and other recommendations in this report.
2. Establish national representative systems of MPAs which, as far as possible, encompass complete ecosystems or habitats and which are integrated with national policies and effective mechanisms for coastal zone management.
3. Develop institutional arrangements to achieve integrated management of each MPA and provide coordination mechanisms to ensure that adjacent land and sea areas are managed in a complementary way.
4. Actively involve local communities and marine resource users in the planning, management and maintenance of MPAs.
5. Bring managers and scientists together to conduct integrated, multi-disciplinary, management-oriented research and monitoring programs to provide a rational basis for selection, planning and management of MPAs.
6. Commence a coordinated effort to systematically monitor the effectiveness of existing MPAs.
7. Develop and disseminate tools and guidelines that can be widely understood and applied for carrying out monitoring and research in MPAs; achieve effective community support and participation in management of MPAs and strengthen the capacity and effectiveness for planning, administration and day-to-day management.
8. Carry out training programs that develop the capacity for MPA management in regions and countries. These programs should train trainers and develop training curricula and use these as a basis for regional- and country-based curricula and training.
9. Establish a global network to support marine resource managers, based on existing regional networks.
10. Carry out further investigations to address biogeographic and other information gaps necessary for the identification of priority areas as part of the global system of marine protected areas.
11. Mobilize domestic resources for marine protected area management from such sources as natural resource taxes and levies user charges, joint ventures with the private sector, trust funds and endowments, and ecotourism.

nomic developmental priorities. The development of national and local management capacity must be key to all proposals.

These activities will need to be complemented by a suite of other actions if a system of MPAs is to be developed that effectively represents the biogeographic zones of the world's seas and contributes to the maintenance of marine biodiversity as well as to the well-being of human communities. A flexible mechanism also must be found to reflect, for example, progress in refining the identification of biogeographic elements that will most likely reveal the need for additional MPAs to create a more representative system of MPAs. To begin this process, the study has identified various priority actions for the establishment of a global representative system of marine protected areas, outlined in Box 2.

MARINE REGION 10
Central Indian Ocean

Sue Wells, S. N. Dwivedi, Samar Singh, and Robson Ivan

BIOGEOGRAPHY AND MARINE BIODIVERSITY

The Central Indian Ocean Marine Region includes the following countries: Bangladesh, the British Indian Ocean Territory (Chagos Archipelago), India (including the Laccadives, Andaman and Nicobar archipelagos), Maldives, Myanmar and Sri Lanka.

The region consists of three distinct areas: part of the Arabian Sea, the Bay of Bengal and a large area of the Indian Ocean proper south of India and Sri Lanka.

Oceanography

The Indian land mass forms a major physical division between the Arabian Sea and the Bay of Bengal. Oceanographically, the Bay of Bengal differs from the Arabian Sea in maintaining a clockwise circulation of major currents during both the northeast and southwest monsoons. The circulation in the Arabian Sea reverses, with surface water masses circulating counterclockwise in the northeast monsoon (November–April, when the North Equatorial Current flows west) and clockwise in the southwest monsoon (May–October when the surface current flows eastward and splits to form clockwise currents in the Arabian Sea and the Bay of Bengal). There is also a major difference in salinity. In the Arabian Sea, evaporation exceeds precipitation and runoff, leading to the formation of high salinity water masses that flow south. The Bay of Bengal has comparatively low salinity due to high runoff and precipitation; in the southwest monsoon, maximum salinity is found at depths of about 500 meters, as high salinity water moves into the Bay from the Indian Ocean (Pernetta 1993a).

The coastline surrounding the Bay of Bengal is heavily influenced by the monsoons, particularly the southwest monsoon that brings heavy rains. Tropical storms also have a major impact; of the 12–13 that occur each year in the Bay of Bengal, three or four of cyclonic strength affect India, Bangladesh and Burma. The northern part of the Bay of Bengal is prone to impact from storms because it concentrates energy from storm centers (Pernetta 1993b).

Coastal Geography and Geology

Shallow accreting coastlines, with deltas and coastal lagoons, dominate in Bangladesh

and parts of India and Sri Lanka. The Bay of Bengal has largely soft substrates off the mainland, due to the extensive river discharge, which are overlain by shallow, usually turbid waters. The coastline of Bangladesh is particularly low-lying, and is unique in the region in that the influence of the sea is felt for a long distance inland. It is characterized by a vast deltaic network, an enormous discharge of sediment laden water and numerous offshore sand and mud bars (Pernetta 1993b). The northern part of the coastline of Myanmar is similar, due to the Irrawaddy delta (UNEP/IUCN 1988). The east and west coasts of India have very different characteristics. The west coast is exposed with heavy surf, rocky shores and headlands, whilst the east coast is shelving and low lying with beaches, deltas, lagoons and marshes (Pernetta 1993c).

The Maldives, the Chagos Archipelago, and the island chains belonging to India (Laccadives, Andamans and Nicobars) are archipelagic. The Maldives, the Chagos Archipelago and Laccadives are composed entirely of atolls, with reefs and sandy islands, and form the Laccadive-Chagos chain that extends southward from India to the central Indian Ocean. In contrast, the Andaman and Nicobar Islands are high volcanic islands, arising from a submerged mountain chain that follows a southward extension of the continental shelf.

Ecosystem Diversity

India has important examples of all the main ecosystems found in the region. Sri Lanka and Myanmar have similar diversity but on a smaller scale. Bangladesh is dominated by estuarine and mangrove ecosystems, and the Maldives and the Chagos Archipelago are made up entirely of atolls. Ecosystem diversity is probably most comprehensively documented for Sri Lanka, where a number of surveys of critical coastal habitats have been carried out, and maps prepared (Pernetta 1993e). The economic value and pressures on the main ecosystem are discussed in the 1993 country reports edited by Pernetta.

Coral Reefs

Information on the reefs of this region is available in UNEP/IUCN (1988). All three major reef types (atoll, fringing and barrier) occur, and the region includes some of the most diverse, extensive and least disturbed reef areas of the Indian Ocean, many of which are among the least scientifically known.

In the north, reef growth is inhibited by massive freshwater and sedimentary inputs from the Indus, Ganges and other rivers, and in the northwest by cold upwelling as well. Bangladesh has almost no reef development due to the high turbidity and soft substrates present, although there is a small reef around Jinjiradwip (St. Martin's Island).

The mainland coast of India has two widely separated areas containing reefs: the Gulf of Kutch in the northwest, which has some of the most northerly reefs in the world, and Palk Bay (with a long fringing reef) and the Gulf of Mannar (with numerous fringing reefs around small islands) in the southeast. There are patches of reef growth on the west coast, for example at Gaveshani Bank. The Andamans and Nicobars have fringing reefs around many islands, and a long barrier reef (320 kilometers) on the west coast. The reefs are poorly known scientifically but may prove to be the most diverse in India and those in the best condition. The Laccadives have extensive reefs but these are equally poorly known.

There are few true coral reefs in Sri Lanka but there are extensive areas of coral around the coast, mainly close to the shore. Most consist of coral communities growing on ancient sandstone (along the west coast) or gneiss or granite outcrops (along the east coast). True reefs are found in various localities such as fringing reefs at Hikkaduwa and Trincomalee and other localities in the south

and east, and offshore reefs in the north such as Bar Reef (probably the most extensive area of true reef in the country) and the south such as the Basses Reefs (reputed to be among the most spectacular and undisturbed in Sri Lanka). Fringing reefs are also found in the north along the Gulf of Mannar and off the Jaffna Peninsula, and on several places on the east coast (Pernetta 1993e).

The main reef areas in Myanmar are in the Mergui Archipelago, which lies sufficiently far from the coast to have clearer water. These reefs are barely known to science, although two brief studies have suggested that they are diverse and extensive (UNEP/IUCN 1988).

The Maldives contain extensive and largely intact reefs, and comprise perhaps one of the most complex reef systems in the world. Several of the atolls have unusual ring-shaped reefs (faroes) in the lagoons, each with its own sandy lagoon and rim of living corals. The atoll lagoons also have numerous knolls and patch reefs (UNEP/IUCN 1988).

The Chagos Archipelago has the largest expanse of undisturbed reef in the Indian Ocean, as well as some of the most diverse. In addition to five atolls, there are two areas of raised reef and several large submerged reefs. Blenheim Reef is notable for its large algal ridge, and the Great Chagos Bank is the world's largest atoll in terms of area (UNEP/IUCN 1988).

In the Laccadives-Chagos chain, a trend of increasing coral diversity has been recorded, from the Laccadives (with nine genera in the northern atolls) to the Maldives (with 41 genera in the northern atolls and 55 in the south) to the Chagos Archipelago (with 60 genera). There is some variation in published figures for this area: for example, 66 genera (240 species) for the Maldives, and 67 genera (about 200 species) for Chagos, but these do not alter the general picture. The Chagos reefs are of particular interest for the presence of an endemic coral *Ctenella chagius* (UNEP/IUCN 1988).

A similar pattern is seen going north along the east and west coasts of India, with highest diversity in the south (134 species in Sri Lanka, 117 in the Gulf of Mannar and Palk Bay) and lower diversity to the north (44 species in the Gulf of Kutch and 13 genera at Jinjiradwip in Bangladesh). Other figures for coral diversity in these areas include 65 genera (171 species) in Sri Lanka; 39 genera (179 species) in the Andamans and Nicobars (Pande and Singh 1991); and 76 genera (342 species) for the whole of India. About 60 species in 30 genera have been recorded from the Mergui Archipelago in Myanmar, and it has been suggested that these reefs could have over 40 genera (UNEP/IUCN 1988).

Mangrove Forests

Of the 22 countries containing the world's major mangrove areas, Bangladesh and India rank 12th and 14th respectively (Hutchings and Saenger 1987). Since half of the 22 countries occur in the Atlantic mangrove province, the South Asian mangroves assume considerable importance from a global perspective: within the Indo-Pacific, these countries rank third and fifth in importance.

Distribution of mangroves is a mirror image of that for coral reefs. While the most extensive and diverse reefs are found in the south of the region, the major mangrove areas are in the north. Figures for total area covered by mangrove are extremely variable but the northern Bay of Bengal, the Sunderbans and the Ganges delta support over 500,000 hectares. The Sunderbans make up the single largest contiguous block of mangrove forest in the world, with 60 percent of the area within Bangladesh and the rest in India. Extensive stands are also found along the northern coastline of Myanmar, which has a total of some 517,000 hectares, mainly in the Irrawaddy Delta (much of which has been degraded), on the Tenasserim and Arakan coast and the offshore islands.

Total estimates for India range from about 100,000 to 700,000 hectares, depending on whether degraded areas are included. The most important area is the Sundarbans; good stands are also found in the Kaveri and Godavari Deltas, in Bhitarkanita and the Gulf of Kutch has about 52,500 hectares. Extensive stands are also found in the Andamans and Nicobars, totalling about 115,200 hectares, and much of this is still relatively pristine.

Mangroves are less developed in Sri Lanka and patchy or thin in the atoll islands of the Indian Ocean. In Sri Lanka, 60 percent of the mangroves in the country are found on the northwest coast in the Puttalam Lagoon and the Dutch and Portugal Bay areas. The total area for the country is estimated at 10,000–12,000 hectares. Pernetta (1993e) lists the most important stands, such as those at Puttalam, Batticaloa, Trincomalee, Jaffna and Gampalia. The Maldives has a few small stands, with very low diversity (Pernetta 1993d).

About 12 genera of mangroves are found within the region (compared with 13 in the Indo-Pacific) (Hutchings and Saenger 1987). Indian mangroves are most diverse with 45 recorded mangrove species and associates; Sri Lanka has 28 mangrove species and mangrove associates, Bangladesh 27 and Maldives about five (Pernetta 1993a). The total floral diversity of the Sundarbans amounts to some 330 species.

As is the case elsewhere, the mangroves of the region have great economic value and have been heavily utilized. For example, a 1977 study estimated that roughly 50 percent of India's mangroves had been destroyed since 1963. Both in western and southern India, and throughout the Bay of Bengal, much of the originally extensive mangrove stands have been removed (UNEP 1985).

Seagrass Beds

Large seagrass beds are present in southern India in Palk Bay and the Gulf of Mannar and in the numerous estuaries and embayments of Sri Lanka. However along much of the coast of western India dense seagrass beds are uncommon or not extensive, probably because of the degree of exposure and turbidity of these waters. There are some seagrass beds in the Laccadives and they are possibly extensive around the Andamans and Nicobars.

In Sri Lanka seagrasses cover an area far in excess of that covered by mangroves and coral reefs, and probably make the largest contribution to the primary production of inshore waters (UNEP 1985). They are most extensive in the north, particularly from Dutch Bay to Jaffna Lagoon and from Mannar to Rameswaram, and may support more than 50 percent of the country's near shore fishery production. Other important seagrass areas are listed in Pernetta (1993e).

There is little evidence for the existence of major seagrass beds off the coast of Bangladesh, perhaps because of the large seasonal fluctuations in salinity (Pernetta 1993b), and there are only small areas of seagrass in the Maldives.

UNEP (1985) estimated that perhaps five percent of the seagrass beds of the Indian Ocean had been destroyed by dredging or infilling.

Other Wetlands

Wetlands, including mangroves (see above) are one of the dominant ecosystems in this region due to the presence of the large deltas of the Ganges, Brahmaputra and Irrawaddy rivers that dominate the head of the Bay of Bengal, the delta in Bangladesh comprising the largest such system in the world. Bangladesh probably has the greatest area of coastal wetlands in the region, with an estimated total of 2.5 million hectares of tidally inundated land (although much has been diked or converted to shrimp ponds): floodplains and coastal mangrove swamps cover almost one third of the country (Pernetta 1993a,b). Scott (1989) provides a detailed description of the coastal wetlands of the Bay of Bengal.

India has about 3,900,000 hectares of estuarine wetlands (134 brackish and 19 coastal wetland areas have been documented). There are also extensive tidal wetlands in Sri Lanka that has an estimated 80,000 hectares of estuaries and deep lagoons and 40,000 hectares of shallow lagoons, tidal flats and mangroves. There are about 45 estuaries and 40 true coastal lagoons, many of which lie along the south and east coasts. Numerous seasonal lagoons form during the wet season and are important for fisheries, salt production and wildlife habitat (Pernetta 1993e). The main wetland sites in the region are described in Scott (1989).

Beaches, Dunes, and Cliffs

Bangladesh is notable for its 145 kilometer stretch of beach from Cox's Bazar to the tip of the Teknaf Peninsula (Pernetta 1993b), and there are numerous sandy beaches on the islands of the atoll chains. Sri Lanka has about 11,800 hectares of beaches and spits extending over 300 kilometer of coast, and sand dunes covering an area of 7,606 hectares (Pernetta 1993e). Sand dunes are present on some of the more exposed parts of the coast of northern Burma (UNEP/IUCN 1988) and on the south-facing coasts of the islets making up Adam's Bridge, which extends from Sri Lanka to India.

Rocky shores are absent from the Maldives, Laccadives, Chagos Archipelago, east coast of India and Bangladesh. There are small amounts in Sri Lanka, and more extensive areas on the west coast of India and in the Andaman and Nicobar Islands.

Islets

There are a number of large archipelagos in the region. The Andamans (50 islands, islets and rocks) and Nicobars (20 islands) are a volcanic chain. The Mergui Archipelago lies off the southern coast of Myanmar and consists of over 800 islands; two other groups of islands are found in Burmese waters, one extending from the Andaman and Nicobar islands to the mainland coast, and another lying off the northern coast. The Preparis Islands and Coco may have important seabird colonies. Numerous islands and islets are found in the Laccadives-Chagos chain; the Maldives, which is the largest group, has 1,200–2,000 islands, the majority of which are less than one square kilometer in size. The Laccadives has about 25 islands on 11 atolls.

There are also small rocky islets off the coasts of the continental countries, such as Sri Lanka (off Hikkaduwa, Trincomalee, Jaffna and the islets of Adam's Bridge) and India (the Gulf of Mannar islands).

In addition to the various rocky, coral or sandy islands lying off the coasts of the continental countries in the region, the deltaic areas are notable for the large number of temporary, semipermanent and permanent islands formed by the networks of distributaries. In the Sundarbans, these are called chars, and are constantly being formed where easily eroded sands and mud collect (Pernetta 1993b).

Open Ocean, Deep Sea, and Upwellings

The Swatch of No Ground is a deep canyon that runs across the continental shelf off Bangladesh; the Burma Trench is another deep canyon in the Bay of Bengal (Pernetta 1993b). Upwellings occur off Orissa (northeast India), the Andamans and the west coast of Sri Lanka during the northeast monsoon.

Species Diversity

Algae

About 78 genera and 174 species of algae have been recorded from Sri Lankan waters (Pernetta 1993e), 285 species from the Maldives (Pernetta 1993d) and 624 species from India (Pernetta 1993c). Several species are exploited commercially on a large scale in

the region, particularly in India and Sri Lanka.

Invertebrates

Diversity is high, and for some groups may show a similar trend to that for corals described above, but it has not been possible to collate available data. A total of 384 mollusks has been recorded from the Chagos Archipelago, suggesting this area has a high diversity (UNEP/IUCN 1988). Many invertebrates are harvested and are of economic importance; there is evidence that some mollusks and crustaceans have been overexploited, and species such as the coconut crab, horseshoe crabs, and certain mollusks are of conservation concern.

Fish

Commercial and subsistence fisheries are important throughout the region and are briefly described for Bangladesh, India, the Maldives and Sri Lanka in Pernetta (1993 b,c,d,e). In most countries the bulk of the catch is subsistence or artisanal. Hilsa is the main species taken in the Bay of Bengal; tuna fisheries are important in Sri Lanka and the Maldives; and although reef fisheries are not as important in this region as in some others, both Sri Lanka and the Maldives export reef fish for the aquarium trade. The Bay of Bengal is particularly rich because of the nutrient input from the large rivers and there is extensive information available for the fisheries of this area through the Bay of Bengal Programme on marine fishery resources.

There has not been time to gather information on fish diversity but this is expected to be high particularly in regions where there are reefs; over 1,200 species of fish have been recorded from the reefs and surrounding ocean of the Maldives (UNEP/IUCN 1988). However, the Chagos Archipelago has a relatively low fish diversity (compared with that for corals and mollusks), perhaps because algal diversity and abundance is also low. The pygmy angelfish *Centropyge flavipectoralis* is thought to be endemic to Sri Lanka.

Marine Turtles

Five species of marine turtle are found in the Indian Ocean, and are considered to be at risk in most countries. These are the green (*Chelonia mydas*), the hawksbill (*Eretmochelys imbricata*), the loggerhead (*Caretta*), the leatherback (*Dermochelys coriacea*) and the Olive Ridley (*Lepidochelys olivacea*). Information on their distribution in Bangladesh, India, Sri Lanka and the Maldives is given in Pernetta (1993 b,c,d,e). There are a number of globally and regionally important nesting sites. These include:

- *Green:* Gulf of Kutch and Saurashtra Peninsula in India; uninhabited islands in Laccadives, Maldives and the Chagos Archipelago.
- *Hawksbill:* Largest population (probably of regional importance) in the Andamans, particularly South Reef and North Brother; probably also nests in the Chagos Archipelago and on uninhabited islands in the Maldives.
- *Olive Ridley:* The most common species in Bangladesh, India and Sri Lanka; about 300,000–500,000 nest in Orissa (two important nesting beaches); many other nesting sites on mainland coast, for example, Sundarbans, Andamans and Nicobar, Laccadives; several thousand nest in southwest Sri Lanka at several sites.
- *Leatherback:* Uncommon, but main populations in Andamans and Nicobars, with a small population in Sri Lanka.
- *Loggerhead:* Rare.

Birds

Globally threatened marine and coastal species that occur in Bangladesh, India, Sri

Lanka and the Maldives are listed in Pernetta (1993 b,c,d,e). There are a number of globally threatened coastal wetland species such as the Spot-billed Pelican *Pelecanus philippensis* and the Lesser Adjutant *Leptoptilos javanicus*. Important coastal areas for birds include the Gulf of Kutch, Chilka Lake, Coringa Wildlife Sanctuary and the Sundarbans in India and several areas in Sri Lanka.

The seabirds of the region are poorly known and do not appear to be abundant in India, Bangladesh or Sri Lanka. The Sundarbans are an important staging and wintering area for gulls and terns, and the islets of Adam's Bridge, off Sri Lanka have some seabird colonies. Many of the atoll islands in the Laccadives-Chagos chain may have seabird colonies, such as Pitti and Baliapani in the Laccadives and several of the Chagos Archipelago islands. Further information on seabirds in the Maldives and other island chains is available in Feare (1984).

Mammals

Antarctic stocks of baleen whales move north into the Indian Ocean in the Antarctic winter, but there may be small independent stocks in the northern Indian Ocean. There are a large number of small cetaceans, some of which are not well known, and many of which are harvested either intentionally or incidentally. The most threatened species are the river dolphins of the Ganges and Irrawaddy; these are sometimes found in estuarine waters but are not truly marine animals and so are not considered here. The Indian Ocean populations of the humpback dolphin *Sousa chinensis* and the spotted dolphin *Stenella attenuata* are considered at risk; the distribution of the latter appears to be closely correlated with mangroves (Pernetta 1993b). Cetaceans are reasonably well known in this region and further information is available in the 1993 country reports and in Gaskin (1985).

The distribution of the dugong extends over most of the region, but appreciable numbers are no longer found. The most important area for this species in the region, and possibly in the whole Indian Ocean, is the Gulf of Mannar and Palk Bay in India, and possibly also in the north of Sri Lanka. Small numbers may still occur in the Gulf of Kutch. In the Andamans and Nicobars the only remaining sites where they definitely occur are Ritchie's Archipelago and North Reef.

Biogeographic Classification

The classification used here has been developed by Dwivedi, Singh, and Ivan (1994).

The Central Indian Ocean Marine Region lies in the middle of the decreasing trend in diversity from Southeast Asia to the East African coast. The eastern part shares biogeographic characteristics with Southeast Asia, while the western part is more like the Arabian Sea and western Indian Ocean. In terms of zoogeography, the region includes parts of both the Indian and Malayan subregions of the Indo-Malayan zoogeographic realm, with Myanmar in the latter, Bangladesh at the junction and the other countries in the former. Hayden, Ray, and Dolan (1984) place the whole region within the Indo-Polynesian province.

The Central Indian Ocean described in the report can be divided into five major areas as given here. These are in general conformity with Hayden (1984), but subsystems that are important and distinct from the point of view of species distribution have also been recognized. Some of these have been recognized earlier by Dwivedi, FAO-BOBP reports and Sherman and others (1993).

The Indian Ocean and the adjoining Arabian Sea and Bay of Bengal lie in the tropical monsoon belt. Here the oceans play a major role in determining the climate, rainfall, productivity and biodiversity. However due to the presence of a large continent, the

oceanographic features change from one region to another.

The Arabian Sea does not have major estuaries and wind induced upwelling plays a dominant role in governing productivity, species distribution and biodiversity. The productivity of the area is affected due to the width of the shelf. The Bay of Bengal has a large number of estuaries and input of lower salinity water is significant. This coupled with storm surges and cyclones, which are a regular feature in the northern part of the Bay, has resulted in creating a surface layer up to 100 meter depth with low salinity and high temperature and a deeper layer with higher density and more saline water.

Bearing these considerations in mind, the Arabian Sea, Bay of Bengal, and open Indian Ocean are recognized as major subsystems. These are further divided due to coastal morphology, water and silt inputs by rivers and estuaries that determine the transparency, salinity and density of water. These form subsystems that are described here. Recognition and characterization of large marine ecosystems have been dealt with by Sherman and others (1993). Dwivedi (1993, in same publication) has discussed the Bay of Bengal ecosystems. The major biogeographic divisions of the Central Indian Ocean are:

- Western Indian Ocean along the Indian Coastline:
  - Southwest coast of India
  - Central west coast of India
  - Northwest coast of India
- Eastern Indian Ocean:
  - Southeast coast of India and Sri Lanka including Palk Bay and Gulf of Mannar extending up to the Krishna delta.
  - Northeast coast of India off Andhra Pradesh and Orissa extending up to the border of west Bengal.
- Northern Bay of Bengal covering the coasts of West Bengal and Bangladesh.
- East Bay of Bengal off southern part of Bangladesh and the coast of Myanmar including the Irrawaddy mouth.
- The Central Indian Ocean including the Maldives and the Chagos Archipelago.

ASSESSMENT OF EXISTING MPAS

Description of National MPA Systems

There are a number of terrestrial and marine protected areas in the Central Indian Ocean Marine Region, that include habitats important for marine biodiversity, such as lagoons, mangroves or turtle nesting beaches. In many cases it has been difficult to determine how far the boundaries of these areas extend and to determine whether subtidal marine elements are included. Nevertheless, an attempt has been made to identify, on the basis of available information (the main sources being Dwivedi, Singh, and Ivan 1994; Pernetta 1993a,b,c,d,e; IUCN,1990 and information in the World Conservation Monitoring Centre Protected Areas Database), which of these protected areas have a marine focus and which are primarily coastal land. Available information suggests that there are 15 protected areas that include subtidal elements and a further 33 that include terrestrial coastal and in some instances intertidal features.

Map 10 shows those MPAs that have been recorded as including a subtidal component; these areas are identified in the national sections below; other coastal protected areas are also listed. Table 10.1 shows the number of marine and coastal protected areas by country.

Bangladesh

The Forest Department of the Ministry of Environment and Forests is responsible for the management of protected areas. Wildlife Sanctuaries are established under the Bangladesh Wildlife (Preservation) Order 1973. The Marine Fisheries Ordinance 1983 provides for the establishment of marine reserves but none has been designated (Pernetta 1993b). There are two coastal protected areas that include intertidal habitat and may include sub-

Table 10.1 Number of Existing MPAs by Country in the Central Indian Ocean Marine Region

Country	*Marine Sites*	*Coastal Sites*
Bangladesh	0	3
British Indian Ocean Territory (Chagos Archipelago)	0	
India	10[a]	6
Andaman and Nicobar Islands	1	13
Maldives	0	
Myanmar	0	
Sri Lanka	4	12
Total	15	34

a. Nine separate sites.

tidal habitat (although the latter could not be confirmed):

- Sundarbans Forest Reserve, east Wildlife Sanctuary, south Wildlife Sanctuary and west Wildlife Sanctuary: Important for mangroves; site accounts in Scott (1989) and IUCN (1990).
- Char Kukri-Mukri Forest Reserve and Wildlife Sanctuary: Important for mangroves and intertidal mudflats. Site accounts in IUCN (1990) and Scott (1989).
- Teknaf Game Reserve and Himchari National Park: Adjacent to the coast, but probably do not include intertidal habitats. Mangroves in the Chakaria Sundarbans Forest Reserve have been logged or so severely degraded that it can no longer be considered a protected area; Scott (1989) provides a site account.

British Indian Ocean Territory (the Chagos Archipelago)

No MPAs have been established; the inaccessibility of the area provides some measure of protection.

India

The Wildlife (Protection) Act 1972 provides for the establishment of national parks and sanctuaries by state governments, and they are administered by the Ministry of Environment and Forests. The Gulf of Kutch Marine Sanctuary and Marine National Park, the Gulf of Mannar National Park and Wandur Marine National Park have been established primarily to protect marine habitats. However, many other protected areas include important marine ecosystems (Pernetta 1993c) and it is often not clear where the seaward boundary is; for example, all protected areas in the Andaman and Nicobars have at least part of their boundaries adjacent to the marine environment, and in many cases cover saltwater creeks that extend inland (Pande and Singh 1991). The main MPAs are identified below. Other coastal areas are also listed:

- Gulf of Kutch Marine Sanctuary and Marine National Park (two areas): Important for fringing reefs, mud and sand flats, coastal marsh, mangrove forest (about 50,000 hectares) probably best developed on western Indian coast, nesting green turtles, occasional leatherback and Olive Ridley; dugong sometimes present; resident and migratory birds; site description in Scott (1989) and UNEP/IUCN (1988).
- Malvan Sanctuary: Important for coral reefs, sandy beaches, turtle nesting and mangroves.
- Chorao Island Wildlife Sanctuary: Estuary, mangroves; recreation and education centre.
- Pichavaram Forest Reserve: Part of much larger (11,000 hectares) mangrove system—only remaining mangrove area in Tamil Nadu and one of the richest and most interesting in India; also important for coastal lagoon, fishing, mollusks, crocodiles; site description in Scott (1989).
- Pulicat Lake Sanctuary (46,102 hectares in Tamil Nadu, 58,000 hectares in Andhra Pradesh): Important for saltwater lagoon (second largest in India), migratory shorebirds, fishing; one of

the largest coastal lagoons in the country; site description in Scott (1989).

- Gulf of Mannar National Park (20,000 hectares, of which 623 hectares is land): Most important mangroves in southern India, seagrass beds, many small islands major green turtle feeding ground, occasional olive ridleys, dugong, dolphins, coral reefs; site description in UNEP/IUCN (1988).
- Chilka Lake Wildlife Sanctuary; Ramsar site: One of largest concentrations of migratory waterfowl in the region and one of the largest coastal lagoons; site description in Scott (1989).
- Sundarbans National Park: Estuarine areas, important for mangrove forest; site description in Scott (1989).
- Bhitar Kanika Wildlife Sanctuary: Islands and beaches located in a deltaic area on the coast of Orissa; globally important site for nesting Olive Ridleys (100,000 nesting turtles in 1970s); site description in Scott (1989).

Other coastal areas include:

- Phansad Wildlife Sanctuary; mangroves.
- Point Calimere Wildlife Sanctuary; important for saltmarsh, mudflats, waterfowl, wintering migrants and associated terrestrial habitats and wildlife; at eastern end of large Vedaranayan Swamp; adjacent turtle nesting project; site description in Scott (1989).
- Coringa Sanctuary; important for mangroves, shallow lagoons, saltwater crocodile; site description in Scott (1989).
- Krishna Reserved Forest; mangroves; site description in Scott (1989).
- Mahanadi Delta crocodile conservation area (16,835 hectares); important for saltwater crocodile, mangroves; site description in Scott (1989).
- Gahirmatha Wildlife Sanctuary; important for saltwater crocodile (main Indian population); mangroves, Olive Ridley turtle nesting; site description in Scott (1989).

Other protected areas on the mainland that may also have marine, or at least intertidal, habitats (see Pernetta 1993c) are Khijadiya Wildlife Sanctuary, Little Rann of Kutch Wildlife Sanctuary, Vedanthangal Wildlife Sanctuary, Vettangudi Wildlife Sanctuary, Balukhand Wildlife Sanctuary, Lothian Island Wildlife Sanctuary, Halliday Island Wildlife Sanctuary, Sajnakhali Wildlife Sanctuary.

There may also be a seabird sanctuary on Pitti Island in the Laccadives, but this is unconfirmed.

Andaman and Nicobar Islands

All the 100 protected areas in the Andaman and Nicobars comprise part or all of small islands and have intertidal, coastal areas; many have mangroves. According to Pande and Singh (1991), a number of these have subtidal habitat; however, it has not been possible to identify these in this report. Wandur Marine National Park includes subtidal marine elements and is highlighted below; other important coastal protected areas are listed:

- Wandur Marine National Park: Possibly the least disturbed group of islands and the richest coral reefs in the Andamans; four turtle species; dugong; mangroves; site description in UNEP/IUCN (1988) and Pande and Singh (1991).

Other coastal areas include:

- Saddle Peak National Park: includes a long rocky beach
- North, Middle and South Button Island National Park: nesting turtles, mangroves
- Barren I. Sanctuary: active volcano, with coral communities
- Battimalv I. Sanctuary (Nicobars): mangroves
- Interview I. Sanctuary: mangroves, hawksbills

- South Reef I. Sanctuary: lies off the tip of Interview I
- Megapode I. Sanctuary (Nicobars): reefs, mangroves
- Narcondam I. Sanctuary: mangroves
- North Reef I. Sanctuary: beaches, corals, mangroves
- La Touche I. Sanctuary: green turtle
- Saltwater Crocodile Sanctuary: an extension of Wandur Marine National Park to the north; numerous creeks and inlets, mangroves, turtles, crocodiles
- South Sentinel I. Sanctuary: small coral island, beaches, large green turtle nesting beach, mangroves; established mainly for coconut crab
- Tillongchang I. Sanctuary: cliffs, mangroves, beaches

Great Nicobar Biosphere Reserve, on the southernmost island of the Nicobars (only 145 kilometers from Sumatra) has no legal status yet but includes important marine areas and mangroves.

Maldives

As yet no MPAs have been established. However, a number of other activities related to protection and management of the marine environment are under way. In particular, the National Environment Action Plan provides a framework for environmental planning and management. Measures are in place to restrict coral mining and reduce marine pollution.

Myanmar

Current conservation and wildlife legislation does not provide specifically for the establishment of MPAs. Thamihla Kyun Wildlife Sanctuary and Moscos Island Sanctuary, managed by the Forest Department, are coastal but do not protect marine habitats (UNEP/IUCN 1988).

Sri Lanka

The focus of marine conservation in Sri Lanka is coastal zone management, and MPAs *per se* have received less direct attention. The Coast Conservation Act enacted in 1981 covers the area within 300 meters landward of mean high water level and two kilometers seaward of mean low water. The Act required the development and implementation of a coastal zone management plan that places most emphasis on control of erosion and sand and coral mining, with a permit system for development activities (Lowry and Sadacharam 1993).

Marine Sanctuaries are established under the Fauna and Flora Protection Ordinance that is to be revised to include specific reference to MPAs. A draft new Fisheries Bill prepared in the early 1980s included provisions for marine reserves and sanctuaries, but it is not known if this is being followed through. Marine areas come under the jurisdiction of many government departments: the Department of Wildlife Conservation is responsible for Marine Sanctuaries, the National Aquatic Resources Agency (NARA) for marine research, the Coast Conservation Department for coastal zone management, and the Ministry of Fisheries and Aquatic Resources for fisheries.

MPAs are being established through the Special Area Management (SAM) project that is establishing management areas at Hikkaduwa Reef and Rekawa Lagoon (see the Appendix).

There are 16 protected areas that include coastal elements, four of which include subtidal elements (Hikkaduwa Marine Sanctuary and Bar Reef Marine Sanctuary have been established specifically to conserve coral reef areas; other areas cover important estuarine, mangrove and other habitats):

- Hikkaduwa Marine Sanctuary: Coral reefs; includes the Rocky Islets Sanctuary; currently management being improved through a SAM project; site account in UNEP/IUCN (1988).

- Kokkilai Lagoon Sanctuary: Estuarine lagoon, sea grass beds, small amount of mangrove; water birds; poorly protected; site account in Scott (1989).
- Bar Reef Marine Sanctuary: Important for coral reefs; recently established and management plan being developed through NARA, which has a nearby research station.
- Ruhuna (Yala) National Park: Coastal area includes a complex of brackish lagoons, several estuaries and 64 kilometers of shore; mangroves and abundant wildlife; site account in Scott (1989).

Other coastal areas include:

- Pigeon Island Sanctuary: marine areas may not be included within boundary; site account in UNEP/IUCN (1988) under "Trincomalee Reefs."
- Wilpattu National Park: includes 40 kilometers of rocky coastline with cliffs, some sandy beaches, dunes and mangroves; site account in Scott (1989).
- Chundikkulam Sanctuary: coastal lagoon, mangroves, seagrass beds; inadequate protection; site account in Scott (1989).
- Trincomalee Naval Headworks Sanctuary.
- Great Sober Island Sanctuary.
- Madhu Road Sanctuary.
- Seruvila-Allai Sanctuary: includes the western part of Ullackalie Lagoon; extensive mangrove, water birds; site account under "Ullackalie" in Scott (1989).
- Kudumbigala Sanctuary.
- Yala East National Park: coastal area includes a complex of brackish/saline lagoons and extensive sandy beaches; Kumana Villu Lagoon has extensive mangroves and is protected as a bird sanctuary; site account in Scott (1989).
- Bundala Sanctuary: includes four shallow brackish lagoons and adjacent sea coast; designated a Ramsar site in 1990; birds, fisheries, tourism; site account in Scott (1989).
- Kalametiya Kalapuwa Sanctuary: two brackish lagoons fringed with mangrove; very important for water birds; site account in Scott (1989).
- Honduwa Island.

There are site accounts for several of these areas in IUCN (1990).

International and Regional Initiatives Relating to MPAs

World Heritage Convention

The following countries are party to the World Heritage Convention: Bangladesh, India, Sri Lanka, Maldives (and possibly the Chagos Archipelago through the UK).

The only marine World Heritage Site in the region is the Sundarbans National Park in India. It has been recommended that the Chagos Archipelago should be nominated.

Ramsar Convention

The following countries are party to the Ramsar Convention: Bangladesh, India, Sri Lanka.

There is one marine Ramsar site (Chilka Lake, India), and two other coastal areas (Sundarbans, Bangladesh and Bundala, Sri Lanka). Several other sites have been proposed for India, including Point Calimere, Khijadia and the Gulf of Kutch.

MARPOL

No areas in the region have been identified under MARPOL.

UNESCO Man and the Biosphere Programme

The following countries have national MAB committees: Bangladesh, India, Sri Lanka.

No marine biosphere reserves have been designated in the region but a number have been proposed for India, including the Gulf

of Kutch, Gulf of Mannar, Chilka Lake and the Sundarbans (Scott 1989). There is a biosphere reserve in the Nicobar Islands but this is not part of the MAB programme (Pernetta 1993c).

UNEP Regional Seas Programme

A Regional Seas Programme was established in 1983 for the South Asian Seas Region (which covers Pakistan, India, Bangladesh, Sri Lanka and the Maldives) but there is no Convention or Action Plan yet. A number of preliminary country studies have been produced such as IUCN/UNEP (1985) and the 1993 reports used in this review.

Other

Relatively few regional initiatives are underway in this region, apart from the fact that the whole area lies within the Indian Ocean Whale Sanctuary. Research into fisheries management issues is being carried out in the Bay of Bengal through cooperation by FAO and other agencies.

Assessment of Representation of Biogeographic Zones within MPAs

The degree to which MPAs in the Central Indian Ocean Marine Region represent the biogeographic regions identified is discussed below. This assessment considers only those 15 protected areas recorded as including a subtidal component. There are an additional 34 protected areas which include terrestrial coastal and in some instances intertidal features.

Most MPAs are located in the Eastern Indian Ocean biogeographic zone, that includes eight MPAs. Four of these are located around Sri Lanka and four along east the coast of India. There are four MPAs covering three separate sites along the west coast of India in the Western Indian Ocean zone.

Table 10.2 Number of MPAs in Biogeographic Zones of the Central Indian Ocean Marine Region

Biogeographic Zone		*Number of MPAs*
I.	Western Indian Ocean	4[a]
II.	Eastern Indian Ocean	8
III.	Northern Bay of Bengal	2
IV.	East Bay of Bengal	1
V.	The Central Indian Ocean	0
	Total	15

a. Three separate sites.

There is one MPA in the East Bay of Bengal, Wandur Marine National Park, which is located in the Andaman Islands. There are two MPAs in the Northern Bay of Bengal zone, (Sundarbans NP and Bhitar Kanika Wildlife Sanctuary in India).

A more detailed analysis would be required to determine whether the existing MPAs effectively conserve a representative range of the habitat and ecosystem types within each of the zones that are represented. However, even without such an analysis it is clear that there are some major gaps.

Four of the six countries or territories in the region (Bangladesh, Maldives, Myanmar and the Chagos Archipelago) have no subtidal MPAs (although Bangladesh has two coastal land protected areas that include intertidal features). The atoll groups of the Laccadive-Chagos chain and the coast of Myanmar are also not represented. There is only one MPA in the Andaman and Nicobar island group.

Rodgers and Panwar (1988) assess representation of the coast and island biogeographic zones in protected areas in India. Protected areas on the coast cover 2.4 percent of the country (two National Parks and 17 other protected areas), and island protected areas cover 0.3 percent of the country (six National Parks and 100 other

protected areas), mainly in the Andaman Islands. The Laccadives and Nicobars have poor coverage. However, there is no assessment of MPAs as such by these authors.

Priority Areas and Recommendations

National Priorities for the Establishment and Management of MPAs

Recommendations are given in the Corbett Action Plan for Protected Areas in the Indo-Malayan Realm (Thorsell 1985). Most sets of recommendations stress the global and regional importance of the coral reefs of the Maldives, the Chagos Archipelago and Laccadives and the coastal wetlands of India, Bangladesh and Myanmar. Several areas need at least bilateral conservation action, such as the Sundarbans (India and Bangladesh), the Gulf of Mannar and Palk Bay (India and Sri Lanka) and the eastern Indian Ocean atoll systems (India, Maldives, the Chagos Archipelago).

The following areas have been identified on the basis of existing and available information by Sue Wells (see Map 10). Dwivedi, Singh, and Ivan (1994) provided a subsequent review of priorities. The recommendations have not yet been reviewed by government authorities in the countries concerned.

Bangladesh

Recommendations for future action in the coastal and marine environment are given in Pernetta (1993b). The priority areas for marine biodiversity conservation are given below.

Proposed new MPAs:

- The Sundarbans: Primarily important for mangroves and associated fauna and flora; there are several existing protected areas that include intertidal habitat and may include subtidal habitat; the area is an important breeding and nursery area for a range of marine species and should be a priority for a MPA.
- Naaf Estuary islands (and adjacent areas including Teknaf Peninsula and Chakaria Sundarbans): Supports a small stand of mangroves with the only population of crab-eating macaques in the country; site accounts for some areas in Scott (1989).
- Jinjiradwip and surrounding marine areas: Important for coral reefs, wintering ground for wildfowl, turtle nesting beach; site account in Scott (1989); recommended for protection in the Corbett Action Plan. The mudflats on the northwest and southeast coasts are important for waterfowl, with the highest priority being Nijhum Dweep (site account in Scott; 1989).

Existing MPAs that require management support:

There are no existing MPAs.

British Indian Ocean Territory (the Chagos Archipelago)

Proposed new MPAs:

This is the largest, most pristine and possibly most diverse expanse of reef in the Indian Ocean.

Existing MPAs that require management support:

There are no existing MPAs.

India

A proposal for a protected areas network has been drawn up by the Wildlife Institute of India (Rodgers and Panwar 1988). Many new sites are recommended for protection, others for expansion, and others for improved management, with the aim that five percent of each biogeographic province should be protected. This would result in 18 parks and 40 protected areas for islands, and

seven parks and 32 protected areas for coasts. These and other recommendations for future action in the coastal and marine environment are given in Pernetta (1993c). The more important areas for marine biodiversity conservation are listed below.

Proposed new MPAs:

- Gulf of Khambhat Wildlife Sanctuary: Important for mangroves, shorebirds, green and olive Ridley turtle nesting beaches; site account in Scott (1989).
- Kundapar Wildlife Sanctuary and estuaries of Karnataka coast: Mangroves and shorebirds; site account in Scott (1989).
- Chilka Lake Wildlife Sanctuary Extension (see above): Proposed extension to the existing Sanctuary to include Nanda Island and important turtle nesting beaches.
- Point Calimere National Park (see above): Existing coastal terrestrial Sanctuary is proposed to be upgraded to National Park, with the extension to include turtle nesting beaches and possible designation of adjacent marine areas as a Ramsar site.
- Kazhiveli Wildlife Sanctuary: Mangroves, waterfowl; one of the last high quality lagoon and estuarine systems on the east coast of India; recommended as a Biosphere Reserve.
- Sundarbans: There is an existing National Park (see above) that includes intertidal and estuarine areas, as well as terrestrial features. The area is an important breeding and nursery area for a range of marine species and should be a priority for sustainable management of the entire marine environment. This could be achieved through the establishment of a large, integrated multiple-use MPA.
- Lakshadweep Archipelago (Laccadives): Management is urgently needed in this area. Improved protection for nesting turtles is recommended for the Indian part of the Indus delta.

Existing MPAs that require management support:

- Bhitar Kanika Wildlife Sanctuary (see below): To be extended to include turtle nesting beaches; management support is required.
- Gulf of Kutch: Improved management of existing Marine Sanctuary and Marine Park, particularly in the southern part; the main threats are cutting of mangroves, exploitation of shells, algae and oysters, dredging and pollution from salt industries and shipping; coral reefs reportedly reduced in area by nearly 50 percent and the mangroves by about 20 percent over the last 10–15 years. The main requirements are to control commercial fishing, identify and control sources of pollution, plan for sustainable tourism development, evolve effective guidelines for planning and managing the marine national park, and to involve the local community (see below).
- Gulf of Mannar National Park: Prior to declaration of the park, reefs in the area had undergone noticeable deterioration, possibly as a result of increased water turbidity from coral mining; management measures need to be improved, particularly to control dugong exploitation (probably the most important area in the region for dugong), and ban coral mining (see below).
- Malvan Sanctuary (see below): One of the least disturbed areas on the west coast of India.

Andaman and Nicobar Island (India)

Proposed new MPAs:

- Andaman and Nicobar Islands: These islands include coral reefs, important nesting beaches for leatherback, hawksbill, olive Ridley and green turtles; du-

gong and saltwater crocodiles. A number of sites already receive some protection but this is mostly for coastal land areas only. Further protection is needed for dugong. Proposals for the protected area system that relate to the marine environment include (Rodgers and Panwar 1988; Pande and Singh 1991):

- Upgrading of some sanctuaries to Park status: Narcondam Island; North Reef Island; South Sentinel Island; Barren Island; and all islets in the west coast Shearme group, the northern Landfall group, and the east coast Table-Brush group
- Little Andamans: 300 square kilometer National Park proposed for southwestern half of island to include turtle nesting beaches and coconut crabs
- Little Nicobar with surrounding islets: proposed as a National Park
- Great Nicobar: northern area (north of Casuarina Bay-Dogma River and Mt Thullier) to be a wildlife sanctuary
- Extension of Mount Harriet National Park to include a marine area.

There are also proposals for amalgamating some of the tiny individual island sanctuaries into ten larger units for more efficient administration; for bringing a larger area of mangroves into the protected area network; and for creating a number of other protected areas. Highest priorities relating to MPAs are as follows (Pande and Singh 1991):

- Creation of North Andaman Peninsula Wildlife Sanctuary
- Creation of a sanctuary in West Rutland to act as a buffer for the Marine National Park
- Establishment of Little Andaman National Park (see above)
- Upgrading of South Sentinel Wildlife Sanctuary (see above) to National Park
- Extension of Button I. National Park (see above) to include Outram I. and surrounding waters
- Upgrading of Narcondam Wildlife Sanctuary (see above) to National Park
- Upgrading of North Reef Wildlife Sanctuary (see above) to National Park
- Establishment of Great Nicobar Wildlife Sanctuary (see above)
- Establishment of Little Nicobar National Park (see above).

Existing MPAs that require management support:

- Wandur Marine National Park: Possibly the least disturbed group of islands and the richest coral reefs in the Andamans; four turtle species; dugong; mangroves; site description in UNEP/IUCN (1988) and Pande and Singh (1991).

Maldives

Numerous recommendations have been produced for the Maldives (see Pernetta 1993d; UNEP/IUCN 1988), and many of these are now outdated, irrelevant or impractical within the current socioeconomic and development context of the country. The National Environment Action Plan (which was not available for consultation for this report) has established a program of activities, and recommendations for MPAs must fit in with these. Given the global importance of the Maldives for marine biodiversity, this area should, however, be represented in any global network of MPAs.

Myanmar

Proposed new MPAs:

In the 1980s, and under the Corbett Action Plan (Thorsell 1985), a number of marine areas were recommended for protection (UNEP/IUCN 1988):

- Moscos Island Wildlife Sanctuary: Coral reefs, turtle nesting; extension recommended to create a marine reserve; site accounts in UNEP/IUCN (1988) and Scott (1989); recommended for protection in Corbett Action Plan.
- Thamihla Kyun Wildlife Sanctuary: Formerly a major green and olive

Ridley turtle nesting site; extension recommended to create a marine reserve; recommended for protection in Corbett Action Plan; site account in Scott (1989).

- Lampi Island and adjacent areas of the Mergui Archipelago: Coral reefs, some turtle nesting; proposed as a marine park to be managed in conjunction with proposed Pakchan Nature Reserve for mangroves; site account in UNEP/IUCN (1988) and Scott (1989).
- Irrawaddy Delta: There are many Reserved Forests in southern part of the delta but no marine protected areas; protection needed for mangroves, turtles, estuarine crocodiles, waterfowl; three sites proposed as Wildlife Sanctuaries: Meinmahla Kyun, Kadonlay Kyun (also recommended for protection in Corbett Action Plan), Letkokken Islands; all are small estuarine islands, surrounded by shallow water with mudflats, mangroves and crocodiles; site account in Scott (1989).
- Sittang Estuary and Gulf of Martaban: Important estuarine system with a large area of mudflats; site account in Scott (1989).
- Central Tenasserim coast and northern Mergui Archipelago: Large area of bays, estuaries, mudflats, mangroves, some reefs, turtles, estuarine crocodile; site account in Scott (1989).

Existing MPAs that require management support:

There are no existing MPAs in Myanmar.

Sri Lanka

Priorities for coastal and marine conservation and management have been identified in a recent report *Coastal 2000* (Olsen and others 1992) and a large number of coastal and marine sites have been recommended for some form of protection (Pernetta 1993e). A recent initiative is the development of SAM plans that will promote local involvement in marine resources management for sites of ecological and economic importance. Two SAM projects have recently been initiated:

- Hikkaduwa Area: A number of recommendations and management proposals have been made for improved management of this area (Pernetta 1993e).
- Rekawa Lagoon: Important for mangroves, lagoon, fish and shrimp fishery; adjacent area is a turtle sanctuary (established under a project run by the UK-based society Care for the Wild).

Sites that appear to be of highest priority (Pernetta 1993e) are listed below.

Proposed new MPAs:

- Puttalam Lagoon, Dutch Bay and Portugal Bay areas: Important for coastal wetlands, seagrasses, mangroves, water birds, turtles, dugong; includes Karaitivu and Kalpitiya lagoons; site account in Scott (1989).
- Negombo Lagoon: Mangroves and seagrass beds; site account in Scott (1989).
- Jaffna Peninsula and Lagoon area: Many important coastal wetland areas; details in Pernetta (1993e) and Scott (1989).
- Palk Bay and Gulf of Mannar: Including Adam's Bridge area wetlands and coral reefs; details of sites in Pernetta (1993e) and Scott (1989).
- Basses Reef: Recommended as a marine sanctuary; site account in UNEP/IUCN (1988).
- Rekawa Lagoon: SAM site (see above).

Existing MPAs that require management support:

- Hikkaduwa Marine Sanctuary (see above)
- Bar Reef: Research under way and management plan being developed with SAREC funding

Other areas recommended for protection and listed in Pernetta (1993e) include:

- Unawatuna Reefs: Recommended as an MPA
- Polhena Reef: Recommended as a marine sanctuary
- Thenaddi Bay, Vandeloos Bay, Pasekudah and Kalkudah Bay area: Reefs, coastal wetlands, mangroves; recommended for protection; site account in UNEP/IUCN (1988) and Scott (1989)
- Pigeon Island
- Muthurajawela Swamp: Mangroves; site account in Scott (1989)

The Corbett Action Plan recommends protection of waters adjacent to Wilpattu National Park. Scott (1989) lists numerous other wetland areas as being of significance.

Regional Priorities for the Establishment and Management of MPAs

The areas outlined have been selected as regional priorities for the establishment and improved management of MPAs protection using the criteria outlined in the introduction to this report (see Map 10). Priorities were identified in a report prepared for IUCN-CNPPA by Dwivedi, Singh, and Ivan (1994). These areas provide broad biogeographic and geographic coverage of most areas and represent a range of different ecosystem types. In selecting the areas the necessity of support from national governments has been recognized and where possible preference has been given to areas where the concerned Government has expressed interest in marine biodiversity conservation and action is already underway.

Insufficient information has been available to recommend any areas in Myanmar. Gathering the data to make such recommendations should be a high priority.

Proposed new MPAs:

- Maldives Atolls (Maldives): The Maldives form the central and largest section of the Laccadive-Chagos chain, which extends southward from India to the centre of the Indian Ocean. As noted previously, the islands support a diverse coral assemblage, with possibly the greatest diversity of reefs in the western Indian Ocean (Pernetta 1994d). A number of sites have been proposed for the establishment of MPAs (see Pernetta 1994d). Although it has not been possible to identify a specific site for the establishment of a MPA, the islands should be a high priority for marine biodiversity conservation.
- Palk Bay and the Gulf of Mannar (Sri Lanka): Palk Bay and the Gulf of Mannar are located off the southeast Indian coastline and the northeast coast of Sri Lanka. The area is shared between these two countries (the Indian component is dealt with below; see the Gulf of Mannar Marine National Park). The region has 96 species of corals from 36 genera; corals in this area are much more diverse than those further north, with highest diversity around Adam's bridge and the Gulf of Mannar (Pernetta 1993c). Coral development in Palk Bay is inhibited by turbidity and turbulent seas for much of the year. Extensive seagrass beds are present in Palk Bay and the Gulf of Mannar and these are important for dugong, which are now increasingly rare. The absence of large metropolitan cities and industries have helped to keep the rich fauna and flora relatively undisturbed; due to shallow waters and rocky bottom it has not become a major shipping lane. The area is rich in mollusk resources that are exploited for commercial purposes. Corals are also mined for liming. The bay supports a fishery of small pelagic fish that are used for making fish meal. This fishery needs sustainable management and conservation. The area is also im-

portant for scientific research by universities and institutes in both India and Sri Lanka. The establishment of an MPA to include the Sri Lankan component of this area is recommended. Cooperation between the governments of India and Sri Lanka would facilitate the management of this area as a complete ecological unit.

- Lakshadweep Archipelago (India): The Lakshadweep (Laccadive) Archipelago lies on the northern part of the Laccadive-Chagos Ridge and is the second largest group of atolls in the Indian Ocean. The archipelago includes about 25 islands of which nine are inhabited. Corals from nine genera have been recorded; in a few places corals have been degraded but they remain healthy on several islands (Agatti, Bangaram, Kadamat and Chetlat). Dolphins, three species of marine turtle and five species of seabirds are present (Dwivedi, Singh, and Ivan 1994). The main threats appear to be sand mining for civil works and over exploitation of bait fish used for catching tuna. The local population depends essentially on tuna fishing and although the local administration is keen to support the establishment of a marine national park, there is some reservation among local fishermen. Provision must be made for traditional fishing to secure public support for the establishment of an MPA.
- Sundarbans (Bangladesh, India): The Sundarbans is a vast complex of intertidal and estuarine areas situated on the border of India and Bangladesh where the Ganges Brahmaputra and Mehgna rivers converge in the Bengal Basin. About 65 percent of the Sundarbans lies in Bangladesh and 35 percent in India. The area includes the most extensive areas of mangrove present in India (constituting more than 60 percent of the area of mangroves remaining in India) (Dwivedi, Singh, and Ivan 1994). A total of 32 mangrove species and 10 seagrass species have been recorded (Dwivedi, Singh, and Ivan 1994). The area provides nursery grounds for many species of fish and invertebrates, including exploited species such as tiger prawns. Its productivity plays a major role in supporting fisheries along the east coast of India (Dwivedi, Singh, and Ivan 1994). Marine turtles, dolphins, estuarine crocodiles and seabirds are also present. The Sundarbans are threatened by the impacts of sewage and industrial pollution, that have resulted in mangrove mortality and the threats to other species. The Sundarbans has been identified as being of high conservation priority for the governments of India and Bangladesh. India has established the Sundarbans National Park while Bangladesh has established a forest reserve and three wildlife sanctuaries. These areas are not managed to effectively conserve marine resources and biodiversity. Given the area's importance it is recommended that MPAs be established in India and Bangladesh to provide for integrated management of marine resources and protection of rare and endangered species.
- Malvan Sanctuary (India): Malvan is one of the very few relatively undisturbed locations along the western coast of India. The nearest major city is Bombay, which is about 400 kilometers away, and the area is largely free from the effects of pollution. The sanctuary includes coral (eight species), mangroves, seagrasses and turtle nesting beaches. Surrounding areas support a commercial trawl fishery. Initial planning for a National Park has commenced. The development of a MPA has the support of the government of Maharashtra and the national government (Dwivedi, Singh, and Ivan 1994) and should be implemented.

- The Chagos Archipelago (British Indian Ocean Territory, United Kingdom): This is the largest, most pristine and possibly most diverse expanse of reef in the Indian Ocean. There are no existing MPAs although the inaccessibility of the area provides some measure of protection. Several sites have been recommended for special protection: Nelson Island for green turtles and frigate birds; the small islands of the Great Chagos Bank and the northern atolls. The whole area has been recommended as a World Heritage Site. An organization has been established dedicated to the protection of the Chagos Archipelago environment (Friends of the Chagos), and a research program on the marine environment of the area is being established through the University of Warwick (UK).

Existing MPAs that require management support:

- Gulf of Mannar Marine National Park (India): A description of this area is provided above (see Palk Bay and Gulf of Mannar). The Gulf of Mannar Marine National Park was established in 1980 to include 21 islands and the surrounding five kilometers of sea. Support for management of this area is urgently required. Cooperation between the governments of India and Sri Lanka would facilitate the management of this area as a complete ecological unit.
- Gulf of Kutch Marine Sanctuary and Marine National Park (India): The Gulf of Kutch is a large inlet of the Arabian Sea, covering approximately 7,350 square kilometers and with a maximum depth of about 60 meters. Most of the Gulf is criss-crossed with mangrove-lined creeks, the intertidal zone being sandy or muddy, or of exposed limestone. Numerous islands are present and most of these support fringing reefs, although these are of low diversity with 44 species recorded (UNEP/IUCN 1988). The two existing MPAs are 45,792 hectares and 16,289 hectares respectively and lie on the southern shore. They include a complex of fringing reefs backed by mud and sand flats, coastal marsh and mangrove forest (Pernetta 1993c). Mangroves, corals, sponges, mollusks, fish, algae, seabirds and marine mammals are all present, although they are increasingly threatened by development on the coast. These threats include the discharge of brine from saltworks and effluents from industrial activities into the park area, land filling, cutting of mangroves and dumping from ships. Management support for the existing MPAs is urgently required. To be effective, this must be implemented within the context of management of all uses in the adjacent land and sea areas.
- Wandur Marine National Park (Andaman and Nocobar Group of Islands—India): The Andaman and Nicobar islands are located between the Bay of Bengal and the Andaman Sea. The northern-most island, Land Fall, is located 190 kilometers from Myanmar while the most southerly, Great Nicobar, is 160 kilometers from Sumatra (Indonesia). The two island groups stretch for about 700 kilometers and include 572 islands, islets and rocks with an area of 8,240 square kilometers. The islands are known for their rich fauna and flora (Dwivedi, Singh, and Ivan 1994). The Andaman group of islands has 27 mangrove species recorded; 64 seaweed species, three seagrass species; the Nicobar group has 27 species of mangroves 105 species of seaweed, and seven species of sea grasses. The islands also support a diverse assemblage of algae, inverte-

brates and fish (Dwivedi, Singh, and Ivan 1994). The Wandoor Marine National Park was established in 1983 off the west coast of South Andaman island mainly to provide protection for five species of sea turtles (leatherback, Olive Ridley, green, hawksbill and loggerhead), coral reefs and associated marine life. The impacts of fishing (although illegal) and tourism activities are the primary threats to the park. The amalgamation of the park with some of the smaller island sanctuaries would provide a more effective basis for management. Expansion and effective management of the park is recommended.

- Bhitar Kanika Wildlife Sanctuary (India): This area is situated on Kanika Island in the Brahmani-Baiterani delta on the Orissa coast about 144 kilometers from Bhubaneshwar. The area receives freshwater input from eight rivers (Bramhani, Batitarni, Baitarni, Dhamra, Patsala, Mahipura, Hansua, Nansina) and is also subject to a tidal influence from the sea that is 12 kilometers away. The existing Sanctuary is well protected by virtue of being surrounded by this river system. Mangroves, saltwater crocodiles, and marine turtles are found within the reserve. The area provides nursery grounds for marine animals including tiger prawns and fish, and is of global significance for nesting Olive Ridley turtles (Dwivedi, Singh, and Ivan 1994). A Wildlife Sanctuary was declared in 1975. This area requires management support.

Other Recommendations

The recommendations below draw on a report prepared for IUCN-CNPPA by Dwivedi, Singh, and Ivna (1994).

Developing an Effective System of MPAs in the Central Indian Ocean

The threats facing marine environments of the Central Indian Ocean are many and well documented (see Pernetta 1993a,b,c,d). These threats include:

- pollution, including direct sewage disposal, discharges from shipping, industrial waste, sediment and nutrient runoff
- land reclamation and coastal construction
- coral mining
- overfishing
- cutting of mangroves for fuel and aquaculture development
- uncontrolled tourism development
- sea level rise.

While some marine environments have been subject to minimal pressure and remain in good condition (particularly some of the offshore islands and atolls), others are under increasing pressure and are becoming heavily degraded.

Although recognition of the need for marine conservation in the region has increased, the degree of national activity in addressing these threats varies greatly. Sri Lanka has established a coastal zone management program, similar initiatives are underway or planned for parts of India and Bangladesh, while the Maldives has developed a National Environmental Action plan.

Although these initiatives are encouraging and should be supported, there has been less activity to establish and manage marine protected areas. A total of 15 protected areas with a subtidal component have been identified in this report. There are an additional 33 coastal protected areas that include coastal land and intertidal features. Only two of the six countries or territories in the region (India and Sri Lanka) have established MPAs. The major marine biogeographic subdivisions are poorly represented by these existing MPAs; one of the five zones has no MPAs (the Central Indian Ocean), while only

a small proportion of the other zones has been protected.

Although a detailed assessment of management of existing MPAs could not be carried out for this report, available information suggests that, with some exceptions, the level of management of most areas is low.

Available information suggests that most of the existing conservation measures have been made under forestry or fisheries legislation. Legislation specifically for establishing protected areas in the marine environment is not well developed, neither are the legal frameworks for development of national MPA systems.

Marine resource management is a specialized subject matter and requires particular skills. Conservation in the region has been focussed on terrestrial issues and there is comparatively much less expertise in marine resource management. The institutions with responsibility for management of MPAs, which are often forestry agencies, require assistance to develop the management expertise to effectively carry out this task. Further, such institutions have insufficient resources in terms of funds, equipment and trained personnel to effectively manage even the few MPAs that have been established. As a high priority, management institutions must be considerably strengthened through the provision of additional staff, training, equipment and funding in order for them to be able to manage MPAs effectively.

Effective management requires data for planning, monitoring and reviewing management activities. Many marine areas in the region are not well studied, very few are effectively monitored. There is a need for more management orientated research and monitoring and closer cooperation between scientists and managers in identifying research priorities and developing research programs that meet management needs.

The development of effective national MPA systems would also be assisted by identifying clear institutional responsibilities for MPAs and mechanisms for coordination of agencies with responsibilities relevant to the marine environment.

Mobilization of the support and commitment of local communities will be important to achieving effective MPA implementation. In the Central Indian Ocean local communities rely on the marine environment for food and income. Marine resource use is the only source of livelihood for many people. Success has been achieved in some instances where local populations recognize that it lies in their interests to conserve marine biodiversity. Failures commonly result where local people are not supportive or actively oppose MPAs. Addressing the need to gain local support will require:

- Participation and representation of local people in the planning and decisionmaking process in establishing and managing MPAs
- Ensuring that MPAs provide tangible financial and social benefits to local communities
- Recognition of and addressing the need to provide for the livelihoods of local people
- Developing mechanisms for effective ongoing cooperation and communication with local communities.

Important lessons can be learned from the Special Area Management project for Sri Lanka, which is supported by the Natural Resources and Environment Policy Project of USAID and implemented through the University of Rhode Island Coastal Resources Management Project. A summary of the lessons learned, extracted from a recent paper by White and Samarakoon (1994) are attached in the Appendix.

Some of the most serious pressures facing marine environments are generated by activities on the land. It is likely that the MPAs will only achieve their objectives if they are part of programs for overall coastal zone planning and management. The develop-

ment and implementation of such programs within all countries in the region should be a high priority.

APPENDIX LESSONS LEARNED FROM THE SPECIAL AREA MANAGEMENT FOR COASTAL RESOURCES PROJECT, SRI LANKA

The following discussion is from White and Samarakoon (1994).

The Special Area Management (SAM) project for Sri Lanka is being carried out by the Natural Resources and Environmental Policy Project of USAID through the University of Rhode Island and its Coastal Resources Management Project. The project applies Special Area Management as a means to achieve resource management within a defined geographical area. The basic premise of SAM is that it is possible to organize local communities to manage their natural resources and that they will continue to do so if they perceive that they derive tangible benefits from such management.

Two sites have been selected for the project: Hikkaduwa Marine Sanctuary, an area that is heavily used for tourism; and Rekawa Lagoon, an area that supports traditional lagoon and offshore fishing, small scale agriculture, coral mining and has potential for tourism development. The purpose of SAM in both sites is to resolve competing demands on resources by planning for optimal and sustainable use.

As planning and development of these two projects proceeds, there are a number of fundamental lessons that have been learned and that may have some wider applicability, particularly as relates to MPAs in other countries in the Central Indian Ocean and to other regions of the world. These are outlined below:

The SAM process must be open, participatory and work toward consensus. All planning meetings must allow a free expression of felt needs whether the participants are small-scale fishermen or national agency managers. In the end, the government and nongovernment groups must work together and continue to have open dialogue during the planning and implementation process.

Decisions must be clear and well documented. Because of the number of different interest groups involved, any binding decisions must be very clearly communicated and abided by. Otherwise mistrust will grow and goodwill will be lost.

National government agencies must understand and accept the process. Although this should be achieved in the beginning, it may not happen until the SAM process has proceeded through several stages. In reality, the SAM process is one of learning for all involved for the duration of the program.

Stakeholder groups must be equally represented in the management process. In the case of Hikkaduwa, stakeholders include fishermen, tourist boat operators and hoteliers among others who have a stake in the resources of beaches, coral reefs and clean marine waters. Because each has a slightly different perspective on how the resource can best serve their needs, planning and management needs to be by consensus of all groups.

Implementation results should be apparent within three years. Timing is critical to maintain the interest and participation of stakeholders and government alike. If results are not forthcoming within a reasonable time, all concerned lose interest.

Monitoring and feedback of results makes the program tangible. Monitoring should be started at the beginning of a SAM planning and implementation process so that changes over time are recorded and understood by all concerned. In this manner, positive results will reinforce participation and further change efforts.

In Sri Lanka, cooperative management is a more appropriate concept than community based management for coastal resources. The national and local governments are in-

herently part of any management efforts for coastal resources in Sri Lanka. It is best to realize that community efforts alone may not work without the support and joint participation of government.

Community groups can make the difference in success or failure. In contrast to the role of government that is required, the enduring efforts of the community groups are also critical and can make the difference for sustainable success. In Rekawa for example, no amount of government effort has stopped coral mining. This can only come when communities decide it is not in their best interest to continue.

Bibliography

Dwivedi, S.N., S. Singh, and R.T. Ivan. 1994. Marine Protected Areas: Central Indian Ocean. Unpublished report prepared for IUCN-CNPPA, Gland, Switzerland.

Feare, C.J. 1984. Seabird status and conservation in the tropical Indian Ocean. In J.P. Croxall, P.G.H. Evans, and R.W. Schreiber, eds., *Status and conservation of the world's seabirds.* ICBP Technical Publication 2. Cambridge, U.K.

Gaskin, D.E. 1985. Cetacean habitats and conservation problems, with special reference to the Indian Ocean. In *Proceedings of Symposium Endangered Marine Animals and Marine Parks, Cochin, India (Vol. 3: Marine Parks, Sanctuaries and Reserves).* Delhi: Marine Biological Association.

Hayden, B.P., G.C. Ray, and R. Dolan. 1984. Classification of coastal and marine environments. *Environmental Conservation* 11(3): 199–207.

Hutchings, P., and P. Saengar. 1987. *Ecology of Mangroves.* St. Lucia, Australia: University of Queensland Press.

Lowry, K., and D. Sadacharan. 1993. Coastal management in Sri Lanka. *Coastal Management in Tropical Asia* 1:1–7.

Olsen, S., D. Sadacharan, J.I. Samarakoon, A.T. White, H.J.M. Wickremeratne, and M.S. Wijeratne. 1992. *Coastal 2000: Recommendations for a resource management strategy for Sri Lanka's Coastal Region* (vols. 1 and 2). CCD/CRMP. Colombo: Government of Sri Lanka and University of Rhode Island.

Pande, P., A. Kothari, and S. Singh, eds. 1991. *Directory of national parks and sanctuaries in Andaman and Nicobar Islands.* New Delhi: Indian Institute of Public Administration.

Pernetta, J.C., ed. 1993a. *Marine protected area needs in the South Asian Seas Region: Development of a system.* Marine Conservation and Development Report. Gland, Switzerland: IUCN.

———. 1993b. *Marine protected area needs in the South Asian Seas Region: Vol. 1 Bangladesh.* Marine Conservation and Development Report. Gland, Switzerland: IUCN.

———. 1993c. *Marine protected area needs in the South Asian Seas Region: Vol. 2 India.* Marine Conservation and Development Report. Gland, Switzerland: IUCN.

———. 1993d. *Marine protected area needs in the South Asian Seas Region: Vol. 3 Maldives.* Marine Conservation and Development Report. Gland, Switzerland: IUCN.

———. 1993e. *Marine protected area needs in the South Asian Seas Region: Vol. 5 Sri Lanka.* Marine Conservation and Development Report. Gland, Switzerland: IUCN.

Rodgers, W.A., and H.S. Panwar. 1988. *Planning a wildlife protected area network in India.* Vols. 1 and 2. Delhi: Wildlife Institute of India.

Scott, D.A. 1989. *A directory of Asian wetlands.* Gland, Switzerland and Cambridge, U.K.: IUCN.

Swaminathan, M.S. 1992. *Biogeographic Classification of the Indian Ocean Realm.* Discussion paper prepared for CNPPA. Gland, Switzerland.

Thorsell, J.W., ed. 1985. The Corbett Action Plan. In: *Conserving Asia's natural heritage.* Gland, Switzerland: IUCN.

United Nations Environment Programme (UNEP). 1985. *Management and conservation of renewable marine resources in the Indian Ocean region: Overview.* UNEP Regional Seas Reports and Studies No. 60. Nairobi.

United Nations Environment Programme (UNEP) and World Conservation Union (IUCN). 1988. *Coral Reefs of the World: Vol. 2 Indian Ocean, Red Sea and Gulf.* UNEP Regional Seas Directories and Bibliographies. Gland, Switzerland: IUCN; Nairobi: UNEP.

White, A.T., and J.I. Samarakoon. 1994. *Special area management for coastal resources: A first for Sri Lanka.* Coastal Management in Tropical Asia No. 2.

World Conservation Union (IUCN). 1990. *IUCN Directory of South Asian Protected Areas.* IUCN, Gland, Switzerland and Cambridge, U.K.

World Conservation Union (IUCN) and United Nations Environment Programme (UNEP). 1985. *Management and conservation of renewable marine resources in the South Asian Seas region.* UNEP Regional Seas Reports and Studies 62. Gland, Switzerland.

MARINE REGION 11
Arabian Seas

Anthony W. Chiffings

BIOGEOGRAPHY AND BIODIVERSITY

The Arabian Seas Marine Region includes marine areas from Djibouti to Pakistan, including the northern part of Somalia, the Red Sea, the Gulf, and parts of the Arabian Sea.[1]

Coastal and marine environments throughout the Arabian Seas Region are subject to increasing human pressures, many of which appear to have resulted in harmful environmental effects. Oil, phosphate mining (Hanna 1982, 1983a), and domestic, urban and industrial pollutants are a problem in several areas in the Gulf and the Gulf of Aqaba and have resulted in local habitat degradation, eutrophication and algal blooms. Throughout much of the Arabian Seas the coastal zone is becoming a repository for solid wastes. In the Red Sea, the ecological effects from oil exploitation, phosphate mining (Hanna 1982, 1983a,b), and industrial inputs (such as from mining) are of increasing concern, and will become more so if deep-sea metalliferous mud begin to be mined (Hanna 1983a; Nawabi 1983).

Ecological problems also result from the loss and degradation of productive coastal habitats caused by coastal landfill, dredging, and sedimentation. In some Gulf States (for example, Saudi Arabia), 40 percent of the coastline has now been developed, and a significant proportion of the shoreline of countries such as Kuwait and Bahrain is artificial. Loss of habitat extends to other parts of the region and to the wider Indian Ocean where approximately 50 percent of mangrove forests may have been lost over the last 20 years (IUCN/UNEP 1985c). Overfishing is a major concern in all areas of the region.

Degradation of coral reefs from heavy collecting and other recreational and tourism uses is becoming widespread, particularly in the Red Sea (Hanna and Ormond 1982; Ormond 1981; Hanna 1991). Fishing and hunting of adult turtles and birds (and their eggs) is extensive in some areas (Hanna 1994). The effects of land-based activities such as nutrient and sediment runoff from phosphate mining (Hanna 1982; Hanna and Ormond 1982), agriculture and grazing, and

reductions in freshwater seepage due to groundwater extraction are also contributing to degradation of coastal environments.

Oceanography

The Arabian Seas Marine Region is a natural unit created by the geological history that formed the Arabian peninsula and its associated regional seas and the maritime climate that is dictated primarily by the seasonal monsoons associated with the Asian continent.

Map 11 shows ideal summer and winter wind distribution and surface circulation patterns for the Indian Ocean. Wyrtki (1973) and Shepherd, Price, and Roberts (1992) provide concise descriptions of the physical oceanography of the Indian Ocean, including the monsoon gyre.

The Red Sea, a product of deep-ocean rifting, extends for 2,100 kilometers from Suez to the Strait of Bab el-Mandeb, which connects it with the Gulf of Aden and the Indian Ocean. The Sea has an average depth of 500 meters, with a maximum of over 2,000 meters, and is noted for some of the hottest and most saline seawater in the world. In the south, surface water temperatures exceed 30°C in summer, while salinity is 40°/oo in the north in winter and up to 46°/oo in the middle of the Suez Canal.

The Red Sea has a number of unique features. It is the warmest and most saline of the world's seas. It has no permanent inflowing coastal rivers or streams, only sudden brief torrents, and mostly northwesterly prevailing winds, which contribute material to the sea floor. The nature and distribution of sediments are unlike those in other seas. The Red Sea is partially isolated from the open ocean (Hanna, personal communication). It is located in an arid, tropical zone. Rainfall in general is sparse and varies widely, with particular areas receiving no rainfall for months or years. Over the sea, rainfall may amount to as little as 10–15 millimeters per year, whereas along the coastline its estimated range is from a few millimeters per year along the northern part of the western shore, gradually increasing to 180 millimeters at Suakin (19°N) (Edwards 1987). These unique features have contributed to making the Red Sea vulnerable to the impacts of human activities.

The Gulf, in marked contrast, is a shallow sedimentary basin with an average depth of 31 meters. Freshwater is supplied by the Shatt el Arab and some Iranian rivers. Surface water temperatures range from 32–33°C in summer to 22–24°C in winter in the south but only 16°C in the north. Salinities generally range from about 38–40°/oo, increasing to more than 60°/oo in areas such as the Gulf of Salwa, but falling to around 37°/oo in the Gulf of Oman. Tides in the Kuwait region range up to 3.5–4.0 meters, whereas south of Al Kobar, on the Saudi coast, they are is less than 1 meter. Even so, strong tidal flows occur throughout the Gulf.

The Gulf of Oman is deep and largely open to the influence of the northern Indian Ocean (Arabian Sea). The oceanic coasts of Yemen and Oman are completely open to the influence of the northern Indian Ocean and are, in parts, subject to large oceanic upwellings that bring nutrientrich water to the surface, causing high productivity.

The coast of Pakistan constitutes the northern boundary of the Arabian Sea, with oceanic influences dominating over those of the continent, which is essentially a subtropical dessert. River flows are monsoonal, with the only major freshwater input coming from the Indus, at the eastern extremity that discharges some 200,000 gallons of water and 450 million tons of suspended sediment annually and forms the Indus cone, a subaqueous delta 1,500–2,000 kilometers long (Pernetta 1993).

Currents in the Gulf and the Red Sea largely result from density gradients in the water column. Evaporation in the Gulf causes movement of water inward through the Strait of Hormuz. Surface salinity is highest in the two large southern Gulf embay-

ments where greatest evaporation occurs. Denser water formed in these regions sinks toward the Strait of Hormuz while less-dense water enters along the surface and northern edge of the Strait, moving in a counterclockwise surface current and leaving the Gulf in the deeper and southern part of the Strait (Sheppard, Price, and Roberts 1992).

Currents in the Arabian Sea result from the removal of surface water during the summer monsoon and its replacement by cooler upwelling water (Sheppard, Price, and Roberts 1992).

Surface water density in the Red Sea rises with a fall in water temperature to the north and evaporation causing increased salinity. Decreasing temperatures and evaporation in the Gulf of Suez result in the formation of dense water that turns under and is returned southward in the deep Red Sea (Sheppard, Price, and Roberts 1992).

Circulation and exchange in the Red Sea is not well understood, but is thought to be quite complex as a product of the low-energy regimes involved. In simple terms though, in winter (September–June) surface water is driven into the Red Sea by prevailing winds from the southeast, beneath which there is a deep outward flow of more dense, saline water. During summer, prevailing winds change to the northwest, driving the upper water layer out of the Red Sea over a deeper inward flow from the Gulf of Aden. Net outflows are 10 percent higher in salinity, and balance the effects of evaporation in the Red Sea.

Tides in the two regional seas are in the range of 0.5–1.5 meters. In both the Red Sea and the Gulf, tidal movement provides nutrients necessary for the vigorous growth of benthic biota. The central Red Sea is almost tideless and has wind-driven seasonal changes in water level that are more significant.

The Arabian Sea coastline of the Arabian peninsula has a tidal range of 1.5–2.5 meters over most of its length, but these tides are thought to be subordinate to the persistent impact of high-energy waves (Sheppard, Price, and Roberts 1992). The Pakistani coast has tides of up to a 3.5-meter range (Pernetta 1993).

Coastal Geography and Geology

The main body of the Red Sea lies in a rift valley separating the African and Arabian plates (Drake and Girdler 1964; Quennel 1958). Plateaus and mountains rise steeply to more than 1,000 meters above sea level north of Jeddah and 3,660 meters in Yemen. The coastal plain is from 2–50 kilometers wide and slopes up gently to the east until it meets the mountains. The mountains are deeply cut by valleys but streams flowing in the uplands fail to cross the coastal plain to reach the sea (Schwartz 1982).

The Gulf of Aqaba is 170 kilometers long and 14–26 kilometers wide and forms part of the Afro-Syrian Rift System with steep walls dropping to great depths (2,000 meters in places). It is separated from the Red Sea by the 6-kilometer wide Straits of Tiran. Fringing reefs lie along most of the Sinai Peninsula shoreline (Hanna, personal communication).

The Gulf of Suez is a wide, shallow basin with an average depth of 20–30 meters, greater depths in the central trough, and a depth of 90 meters at the entrance to the Red Sea. The fringing reefs in the Gulf of Suez are not as well developed as those in the Gulf of Aqaba.

The Red Sea Barrier Reef is located 10–40 kilometers off the coast of Saudi Arabia and is about 400 kilometers long and several kilometers wide. The platform surface is 30–60 meters deep, on which sit many steep-sided patch reefs. Almost continuous marginal coral reefs occur along much of the coast from the Gulf of Aqaba to the Strait of Bab al-Mandeb. A similar description of the reef morphology also applies to the African side of the Red Sea. The mainland coast along the southern Red Sea has experienced less

uplift than other areas, with some subsidence in recent times. The Farasan and Dahlak Archipelagos are relicts of an ancient carbonate platform a few hundred meters thick that grew on ancient evaporitic salt deposits.

The Gulf lies between the Arabian and Iranian plates, and there is a strong contrast between the sheer eastern coast and the flat, low western coast. The Arabian western coast is generally low, flat and sandy. Beach sands may be cemented into beach rock. Often a sandbar overtopped by dunes isolates large lagoons flooded in winter but dry and covered by salt or gypsum for the rest of the year. Extensive algal and intertidal flats occur south of the Bahrain archipelago. The coast of the United Arab Emirates is characterized by a number of broad, sandy flats and lagoons and edged with barrier and fringing reefs.

At the northern end of the Gulf is the vast deltaic plain of the Euphrates, Tigris and Karun rivers that is formed of swamps, sandbars, spits and islands with fluctuating boundaries. The eastern coast is a region of extensive continental sedimentation. It is flat and low as far as Bushehr, then rocky and cliffed. In front of Ras Musandam the coast forms a large recess at the Strait of Hormuz, with two main islands—Queshm and Hormuz. Along the north shore, cliffs and deltaic plains alternate.

The open, oceanic coast of Oman and Yemen includes sandy and rocky stretches with ragged cliffs. The southern coast of the Arabian peninsular is composed of rocky headlands with cliffs alternating with shores of fine sands buffeted by oceanic swells.

The Baluchistan coast (700 kilometers, 75 percent of which is in Pakistan) is steep with rugged outcrops and is dominated by short, sandy beaches backing on to high, near-vertical cliffs or sometimes sandy plains or dunes. Much of the area is volcanically active. Eastward, greater variation occurs, from steep cliffs, up to 145 meters high, to tidal lagoons, including tidal deltas, and mud volcanoes. The Indus Delta, with its extensive mudflats, tidal channels and mangroves, has already been described (see Pernetta 1993).

Ecosystem Diversity

The following discussion is adapted from Sheppard, Price, and Roberts (1992) and Hanna (1991 and 1994).

Sabkha

Sabkha is a widespread inter- and supratidal habitat, measuring many kilometers across in places. It forms flat plains, with crusts of sodium chloride and gypsum, with important "algal mats" a few centimeters thick, beneath which is a black reducing layer. The mats are complex associations of cyanophytes, bacteria and diatoms. Pools are a special feature of sabkha. Those with subterranean connection with the sea have a relatively high benthic diversity. With increasing isolation from the sea, diversity falls and the persistent microbial biota then forms a typical mat. These are highly productive and fix nitrogen. When desiccated in summer, mats become dry and crisp, breaking into characteristic polygons.

Large areas of Sabkha are found in the United Arab Emirates, the Bar al Hiskmann peninsula in Oman, along the shores of the Gulf of Suez, and much of the Saudi Red Sea coast.

Marshes and Wetlands

Salt marshes have been greatly reduced or eliminated throughout much of Arabia, although marshes of the Shatt al Arab still cover approximately 18,500 square kilometers. Eleven halophytic community types have been described, largely on the basis of elevation and periodicity of immersion. In places, reed vegetation is strongly enhanced by sewage enrichment, when it may reach heights of up to 5 meters. In the Gulf and parts of the Red Sea (not the northern Red

Sea), many new marsh communities are appearing as a result of sewage outfalls along the coast of Saudi Arabia and near Port Sudan. Enrichment not only stimulates marsh development, but in the case of the Red Sea, also adds significant nutrient loads. These areas act as a focus for numerous species of birds, especially migrants.

About 3 percent of the Egyptian coast is comprised of saltmarsh (Hanna 1994). Saltmarshes in the northwestern Red Sea are located around Ras-Mohammed, Abu-Monqar, Wadi El-Gemal islands and Gebel Elba.

Numerous deltas and estuaries with extensive intertidal mudflats and their associated wetlands occur along the Pakistani coast. The Indus Delta has an estimated 3,000 square kilometers of delta marshes.

Sandy Shores

Most sandy shores in the northern Red Sea are narrow beaches adjoining coral reef flats, which themselves are usually narrow. Broader beaches occur where the reef edge swings further out from shore, leaving a lagoon. Sand beaches are most important and extensive in the Arabian Sea. A study by McCain (1984) found that in the Gulf every square meter could contain 400,000 animals, each over 0.5 millimeters in size, with faunal abundance significantly correlated to slope. The total number of species found in this study was 147, much less than on the rocky shores. Sandy beaches are also a feature of parts of the Gulf of Oman and the Pakistani coastline.

Rocky Shores

The diversity of rocky shores is significantly higher than that of sandy beaches or mud, although biomass may be less. Hanna (1994) found that about 20 percent of the Egyptian Red Sea coast is formed by rocky, erosional, wave-cut cliffs. Basson and others (1977) note that the rocky intertidal in the Gulf is much less productive than sandy intertidal areas, attributing this to intense heating at low tides in summer. The rocky shores of Oman show a general increase in diversity southward, although little taxonomic work has been done in this area (Jones 1986; Campbell 1988).

Detailed descriptions of the Red Sea are provided by Jones, Ghamrawy, and Wahbeh (1987). Much of the available rocky intertidal zone of the north occurs in erosion notches of fossil cliffs. These provide a more moist and sheltered habitat than do the horizontal expanses of intertidal rock that are common in the south and support a greater range of the fauna.

Rocky shores are a major feature of the Gulf of Oman and the Pakistani coastline, as well as the Arabian Sea shore of Oman and Yemen.

Mangroves

The mangroves of Arabia include communities that grow on soft-bottom and hard-bottomed substrates, the latter being more prevalent in the northern Red Sea. Compared with other Indian Ocean mangroves, the number of mangrove and associated species in the Arabian Seas Marine Region is low, although most of the characteristic faunal zones are still present. Low diversity is attributed to the generally severe climatic and environmental conditions (such as high salinity), in conjunction with the more limited range of suitable habitats and niches.

Avicennia marina grows in both types of substrates and is the dominant mangrove species, tolerating the high salinities (40–50°/₀₀) and extremes of water temperature (12–35°C) associated with the Arabian Seas region. In the Red Sea, three other species are known but are uncommon. The northern latitudinal limit (27–28°N) of naturally occurring mangal ecosystems in both the Red Sea and Gulf is attributed largely to cold winter temperatures.

Mangroves are tallest (5–7 meters) in the southern Red Sea, where the continental

shelf is wider and the intertidal slopes more gradual, allowing development of better sedimentary conditions. In parts of Oman, *Avicennia* reaches 6 meters, whereas in the Gulf it is poorly developed and often stunted (1–2 meters), at least along western shores. Productivity of mangroves in the region is considered to be generally low, with the exception of the Indus delta (see below), although few quantitative studies have been undertaken.

Interactions between mangroves and adjacent ecosystems are probably greatest in the southern Red Sea and undoubtedly make a significant contribution to coastal productivity. Important mechanisms include transfer of nutrients and energy, aided by movements of fauna. Stabilization of shoreline sediments is also enhanced by mangroves, particularly in the southern Red Sea.

The Indus Delta has an estimated 44 percent of its intertidal area (260,000 hectares) covered in mangroves of four species, *Avicennia officinalis, Rhizophora conjugata, Ceriops tagal,* and *Salsola foetida,* that reach heights of 12–15 meters. These species line the tidal channels that extend inland for considerable distances. Tidal influence reaches 97 kilometers upstream as far as Tatta. These mangrove systems are extensively studied (Pernetta 1993). Mangrove areas are also found at other sites along the Pakistani coast.

Coral Reefs

The diverse and spectacular coral reefs for which the Red Sea is renowned are found only in its central and northern half. North of 20°N reefs are typically well developed and drop steeply into deepwater; south of 20°N, reefs occur in a shallow, turbid environment and are less developed. Greatest development occurs in offshore barrier reefs and in reefs fringing 1–7 kilometers wide alluvial plains on the mainland. Thinner reefs cover the Gulf of Aqaba and other northern shores. The continental shelf widens to the south and mainland shores are dominated by mangrove and sand beaches. Well-developed reefs occur around the Farasan and Dahlak Islands, which also support extensive mangroves.

The Gulf of Aden has very poor reefs because of upwelling water and sandy shorelines, and this condition continues down the coast of Somalia for 500 kilometers and north to the Muscat area of Oman. Further north, Musandam has the most diverse reefs, while Iran probably has the most developed. The coast of the United Arab Emirates is low lying and mostly swampy. Offshore the water is very shallow and rich in seagrasses, and while it is generally muddy and unsuitable for most corals, there are numerous patch reefs.

Algal reefs occur in the southern Red Sea in low-energy conditions. They support dense brown algal cover and provide important hard substrate in otherwise sandy areas.

A longitudinal series of coral reefs lie along the axis of the Red Sea on ridges resulting from normal faulting and upward movement of underlying salt deposits. These are widespread in the Red Sea. Atolls are also numerous and are found mostly on the ridges. Diverse reefs are found between Ras Shukhei and Quseir along the Egyptian coast and in the area of Ras Mohammad and the Straits of Tiran (Hanna, personal communication).

There is a fairly distinct Arabian coral species grouping. Within it, there is a single, principal division into a Red Sea group, and a Gulf of Oman/Arabian Sea group, which then fuses with the Gulf. In the Red Sea there are 13 principal coral communities, some of which can be subdivided further into a total of 22 recognizable units. Most show considerable localization, correlated with latitude but linked with gross changes in coastal bathymetry and morphology. On any one reef in the Red Sea, the general pattern of coral diversity with depth follows that of most Indo-Pacific reefs, rising to a maximum at 5–20 meters deep before declin-

ing. About two-thirds of species have a depth distribution that is not significantly skewed to deep or shallow water. Coral cover is usually less than 50 percent, but in sheltered areas one or two species, especially *Porites,* may cover 80 percent of the substrate.

In the Gulf, fewer coral communities exist: only five are recorded from Bahrain. Kuwait, Qatar, Bahrain and the United Arab Emirates have 30 species or less. Despite this, coral cover is high. The richest reefs known surround Saudi Arabian coral cays. At the entrance to the Gulf, Musandam contains reefs dominated by *Porites* and *Acropora.* In the Capital Area of Oman, substantial monospecific reefs of *Pocillopora damicornis* occur. Coral-dominated communities become rare further south.

Seagrasses

Eleven seagrass species are known for the Arabian Seas Marine Region, of which *Halodule uninervis* and *Halophila ovalis* are the most prevalent. Diversity is greatest in the Red Sea proper (10 species) and lowest in southeast Arabia (4 species) and the Gulf (4 species). Seagrass beds also attain greatest development in the Red Sea, particularly toward the south, despite the reverse trend shown by certain species. The seagrass distribution and diversity of the Pakistani coast is not well described at this time.

Studies on seagrass standing crop have been undertaken mostly in the northern Red Sea. Highest biomass is associated with *Thalassodendron ciliatum, Thalassia hemprichii* and *Syringodium isoetifolium.* Biomass of *Halodule uninervis*–dominated communities in the Gulf are comparable to figures for similar species in the Red Sea and elsewhere.

Seagrasses provide a mostly indirect food source and habitat for both resident fauna and temporary visitors, including commercially important fish and crustaceans (for example, *Penaeus semisulcatus).* Despite regional variation, available data suggest that both species richness and abundance of fauna are greater in the Gulf than in the Red Sea, at least in its northern parts. Benthic fauna (within seagrasses and sand or silt) in the Gulf are principally suspension feeders, that utilize more abundant organic particulates than occur in the clearer waters of the northern Red Sea.

Upwellings

In summer, prevailing winds flow down the Red Sea for its entire length, reinforcing the clockwise airflow in the Arabian Sea. This generates strong southwesterly winds, leading to cool, nutrient-rich upwelling. Upwellings result in higher nutrients and the development of Ecklonia kelp beds in places, inhibiting the development of coral reefs.

Species Diversity

The following discussion is adapted from Sheppard, Price, and Roberts (1992).

Plants

Seaweeds

There are extensive areas dominated by macroalgae on both reefs and other substrates. Brown algae are mostly of small species, although large forms occur on reef crests and in the Arabian Sea where upwelling is important. Green and red types are ubiquitous, the latter including some species that grow deeper in the Red Sea than anywhere else due to their utilization of blue light and energy-conserving growth patterns. Calcareous red algae are mainly restricted to very shallow areas. For many species, vigorous water movement is essential, although dense algal growth also occurs on unconsolidated substrate, helping to stabilize it. In a list derived from numerous earlier collections, Papenfuss (1968) recorded nearly 500 species of algae from the Red Sea. Basson and others (1977) and Basson

(1979) recorded only about one-tenth of this number of fleshy algae in the Gulf, and there has been little systematic collecting subsequently to indicate what the true numbers are.

In the Gulf there is usually a gradation from coral to algal domination on limestone platforms as stress increases, causing a demise of both corals and reef growth. In these conditions, usually termed "marginal," algal dominance arises from shading, greater tolerance of temperatures below 18°C, and high levels of dissolved nutrients.

Phytoplankton

Many species of plankton found in the Indian Ocean are absent from the Gulf and the Red Sea. Of 452 known Indian Ocean dinoflagellates, 130 have been recorded in the Arabian Sea, 88 in the Red Sea, and fewer still in the Gulf. The decline westward in the Red Sea is partly compensated by the presence of several endemics and by blooms of *Oscillatoria erythraeum*. Cell densities similarly decline westward. While the trend is similar in winter and summer, winter cell counts are one to two orders of magnitude greater. There is a large input of mesoplankton from the Gulf of Aden at peak times of influx, though most do not survive beyond the central Red Sea. In the Gulf, plankton densities are much greater than in the Red Sea, most being diatoms. Phytoplankton in the Arabian Sea is also dominated by diatoms as is typical of tropical upwelling areas. This area is the most fertile part of the Arabian Seas Marine Region

Pelagic primary productivity of the Red Sea is highest in the south. In the very clear Gulf of Aqaba, significant production continues to depth of about 200 meters (compared to 40 meters in the Arabian Sea). Summer values are approximately half those of winter.

Zooplankton

Zooplankton diversity declines westward. Peak numbers throughout the Red Sea lag a few weeks behind those of phytoplankton. Calanoid copepods are the most important group with 300 species in the Arabian Sea, 60 in the southern Red Sea, and 46 in the north. Euphausiids are important in terms of biomass, although of 22 Indian Ocean species, only 10 occur in the Red Sea. In the Gulf, zooplankton shows marked temporal and geographic variation; diversity is less than in the Arabian Sea but is similar to that in the Red Sea with 33–45 species per cubic meter near offshore islands. Densities are high and as many as 3,000 individuals per cubic meter have been recorded.

There is marked vertical stratification of zooplankton in the Red Sea. Peak diversity and abundance remain within the photic zone, but a secondary maximum is found near the oxygen minimum layer at 400-meters. Close to shore, demersal zooplankton and larvae of reproducing invertebrates tend to dominate measurements of numbers and productivity.

Fish

There are marked differences throughout the Arabian Seas Region in the structure and composition of fish assemblages, reflecting the heterogeneous nature of the environment.

The most diverse assemblages occur within the Red Sea with a total of approximately 1,000 species present (including non-reef species). The Gulf supports only about 200 species in total, of which at least 125 are found on reefs. Within the Red Sea there are major differences in assemblage composition between areas north and south of latitude 20°N. This may be due to the differences in reef habitat between these areas or differences in water quality, particularly the limit of penetration by nutrient-rich water from the Gulf of Aden (which occurs at around 20°N), and north–south gradients in temperature, salinity and turbidity.

The Gulfs of Aqaba and Suez support distinctive fish assemblages. Those of the Gulf

of Suez share greater affinities with southern Red Sea assemblages than with the Gulf of Aqaba, probably due to its shallow, turbid nature. The Gulf of Aden marks a division between a fauna dominated by Red Sea species to one dominated by Indian Ocean species in the Gulf of Oman and the Gulf. Upwelling of cold water in the Arabian Sea appears to provide this major biogeographic barrier. Compared with the Red Sea, reefs of the Gulf and Gulf of Oman support low-diversity fish assemblages. This probably reflects the scarcity of reef habitat and the extreme environmental conditions.

Although the region is relatively rich in terms of commercial finfish and shellfish species, the fisheries sector plays only a minor role in most national economies. In most countries the contribution of the fisheries sector to the gross domestic product is less than 1 percent. However, in the Sultanate of Oman revenue from fish was equivalent to 36.5 percent of the total oil export revenue for 1984, and fish currently are the most important export product after petroleum. In general, fisheries of the region seem to be suffering from overexploitation. This is particularly true in the case of the shrimp fisheries. Aside from overexploitation resulting from inadequate fisheries management, degradation of the environment is probably a major cause of the decline in fish and shrimp catches. This degradation includes the elimination of important nursery areas (especially for shrimp) by land reclamation and dredging in the coastal areas, destruction of feeding and breeding habitats by bottom trawling, and increased marine pollution by discharge of liquid and solid wastes into the marine environment. In addition, selective fishing for species of predator fish may have upset the balance between the different species.

Marine Reptiles

Sea Snakes

A recent review of snakes of Arabia (Gasperetti 1988) records that of the 55 species of sea snakes, 9 or 10 occur in some coastal waters of Arabia. All but one species of sea snake are found in shallow coastal waters, which may be turbid and where there is organically rich substrate. Notably, sea snakes do not occur in the Red Sea.

Turtles

Table 11.1 gives details of breeding turtle records and counts around Arabia (Miller, personal communication; Symens, personal communication; Sheppard, Price, and Roberts 1992).

The region is now very important for several species of turtles. A significant reduction in numbers of turtles from overexploitation has taken place (Miller 1989; Frazier, Ber-

Table 11.1 Breeding Turtle Records and Counts around Arabia

Location	*Green*	*Hawksbill*	*Loggerhead*	*Olive Ridley*
Gulf islands	750–1,000	100–300		
Daymaniyat Islands	+			
Capital Area, Oman	+	+		
Rass al Hadd	6,000			
Masirah Island	+	80	30,000	230
Gulf of Kutch				+
Gulf of Aden	—			
Red Sea	+	+		

— Data not available.

+ Indicates areas known to be important but for which reliable counts are not available.

tram, and Evans 1987). The most important part of the region for turtles is the Arabian Sea both in terms of numbers of breeding species and abundance of nesting individuals. Present levels of turtle populations are clearly reduced, providing a focus for conservation efforts in the region (Clarke and others 1986).

Marine Mammals

Dugong

The dugong occurs in both the Gulf and Red Seas. It has not been recorded along the Arabian shores of the Arabian Sea where very few sites of suitable habit occur. In Oman, there have been no confirmed sightings of dugong. The estimated Gulf population is 7,310 (about 1,300) individuals, making this the most important area for the species in the western part of its range, and second in global importance only to Australia. In the Red Sea dugong are estimated to number about 4,000. Dugong are actively hunted and are also caught accidentally (Preen 1989).

Whales and Dolphins

There has been no systematic survey of whales or dolphins in any of the coastal waters of the Arabian Seas. The greatest number of records come from the Arabian Sea, where both dolphins (and toothed whales) and several baleen whales have been reported. At least a dozen species of dolphin, and finless porpoise, have been recorded for the Arabian Sea and coastal waters. Fourteen species of cetacean, including three species of great whale (blue, Bryde's and sperm), have been recorded in the Gulf of Aden (Smith and Smith 1991).

Gallagher (1991) lists 14 species of toothed whale and dolphin from Oman, based on a collection of stranded carcasses. Humpback whales are believed to breed off Oman, and the highly productive upwellings that occur along this coast are thought to be an important feeding area for this endangered species (Reeves, Leatherwood, and Papastavrou 1991). Papastavrou and Salm (1991) describe a small-scale marine mammal fishery in Oman.

Basson and others (1977) reported that several species of dolphin occur in the Gulf, some in schools of hundreds. Four small-cetacean species are known to occur in the Gulf, including the finless porpoise (*Neophocaena phocanoides*). Three to four species of great whales have also been recorded, although it is probable that these animals are not resident but strand after becoming trapped (Preen, personal communication).

Concern about the long-term survival of marine mammals in the Gulf has arisen as a result of a series of die-offs. In 1983 at least 38 dugong and 33 dolphins stranded along the Saudi Gulf and Bahrain. This die-off was coincidental with the Nowruz oil spill, but there was no direct evidence to link the two events (Preen 1989). In 1986 over 500 dolphins died in Saudi Arabia, Bahrain and Qatar (Preen 1991). In 1991 at least 79 dolphins and 14 dugongs stranded along the Saudi coast of the Gulf of Salwa. This die-off coincided with the Gulf War oil spill, but occurred several hundred kilometers south of the most heavily polluted area (Preen 1991).

Frazier, Bertram, and Evans (1987) reported that eight species of dolphins and toothed whales occur in the Red Sea and claimed that the Spotted dolphin (*Stenalla attenuata*) was the most common. IUCN/MEPA (1987) reported from their coastal surveys along the Saudi coast that more than 90 percent of dolphin sightings were of the common dolphin (*Delphinus delphis*), whereas in the southern Red Sea, at least around the Farasan islands, the spinner dolphin (*Stenella longirostris*) is the most abundant species (Preen, personal communication). These differences in reporting may reflect either an area difference, or misidentification. While baleen whales were not reported by Frazier, Bertram, and Evans (1987) or IUCN/MEPA (1984, 1987) more recent evidence suggests that some whales are

relatively common in at least the southern Red Sea. Four whales, thought to be Bryde's whales, were observed during an aerial survey of the Farasans in August 1987 (Preen 1989), and in another survey in September 1993, three animals were seen (probably *Balaenoptera edeni*) and four skeletons located. Local fishermen maintain that whales occur in the area all year-round (Preen, personal communication). Four whale skeletons, possibly *B. edeni, B. physalus, B. borealis*, and *B. musculus*, were recorded in Yemen in 1988 (Preen, personal communication) and whales, possibly Bryde's have been seen blowing off Kamaran Island (Porter, personal communication).

It should be noted that the whole of the region is part of the Indian Ocean Whale Sanctuary established in 1979 to provide protection to the great whales from commercial whaling (Holt 1983).

Biogeographic Classification

The following provisional biogeographic classification of the Arabian Seas Region was prepared by Tony Chiffings and is based on the approach of Hayden, Ray, and Dolan (1984) and other sources as noted (see Map 11).

Realms and Regions

Hayden, Ray, and Dolan (1984) defined an equatorial boundary separating the northern Indian Ocean from the greater part of the Indian Ocean at between 5–10°S latitude. They consider it to be a single ocean realm. This classification is well supported by the physical evidence. Regional circulation is strongly influenced by monsoons down to a latitude of 10°S, resulting in a semiannual reversal of the surface circulation. Regional water movement is also influenced by the outpouring of cold, high-salinity water from the Arabian Gulf, and to some extent the Red Sea, leading to an independent rudimentary meridian circulation (Dietrich 1973). It should be noted that in no other ocean does such a reversing, monsoon gyre form (Wyrtki 1973).

The boundary between the northern Indian Ocean monsoon system of circulation and the subtropical gyre is well defined by a subsurface front that separates the low-oxygen, high-nutrient waters in the north from the high-oxygen, low-nutrient waters in the south (Wyrtki 1973). Nutrients, chlorophyll "a" concentrations, and primary production data presented by Krey (1973) also support this division.

Wyrtki (1973) provides a concise description of the physical oceanography of the Indian Ocean, including the monsoon gyre. Sen Gupta and Naqvi (1984) review the chemical oceanography of the northern Indian Ocean.

Hayden, Ray, and Dolan (1984) considered the coastal area from Pakistan to Somalia to be the Coastal-margin realm "Eastern monsoon (J)," a realm that also appears on the eastern side of India. Both share common wind distribution and surface current patterns. The important distinction between the two is the high volume of river runoff in the Bay of Bengal and a large excess of evaporation over precipitation and runoff in the Arabian Sea, Arabian Gulf and Red Sea (Sen Gupta and Naqvi 1984).

The Red Sea and Arabian Gulf are both considered by Hayden, Ray, and Dolan (1984) as marginal seas. Again, this distinction is well supported by the physical oceanographic evidence (for example, Detrich 1973; Wyrtki 1973; Morcos 1970 and Hunter 1982 and 1983).

Comparison of surface distributions of temperature, salinity, oxygen, phosphate-phosphorus, nitrate-nitrogen, relative transparency, and silicates all suggest that Socotra Island and its associated islands should be considered a barrier between the eastern Somalia coast and the Gulf of Aden and that the Gulf of Aden should be considered a region separate to both the Red Sea and the upwelling area along the Oman coast. Based

on these data the latter should also be considered a region in its own right (Swallow 1984; Currie, Fisher, and Hargreaves 1973; Wyrtki 1973; McGill 1973; El-Sayed and Jitts 1973). Distribution data for total pigment concentrations during both monsoon periods for the Red Sea and western Arabian Sea presented by Halim (1973) also support this conclusion.

Tertiary production data for the Indian Ocean presented by Cushing (1973) support both the classification of the northern Indian Ocean into a distinct realm, and the identification of the areas adjacent to the Omani and northern Somali coasts as distinct regions. Limited total net biomass distribution data presented by Rao (1973) also support the latter conclusion.

Based on temperature and salinity data and inferred circulation (Morcos 1970; Edwards 1987), five distinct regions are recognized within the Red Sea. The southern (RS1), central (RS2) and northern (RS3) Red Sea form distinct regions based largely on salinity discontinuities and inferred mixing.

Weikert (1987) describes a sharp nutrient decline in surface waters at 19°N consistent with the maximum extension of Gulf of Aden water, which is presumably reflected also in the rate of salinity change shown in Edwards (1987). Weikert (1987) also divides the body of the Red Sea into three regions in tabulated data for daily primary production, phytoplankton and zooplankton biomass, and abundance of the oceanic waters. The northern segment extends down to 24°N, the central segment from there on down to 18°N, and the southern segment from there on. These divisions fit well with the physical parameters.

The Gulf of Aqaba (RS4) and the Gulf of Suez (RS5) form two additional distinct regions, with the Gulf of Suez being relatively shallow (50 meters), vertically well mixed due to wind, and having well-developed latitudinal salinity and temperature gradients. This is in contrast to the Gulf of Aqaba that, as a deep (800–1,800 meters) continuation of the Red Sea, has seasonally related vertical mixing and less evident salinity and temperature gradients (Morcos 1970).

The Arabian Gulf has been regionalized on the basis of temperature, salinity, and circulation patterns presented by Hunter (1982) into five biogeographic regions. As with the Red Sea, discontinuities in salinity have been used as the principal demarcation element. The Arabian Gulf is a shallow sea (mean depth 35 meters) where evaporation exceeds runoff and precipitation gives rise to dense, saline waters, particularly in the shallow areas (less than 10 meters) of the southern and southwestern coasts (Hunter 1982). These areas form three of the regions determined here in this report—the Kuwait-Saudi coastal region (AG3), the Gulf of Salwa (AG4), and the Qatar-UAE region (AG5). The strongly influenced freshwater region of the Shatt-al-Arab (AG2) and the body of the Gulf from a 10-meter depth across to the Iranian coastline (AG1) form the forth and fifth regions, respectively.

Faunal Provinces

The Somalia, southern Arabian peninsula, and Arabian Gulf coasts are classified as a single faunal province (Western Indian ocean) by Hayden, Ray, and Dolan (1984). The Pakistani coast is considered the westernmost extent of a province (Indo-Polynesian) that extends right through to southern China, along the northeastern coast of Australia, and around the New Hebrides and New Caledonia. The Red Sea is classified as a separate province.

The identification of the Red Sea by Briggs (1974) as a separate province is well supported by the information in more recent reviews of the fauna and flora of the Red Sea (in Edwards and Head 1987). Crossland and others (1987), in reviewing all of the available data for the eastern side of the Red Sea, classified it into four different regions based on a review of existing biological data. This is a classification that could be ex-

tended across to the western coast given the consistency with relevant isoclines (see above), and commonality of physiography and such biological features as coral reefs (Bemert and Ormond 1981). Such a conclusion is consistent with that of Moore (1987) when considering the nutrient and phytoplankton status.

The five regions recognized above for the Red Sea appear to be largely consistent with the floral and faunal subprovinces recognized by Crossland and others (1987), although they placed the southern boundary for the central segment at 22°N, not 24°N. This is coincidental with the start of the southward-extending continental shelf, suggesting that the shallow bathymetry is an important controlling fact for these southern, inshore communities. This is an observation that Moore (1987) also strongly supports. It is important to note that in Edwards and Head (1987) the discussion of subdivisions does not always make the distinction between nearshore coastal distributions and those offshore or oceanic .

The inclusion of the Arabian Gulf by Briggs (1974) in the Western Indian Ocean province may no longer be appropriate. Price (1982) reported that 12 percent of echinoderms are endemic and that the levels of endemism for Arabian Gulf fish is higher than originally thought, and may approach those of the Red Sea. As a result, the Arabian Gulf has been recognized as a separate faunal province here.

Within the Arabian Gulf itself the division into subprovinces is difficult in that the biotopes of the Gulf have not been specifically considered in this way before. In addition, while the coastal areas of Kuwait, Saudi Arabia and Bahrain have been extensively studied (for example, Basson 1977; Jones 1986; MEPA 1987b,c; Price, Vousden, and Ormond 1983; Price and others 1987) studies elsewhere in the Gulf are limited. Based on this work, it seems reasonable to identify the Gulf of Salwa and the Kuwait-Saudi coasts as separate and distinct biogeographic entities. The status of the Iraq-Iran and the Qatar-UAE coastal regions remains unqualified.

Until more evidence is forthcoming, the northern region of the Gulf of Oman and the Pakistani region can appropriately be considered as part of the Indo-Polynesian province, as identified by Briggs (1974).

It should be noted that Sheppard, Price, and Roberts (1992) have most recently provided a detailed analysis and discussion of the biogeography of the Arabian region. They concluded that it was appropriate to designate the whole region as a biogeographic subregion, and not at the level of its component seas and gulfs. Even so, they recognized important ecological gradients or controls in species distribution and abundance that have been a prime consideration here for the boundaries identified in establishing the individual provinces, as this is considered most meaningful to the process of identifying areas for which MPAs are needed.

ASSESSMENT OF EXISTING MPAS

Description of National Systems

The following information is provided by Chiffings (1992) and is based on data from the World Conservation Monitoring Center (WCMC) and other sources as indicated.

Nineteen marine protected areas have been identified as having been declared under relevant national legislation (Map 11). Numerous other areas have been proposed as MPAs in scientific surveys and evaluations conducted over the last 10–15 years. There are also a number of coastal protected areas, many of which include intertidal terrain but have not been included as MPAs in this report because available information suggests that the marine component is relatively minor or incidental. A list of these areas is included in the Appendix.

The present level of management and active protection against human degradation

for most existing marine protected areas is not known. Some countries are making progress toward the establishment and management of MPAs, these include Oman, Saudi Arabia and Egypt. These initiatives should be recognized and encouraged. However, in most parts of the region the present level of protection for conservation of biodiversity is low.

Bahrain

Bahrain has no identified marine conservation areas except for Ras Tubli (Tabuli Bay) as a Nature Reserve, although the distribution of principal habitats is well understood. Damage from oil spills as result of the 1991 Gulf War was considerably less than on the Saudi coast. The Gulf of Sulwa region, including Bahraini and Qatari waters, contains the world's second largest population of dugong (Preen 1989) and therefore constitutes an area of vital conservation significance for this species.

Djibouti

Coral reefs occur to the west of the port of Djibouti and in the archipelago of the Sept Fréres, at the entrance to the Red Sea. An area of coral reef extending from the lighthouse at Musha to the Ile du Large is protected (IUCN 1992).

The following MPAs have been identified:
- Musha Territorial Park (Iles Moucha)
- South Maskali Islands Integral Reserve (occurs within Musha TP)

Egypt

Egypt has proposed a number of MPAs for the northern Red Sea and along the Sinai peninsula in both the Gulf of Suez and Gulf of Aqaba. The Government of Egypt has recognized the need for sustainable development in coastal regions and has requested assistance from the GEF to develop a coastal zone management program. This initiative would provide an important opportunity to establish a system of MPAs to conserve marine biodiversity and manage the use of marine resources in a sustainable manner. To date, six MPAs have been declared (one of which is an extension to an existing area).

The following MPAs have been identified:
- Abu Gallum Multiple Use Management Area
- Gebel Elba Conservation Area
- Nabq Multiple Use Management Area
- Ras Mohammed National Park

Ras Mohammed Sector, additional marine areas:
- Tiran-Sanafir Islands Protected Area

Ethiopia

The state of knowledge for much of the Gulf of Aden and the western Red Sea is extremely poor, with the exception of specific areas in Sudan and the Egyptian coast. The Ethiopian coastline is one of the least populated coastlines in the world and is owned by some of the poorest people in the world. Until recently the country has been torn by civil war for extended periods of time. One MPA has been declared but its present biological and management status is unknown. At present an IUCN adviser is working with the new Eritrean government on marine conservation issues.

The following MPAs have been identified:
- Dahalac Marine National Park

Islamic Republic of Iran

There is a number of protected areas along the Iranian coast. These include two of the three biogeographic zones covered by this country's coastline, the exception being the Indo-Pacific. However, the majority of these seem to be coastal terrestrial areas with others being proposed marine areas (for exam-

ple, Hara Marine Park). Only one established MPA could be confirmed. Its present legal status is not clear because it was declared prior to the Revolution in 1979. Likewise its level of management, the extent of degradation following eight years of war with Iraq, and possible impacts from the more recent Gulf War are not known.

The following MPA has been identified:
- Shidvar Wildlife Refuge

Iraq

There are no declared MPAs along the relatively short Iraqi Arabian Gulf coastline, which is restricted to an area next to the town of Faw by the mouth of the Shatt al Arab (mouth of the Euphrates and Tigris rivers). Areas that have not been developed and that are recommended for protection include the mudflats near Khore Zubair and Khor abd Allah (WCMC 1991). Prior to the Gulf War clear evidence of mangrove die-off in these areas was available in satellite imagery, and aerial surveillance immediately after the war showed strong indications of impact from oil spills, as well as other war damage. Drainage of the marsh areas of the Tigris-Euphrates Delta, and the damming of these two rivers may have a very large impact on the northern Gulf marine ecosystems.

Saudi Arabia

Saudi Arabia, through its Meteorological and Environmental Protection Administration (MEPA), has had detailed coastal surveys undertaken by IUCN for both its Arabian Gulf and Red Sea coasts (MEPA 1987a,b,c). A National Coastal Zone Management Plan has been proposed, which includes the identification of environmentally sensitive areas that need to be evaluated in detail prior to establishing a system of protected areas. An initial evaluation of these areas has been undertaken for the National Commission for Wildlife Conservation and Development (NCWCD) to identify areas for inclusion in the National Protected Areas System Plan (Chiffings 1989; Child and Grainger 1990). With the adoption of the System Plan, a review of each of the recommended areas and preparation of detailed management proposals is planned.

The northern Saudi Arabian Gulf coastal area was severely impacted by oil spills as a result of the Gulf War. Environmental consequences of the oil spills and burning oil wells have been determined from a number of studies (see Al-Rabah 1993; Price and Robinson 1993; CEC/NCWCD 1992, 1994; Sadiq and McCain 1993). A large-scale reevaluation of proposed MPAs has been made, based on detailed surveys and studies on damage and recovery, by an interdisciplinary team of more than 50 scientists from six European countries, Saudi Arabia, Kuwait and Bahrain (CEC/NCWCD 1992, 1994). As a result, a new MPA is being established comprising the two large embayments north of Jubail and the offshore coral islands. Other identified areas on the Saudi Gulf coast (for example, Tarut Bay) are suffering from severe degradation due to development.

The following MPAs have been identified:
- Farasan Islands Protected Area
- Um Al-Qamari Island Protected Area

Kuwait

Kuwait has no designated marine protected areas, although based on a major study by the Kuwait Institute for Scientific Research in 1988, the government had identified a series of nature conservation areas that were proposed in its Master Action Plans (WCMC 1991). While the coral islands of Qaru, Kubbar and Umm al-Muradum are only small areas on a regional scale, they are important to the protection of rare, high-latitude coral reefs and green turtle–nesting beaches. The shallow waters of Kuwait Bay are a critical nursery habitat for commercial species of

shrimp and fish and contain a unique species of mudskipper. The Bay, unfortunately, is rapidly succumbing to intense urban development pressure, including infilling.

Oman

Oman has a strong commitment to a coastal zone management program, which has been developed with IUCN, that includes the identification, declaration and management of MPAs. Oman is a particularly successful example of coastal zone management planning in the Arabian Seas. The government's commitment to coastal zone management has resulted in significant contributions to conservation of coastal and marine environments.

There are five coastal protected areas, three of which are MPAs and cover a range of environments, species, objectives and management issues. These vary from the remote Daymaniyat Islands where there are minimal resource use conflicts and globally significant habitats for hawksbill turtles and seabirds to the Qurum mangroves that lie in the heart of a major residential area (Price and Humphrey 1993). Other factors also contributing to marine conservation include traditional fishing controls, fisheries legislation and strict controls over land developments.

The following MPAs have been identified:

- Daymaniyat Islands National Nature Reserve
- Khawr Salalah BS Managed Nature Reserve
- Quru Managed Nature Reserve
- Ra's al Hadd (Turtle Reserve) Managed Nature Reserve
- Ra's al Jumayz National Nature Reserve

Pakistan

At present the status of MPAs in Pakistan is not clear. While Preen (1993) reports four, Niaz Rizvi, and Abdul Majid (personal communication) report no MPAs in Pakistan. Those proposed are intended to protect turtle nesting beaches. The exception is the recognition of the Indus Delta as a region of major conservation significance. Pernetta (1993) provides greater detail.

Qatar

Qatar has recently completed a detailed coastal inventory using fine scale, airborne image analysis, but has not declared MPAs as yet.

Republic of Yemen

The Republic of Yemen has identified four areas as proposed MPAs, including the Island of Socotra. The state of knowledge of the Republic's coastline is reasonably well known, particularly with respect to exploited fish resources. Available information is summarized in Sanders and Morgan (1989).

Sudan

The Sudan Marine Conservation Committee—an interdepartmental committee established in 1978—is responsible for marine conservation in Sudan. At present the Committee is concentrating on conservation activities in the Port Sudan area and a Marine National Park at Sanganeb (Nasr 1985). In 1984, Sudan agreed to cooperate with Egypt and established a protected area that includes the offshore islands and coastal mangrove stands in the Abraq, El Deib and Gebel Elba areas (Hanna, personal communication)

The following MPAs have been identified:

- Sanganeb Atoll Marine National Park
- Abraq, El Deib and Gebel Elba area Conservation Area

United Arab Emirates

Information on coastal marine areas in the United Arab Emirates (UAE) is very sparse.

Except for some areas that have been identified as proposed MPAs and Khor Dubai that has been declared a Nature Reserve, no areas have been declared. The central western area of the UAE (bounded by Abu al Abyad Island, Bu Tinah shoal and Ruwais) contains a large proportion of the Gulf dugong population and is of international significance for the conservation of this species (Preen 1989).

Other National Initiatives

In the Red Sea, protected areas have also been established in other countries (for example, Israel and Jordan), often in conjunction with zoning and other resource use policies. Further information on marine conservation in the regions is available in IUCN/UNEP (1985b), Ormond (1987), and Sheppard and Wells (1988).

International and Regional Initiatives Relating to MPAs

The following information is provided by Sheppard, Price, and Roberts (1992).

UNEP Regional Seas Programme

Included in the Regional Seas Programme are the Red Sea and Gulf of Aden region, and the Kuwait Action Plan (KAP) region (also known as the Gulf or the Regional Organization for Protection of the Marine Environment sea area or region).

The Kuwait Action Plan forms part of the broader Kuwait Regional Convention for the Protection of the Marine Environment from Pollution. All Gulf countries are signatories to the convention, the aims of which include the prevention and control of pollution from ships and other causes, the establishment of national standards, and the development of national research and monitoring programs relating to all types of pollution. The KAP operates through close cooperation with international organizations, regional organizations (for example, ROPME) and also with many national organizations, institutions and focal points. Many of the major conservation and research initiatives in both the Gulf and Red Sea have been part of UNEP's Regional Seas Program. After the 1991 Gulf War, ROPME was revitalized and moved back into its secretariat in Kuwait.

The Red Sea and Gulf of Aden Action Plan is based on the Regional Convention for the Conservation of the Red Sea and Gulf of Aden. Actively involved have been regional organizations such as ALECSO (Arab League Educational, Cultural and Scientific Organization), PERSGA (Environmental Program for the Red Sea and Gulf of Aden) and others, with ALECSO coordinating all activities and providing the interim secretariat for PERSGA, based at MEPA in Jeddah, Saudi Arabia. At present a revised plan is being drawn up following a recent meeting in January 1994 at Arab League headquarters in Cairo.

Other Regional and International Agreements

In addition to the UNEP Regional Seas Programme, there are other important regional agreements (Johnston 1981; Couper 1983; IUCN/UNEP 1985a,b; IUCN 1987). Included are the African Convention on Conservation of Natural Resources, the Saudi-Sudanese Red Sea Commission (deep-sea mining), the Arab Declaration on Environment and Development, the Gulf Cooperative Council (GCC), Marine Emergency Mutual Aid Centre (MEMAC), Gulf Area Oil Companies Mutual Aid Organization (GAOCMAO). These and other agreements relate to environmental management and pollution control.

Important international agreements include parts of the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on International Trade in Endangered Species (CITES), the Ramsar Convention, the Bonn Convention on Migratory Species, the Indian Ocean Alliance, Interna-

tional Biological Program (IBP), Man and the Biosphere Programme (MAB), the World Heritage Convention and others (Johnston 1981, Couper 1983) (Table 11.2).

Upholding regional and international agreements is particularly important in seas like the Red Sea and Gulf whose transboundary resources constitute global commons shared by many countries.

World Heritage

There are no World Heritage Sites in the region with a marine component.

Ramsar

The following Ramsar sites include marine habitat components:

- Shadegan Marshes and mudflats of Khor-al Anaya and Khor Musa (Iran)

UNESCO Man and the Biosphere Programme

As yet there are no marine Biosphere Reserves in the region.

MARPOL

The Red Sea, Gulf, Gulf of Oman and Gulf of Aden have been declared Special Areas under Annex I and V of the MARPOL treaty.

Assessment of Representation of Biogeographic Zones within MPAs

The following assessment is based on Chiffings (1992).

Gulf of Aden (GA)

There is only one site protected (Iles Moucha and South Maskali Islands) and three more identified. The biogeographic region is poorly represented, but even more poorly described. The coastlines of Somalia, Djibouti and the Republic of Yemen all need surveying before it will be possible to make recommendations on the location of suitable MPAs. The one exception to this is the Socotra Island archipelago that forms a boundary between the major Somali upwelling and the Gulf of Aden. This complete area should have very high priority for establishment as a Biosphere Reserve. This may require a cooperative effort between Somalia and the Republic of Yemen. Prior to the present civil war a proposal to establish Socotra Island (only) as a Biosphere Reserve was being prepared by the Environmental Protection Council of Yemen, together with UNESCO. A GEF funded coastal zone management program, focused on the Red Sea, was also to begin at the time that civil war broke out.

Table 11.2 Countries in the Arabian Seas Region that Are Party to the Major Conventions

Country	*World Heritage*	*Ramsar*	*UNESCO MAB*
Egypt	✓	✓	✓
Iran	✓	✓	✓
Jordan	✓	✓	
Kuwait			
Oman	✓		
Pakistan	✓	✓	
Saudi Arabia	✓		
United Arab Emirates			
Yemen	✓		

Southern Red Sea (RSl)

With two existing MPAs and numerous proposals for additional areas, the eastern Red Sea coast of the southern Red Sea zone is well covered in terms of MPAs that will ensure adequate conservation of biodiversity when the proposed areas are proclaimed and actively managed. At present, the risk of severe human degradation is relatively low but ever increasing as development proceeds in both southern Saudi Arabia and Yemen. It is worth noting that commercial

oil fields have been found offshore of the Yemen coast.

The western side of the southern Red Sea area is very poorly represented and just as poorly documented. There is one existing MPA in the Dahlac Islands. The area, however, does not seem to threatened by major development proposals. The Ethiopian and Eritrean people were until recently in the grip of one of the worst famines in modern African history and suffering the ravages of a civil war. This coast will need surveying before it will be possible to make recommendations on the location of suitable MPAs.

Central Red Sea (RS2)

Although there are as yet no established MPAs, the eastern side will be well covered by the Saudi system of proposed MPAs. However the western side is in need of strengthening. There are three existing MPAs along this coast but few other sites have been identified. Before a decision is taken as to where major biodiversity MPAs should be established in Sudan and southern Egypt, coastal and marine inventories need to be completed and compiled. In the case of the Sudan this could be arranged through the Sudan Marine Conservation Committee. The Egyptian coast has been assessed in the past (Hanna, personal communication) and these data need to be brought together for analysis and identification of priority sites and information gaps.

Northern Red Sea (RS3)

There are three existing MPAs in this zone and numerous proposals for additional areas. This is the one section of the Red Sea that has a good coverage of proposed MPAs on both coasts. It is now necessary to develop detailed management plans for these areas, particularly on the Egyptian coast as tourism is a fast-growing industry that may threaten the natural marine resources it depends on. The impact of oil pollution on the Egyptian Gulf of Suez and northern Red Sea are a major cause of reef and fisheries deterioration (Hanna, personal communication).

Gulf of Aqaba (RS4)

There are two existing MPAs in the Gulf of Aqaba and proposals for a number of additional areas. The eastern side has been well surveyed by Saudi Arabia and Jordan, and the Sinai side by Fishelson (1980). As it is an area of low population and represents an important international security corridor, extensive impacts from development are relatively unlikely in the immediate future.

Gulf of Suez (RS5)

There are no existing MPAs and those proposed are clumped at the Red Sea end of the Gulf. The same comments apply here as for the western, central Red Sea. Existing data need to be brought together to allow an initial assessment before proceeding in the selection representative areas.

Southern Oman (OM)

There is one existing MPA and numerous sites have been identified for MPA status. This area is part of the Omani CZM program and as such has a good representation of MPAs intended to conserve biodiversity.

Indo-Pacific (IP1)

There are four existing MPAs. On the Omani side of the Gulf of Oman the same comments apply as above for the southern Omani coast.

The Iranian and Pakistani coasts are very poorly represented with no existing MPAs and few additional areas proposed. Again, the present state of knowledge about this coast is poor and therefore requires systematic documentation before appropriate recommendation on the location of suitable MPAs. Because of the importance of parts of

this coastline to individual species (for example, turtles and migratory waders), detailed knowledge about specific areas already exists. The next step is to review this information to identify what additional information is necessary in order to proceed further. Preen (1993) has done this for Pakistan and proposes a list of protected areas.

Arabian Gulf Basin (AG1)

There is one existing MPA. There are several other coastal areas that appear to provide a good geographic cover, but the existence of a marine component, its actual extent, and the present biological and management status of each of the sites needs to be established.

Shatt al Arab (AG2)

There are no existing MPAs. The Shadegan marshes (included in a protected area that includes intertidal elements) is a site of major international significance for a wide range of both resident and migratory birds, hence their status as a Ramsar Treaty site. As with the rest of the Gulf their present biological status needs to be assessed so that a remediation plan can be prepared for the Gulf region as a whole (see below).

Southern Coastal Arabian Gulf (AG3)

There are no existing MPAs and although the extent of proposed MPAs represents the biodiversity needs of this region, the present biological status of these areas needs to be assessed following the impacts of the Gulf War. The ever-increasing impacts of development are also a major threat, with some areas already suffering major habitat loss and associated environmental degradation.

Gulf of Salwa (AG4)

There are no existing MPAs. Two areas proposed by Saudi Arabia are representative of the western part of the Gulf of Salwa. Given the relatively pristine nature of the area and its global importance to the conservation of Dugong (Preen 1989), there is the urgent need though, to see these and comparable areas in Bahrain and Qatar waters committed as a major Biosphere Reserve.

Qatar-UAE Coastal (AG5)

There are no existing MPAs, and while the United Arab Emirates have proposed a good representative sample of areas on the eastern side of the region these may not fully meet biodiversity conservation needs. Although it represents a diverse and important set of habitats there is no known systematic, nor overall, survey of the region. This region is also an area of particular conservation significance to dugong (Preen 1989). Again, surveying at a regional scale to identify nature and extent of major biotopes is the most important priority at this time.

PRIORITY AREAS AND RECOMMENDATIONS

The following recommendations and priority areas are a product of the review process carried out to develop this report. Due to the limited feedback from some parts of the region they do not necessarily represent the views of the relevant authorities within each of the listed countries. Priorities for Kuwait and Oman were submitted by relevant government authorities.

National Priority Areas for Marine Biodiversity Conservation

Further contact with many of the countries in the region will be required to identify areas of national conservation significance. Based on the submissions received, the following areas can be highlighted.

Egypt

- El-Ghardaqa

- Abu Monqar and El-Gaftun Islands
- Shadwan and Gubal Islands
- Tiran/Sanifar Islands and Ras Mohammed
- Gabel Elba together with Siyal and Rawabel Islands

Kingdom of Saudi Arabia

- Farasan-Gizan area

Kuwait

- Coral Islands of Qaru, Kubbar and Umm al-Muradam
- Kuwait Bay

Oman

- Daymaniat Islands

Regional Priority Areas

The areas listed below have been identified as being of highest priority at the regional level after consideration of the criteria listed in the introduction to this report. Most areas are proposals for the establishment of new MPAs rather than direct support to the management of existing areas, although in some instances the priority areas are large and include one or more smaller MPAs. Improved management of such MPAs should be a priority. In some cases only limited information has been available to describe particular areas.

Proposed New MPAs

- The Arabian Gulf-Gulf of Salwa (Saudi Arabia, Bahrain, Qatar (26°0′N, 50°5′E)): As a complete biogeographic province this area is of global importance. It is also has global status as a major conservation area for the dugong and other rare and endangered species. It is therefore recommended that, over and above the specific areas identified in Saudi Arabia, the Gulf of Salwa, shared between Saudi Arabia, Bahrain and Qatar, be considered a priority area for the establishment of a regional MPA (such as a Biosphere Reserve) so as to ensure the protection of a major part of the Gulf dugong population—the largest known outside of Australia (Preen 1989). Protection should also be afforded to the seagrass beds, reefs and island of the central western area of the UAE (approximately bounded by Abu al Anyad Island, Bu Tinah shoal and Ruwais), as this area supports most of the remainder of the Gulf dugong population and is suspected of being an important turtle feeding area.
- Farasan-Gizan Area-Red Sea (Saudi Arabia (16°8′N, 42°5′E)): This area includes the Farasan archipelago of over 100 islands (largest, 381 square kilometers) with its extensive series of fringing and patch reefs. Inshore waters include large areas of mangroves, mudflats and seagrass beds that support one of the three important dugong populations known from the Red Sea and a large shrimp fishery. Preliminary evidence suggests that the area is an important site for cetaceans, with herds of up to 600 spinner dolphins seen in the area and large baleen whales occurring among the Farasan Islands throughout the year. Most of the area is largely undisturbed and has been the subject of a number of recommendations for protection (UNEP/IUCN 1988). There is an MPA established in the immediate vicinity of Farasan Islands. It is recommended that protection be extended to cover a wider area of the archipelago.
- Tiran Islands Area (Egypt, Saudi Arabia (28°0′N, 34°8′E)): These islands occur at the mouth of the Gulf of Aqaba and include Tiran, Sinafir and Burqan Islands. There are well developed and diverse reefs and abundant fish life, and

dugong have been recorded. Green turtles nest on Tiran and Sinafir Islands. The straits between the islands are an important shipping lane. The islands have been proposed for protection by a number of studies (UNEP/IUCN 1985a,b,c) and are included in the Saudi coastal planning process. The Egyptian government also has a coast guard station on one island and has appointed park rangers to the area. Parts of the area fall within three Egyptian MPAs: Ras Mohammed National Park, Nabq Multiple Use Management Area, and Tiran-Sanafir Islands Protected Area.

- Straits of Gubal (Egypt (27°5′N, 34°0′E)): This area lies at the entrance to the Gulf of Suez and includes the islands of Gubal, Giftun, Shadwan, El-Ghardaqa, Abu-Ramada, Magawish, Abu-Monquar, El-Fanidir, Abu-Galawa and Abu Sadaf. The Straits are a major shipping lane for ships passing through the Suez Canal. The area includes well-developed and diverse coral reefs and nesting grounds for hawksbill turtles and has been the subject of a number of recommendations for protection (UNEP/IUCN 1988).
- Southern Egypt (proposed) Marine Park: Mersa Alam—Sudanese Border (Egypt (23–27°N, 33–35°5′E)): This section of the Egyptian Red Sea coast includes the Gebel Elba and Ras Banas areas, both of which exhibit high biodiversity, and typical marine areas of the western Red Sea coast. The area is described by UNEP/IUCN (1988) and has been proposed for a large MPA that would incorporate a range of levels of protection (see also Ormond 1980, 1981). There is an existing MPA at Gebel Elba.
- Socotra Island (Yemen (26°0′N, 51°0′E)): The Socotra Island archipelago forms the boundary between the major Somali upwelling and the Gulf of Aden and is of high priority for protection.
- Wejh Bank (Saudi Arabia (25°6′N, 36°8′E)): The Wejh Bank is a very large complex of reefs surrounding a central lagoon containing many small patch reefs and mangroves. Patch reefs have high coral cover and dugong may be present. The area lies in an isolated region with little effects from development (UNEP/IUCN 1985a,b,c). The Wejh Bank area is one of the three very important areas for dugong along the eastern Red Sea coast.
- Qishran Islands-Ras al Askar (Saudi Arabia (20°3′N, 39°8′N)): On the central Red Sea Coast near the town of Al-Lith, this area straddles biogeographic areas RS1 and RS2. The third of the three most important dugong areas on the east coast, it includes numerous islands, mangrove areas, coral reefs and seagrass beds. Quishran and other islands in the area are known turtle-breeding sites (Miller 1989).
- Marshes of the Tigris and Euphrates (Iraq (30°5′N, 40°0′E)): The draining of these marshlands and the damming of the two rivers has the potential of dramatically altering the ecology of the marine systems in the northern Gulf, as well as the critical transmigratory feeding, and breeding habitats for waders.
- Ras Suwahil (Saudi Arabia (28°7′N, 34°8′E)): The area has been identified as a proposed MPA.
- Outer Indus Delta (Pakistan (24°0′N, 67°5′E)): The area extends southeast from Karachi to the Indian border. Management plans are being proposed.

This report has not concentrated on the important marine and coastal bird areas in the region. These have been identified over the past two years in a project that culmi-

nated in the publication, *Important Bird Areas (IBAs) in the Middle East*, by Birdlife International. Over 100 of the 400 sites identified are coastal and marine and have been selected because of the occurrence of globally or regionally threatened species, concentrations of seabirds or waterfowl, or the presence of species wholly or largely restricted to the Middle East (Porter, personal communication).

Existing MPAs that Require Management Support

No existing MPAs have been recommended as individual priority sites for management support. However, a number of existing MPAs fall within some of the areas proposed above, and these MPAs should be candidates for management support. These include the Farasan Islands (Saudi Arabia), Nabq Multiple Use Management Area, Ras Mohammed National Park and Tiran-Sanafir Islands Protected Area (Egypt), and Gebel Elba Conservation Area (Egypt).

Other Recommendations

The following are recommendations for action at the regional or national levels of activity. To date, there is not enough detailed knowledge of specific areas or incountry programs to make sensible recommendations as to where more specific efforts should be placed. A general note, however, is that action at the local level may frequently have a training and awareness role well beyond the return to the immediate region.

This region is one where the coastal resources are either extremely well documented and a major coastal zone management undertaking has already been initiated, or where there is little or no systematic understanding and conservation efforts are the domain of a very small number of concerned government officials.

At this time the major knowledge gaps are the lack of systematic surveys of species and community composition for large parts of the region—the Gulf of Aden, the western side of the Red Sea, particularly the southern and central region, the Qatar-UAE region of the Arabian Gulf, and the northern side of the Arabian Gulf and Gulf of Oman. Considering the extensive nature of these areas, it is proposed that in the first instance there should be an emphasis on systematic survey using a systems approach that identifies the nature and extent of key biotopes at regional scales. This can be done relatively quickly and cheaply by a small team using modern mapping techniques including satellite imagery, oblique aerial photography, and limited ground survey (for example, Price and others 1987, MEPA 1987b). This is a particularly powerful approach when coupled with local knowledge and expertise. This kind of approach is likely to prove to be the most efficient method of gathering the data necessary to carry out an assessment of priority areas for MPAs.

The following recommendations are made for actions that are considered to be of regional priority:

- The Arabian Gulf as a complete biogeographic province is of global importance in its own right. It has global status as a major conservation area for dugong (classified as vulnerable) and other rare or endangered species.
- A regional survey of the Gulf of Aden is a basic first step to identifying areas for inclusion in a system of MPAs. Particular attention should be given to the Socotra archipelago. The Royal Geographic Society of the U.K. planning for a expedition to study biogeographic features of the Gulf of Adenand adjacent areas has been disrupted due to recent political events in Yemen, as has a GEF-funded coastal zone management program for Yemen.
- Where some information already exists, for example, in Pakistan, Iran, Egypt and

the Sudan, support should be given to enable reviews, such as that recently completed for Pakistan, to be undertaken to identify major gaps in knowledge (Pernetta 1993).

- A preliminary appraisal should be obtained of the vulnerability of the coast of Ethiopia and the Sudan to development pressures in order to establish a priority on the need for further action. After identifying areas of present or high potential impact, a program should be supported to enable resource use planning and management so that exploitation can be undertaken in a sustainable manner.

NOTE

1. The region, originally referred to as the North West Indian Ocean Region, includes the Red Sea and its two Gulfs, the Gulf of Aden, the Arabian/Persian/Iranian Gulf, the Gulf of Oman, and that part of the northern Indian Ocean generally referred to as the Arabian Sea. The descriptor "Arabian Seas" has now been adopted as a clearer description of the region biogeographically, without compromising local naming conventions. In keeping with the convention adopted by Sheppard, Price, and Roberts (1992), the Arabian/Persian/Iranian Gulf shall be referred to throughout the text as the "Gulf" (see also the discussions on naming conventions and biogeographic considerations in the same reference).

Appendix Unconfirmed/Proposed MPAs in the Arabian Seas Marine Region

Country/ Territory	*Protected Area Name*	*Zone*	*IUCN Category*	*Area (hectares)*
Egypt	Giftun Islands MP	RS5	PRO	
	Gubal Islands MR	RS5	REC	
	Hamata Marine Zone NA	RS3	PRO	
	Hurghada NR	RS5	PRO	
	Qulan Islands MR	RS3	PRO	
	Ras Burkha	RS4	REC	
	Ras Garra	RS5	REC	
	Shadwan (Shaker) Island MR	RS5	PRO	
	Southern Egypt MP	RS3	REC	
	Straits of Tiran MP	RS3	REC	
Iran	Chah Bahar and Pizom Bays	IP1	PRO	
	Halileh Rud Mud Flats (Hale-Rud Marshes)	AG1	PRO	20,000
	Hormoz Island Biosphere Reserve	AG1	I	
	Khouran Straits Biosphere Reserve	AG1	PRO	
	Qeshm Islands and Bandar Marine Park	AG1	PRO	
	Rude-e-Gaz (Rud-e-Hara) Mangroves	AG1	PRO	
	Shadvar BR (Sheedvar)	AG1	PRO	
Jordan	Aqaba MaNR	RS4	PRO	
	Aqaba MP	RS4	PRO	
Kuwait	Bobiyan MP	AG2	REC	
	Failaka Island (North) NR	A3	REC	
	Failaka Island (South) NP	AG3	REC	
	Failaka Island (South) NRA	AG3	REC	
	Jal al Zhor NP	AG3	PRO	30,000
	Jal al Zhor NRA	AG3	PRO	
	Khawr Mu Fattah PA	AG3	PRO	
	Kubbar (Jazirat Kubbar) PA	AG3	REC	600
	Qaruh MP	AG3	REC	
Oman	Al Hallaniyah NScR	OM	PRO	2,500
	Al Salamah NNR	I P1	PRO	60
	Arkad NRR		PRO	264,000
	Bandar Jissah NScR	IP1	V	700
	Bandar Khayran NNR	IP1	VIII	1,400
	Barr al Hikman NNR	OM	PRO	288,000
	Bu Rashid NNR	IP1	PRO	50
	Dalkut-Kharfot NNR	OM	IV	
	East Masirah NNR	OM	PRO	4,500
	East Sharbithat	OM	IV	
	Fanaku NNR	IP1	PRO	20
	Hamar an Nafun NNR	OM	PRO	120
	Jabal Abu Daud NScR	IP1	PRO	35,000
	Jabal Bani Jabir NScR	IP1	PRO	138,000
	Jabal Hammar NSR + Sidah NNR	OM	IV & V	
	Jabal Letub NNR	IP1	PRO	8,900
	Jabal Qamar NScR	OM	V	58,000
	Jabal Qatar NNR	IP1	PRo	44,000
	Jabal Samhan NNR	OM	IV & V	346,000
	Janabah Coast NScR	OM	PRO	69,000
	Jazirat Abu Sir NNR	IP1	PRO	150
	Jazirat Habalayn NNR	IP1	PRO	10
	Jazirat Hamra NNR	IP1	PRO	30

Country/ Territory	*Protected Area Name*	*Zone*	*IUCN Category*	*Area (hectares)*
Oman *(continued)*	Jazirat l Khayl NNR	IP1	PRO	300
	Jazirat Musandam NNR	IP1	PRO	500
	Jazirat Umm al Fayyar in NNR	IP1	PRO	50
	Jazirat Umm al Ghanam NScR	IP1	PRO	500
	Kachalu NNR	IP1	PRO	10
	Khatmat Malahah NNR		PRO	50
	Khawr Balid NNR	OM	PRO	200
	Khawr Bat'ha NRR		PRO	30
	Khawr Dahariz NNR	OM	IV	150
	Khawr Hawasinah NRR		PRO	10
	Khawr Juraym NNR		PRO	20
	Khawr Kashmir NRR		PRO	50
	Khawr Mughsayl NScR	OM	VIII	10
	Khawr Nabr NNR		PRO	2,300
	Khawr Qurm NSCR	OM	VIII	70
	Khawr Rawri NNR	OM	IV & V	1,100
	Khawr Saham NNR		PRO	80
	Khawr Sallan NNR		PRO	100
	Khawr Sawli NNR	OM	IV	300
	Khawr Shinas NNR		PRO	2,100
	Khawr Taqah NNR		PRO	300
	Kuria Muria NNR	OM	IV	250,000
	Marbat NScR + Raaha NNR	OM	IV &V	26,000
	Masirah Straits NNR	OM	PRO	86,000
	Musandam NRR		PRO	132,000
	Musandam Peninsula	IP1	PRO	15,800
	North Jazir NNR	OM	PRO	15,000
	Ra's Suawadi NScR	IP1	V	1,500
	Ras Abu Daud	OM	VI	
	Razat NNR	OM	IV	1,000
	Sadh NScR	OM	V	3,500
	Salalal NNR	OM	VIII	6,800
	Shinas NScR	IP1	PRO	300
	South Jazir NScR + Khur Ghauri NNR	OM	IV & V	18,000
	South Masirah NNR	OM	PRO	19,000
	Wadi ash Shuwaymiyah NRR + Shuway. NScR	OM	IV & V	12,500
	Wadi Hawir NNR	IP1	PRO	3,300
	Wadi Nhart NNR	OM	IV	5,500
	Wahibah NRR	OM	PRO	
	Wardi Hinna NSR	OM	V	
Pakistan	Astola Island (Haft Talar)	IP1	REC	0
	Hawkes Bay/Sandspit Beaches	IP1	REC	0
	Jiwani turtle beaches	IP1	REC	0
	Ormara turtle beaches	IP1	REC	0
	Pasni Coast	IP1	REC	0
Saudi Arabia	Abu Ali/Dawhat Dafi & Musallamiyah	AG3	IV	0
	Abu Duda	RS2	I	0
	Al Hasani & Libana Islands	RS3	IV	0
	Al Uqayr Bay & Coastal Region	AG4	IV	0
	Arabiyah Island	AG3	IV	0
	Coastline South of Sharm Zubeir	RS3	IV	0
	Ghubbet Bal'aksh	RS3	IV	0
	Harimal Island	RS2	I	
	Harqus Island	AG3	IV	0

Country/ Territory	*Protected Area Name*	*Zone*	*IUCN Category*	*Area (hectares)*
Saudi Arabia *(continued)*	Inner Farasan Bank Reefs & Islands	RS1	IV	0
	Jana Islands	AG3	I	0
	Jeddah Salt Marshes	RS2	IV	0
	Jurayd Island	AG3	IV	0
	Karan Island	AG3	I	0
	Khawr al Ja'afirah & Islands., Ras al Tarfa	RS1	IV	0
	Khor Al Wahla	RS1	I	0
	Khor Amiq & Raqa	RS1	IV	0
	Khor Itwad	RS1	IV	0
	Khor Nahud	RS1	IV	0
	Kurayn Islands	AG3	IV	0
	Marqa Islands	RS1	I	0
	Marsa al Usalla & Mersa Tawil	RS2	I	0
	Marsa Umm Misk	RS2	IV	0
	Mastura Beach	RS2	I	0
	Mersa al Sarraj	RS2	IV	0
	Oreste Point	RS1	IV	0
	Outer Farasan Bank Reefs & Islands	RS1	IX	0
	Qalib Islands Chain	RS3	I	
	Qishran	RS1-2	I	0
	Qurayyah region	AG3	IV	
	Ras Abu Madd to Sharm Hasi	RS2	II	0
	Ras Baridi-Sharm al Kwawr	RS2	IV	
	Ras Hatiba	RS2	II	0
	Ras Suwahil & Maqna N. Beach	RS4	IX	0
	Safaniya/Manifa Bay complex	AG3	IV	0
	Sharm Dumagha & Sharm Antar	RS3	IV	0
	Sharm Yanbu	RS2	I	0
	Sharm Zubeur	RS3	I	0
	Shi'Abu Al Liqa	RS1	IV	0
	Shib Al Kabir	RS1	IV	0
	Shu'aybah	RS2	II	0
	South Gulf of Salwah	AG4	IX	0
	Tarut Bay Complex	AG3	VIII	0
	Tiran Islands area	RS3	IX	0
	Wejh Bank	RS2	IX	0
Sudan	Mukawwar MNR	RS2	PRO	1,200
	Port Sudan MNP	RS2	PRO	0
	Sanganeb Atoll MNP	RS2	PRO	100
	Suakin Archipelago NP	RS1	PRO	0
United Arab Emirates	Abu al Abyadh Islands PriR	AG5	UA	0
	Abu Dhabi mangrove & coastal wetlands	AG5	REC	1,500
	Arzaneh Islands BS	AG5	REC	0
	Ganadah (Ras Ganadah) Lagoon & mangrove	AG5	REC	22,000
	Hammanya Lagoon	AG5	REC	200
	Jebel Ali turtle beaches R	AG5	REC	1,500
	Kalba mangroves	AG5	REC	0
	Khor Dubai marshes	AG5	REC	0
	Merawwah Islands	AG5	REC	0
	Qarnein Islands	AG5	REC	0
	Ramms Lagoon R	AG5	REC	0
	Umm al-Qaiwain Lagoon & island PriR	AG5	UA	1,000
	Zirkuh Islands BS	AG5	REC	0

Country/ Territory	*Protected Area Name*	*Zone*	*IUCN Category*	*Area (hectares)*
Yemen, Republic of	Al Khawkhah	RS1	REC	0
	Al Mukha	RS1	REC	0
	Dhubab	RS1	REC	0
	Hidran marshes	RS1	REC	0
	Humar Island	RS1	REC	0
	Jabal Sabir-Wadi Thabad wadis	RS1	REC	0
	Kumran islands R	RS1	PRO	0
	Ra's Katanib Island	RS1	REC	0
	Ras Isa MP	RS1	REC	0
	Uqban (Ukban) Islands	RS1	REC	0
	Wadi Rima estuary	RS1	REC	0
	Wadi Siham	RS1	REC	0
	Zubayr Islands	RS1	REC	0
	Zuqur Islands MNP	RS1	REC	0
Yemen	Nishtun	GA	REC	0
	Perim Isles	GA	REC	0
	Ra's Abu Quizara	GA	REC	0
	Socotra Island PA	GA	PRO	362,500

BIBLIOGRAPHY

Al-Rabah, A., ed. 1993. Theme issues on air and sea pollution. *Arabian Journal of Science and Engineering* 18(2): 85–291

Basson, P.W., J.E. Burchard, J.T. Hardy, and A.R.G. Price. 1977. *Biotopes of the Western Arabian Gulf.* Aramco, Dhahram.

Basson, P.W. 1979. Marine algae of the Arabian Gulf coast of Saudi Arabia. *Botanica Marina* 22: 47–64.

Bemert, G., and R. Ormond. 1981. *Red Sea Coral Reef.* London: Kegan Paul International.

Birdlife International. N.d. Important Bird Areas in the Middle East. Forthcoming.

Briggs, J.C. 1974. *Marine Zoogeography.* New York: McGraw-Hill.

Campbell, A.A. 1988. The echinoderm fauna of Dhofar (Southern Oman) excluding Holothuriods. In Burke and others, *Echinoderm biology.* Rotterdam, Netherlands: A. A. Balkema.

Commission of European Communities (CEC) and National Commission for Wildlife Conservation and Development (NCWCD). 1992. *Establishment of a Marine Habitat and Wildlife Sanctuary for the Gulf Region.* Final report of Phase 1. Jubail and Frankfurt.

———. 1994. *Establishment of a Marine Habitat and Wildlife Sanctuary for the Gulf Region.* Final report of Phase 2. Jubail and Frankfurt.

Chiffings, A.W. 1989. A draft marine protection area system plan for the Kingdom of Saudi Arabia. IUCN/NCWCD Specialist Report, Riyadh, KSA.

———. 1992. The Global Representative System of Marine Protected Areas, North Western Ocean (Region B). Unpublished preliminary working document, CNPPA/World Bank Biodiversity Project, Washington, D.C.

Child, G., and J. Grainger. 1990. *A system plan for wildlife conservation and sustainable rural development in Saudi Arabia.* National Commission for Wildlife Conservation and Development, Riyadh, KSA.

Clarke, J.E., F. Al-Lumki, V.C. Anderlini, and C.R.C. Sheppard. 1986. *Sultanate of Oman: Proposals for a system of Nature Conservation Areas.* Gland, Switzerland: IUCN.

Couper, A., ed. 1983. *The Times atlas of the oceans.* London: Times Books.

Crossland, C.J., S.A. Dawson, S.M. Stafford, and C.J. Marshall. 1987. *The Red Sea Saudi Arabia: Analysis of coastal and marine habitats of the Red Sea.* MEPA Coastal ,and Marine Management Series Report No. 1.

Currie, R.I., A.E. Fisher, and P.M. Hargreaves. 1973. Arabian Sea upwelling. In B. Zeitzschel, ed., *The biology of the Indian Ocean.* London: Chapman and Hall.

Cushing, D.H. 1973. Production in the Indian Ocean and the transfer from primary to the secondary level. In B. Zeitzschel, ed., *The biology of the Indian Ocean.* London: Chapman and Hall.

Drake, C.L., and R.W. Girdler. 1964. A geophysical study of the Red Sea. *Journal Geophysics* 18:473–95.

Edwards, F.J. 1987. Climate and oceanography. In A.J. Edwards J. and S.M. Head, eds., *Key environments: Red Sea.* Oxford, U.K.: Pergamon Press.

El-Sayed, S.Z., and H.R. Jitts. 1973. Phytoplankton production in the Southern Indian Ocean. In B. Zeitzschel, ed., *The Biology of the Indian Ocean.* London: Chapman and Hall.

Fishelson, L. 1980. Marine reserves along the Sinai peninsula (northern Red Sea). *Helgolander wissenschaftliche Meeresuntersuchungen* 33:624–40.

Frazier, J.G., G.C. Bertram, and P.G.H. Evans. 1987. Turtles and marine mammals. In A.J. Edwards and S.M. Head, eds., *Key environments: Red Sea.* Oxford, U.K.: Pergamon Press.

Gallagher, M.D. 1991. Collections of skulls and Cetacea: Odondoceti from Bahrain, United Arab Emirates and Oman, 1969–1990. In S. Leatherwood and G.P. Donovan, eds., *Cetaceans and cetacean research in the Indian Ocean Sanctuary.* Marine Mammal Technical Report Number 3. Nairobi: UNEP.

Gasperetti, J. 1988. Snakes of Arabia. *Fauna of Saudi Arabia* 9:169–400.

Hanna, R.G.M. 1982. *Abnormal flouride concentrations in the Northwest Red Sea Coast.* Proceedings of International Conference on Marine Science in the Red Sea, Al-Ghardaqa, Red Sea.

———. 1983a. Oil Pollution on the Egyptian Red Sea Coast. *Marine Pollution Bulletin* 14(7): 268–71.

———. 1983b. Environmental implications of the hot brine pools and their mining in the Red Sea. Conference of mining in Egypt, Ismailia, Egypt. *A.M. Petroleum Association* 39.

———. 1991. Available data for management of the Egyptian Red Sea coastal areas. The Seventh Symposium on Coastal and Ocean Management, 8–12 July, Long Beach, California. *Coastal Zone 91, American Society Civil Engineering* 4: 3,433–45.

———. 1994. Physical effects of oil and dispersants on the different geomorphological Red Sea coastal environments. Unpublished report.

Hanna, R.G.M., and R.G.G. Ormond. 1982. Oil pollution, urchin erosion and coral reef deterioration in the Egyptian Red Sea. *Iraqi Journal of Marine Science* 1(1): 35–7.

Hayden, B.P., G.C. Ray, and R. Dolan. 1984. Classification of coastal and marine environments. *Environmental Conservation* 11:199–207

Holt, S.J. 1983. The Indian Ocean whale sanctuary. *Ambio* 12:345–7.

Hunter, J.R. 1982. *The physical oceanography of the Arabian Gulf: A review and theoretical interpretation of previous observations.* Proceedings of Conference on Marine Environment and Pollution, Kuwait.

Hunter, J.R. 1983. *A review of the residual circulation and mixing processes in Kuwait Action Plan Region, with reference to application modelling techniques.* UNESCO report of a symposium-workshop, UPM, Dahran. *Marine Science* 28(1984): 37–45.

Jones, D.A. 1986. *A field guide to the seashores of Kuwait and the Arabian Gulf.* University of Kuwait.

Jones, D.A., M. Ghamrawy, and M.I. Wahbeh. 1987. Littoral and shallow subtidal environments. In A. Edwards and S.M. Head, eds., *Key environments: Red Sea.* Oxford, U.K.: Pergamon Press.

Johnston, D.J., ed. 1981. *The environment law of the sea.* IUCN Environmental Policy and Law Paper No. 18. Gland, Switzerland.

Krey, J. 1973. Primary production in the Indian Ocean. In B. Zeitzschel, ed., *The biology of the Indian Ocean.* New York: Springer Verlag.

McCain J.C. 1984a. Marine ecology of Saudi Arabia: The intertidal infauna of the sand beaches in the northern area, Arabian Gulf, Saudi Arabia. *Fauna of Saudi Arabia* 6:53–78.

McGill D.A. 1973. Light and nutrients in the Indian Ocean. In B. Zeitzschel, ed., *The biology of the Indian Ocean.* London: Chapman and Hall.

Meteorological and Environmental Protection Administration (MEPA). 1987a. *The Arabian Gulf Saudi Arabia: An assessment of biotopes and management requirements for the Saudi Arabian Gulf coastal zone.* MEPA Coastal and Marine Management Series Report No. 3.

———. 1987b. *The Red Sea: An assessment of management requirements for the Saudi Arabian Red Sea coastal zone.* MEPA Coastal and Marine Management Series Report No. 2.

———. 1987c. *The Red Sea and Arabian Gulf Saudi Arabia: A national coastal zone management programme to balance future growth with protection of coastal resources.* Jeddah, Saudi Arabia: MEPA.

Miller, J.D. 1989. *Marine Turtles: Volume 1 An assessment of the conservation status of marine turtles in the Kingdom of Saudi Arabia.* MEPA Coastal and Marine Management Series No. 9.

Morcos, S.A. 1970. Physical and chemical oceanography of the Red Sea. *Oceanorg. Marine Biology Annual Review* 8:73–202.

Moore, R.J. 1987. *The nature and diversity of Red Sea coral reefs in relation to water productivity: A rational basis for management of living resources.* Proceedings of first National Conference on Wildlife Conservation and
lopment NCWCD, Riyadh, KSA.

Nasr, D.H. 1985. Coral reef conservation in Sudan. In *Proceedings Fifth International Coral Reef Congress (Tahiti).*

Ormond, R.F.G. 1980. Management and Conservation of Red Sea Habitats. In *The coastal and marine environments of the Red Sea, Gulf of Aden and Tropical Western Indian Ocean.* Proceedings of Symposium, Khartoum (January). The Red Sea and the Gulf of Aden Environmental Programme Jeddah 2: 135–162.

———. 1981. *Report on the need for management and marine parks in the Egyptian Red Sea.* Cairo: Institute of Oceanography and Fisheries, Academy of Sciences.

———. 1987. Conservation and management. In A.J. Edwards J. and S.M. Head, eds., *Key environments: Red Sea.* Oxford, U.K.: Pergamon Press.

Papastavrou, V., and R.V. Salm. 1991. A note on recent sightings and strandings of cetaceans in Oman: Ra's Sawadi to Rakhyut. In S. Leatherwood and G.P. Donovan, eds., *Cetaceans and cetacean research in the Indian Ocean Sanctuary.* Marine Mammal Technical Report Number 3. Nairobi: UNEP.

Papenfuss, G.E. 1968. A history, catalogue and bibliography of benthic Red Sea algae. *Israel Journal of Botany* 17:1–118.

Pernetta, J.C., ed. 1993. *Marine Protected Area needs in the South Asian Seas Region (Vol. 4 Pakistan).* Gland, Switzerland: IUCN.

Preen A. 1989. *The status and conservation of dugongs in the Arabian Seas Region,* MEPA Coastal and Marine Management Series Report No. 10.

———. 1989. *Dugongs: Volume 1 The status and conservation of dugongs in the Arabian Region.* MEPA Coastal and Marine Management Series Report No. 10.

———. 1991. Report on the die-off of marine mammals associated with the Gulf war oil spill. Unpublished report to National Commission for Wildlife Conservation and Development, Saudi Arabia.

Preen, A., and World Conservation Union (IUCN). 1993. *Farasan Marine Protected Area: Management plan for the ecologically sustainable use of marine resources.* IUCN report to the National Commission for Wildlife Conservation and Development, Saudi Arabia.

Price, A.R.G. 1982. Comparison between echinoderm faunas of Arabian Gulf, SE Arabia, Red Sea and Gulfs of Aqaba and Suez. *Fauna of Saudi Arabia* 4:3–21

Price, A.R.G., D.H.P. Vousden, and R.F.G. Ormond. 1983. *Ecological study of sites on the coast of Bahrain, with special reference to the shrimp fishery and possible impact of the Saudi-Bahrain Causeway under construction.* IUCN report to UNEP Regional Seas Program, Geneva.

Price, A.R.G., A.W. Chiffings, M.A. Atkinson, and T.J. Wrathall. 1987. *Appraisal of resources in the Saudi Arabian Gulf.* Proceedings of the Fifth Symposium Coastal and Ocean Management. American Society of Civil Engineers.

Price, A.R.G., and S.L. Humphrey, eds. 1993. *Application of the Biosphere Reserve Concept to Coastal Marine Areas.* Papers presented at the UNESCO/IUCN San Fransisco Workshop, 14–20 August 1989. A Marine Conservation and Development Report. Gland, Switzerland: IUCN.

Price, A.R.G., and J.H. Robinson, eds. 1993. *The Gulf War: Coastal and marine environmental consequences.* Marine Pollution Bulletin 27: 1–380.

Quennel, A.M. 1958. The structural and geomorphic evolution of the Dead Sea rift. *Geological Society London Journal* 114: 1–24.

Rao, T.S.S. 1973. Zooplankton studies in the Indian Ocean. In B. Zeitzchel, ed., *The biology of the Indian Ocean.* London: Chapman and Hall.

Reeves, R.R., S. Leatherwood, and V. Papastravrou. 1991. Possible stock affinities of humpback whales in the Northern Indian Ocean. In S. Leatherwood and G.P. Donovan, eds., *Cetaceans and cetacean research in the Indian Ocean Sanctuary.* Marine Mammal Technical Report Number 3. Nairobi: UNEP.

Sen Gupta, R., and S.W.A. Navqui. 1984. Chemical oceanography of the Indian Ocean, north of the Indian Ocean, north of the equator. *Deep Sea Research* 34:671–706.

Sadiq, M., and J.C. McCain. 1993. *The Gulf War aftermath: An environmental tragedy.* Dordrecht, The Netherlands: Kluwer.

Sanders, M.J., and G.R. Morgan. 1989. *Review of the fisheries resources of the Red Sea and Gulf of Aden.* FAO Fisheries Technical Paper 197. Rome.

Sheppard, C.R.C., and S. Wells. 1988. *Directory of Coral Reefs of International Importance (Vol. 2: Indian Ocean Region).* Gland, Switzerland: IUCN; Nairobi: UNEP.

Sheppard, C.R.C., A. Price, and C. Roberts. 1992. *Marine ecology of the Arabian Seas Region: Patterns and processes in extreme tropical environments.* London, U.K.: Academic Press.

Smith, J.A., and G.J. Smith. 1991. *Cetacean observations from the Somali Democratic Republic, September 1985 through May 1987.* In S. Leatherwood and G.P. Donovan, eds., *Cetaceans and cetacean research in the Indian Ocean Sanctuary.* Marine Mammal Technical Report Number 3. Nairobi: UNEP.

Swallow, J.C. 1984. Some aspects of the physical oceanography of the Indian Ocean. *Deep Sea Research* 34: 639–50.

Weikert, H. 1987. Plankton and the pelagic environment. In A.J. Edwards and S.M. Head, eds., *Key environments: Red Sea*. Oxford, U.K.: Pergamon Press.

World Conservation Monitoring Centre (WCMC). 1991. Environmental effects of the Gulf War, Briefing Notes.

World Conservation Union (IUCN). 1987. Arabian Gulf. *Saudi Arabia: An assessment of biotopes and coastal zone management requirements for the Arabian Gulf*. MEPA Coastal and Marine Management Series, Report No. 5. Gland, Switzerland.

———. 1992. *Protected areas of the world: A review of national systems (Vol. 3 Afrotropical)*. Gland, Switzerland and Cambridge, U.K.: IUCN.

World Conservation Union (IUCN) and Meteorological and Environmental Protection Administration (MEPA). 1984. *Management of Red Sea coastal resources*. Recommendations for protected areas Saudi Arabia. Marine Conservation Programme, Report No. 5.

———. 1984. *Report on the distribution of natural habitats and species in the Saudi Red Sea Saudi Arabia*. Marine Conservation Programme, Report No. 4 Parts 1 and 2, 1–274 pp.

World Conservation Union (IUCN) and United Nations Environment Programme (UNEP). 1985a. *Management and conservation of renewable marine resources in the Indian Ocean region: Overview*. UNEP Regional Sea Reports and Studies No. 63. Nairobi.

———. 1985b. *Management and conservation of renewable marine resources in the Indian Ocean region: Overview*. UNEP Regional Sea Reports and Studies No. 64. Nairobi.

———. 1985c. *Management and conservation of renewable marine resources in the Indian Ocean region: Overview*. UNEP Regional Sea Reports and Studies No. 60. Nairobi.

Wyrtki, K. 1973. Physical oceanography of the Indian Ocean. In B. Zeitzschel, ed., *The biology of the Indian Ocean*. New York: Springer Verlag.

MARINE REGION 12
East Africa

Gudrun Gaudian, Anderson Koyo, and Sue Wells

BIOGEOGRAPHY AND MARINE BIODIVERSITY

The East African Marine Region includes the following countries: Comoros, Kenya, Madagascar, Mauritius, Mayotte and Reunion (France), Mozambique, Seychelles, Somalia, and Tanzania (including Zanzibar). The Chagos Archipelago, although claimed by Mauritius, is covered under Marine Region 8, West Africa.

Much of the information in this section is based on IUCN and UNEP reports in the series *UNEP Regional Seas Reports and Studies* prepared in the 1980s as background documentation for the Action Plan for the East African Region of the UNEP Regional Seas Programme. To avoid duplication and in the interest of brevity, the original sources cited in these references have not been repeated here, and readers should refer to the UNEP studies for further details; it has not been possible to check all the information in these reports. In 1993, a project was initiated under the UNEP Regional Seas Programme as part of the Eastern African Action Plan to compile an Eastern African Coastal and Marine Environment Resources Database and Atlas. This will involve the collation of information on natural resources that will be summarized on country maps to be available in 1998.

Oceanography

Oceanic current patterns and monsoon seasons have a major influence on the biogeography and biodiversity of the region. The permanently west-flowing South Equatorial Current, 6°S–20°S, is partly diverted south along the eastern Madagascar coast where it becomes the Madagascar Current. The main South Equatorial Current, on approaching the mainland, splits to form the northward flowing East African Coastal Current (EACC), and the southward flowing Mozambique Current. The latter joins the Madagascar Current to form the Agulhas Current (IUCN/UNEP 1985).

From April to October the EACC is under the strong influence of the southeast monsoon, causing it to flow faster (mean velocities of 4–5 knots, occasionally reaching 7 knots) along the Somali coast. The increas-

ing offshore component of the winds north of the equator causes a cold-water upwelling. This area therefore has potentially high fishery productivity. The northeast monsoon (November to March) generates the southward flowing coastal Somali Current that joins the EACC at about 2°N and generates the eastward-flowing Equatorial Counter Current (IUCN/UNEP 1985).

The Mozambique and Madagascar currents generate internal currents and eddies within the Mozambique Channel and may transport prawn larvae and other marine larvae to the Mozambique coast from along the mangrove and prawn-rich western coast of Madagascar. The southward flowing Agulhas Current is dominant along the eastern coast of South Africa, rarely dropping below 21°C (IUCN/UNEP 1985) (see Map 12).

The tides in the region are predominantly diurnal with a range of up to 4 meters in some areas. Tidal currents can be extremely strong, particularly along breaks in the reef or narrow passages. The surface water temperature affects the distribution of both benthic species and fish; temperature ranges in the region are shown in Table 12.1.

Table 12.1 Surface Water Temperature in the East African Marine Region

(centigrade)

Latitude	*February*	*May*	*August*	*November*
10°N–0°S	25–26	28–29	21–25	26–27
0°N–10°S	26–28	28	24–26	27
10°N–20°S	28	25–28	23–24	25–27
20°N–30°S	25–28	22–25	20–23	22–25

Source: IUCN/UNEP (1985).

Coastal Geography and Geology

In general, the continental shelf is narrow, averaging 15–25 kilometers in width. Along the mainland, it varies from as narrow as a few 100 meters off Pemba on the coast of Mozambique to nearly 145 kilometers in the Bight of Sofala, also in Mozambique. Table 12.2 shows the area of continental shelf per country and the length of coastline. The shelves and banks are areas of intensive biological activity and productivity, and the narrower the shelf, the less productive the sea area. The Western Indian Ocean is relatively fisheries-poor compared with other regions. The seabed drops rather sharply after the continental shelf, plunging to depths of about 4,000 meters that extend eastward across the Indian Ocean except where interrupted by submerged platforms and islets associated with the island countries (IUCN/UNEP 1985).

Much of the African mainland coast and the eastern coast of Madagascar are relatively unindented due to the absence of large rivers and the parallel coastal currents. Further south, however, notably in Mozambique, low-energy coasts are found that are protected from the Indian Ocean waves, resulting in the deposition of large volumes of riverine sediments. The west coast of Madagascar consists of sandy beaches and fluvial deposits; the east coast has steeply shelving shores and a wave-battered, narrow strand on rocks (Alusa and Ogallo 1992; Cooke 1994, in litt.).

The Seychelles Ridge is principally granitic and is believed to be a fragment of a previously existing continental mass. It supports the Seychelles, a group of about 100 islands spread over a large area. The islands to the northeast are granitic, but to the south and west there are a number of coralline islands and limestone banks. The Comoros comprise four isolated, volcanic seamounts at

Table 12.2 Estimated Shelf Area, Length of Coastline and Coastal Population for Countries in the East Africa Marine Region

Country	*Estimated Shelf Area (0–200 meters) (square kilometers)*	*Length of Coastline (kilometers)*	*Coastal Population (percentage of total)*
Comoros	900	350	440,000 (88)
Reunion	—	207	546,000 (99)
Seychelles	48,000	600	66,600
Mauritius	1,865	320	1,100,000 (74)
Somalia	32,500	3,000	1,600,000 (30)
Kenya	6,500	500	1,640,000 (7)
Tanzania	30,000	900	3,690,000 (15)
Mozambique[a]	120,000	2,500	3,000,000 (20)
Madagascar	135,000	6,000	2,000,000 (18)

a. In Mozambique, 11,250,000 people, or 75 percent of the total population, live within 40 kilometers of the coast (Gove 1994, in litt.).

Source: IUCN/UNEP (1985); Alusa and Ogallo (1992); Government of Seychelles (1990); la Hausse de Lalouvière (1994, in litt.); Gawler and Agardy (1994); Lebigre (1990); Fagoonee (1994, in litt.).

the northern end of the Mozambique Channel, with a number of smaller islands. The Mascarene Plateau is a major discontinuous mid-ocean ridge, breaking at the surface in a series of islands and banks stretching from Reunion to the Seychelles; it includes Mauritius, Reunion and Rodriguez and numerous shoals, seamounts, and large, submerged shallow banks. The islands are volcanic and are separated by deepwater (IUCN/UNEP 1985; Alusa and Ogallo 1992).

Ecosystem Diversity

Marine and coastal habitats are classified into 38 types in IUCN/UNEP (1984a) and subdivided into three groups: coastal, offshore, and pelagic environments. For the purpose of this report, the 38 types have been condensed into a few major habitat forms. Most attention has been given to coral reefs and mangroves, since these are particularly diverse and are both ecologically and biologically important ecosystems in the region.

Coral Reefs

The occurrence and distribution of coral reefs depend primarily on surface water temperature, the availability of substrate for corals to settle out and grow on, and water clarity or turbidity. Well-developed fringing reefs and patch reef complexes occur along major sections of the narrow continental shelf of the East African mainland and around the oceanic islands between 5°N and 25°S. They are most extensive where the shelf broadens out around islands and are broken by major river outflows. Some of the submerged oceanic banks (see below) may also have extensive coral reefs, but these are poorly known. Detailed information on reef distribution in each country is available in UNEP/IUCN (1988).

Seasonal cold upwelling inhibits coral growth along much of the northern coast of Somalia. Reef growth increases toward the Kenyan border to the south, and although very little is known about the coral reef fauna in this region, it is thought that close to the Kenyan border it resembles that of the adjacent Kenyan reefs. These northern

Kenyan reefs are predominantly rocky or algal reefs and have low coral cover, perhaps related to the comparatively nutrient-rich waters in this region and the different ecology of the area generated by the alternating current system: in the northeast monsoon, the reefs receive larvae from the Somali coast and Arabian Sea; in the southeast monsoon, from the coastal areas to the south (Samoilys 1988a,b).

South of northern Kenya to the border of Mozambique, there is high coral diversity and good coral reef growth in many areas. Coral reefs along the coastline of Tanzania and Kenya form an almost continuous fringing reef, broadly following the contours of the coastline and consequently are situated relatively close to the shore. The fringing reefs are generally broken only in the vicinity of rivers and bay mouths. On islands such as Zanzibar, Pemba and Mafia, patch reefs predominate on the western sides and well-developed fringing reefs on the eastern sides, which may be among the finest remaining reefs in the region. Given the direction of the prevailing currents, these reefs may be sources of larvae to other reefs along the mainland coast.

Comparatively little is known about the distribution and extent of coral growth in Mozambique. The continental shelf is narrow, plunging to 2,500 meters within 30 kilometers of the coast. There are no true reefs but abundant coral assemblages occur on beach rock reefs, fossil relics of past continental shores, and the distribution of coral growth is influenced by the 25 river systems that discharge onto the coast. One of the southernmost areas of shallow coral growth in the region is around Inhaca Island, Mozambique (Salm 1976a; Mondego 1992, in litt.), an area close to the southernmost limit of the littoral fauna and flora characteristic of the East African coast. Other major coral assemblages include isolated reefs such as Silvia and Zambia between Inhambane and Bazaruto, the Bazaruto Archipelago, the Primeiras Segundo Archipelago, the coast between Angoche and Pemba, and the Quirimbas Archipelago. Most of these assemblages are reasonably healthy, the main impact probably being natural damage such as from cyclones (Dutton 1994, in litt.).

Madagascar, despite the temperature difference between the northern and southern coast, has high coral species diversity on most of its reefs (over 60 coral genera have been recorded). The barrier reefs in the southwest are the most extensive in the Indian Ocean and among the largest in the world, with about 200 kilometers of true barrier (including the 18–24 kilometers long Grand Recif de Toliara), 200 kilometers of fringing reefs, and a number of offshore coral islands. There are also extensive fringing reefs on the east coast, particularly at Nosy Boraha and the Baie d'Antongil, and on the northeastern and northwestern coasts.

Coral reefs and associated organisms are diverse and abundant around the oceanic islands in the region. The Seychelles are the only part of the region in which atolls, such as Providence, Cosmoledo, Aldabra, Astove, Farquhar and Desroches, are found. The granitic islands have small, fringing reefs, and reefs also occur around the coralline islands and on the submerged limestone banks such as Saya de Malha and Nazareth, although their structure and fauna are largely unknown. In the Mascarene Islands, reef development decreases from east to west, reflecting the volcanic ages of the islands. Extensive reefs surround Mauritius (for example, Salm 1976b) and Rodrigues (the oldest island, with the best reef development, covering an area of 200 square kilometers). There is some reef development around Tromelin, Europa, Bassas de India and Juan de Nova, and only a small amount around Reunion, which is still volcanically active (Montaggioni and Faure 1980). The Cargados Carajos Shoals, a submerged bank that is a dependency of Mauritius, has over 190 square kilometers of coral reef and a

massive algal ridge, probably the largest in the Indian Ocean. The Comoros have well-developed reefs, and there is a large barrier reef around Mayotte.

Throughout the region, reefs play an important role in coastal protection, fisheries and tourism, but are nevertheless under serious threat from diverse factors including overutilization and coastal development, compounded by lack of awareness and lack of trained and experienced personnel available for reef management.

Mangrove Forests

The total area of mangrove in the region is estimated to be 1,200,000 hectares, although precise figures vary (for example, Fisher and Spalding 1992; CEC 1992). Mangrove distribution can be correlated with the presence of coastal indentations and large river discharges. Much of the mainland coast, especially north of Kenya, is relatively unindented, partly due to the absence of large rivers and to the coastal currents that flow parallel to this coast. Relatively few mangrove stands are therefore found in northern Somalia; a similar situation is also noted for the east coast of Madagascar, where the Madagascar Current flows parallel to the coast. More-extensive mangrove forests are found in the extreme south of Somalia in the Bay of Buur Gaabo (where three estuaries are tidal for long distances inland (Hughes and Hughes 1992)) and along the coasts of Kenya and Tanzania where there are suitable conditions for growth.

Kenya has some 65,000 hectares of mangrove (Ferguson 1993; Ntiba 1993); the largest areas are the districts of Lamu (46,229 hectares, extending along the coast northward through the Kiunga Marine Reserve), Kwale (6,345 hectares, extending south along the coast from Diani to the Shimoni area) and Kilifi (6,378 hectares, extending from Kilifi Creek north to Mida Creek and Watamu). Smaller areas of mangrove are found in the Mombasa district (3,059 hectares) and the Tana River Delta (369 hectares), which has the only significant stand of *Heritiera littoralis* in Kenya.

In Tanzania, stands are more extensive, totalling 115,500 hectares (Semesi 1991), of which 3,200 hectares are found in the Rufiji River Delta, with smaller stands in the Kunduchi and Lindi regions, especially in the Tanga River Delta (UNEP 1989), 1,200 hectares on Pemba and 4,700 hectares on Unguja (Zanzibar). These figures may be more accurate than those provided by Hughes and Hughes (1992) (196,000 hectares) and Stuart, Adams, and Jenkins (1990) (200,000 hectares); other figures are available in Semesi and Howell (1989). As a result of the many river systems in Mozambique, mangrove forests are even more extensive, up to 500,000 hectares, of which 79 percent are located on the Zambezi River (Gove 1994). Stuart, Adams, and Jenkins (1990) suggested a total of 100,000 hectares but this is considered an underestimate.

On Madagascar all large river estuaries are in the west and support about 327,000 hectares of mangrove, with only a few stands covering about 5,000 hectares on the east coast (CEC 1992). Lebigre (1990) suggests 425,000 hectares for the west coast and 4,815 hectares for the east coast. The north and west coasts support some of the most extensive stands of mangroves in the region; for example, at Baie de Bombetoka (46,000 hectares) on the Betsiboka River where the low human population density has been largely responsible for their survival and at Baie de la Mahajamba further north.

There are small stands in the granitic Seychelles, and the two best undisturbed stands are on Curieuse at the end of Bay Laraie and at one site on Mahe. Mangroves are rare on the atolls except on Aldabra where a stand fringes the shore of its large lagoon. On Mauritius, very narrow (only tens of meters wide) mangrove stands are found along the east, southeast and northeast coasts, totalling

about 1–2 square kilometers. The best developed of these are on the east coast islands such as Ile aux Cerfs (Turner 1994, in litt.). There are relatively undisturbed but very small stands on the Comoros, notably in a few bays on Moheli, and small stands occur on Mayotte. Reunion has about 12 square kilometers of mangrove (IUCN/UNEP 1985).

African mangroves have a relatively low faunal and floral diversity compared with Southeast Asia, but nonetheless provide important habitat for shorebirds and fish-eating birds. A total of 11 mangrove species are known to be in the region: *Rhizophora mucronata*, *Ceriops tagal*, *C. boiviniana*, *Bruguiera gymnorrhiza*, *B. cylindrica*, *Avicennia marina*, *A. officinalis*, *Sonneratia alba*, *Xylocarpus molluccensis*, *X. granatum*, and *Heritiera littoralis*. Eight have been recorded from Kenya, with possibly another species occurring (Ferguson 1993); eight species have also be recorded from Tanzania of which two (*X. molluccensis* and *A. officinalis*) are very rare (Semesi 1990); nine species have been recorded from Zanzibar (Jiddawi and Muhando 1990) and from Madagascar (Jenkins 1987). Mangrove diversity in Somalia is much lower, with only about two species having been recorded (UNEP 1987). Additional information can be found in Hughes and Hughes (1992).

As with coral reefs, mangroves throughout the region are under threat from a diverse range of pressures including overutilization (Semesi and Howell (1989) and Semesi (1991) list their uses) and lack of resources, expertise and institutional capacity to manage them.

Seagrass Beds

Seagrass beds are found in all countries in the region (IUCN/UNEP 1984a). In Somalia, there are few on the north coast, but they are extensive along the south coast from Adale to Chiamboni (UNEP 1987). In Tanzania seagrass beds are found in all bays and on the west side of Pemba, Unguja and Mafia Islands; the inshore area from Njao Gap to Port Cockburn is particularly productive with extensive algal and seagrass beds. In Kenya, seagrass and algal beds are well represented in the Mombasa, Diani and Malindi areas. Dense seagrass beds are found in sheltered waters in Mozambique probably along the entire coast but notably at Inhaca I., Inhambane, and the Bazaruto Archipelago, which reportedly has the most extensive beds in the region (Salm 1994, in litt.; IUCN/UNEP 1984a) and Angoche (Dutton 1994, in litt.). In Madagascar, there are extensive seagrass beds in the lagoons north of Toliara, in bays around Nosy Be (Cooke 1994, in litt.) and in many other areas around the coast (Vasseur 1994, in litt.). In the Seychelles, seagrass beds are dense throughout the islands, especially those on the Seychelles and Amirantes Banks and at Desroches Atoll (Salm 1994, in litt.).

According to Aleem (1984), 9 seagrasses have been identified in the region, 7 of which are common; however, 12 species are known from Madagascar alone (Vasseur 1994, in litt.). The main genera are *Cymodocea*, *Thallassia*, *Thalassodendron*, *Halodule* and *Syringodium*. Seagrass beds in the region are under threat from intensive use of bottom traps and beach seines, explosives fishing (UNEP 1989), sand mining and dredging.

Other Wetlands

The distribution of coastal wetlands is closely linked to the distribution of rivers. Bays and estuaries with intertidal sand and mud flats and other wetland types are found in most parts of the region, but tend to cover very small areas in the island nations and are also infrequent along the coast of Somalia. Brackish coastal barrier lagoons are found only in Mozambique and Madagascar (a chain of shallow lagoons on the east coast that form the Pangalanes Canal, an inland waterway). Further details are provided in Hughes and Hughes (1992).

Somalia has comparatively few wetland areas. There are tidal wetlands along the Gulf of Aden, the best developed in the west between Saada Din Island and Saba Wanak where 24 watercourses approach the sea. There are several lagoons on the east coast. The Juba discharges into the Indian Ocean near Kismayo, and there are a number of seasonal streams elsewhere (UNEP 1987; Hughes and Hughes 1992). Major deltas in Kenya are the Tana River Delta (20,000 hectares) that is some 10 kilometers wide at its mouth, and the Galana/Sabaki River that enters the sea north of Malindi through a swampy floodplain.

Tanzania has several major estuaries including the Ruaha/Rufiji Delta (the confluence of the two rivers forming a massive headwater floodplain at the point of entry into the Indian Ocean), the Pangani River and floodplain in the north, the Ruvu River with its swampy estuary north of Bagamoyo opposite the southern tip of Zanzibar, and the Wami estuary, floodplain and tidal swamps. In Mozambique, about 25 rivers discharge along the coast including the Limpopo, Save, Zambezi, and many others that give rise to swampy lagoonal areas. Rivers on the northeast coast (Rovuma, Messalo, Montepuez, Megaruma, Lurio) have very seasonal flows and carry less alluvium and water to the coast than those further south; in some cases they spread into long narrow lakes and estuaries immediately prior to the coast. Important estuaries are also found along the west coast of Madagascar (IUCN/UNEP 1984a; Hughes and Hughes 1992).

Beaches, Dunes, and Cliffs

Sandy beaches, rocky shores, and cliffs are found in all countries. Dunes are found in all countries except the island nations of La Reunion, Comoros and Seychelles. They are best developed in Mozambique in the south; dense undisturbed dune forest occurs along a considerable part of the central coast, and more or less continuously from Inhaca south to the border (Salm 1994, in litt.); at least 50 percent of the Mozambique coast is made up of sandy beaches (Dutton 1994, in litt.). In Kenya, there are limited dunes north of the Galana River mouth and south of the Tana River Delta. Sandy beaches are widespread on the mainland coast, particularly along the Somalia coast where they are interspersed with rocky cliffs and headlands, on the Tanzania coast where they are sometimes backed by steep limestone cliffs, and along the Mozambique coast. Large, coral sand barrier beaches and dunes are found along the east coast of Madagascar (Alusa and Ogallo 1992), and there is a small fragment of dune forest in the private reserve at Ste. Luce in the southeast (Cooke 1994, in litt.).

Islands and Submerged Banks

Small islands are found offshore in all the countries (IUCN/UNEP 1984a): including Kiwaiyu, Simambaya, Pate, Manda, Wasini Islands in Kenya; Yambe, Karange, Mafia, Songo Songo, Mbundya off mainland Tanzania; Chepani, Kepandiko, Chango, Bawi, Mesali, Latham, Mwemba off Zanzibar and Pemba; Chiamboni, Famau Uali, Ciandara, Hagi Bulle, Dorcasi and Ciula off Somalia; and a number such as Bazaruto, Benguerua, Amato, Primeiras and Segundas, Inhaca, and Matemo and Agoche off Mozambique. Numerous others are found in the island nations of the Indian Ocean. Some of these are important for seabird nesting colonies (see discussion below).

The region has a number of large, partly or completely submerged limestone plateaux notably around Mauritius, including Hawkins, Soudan, St. Brandon and Nazareth Banks and the Cargados Carajos Shoals; the Seychelles and Amirante Plateaus and Constant, Saya de Malha, Platte and La Perle Banks around the Seychelles; and the St. Lazarus and Almirante Leite Banks off Mozambique. The Paisley Seamount off Mozambique and Tromelin and La Perouse are major seamounts in the region (IUCN/UNEP 1984a).

The Banc du Geyser, a large horseshoe-shaped reef, lies in international waters and is probably part of the Comoros volcanic chain. It is submerged at high tide and has experienced virtually no human impact (other than shipwrecks) on account of its isolation (Polunin and Frazier 1974). As in other regions, such areas are important fishing grounds but are very poorly known.

Open Ocean, Deep Sea, and Upwellings

Small upwellings probably occur seasonally throughout the region, and more significant ones are found in the offshore waters of Somalia (the Ras Hafun upwelling) and off the coast of Mozambique (IUCN/UNEP 1984a). Minor deep-sea trenches occur off Reunion and Mauritius (the Mauritius trench) and Seychelles (the Amirante Trench) (IUCN/UNEP 1984a). The deepwater resources of the region are still largely unexploited and poorly known, but potentially may provide rich fisheries.

Other Habitats

A variety of other habitats are described in IUCN/UNEP (1984a), including limestone caves (Kenya, Madagascar, Mauritius), rocky fringing reefs (Mozambique, Madagascar), and the unique sabellariid reefs of Inhaca Island in Mozambique.

Species Diversity

Seaweeds

There is little information on the diversity and distribution of seaweeds in the region, although there are a number of publications on Kenya (Moorjani and Simpson 1988; Yarish and Wamukoya 1990; Wamukoya 1992), where a total of 350 marine algae have been recorded and on the seaweeds of Mauritius (Turner 1994, in litt.; Fagoonee 1994, in litt.; Mishigeni 1985). Several seaweeds (*Gracilaria, Euchema, Sargassum, Turbinaria*) are of commercial importance in the region and are exploited or farmed, notably in Kenya and Zanzibar (Jiddawi and Muhando 1990).

Invertebrates

It has not been possible to provide a full review of the diversity of invertebrate groups. Certain groups, such as mollusks, are reasonably well known. For example, Kenya has 135 species of coral reef–associated gastropods (McClanahan 1989). A number of endemic mollusks are known from the Indian Ocean islands, such as the double harp (*Harpa costata*) and the violet spider conch (*Lambis violacea*), both endemic to Mauritius, but there is little endemism along the mainland coastline, although endemic mollusks have been reported from the Bazaruto Archipelago in Mozambique (Dutton 1994, in litt.). This pattern is probably reflected in other invertebrate groups, such as fish (see below).

Many marine invertebrate species are of commercial value in the region, including mollusks (green snail, pearl oysters, gastropods and bivalves for the shell trade, and a wide range of edible species including octopus and squid), crustaceans (spiny lobsters, crabs, prawns), coral (black and stony corals for the curio trade; stony corals for construction and lime) and echinoderms (sea cucumbers). There is considerable information available. For example, Cosmoledo and Aldabra are important areas for green snail in the Seychelles (IUCN/UNEP 1984a); there are major shrimp and lobster fisheries in Madagascan waters, lobster and sea cucumber fisheries in Tanzania (the two main prawn fishing grounds in Tanzania are Bagamoyo and areas adjacent to the Rufiji Delta (UNEP 1989; Gaudian and others 1993]); and there is an important tiger prawn fishery in Mauritius (la Hausse de Lalouvière 1994, in litt.). Subsistence fisheries for numerous invertebrate species take place throughout the region.

There are indications that in several areas commercially valuable invertebrate resources

are overexploited, but much of the information is anecdotal. There have been decreases in the catches of shrimp (prawns) by trawler off the coast of Mozambique (Halim 1984; Wynter 1987) perhaps due to silt reduction or mangrove destruction as a result of the damming of rivers, or most likely a combination of both. Studies have been carried out comparing densities of economically important mollusks inside and outside marine protected areas, and there is some suggestion that densities may be more closely related to the density of gastropod predators than to the intensity of collection by humans (McClanahan 1989).

Few marine invertebrates have been designated as threatened in the region. The coconut crab, that is globally threatened, is abundant (and protected) on Aldabra, extinct throughout much of the Seychelles, present on some offshore islands of Tanzania (for example, Mbudya Island and islets off Mafia Island), and possibly present also in the Comoros and some of the outer Mascarene Islands such as the Cargados Carajos shoals (IUCN/UNEP 1984a; la Hausse de Lalouvière 1994, in litt.).

The Seychelles are unique in that MPAs have been created specifically for mollusks (see below) (IUCN/UNEP 1984a). Other countries have introduced legislation to prohibit or regulate the collection of various marine invertebrates either by seasonal closures or other licensing and enforcement procedures. For example, Mauritius has banned the collection and sale of shells and coral since March 1985 (Fagoonee, personal communication)

Fish

The reef fish of the region are reasonably well known. Briggs (1974) identified Mauritius, Reunion and Rodrigues as sites of high endemism for reef fish, and McAllister and others (1993) identified Madagascar and the islands to the north and east as an area of high reef fish diversity. For example, 552 species of fish have been recorded from the Toliara reefs (Harmelin-Vivien 1977), and about 900 species of fish are known from the Seychelles, of which one-third are associated with reefs (GEF 1992). Deepwaters around the Comoros are the home of a unique fish, the coelacanth, that is a living fossil and is now under threat from collectors; one specimen was found in Mozambique waters in 1993.

Samoilys (1988a,b) found significant differences in Kenya in diversity and fish community structure between the northern rocky/algal reefs and the southern coral reefs: the highest diversity in the 15 families studied, comprising 121 species, was found in the Shimoni region; Kiunga, in the north, was least diverse. Over 150 species of fish (excluding many small cryptic species) were recorded from a 100-meter wide section of reef at Kisite Island in the south (Bock, unpublished data). A number of other studies of the reef fish of Kenya have been carried out, including McClanahan and Muthiga (1988) and Watson and Ormond (N.d.). Reef fish are also being studied on the reefs around Mafia Island in Tanzania and Zanzibar.

Tuna are heavily exploited by foreign vessels and recent indications show overexploitation (Andrill 1984), although in the Seychelles stocks may still be underexploited (la Hausse de Lalouvière 1994, in litt.). Artisanal fishermen in the region have also noticed marked decreases in catches of large pelagic migratory species (Nhwani 1988; UNEP 1989; Scullion 1989; Gaudian and others 1993). Fishing with trawlers is becoming increasingly common in the region. Their impact on benthic communities and the recruitment of juveniles is not known, but the adverse impacts of trawlers off the coast of Kerala in India should be borne in mind (Kurien and Mathew 1982). In the Tanga region of Tanzania, catches from 1984 to 1986 suggest that there has been a shift from inshore demersal fish normally found on reefs and in coastal areas to pelagic species, pre-

sent and migrating in the offshore fishing grounds (UNEP 1989). The coast of Somalia is considered to be lightly fished, with potential for expanded artisanal and industrial fisheries (Ahmed 1988).

Reef fish are heavily exploited in the region and in Kenya are found, with a few exceptions, in larger sizes and higher population densities within MPAs (McClanahan and Obura 1993; Watson and Ormond, N.d.). Also important in the region is the game fishery for marlin, tuna and shark in deepwaters around the island shelves.

Reptiles

Five species of marine turtle nest along the mainland coast of East Africa and on the islands of the western Indian Ocean: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*) and the olive Ridley (*Lepidochelys olivacea*). Green and hawksbill turtles are most common and are found in localized nesting populations throughout the region. In most areas, marine turtles are at risk from exploitation and from disturbance and damage to their nesting beaches and feeding grounds.

The main nesting beaches for green and hawksbill turtles are on islands. Europa, Tromelin and Aldabra have the highest nesting density of green turtles and hundreds nest on St. Brandon in the Carjados Carajos Shoals (la Hausse de Lalouvière 1994, in litt.; Turner 1994). Smaller numbers nest in the granitic and southeast islands of the Seychelles, on the west coast of Madagascar, and in the Comoros (Itsamia and Nioumachoa islets on Moheli; Sima on Anjouan; and Mayotte) (IUCN/UNEP 1984b, 1985). The nesting density of hawksbills is lower, with the largest populations on the granitic islands and in the Amirantes (particularly Poivre and Coetivy) in the Seychelles. Most of the Seychelles nesting sites are protected.

Much lower densities of turtle nesting occur on the mainland coast. In Mozambique, four species nest at Bazaruto, two at Inhaca; the largest site for green turtles is the Primeiras and Segundas Islands. Mozambique has significant nesting areas also for loggerhead, leatherbacks, and in the north, for olive Ridleys; in the north there is also an important feeding area for loggerheads. Most of these sites are protected or proposed for protection. Although most species also occur in Tanzania and Kenya, nesting populations are smaller or have declined in these countries. In Kenya, only green and hawksbill turtles have been recorded recently; the main feeding and nesting areas are in the Ras Tenewi area in the north and Mpunguti areas in the south (Olendo 1993). Tanzania reportedly has important feeding grounds for loggerheads (IUCN/UNEP 1984a). Misali Island, off Pemba in Tanzania, has important nesting sites for two turtle species. Green turtle and hawksbill nest in Somalia; early observations suggest that the highest numbers are at Basaso and Habo in the north and in Marca, Brava and Kismayo waters (UNEP 1987).

The main causes of decline of turtle populations in the region are coastal development that affects nesting beaches and incidental take of turtles in fishing nets. Turtles are also used for food and are highly sought after by fishermen in some areas (for example, Zanzibar) (Gaudian, personal communication).

Crocodiles may occur in coastal waters but information has not been obtained on them, or on sea snakes.

Birds

The region has a diverse assemblage of seabirds, including frigate birds, tropic birds, boobies, shearwaters, terns, noddies and gulls. Boobies are of particular concern as they have declined throughout the western Indian Ocean, and Abbot's booby *Sula abbotti* is now extinct in the region.

Numerous islands and islets support large seabird colonies, including Aldabra, Aride,

Cosmoledo, Desnoeufs, Cousin, Cousine, Recif, Farquhar, Boudeuse, Bird, African Banks, Astove, Providence and the Amirantes in the Seychelles; St. Brandon, Round, Serpent off Mauritius as wells as islets around Rodrigues; Tromelin and Ile du Lys in Reunion; I. Magnougni (Nioumachoua Islands off Moheli) and I. M'Chaco (Moheli) in the Comoros (IUCN/UNEP 1984a and b, 1985; Feare 1984). Major colonies along the mainland coast include islands off Kisite/Mpunguti, Kiunga (which has the single largest population (8,000 breeding pairs) in the world of Roseate Terns (*Sterna dougalli*) in Kenya, Latham Island in Tanzania, and some of the outer islands of the Quirimbas Archipelago in Mozambique. The coralline island of Nosy Manitra off the southwest coast of Madagascar has a population of about 4,000 *Sterna dougalli*, about 10–15 percent of the world population (Cooper, Williams, and Britton 1984).

There are also several important areas for waders and migrating birds, particularly on the African mainland coast, such as Inhaca Island and the Zambezi River Delta in Mozambique. The Tana River Delta in Kenya is a major wintering ground for hundreds of migrant birds and home to thousands of resident species. Other important coastal and marine birds include the Madagascar fish eagle *Haliaeetus vociferoides*, which is endemic to Madagascar, of which fewer than 40 pairs occurred in the mangroves and on offshore islets of the northwest coast in the 1980s (Collar and Andrew 1988); numbers may be higher now but are still not large (Nicholls 1994, in litt.).

Marine Mammals

The extent of the dugong's distribution and migrations along the mainland coast of East Africa is not known, but its most important remaining habitat is thought to be in Mozambique (IUCN/UNEP 1984a), particularly in the Bazaruto Archipelago, which may have the last viable population in the region (Dutton 1992, 1994) and possibly at Inhaca. Small populations occur in other areas such as Kiunga, Ras Tenewi (Kenya) (Olendo 1993), Rufiji Delta and Kilwa region (Tanzania) and possibly also Antonio Enes and the Primeiras and Secundas Islands in Mozambique and in the mangrove areas between Kismayo and Chiombo in Somalia. The dugong is very rare in the island states and has never been resident in some island groups such as the Seychelles (Nicholls 1994, in litt.); it is extinct around Mauritius and Mayotte (IUCN/UNEP 1984a,b; Salm, personal communication 1993). In Madagascar, they still occur (although they are not common) from the Tsiribihina River area along the entire northwest coast and the east coast to at least as far south as Ile Sainte Marie (Nicholls 1994, in litt.); however, they have not been seen in the Toliara region since the 1960s (Cooke 1994, in litt.).

Cetaceans are abundant in the productive areas of the Indian Ocean but there is little information on their distribution. At least 15 species have been recorded. A training workshop on marine mammals was held for the region in Kenya in 1991. The Mauritius Marine Conservation Society has produced a field guide to the marine mammals of Mauritius (MMCS 1991), and one is being produced for the West Indian Ocean. Marine mammals are protected under the national legislation of some countries (for example, Mauritius).

Biogeographic Classification

The classification of Hayden, Ray, and Dolan (1984) identifies three coastal realms for this region:

- Monsoon (coast of Somalia)
- Intertropical (Kenya, Tanzania, Comoros and northern part of Madagascar)
- Tropical (coasts of Mozambique and Madagascar)

Three hydrographic zones, based on currents, have also been determined within the region (Alusa and Ogallo 1992):

- The Somali upwelling zone
- The Monsoon current zone, covering the coasts of Tanzania, Kenya and the Seychelles
- The Agulhas and Mozambique current zone, which is subject to seasonal cyclonic influences from December to April, and covers the Comoros, Madagascar, Mauritius and Mozambique.

Given the complexity and lack of compatibility between these classifications, a much simpler geographical approach has been taken for the purpose of this report. The region has been divided into two main subdivisions: (a) Madagascar and the coastline of mainland Africa, and (b) the oceanic islands of Comoros, Seychelles, Mauritius, Reunion and Mayotte.

The coasts of East Africa and Madagascar can be treated together as continental-type coastlines with a relatively narrow continental shelf. From northern Mozambique to southern Somalia, the coast is broadly characterized by alternating regimes of beaches and rocky outcrops with fringing coral reefs and large estuarine areas characterized by delta formation and extensive mangrove stands. The islands are more heterogenous ranging from the small, rugged volcanic islands of the Comoros to the granitic and coralline islands of the Seychelles. However, from the biogeographic viewpoint, Sheppard (1987) has shown that the Madagascan coral fauna is more similar to the Comoros and other island states than to the East African mainland.

The following broad biogeographic zones are proposed:

- Red Sea/Indian Ocean interface (north coast of Somalia), characterized by exceptional coral reefs with high biological diversity, submersed volcanic activity, seasonally clear waters
- Northern area, which is dominated by seasonal colder upwellings and no coral reefs.
- Central area, dominated by tropical and subtropical coastal habitats such as coral reefs and mangrove forests, large intertidal mudflats and seagrass beds, and associated high marine biological diversity where habitats are still intact
- Southern area, ranging from the middle of Mozambique to the south African border, where subtropical coastal conditions peter out and the water becomes colder; where there are few coral reefs and rocky shores are common; and where diversity and endemism are high
- Oceanic islands, including the island groups of the Seychelles, Mauritius and Comoros, characterized by fringing and patch reefs, high diversity where reefs are present, and often high endemism.

ASSESSMENT OF EXISTING MPAS

Description of National MPA Systems

In 1984, there were 40 MPAs and 23 coastal protected areas in the region, protecting a total area of sea of less than 1,900 square kilometers; an additional 42 MPAs and 17 coastal sites were proposed (IUCN/UNEP 1984a). The current distribution is shown in Table 12.3.

There are no MPAs of any description in the Comoros and Somalia. A meaningful total is difficult to calculate from these figures. The total of 68 sites are covered by protected areas gazetted for marine life of some form, including 18 coastal protected areas on land that protect turtle and seabird nesting sites but do not include coastal waters. Of the total sites, 50 include coastal waters, including 13 fishing reserves (Mayotte, Reunion and Mauritius) and 4 marine mollusk reserves. Only a few of these areas have been effectively implemented and managed. There has been little change since the mid-1980s.

Table 12.3 Distribution of Marine and Coastal Sites in Protected Areas in the East Africa Marine Region

Country	*Marine Sites*	*Coastal Sites*
Kenya	5 sites: 4 Marine National Parks 6 Marine National Reserves	
Tanzania	8 Marine Reserves: Sites gazetted but none enforced	
Mozambique	1 Marine Reserve 1 Marine National Park 2 Game Reserves	1 Game Reserve
Madagascar	1 Marine Park	1 Special Reserve
Ile de la Reunion	6 Fishing Reserves 4 turtle protected areas (not enforced)	
Mauritius	6 Fishing Reserves (not enforced)	9 island Nature Reserves
Mayotte	1 Fishing Reserve	
Seychelles	1 Strict Nature Reserve/WHS 5 Marine National Parks 5 Special Reserves 4 marine mollusk reserves	7 seabird islet protected areas
Total	50	18

Comoros

There are no MPAs in the Comoros proper, although one is being developed (see below). In 1993, a National Policy for the Environment was adopted. An Environmental Action Plan is being developed for submission to donors, and new environmental legislation is being prepared (Jeudy de Grissac 1994, in litt.).

Kenya

Kenya has one of the most extensive MPA systems in the region, with some of the longest established sites (the reefs at Malindi and Watamu were first protected in 1968). National Parks and Reserves come under the Wildlife (Conservation and Management) Act of 1976 and are administered by the Kenya Wildlife Service (KWS). All mangroves are managed by the Forest Department as Forest Reserves, but are under threat as these reserves do not ensure protection. However, a recent Memorandum of Understanding between the Forest Department and Kenya Wildlife Service should lead to better management. Despite problems, Kenya probably has some of the most active management in the region with a relatively large force of trained MPA staff.

There are two types of MPA in Kenya. Marine National Parks are strictly protected areas for biodiversity and natural resources, in which fishing and removal of marine organisms are prohibited and only tourism is per-

mitted, within designated areas. Similar regulations apply to Marine Reserves, but in these, traditional forms of fishing are permitted. In some areas, the Marine National Parks lie within or adjacent to the Marine Reserves, so the whole area comprises a strictly protected core area and a buffer zone in which sustainable exploitation is allowed.

There are currently four Marine National Parks and six Marine National Reserves (which cover five geographically separate sites of conservation importance):

- Kisite Marine National Park and Mpunguti Marine National Reserve: Established 1978; located on the south coast off Shimoni and south of Wasini Island; important for coral reefs that surround four small limestone islets with nesting seabirds, and for fisheries; site description in UNEP/IUCN (1988).
- Kiunga Marine National Reserve and Biosphere Reserve: Established in 1979 (designated a Biosphere Reserve in 1980); located on the northernmost part of the coast, just south of the Somali border; important for coral reefs, islets with nesting seabirds, dugong, nesting turtles, and relatively pristine stands of mangroves. The relative inaccessibility of the area has meant that tourism is negligible within the reserve; 25 officers have recently been recruited and trained by Kenya Wildlife Service to work in the reserve, and a boat with outboard engine has been provided. Management of this reserve is to be integrated with that of the adjacent Dodori Coastal Reserve, which has important tidal swamps (Hughes and Hughes 1992) (site description in UNEP/IUCN 1988).
- Malindi/Watamu Marine National Parks and Malindi/Watamu Marine National Reserves and Biosphere Reserve: Established in 1976 and designated a Biosphere Reserve in 1979), this area is located south of Malindi to Mida Creek. It is important for fringing and offshore coral reefs, the famous coral gardens within the lagoon, seagrass beds, the estuarine Mida Creek with mangroves, mud flats and important shorebird populations (site description in UNEP/IUCN 1988).
- Mombasa Marine National Park and Mombasa Marine National Reserve (the park lies within the reserve): Established 1986; extends from Nyali to Mtwapa Creek, and includes a 100 foot strip inland from high water mark; established to protect a representative area of coral reef ecosystem with associated beaches and other ecological features. The area lies in the most important and extensive tourist area in Kenya.
- Diani Chale National Marine Reserve: Established 1993; located 25 kilometers south of Mombasa extending south to include Chale Island; encompasses reefs, fishing grounds and mangroves, sea bird nesting site on Chale I., and limestone caves; the area is a prime site for tourism (the Diani Tourist Complex) and is being overused; a management plan is currently being prepared, and protective measures have already been initiated; site description in UNEP/IUCN (1988).

The main problems are damage from sedimentation caused by land-based pollution and poor upcountry cultivation practices, illegal fishing activities, and poorly controlled tourism. Spear fishing is illegal, yet there are hotels that advertise spear fishing as an "attraction" for their guests. Some coral reefs, like the inner reef off the Diani coast, and parts of the Mombasa inner reefs have very little marine life left for the tourists to observe and enjoy. There has been too much pressure from tourists, boats, fishermen and shell collectors for the reefs to sustain. Dynamite fishing occurs in the far

south in the Shimoni/Vanga area, possibly by fishermen from Tanzania, although a major effort is under way to halt this in the Kisite/ Mpunguti Marine National Park and Reserve. A joint coral reef conservation project is under way under KWS, Kenya Marine Fisheries Research Institute and Conservation International aimed at improving management of the reefs (McClanahan and Obura 1993).

Madagascar

There is one Marine Park that includes coastal waters and one Special Reserve that includes coastal land, but neither of these two areas has effective management.

- Reserve de la Biosphere du Mananara (140,000 hectares): Established in 1989, it covers 1,000 hectares of islets, coral reefs and sea, with some mangroves and includes reefs up to 200 meters or more offshore and good dugong habitat (Nicholls 1994, in litt.; Stuart, Adams, and Jenkins 1990; WCMC 1992).

  Nosy Mangabe Special Reserve (520 hectares): Established to protect the aye-aye but includes coastline, mangroves and nesting seabirds.

Five areas (Nosy Anambo and Nosy Iranja (Antsiranana Province); Chesterfield Island, Nosy Ve and Nosy Trozona (Toliara Province)) were reportedly designated as Strict Nature Reserves for nesting green and hawksbill turtles in 1923, but this regulation is not enforced (UNEP/IUCN 1988; Nicholls 1994). There is a locally declared reserve at Nosy Tanikely where fishing is prohibited within 50 meters of the shore; the reserve was set up mainly in the interests of tourism and has no legal status at present (see below).

Very little is currently being invested in marine conservation and MPA establishment, compared with that for the terrestrial resources. This urgently needs to be rectified, given the importance of this country in the region for its large area of mangroves and extensive fringing and barrier reefs. Most marine conservation effort is currently going into the Grand Recif at Toliara. WWF carried out a survey of the area in 1992, covering ecological, social and economic aspects, and recommendations have been drawn up (see below) (WWF 1993).

Mauritius

There are no effective MPAs in Mauritius. The six fishing reserves, in which fishing is prohibited are very poorly enforced (UNEP/IUCN 1988):

- Flacq Fishing Reserve
- Riviere du Rempart-Poudre d'Or Fishing Reserve
- Black River Fishing Reserve
- Grand Port-Mahebourg Fishing Reserve: (large-scale sand extraction is taking place in this area)
- Port Louis Fishing Reserve
- Trou d'Eau Douce Fishing Reserve

There are a number of other protected areas, principally on offshore islets including those around Rodrigues. These were created in several cases for their endemic terrestrial fauna and do not include intertidal habitat, although several are adjacent to important areas of reef or have significant seabird nesting colonies. They are described in UNEP/IUCN (1988) and IUCN/UNEP (1987) and are listed below:

- Coin de Mire (Gunner's Coin) Nature Reserve: (Seabird population recently reduced through poaching)
- Ile Plate Nature Reserve
- Ile aux Aigrettes Nature Reserve
- Ile aux Serpents Nature Reserve
- Ilot Gabriel Nature Reserve
- Ilot Marianne Nature Reserve
- Round Island Nature Reserve
- Ile aux Cocos Nature Reserve (Rodrigues)
- Ile aux Sables Nature Reserve (Rodrigues)

The Terre Rouge Estuary Bird Sanctuary covers intertidal and estuarine habitat and was created for migratory birds.

A new Wildlife and National Parks Act was enacted recently and a new Fisheries Act is to be drafted (Dulloo 1994, in litt.). Conservation initiatives are also under way through a collaborative project of the University of Mauritius and the University of Bangor (U.K.), and a coastal zone inventory has been prepared, using LANDSAT, in preparation for coastal zone management planning. Fagoonee and Daby (1993) contain additional information.

Mayotte (France)

Mayotte has one MPA:

- Passe en S Strict Fishing Reserve (Mayotte Lagoon): Primarily a fishing reserve but also important for nesting seabirds, green turtles, mangroves, and coral reefs.

Mozambique

There are two MPAs that include relatively large areas of coastal waters:

- Ilhas da Inhaca e dos Portugueses Reserve: Important for coral reefs, seagrass beds, varied intertidal habitats, mangroves, dunes, marine invertebrates, turtles, dugongs; managed by the Inhaca Marine Biological Station; part of the area has been recommended as a Biosphere Reserve (World Bank 1993a; Stuart, Adams, and Jenkins 1990) (site description in UNEP/IUCN 1988).
- Parque Nacional do Bazaruto: Covers the islands of Bangue, Magaruque and Benguerua and lies between Bazaruto I and Santo Sebastian Peninsula and a 5-kilometer marine area around them (total area 15,000 hectares); important for turtles, dugongs, coral reefs; about 300 loggerhead turtles (Stuart, Adams, and Jenkins 1990). A management plan has been produced and is being implemented (Dutton 1992; Stuart, Adams, and Jenkins 1990; IUCN/UNEP 1987; World Bank 1993a) (site description in UNEP/IUCN 1988). Bazaruto Island and Santa Carolina (Paradise) are Zonas de Vigilencia where certain marine organisms are protected. Paradise Island is listed as a Marine National Park of 377,000 hectares in the WCMC Protected Areas Database (1992).

In addition there are three coastal Game Reserves. Two of these, Marromeu and Pomene, seem to include significant subtidal marine elements:

- Marromeu Game Reserve: Lies within the Zambezi Wildlife Utilization Area in the Zambezi River Delta; includes coastal dune forest, wetlands, mangroves, seagrass beds as well as terrestrial fauna and habitats; turtles (UNEP/IUCN 1988; World Bank 1993a).
- Pomene Game Reserve: Includes coastal dune forest, estuaries, mangroves, turtles (five species), dugong, dolphins as well as terrestrial fauna (UNEP/IUCN 1988; IUCN/UNEP 1987).

One of the Game Reserves is coastal:

- Maputo Game Reserve: This area includes coastal dune forest, beaches, mangroves, turtles (leatherback and loggerhead), as well as terrestrial fauna (UNEP/IUCN 1988; World Bank 1993a), but possibly not the coastal waters. A marine mammal project is being started in Maputo Bay outside the Reserve.

Ile de la Réunion

The three fishing reserves that were closed to fishing (except on foot and by line) on a rotational basis (see UNEP/IUCN 1988) were replaced in February 1992 by permanent reserves (Waller 1994, in litt.) in which fishing

is prohibited and certain regulations govern the mooring of boats:

- Cap la Houssaye (covering part of the barrier reef)
- Saline l'Hermitage (covering part of the barrier reef)
- Saline l'Hermitage (lagoon)
- Saint-Leu (lagoon)
- L'Etang (lagoon)
- St. Pierre (lagoon)

Four of the island dependencies were declared as Reserves Naturelles to include all marine and terrestrial life but none have been formally designated (the islands are also claimed by Madagascar) (site descriptions in UNEP/IUCN 1988).

- Ile Europa Reserve Naturelle: This area is important for nesting seabirds, green and hawksbill turtles.
- Iles Glorieuses Reserve Naturelle: The area is important for nesting seabirds, green and hawksbill turtles.
- Ile Tromelin Reserve Naturelle: The area is important for nesting green and hawksbill turtles.
- Ilot de Bassas de India Reserve Naturelle: The area is important for nesting green and hawksbill turtles.

Ile Juan de Nova was also initially declared a Reserve Naturelle but was replaced by Bassas de India under later legislation.

Seychelles

The Seychelles has 22 protected areas that include habitat of importance to marine biodiversity. There are 15 MPAs that include coastal waters (including four areas established to protect marine mollusks). Seven other areas have been established to conserve seabird and in some cases turtle nesting areas, but do not include coastal waters. About 27,000 hectares of seas and reefs have legal protection (Shah 1991), but although management plans have been prepared for many of the sites, not all have been implemented and there is no active management for several sites. An Environmental Management Plan was adopted in 1991–92, and all conservation initiatives are carried out under this. Information on institutional arrangements and legislation for marine biodiversity protection is provided in Shah (1991) and GEF (1992). Funding from the EU and the Royal Society for the Protection of Birds has enabled Birdlife International to appoint a trainer for National Park rangers and wardens for three years; this project comes to an end in July 1994, and a U.S.-funded Marine Parks Headquarters and training center was established in February 1993 on St. Anne (Shah 1994, in litt.).

- Aldabra Atoll Strict Nature Reserve and World Heritage Site: This site has undisturbed coral atoll with endemic birds, giant tortoise, nesting green turtles, green snails. It is managed by the Seychelles Island Foundation (site description in UNEP/IUCN 1988).
- St. Anne Marine National Park: This Park is important for islands, coral reefs, seagrass beds, nesting turtles; managed by the Department of the Environment; management plan to be developed with technical assistance from the IUCN Eastern African Regional Technical Office and funding from the EU (site description in UNEP/IUCN 1988).
- Curieuse Marine National Park: The Park is important for coral reefs, although these are badly damaged (Waller 1994, in litt.), sandy beaches, nesting turtles; managed by the Department of the Environment; rehabilitation project under way with funding from France and technical assistance from the IUCN Eastern African Regional Technical Office (site description in UNEP/IUCN 1988).
- Port Launay Marine National Park: This Park is important for sandy beaches,

coral reefs, seagrass beds; little active management (site description in UNEP/IUCN 1988).

- Baie Ternay Marine National Park: This area is important for coral reefs, algal flats; little active management (site description in UNEP/IUCN 1988).
- Silhouette Marine National Park: This Park includes reefs, mangroves and granite boulder-associated marine life (Shah, personal communication).
- Cousin Island Special Reserve: This area has nesting turtles and seabirds; it is managed by Birdlife International (site description in UNEP/IUCN 1988). The Reserve includes marine areas out to 400 meters from the shore (WCMC 1993b).
- Aride Island Special Reserve: The Reserve has nesting turtles and seabirds; it is managed by the Royal Society for Nature Conservation (site description in UNEP/IUCN 1988).
- African Banks Protected Area
- Ile Cocos Protected Area (includes Ile la Fouche and Ilot Platte)
- Desnoeufs Protected Area

Four protected areas have been established to protect marine mollusks:

- Brulee-Pointe au Sel Reserve
- Northeast Point Reserve
- La Passe-Grosse Roche Reserve
- Anse-Boudin-Pointe Zanguilles

An additional seven protected areas include coastal and possibly intertidal elements, but do not seem to include subtidal terrain:

- Ile Seche Nature Reserve: This islet has nesting seabirds.
- Ile aux Fous Nature Reserve: This islet has nesting seabirds.
- Les Mamelles Nature Reserve: This islet has nesting seabirds.
- Ile aux Vache Nature Reserve: This islet has nesting seabirds.
- Lamperiaire Nature Reserve: This islet has nesting seabirds.
- Boudeuse Nature Reserve: This islet has nesting seabirds and green and hawksbill turtles.
- Etoile Nature Reserve: This islet has nesting seabirds and green and hawksbill turtles.

Further information is provided in Shah (1993).

Somalia

There are currently no MPAs and no legislation concerning their establishment and management, although the WCMC Protected Areas Database lists Bushbush Game Reserve as an MPA.

Tanzania

Several areas were gazetted as marine reserves under Government Notice, 1975, and are the responsibility of the Ministry of Natural Resources:

- Dar es Salaam reserves (four sites):
  - Mbudya Marine Reserve
  - Bongoyo Marine Reserve
  - Pangavini Marine Reserve
  - Fungu Yasini Marine Reserve
- Chole Bay and Tutia Marine Reserves (Mafia Island, two sites):
  - Maziwi Island Marine Reserve
  - Tanga Coral Gardens Marine Reserve

However, none of these sites have been implemented as MPAs (UNEP 1989) and many have deteriorated to such an extent that they may no longer be worth protecting. Maziwi Island has disappeared through erosion, probably partly due to reef damage (Fay 1992), and the Dar es Salaam reserves are all in poor condition, in most cases be-

cause of dynamite fishing. However, some sites could recover if effective management were implemented soon; even some areas on the Dar es Salaam reefs have been found to be healthy. At two sites conservation initiatives are now under way:

- Tanga: In the mid-1980s, coral cover in Tanga Coral Garden Marine Reserve was down to 20 percent (IUCN 1987) and it was not considered worthy of protection (UNEP 1989), although some parts still had good reefs and fish populations (Riedmueller, personal communication 1992). The Tanga Regional Authority is implementing a coastal zone management project with technical assistance from the IUCN Eastern Africa Regional Office. This involves mapping and classifying the reefs and developing a management strategy for the coral reef area as a whole and a plan for Tanga Coral Gardens Reserve (if justified), involving community-based management and reef restoration as appropriate.
- Mafia Island and the Rufiji Delta: Chole Bay and Tutia Marine Reserves, if they functioned, would be inadequate given the importance of this area for marine biodiversity (coral reefs, mangroves, the delta and estuary, dugongs and turtles (IUCN/UNEP 1984a, Gaudian and Richmond 1990). The reefs around Mafia, with 350 reef fish, 40 genera of corals, are among the best on the East African coast and certainly within Tanzania. Following various proposals for the area (UNEP 1989), including a suggestion that it should be designated as a Biosphere Reserve (Ngoile 1989), efforts are under way to establish Mafia Island as Tanzania's first Marine National Park (Gaudian and others 1992). Extensive survey work has been undertaken by Frontier, a U.K.-based organization; there is good local support; and support has been provided by WWF and NORAD. A draft management plan has been prepared and proposals made for legislative and management procedures, resource assessment and community involvement (Horrill and others 1992).

The WCMC Protected Areas Database lists Saadani Game Reserve, on the Tanzania mainland coast, as having mangroves, but no further information is available.

The institutional framework for the management of marine resources and MPAs needs improvement. New legislation to enable the implementation and ratification of effective MPAs in both Tanzania and Zanzibar is being proposed (Gaudian and others 1993).

On Zanzibar, a Nature Conservation Areas Committee has recently been established, linked to the Commission for Lands and Environment, and will be responsible for the establishment and management of MPAs. Zanzibar legislation of 1988 allows for the declaration of marine sanctuaries and territorial marine parks. No MPAs have been formally designated, but GEF funding has permitted preliminary work toward the establishment of a number of community-managed MPAs, to be managed by fishing villages such as Mwemba Island (Horrill 1992b) and Fumba (Horrill 1992c) (see below). In some areas, fish populations and catches have already improved as a result of changes in management practices.

International and Regional Initiatives Relating to MPAs

Despite the international importance of this region in terms of marine biodiversity and resources, very few sites have been designated under the various international and regional agreements that contribute to marine biodiversity protection.

World Heritage Convention

Madagascar, Mozambique, Seychelles and Tanzania are party to the convention. The only marine and coastal World Heritage Site in the region is Aldabra Atoll, which was created a WHS in 1982, largely because of its terrestrial endemic species and giant tortoises but also for its large nesting populations of green turtles and seabirds. Round Island and Serpent Islands, shelf islands on the Mascarene Plateau, are considered worthy of World Heritage Site status, principally for their endemic terrestrial fauna and flora, although they also support major seabird colonies and rich coral growth. The Bazaruto Archipelago in Mozambique might be considered for World Heritage status (Elder 1994).

Ramsar Convention

To date, Kenya is the region's only party to the Ramsar Convention. As yet no coastal wetlands within the region have been nominated, although Kenya is preparing to nominate the Tana River Delta. Mozambique is not yet a party but the Marromeu Delta has been identified as a site worthy of Ramsar status (Dutton 1994, in litt.).

MARPOL

Waters around Aldabra and Mahe in the Seychelles (the only MARPOL signatory) are designated as "Areas to be Avoided" under IMO's General Provisions on Ships Routing. These are the only areas in this region that have specific protection from vessel pollution.

UNESCO Man and the Biosphere Programme

Kenya, Madagascar, Mauritius and Tanzania have national MAB committees, but the only marine and coastal Biosphere Reserves in the region are at Malindi/Watamu and Kiunga in Kenya and the Reserve de la Mananara Nord in Madagascar. A number of other sites have been proposed as Biosphere Reserves, such as the Grand Recif in Madagascar.

UNEP Regional Seas Programme

All countries in the region can participate in the Action Plan for the Protection, Management and Development of Marine and Coastal Environments in the East African Region, with its associated Convention. The Convention will come into force when six countries have ratified or acceded. So far, four countries (Somalia, France (Reunion), Kenya, and Seychelles) have ratified, and one (Madagascar) is a signatory; the Comoros will shortly accede. The Convention has two protocols covering (a) marine pollution issues and (b) the protocol on Protected Areas and Wild Fauna and Flora, which is relevant to this report. This requires parties to protect, or manage sustainably, the species listed in four Annexes; establish protected areas for rare, threatened, endemic, migratory and economically important marine species; and establish a regional program for the creation of a network of protected areas (Iqbal 1992). The species listed largely reflect those that are considered globally threatened by IUCN and that occur within the region.

Annex I covers wild flora. Eleven threatened species are listed, all of which are terrestrial but found in coastal habitats. Annex II covers wild fauna. In addition to many threatened terrestrial species found in coastal habitats, the list includes the dugong, humpback whale, blue whale, three species of turtle (olive Ridley, leatherback and loggerhead), six species of mollusk (triton's trumpet, trochus, fluted giant clam, small giant clam, horse's hoof clam and pearl oyster), the coconut crab, black coral and whip coral, and several shorebirds. Annex III covers harvestable fauna, and includes mainly game animals that occur on the coast, but also spiny lobsters, the green turtle and the hawksbill. Annex IV covers migratory spe-

cies and all the listed species are marine: the dugong, humpback whale, blue whale, and five species of turtle (green, hawksbill, olive Ridley, leatherback and loggerhead).

Other

A large area of the Indian Ocean, to 55 degrees south, extending west to the East African coast has been designated as the Indian Ocean Sanctuary for the protection of cetaceans.

At a meeting on Large Marine Ecosystems in 1993, a proposal was submitted to the GEF for a regional program to assess, monitor and protect the resources of the Somalia Coastal Current Ecosystem.

Assessment of Representation of Biogeographic Zones within MPAs

Table 12.4 outlines the number of MPAs in each of the biogeographic zones identified in the East Africa Marine Region. Only those MPAs that include coastal waters have been included in this assessment. A total of 50 such areas have been identified in this report; a further 18 protected areas include coastal terrestrial or intertidal features.

The five biogeographic zones that have been identified are rather unevenly represented within existing MPAs. Zone A, the north coast of Somalia, and Zone B, the northern area (comprising most of the Indian Ocean coast of Somalia) have no MPAs. Zone C, the central area, is much larger and has a large number of MPAs in Kenya and several projects under way in Tanzania (14 MPAs in all). Madagascar (1 MPA) however is poorly represented, and yet has sites of regional importance, particularly some of the most extensive stands of mangrove in the region on the west coast. Zone D, the southern part of Mozambique is also poorly represented in MPAs (4 MPAs). All the oceanic islands (Zone O, 32 MPAs) except the Comoros have MPAs, although there is considerable variation in the extent to which they are managed. The new EC regional project (see below) should improve MPA coverage in this biogeographic zone.

Table 12.4 Representation of Biogeographic Zones in Existing MPAs in the East Africa Marine Region

Biogeographic Zones	*Number of MPAs*
A. Red/Sea/Indian Ocean interface	0
B. Northern Area	0
C. Central Area	14
D. Southern Area	4
O. Oceanic Islands	32
Total	50

The major seabird nesting colonies in the region are already included in 15 protected areas or have been proposed for protection in a further 10 sites (IUCN/UNEP 1984a), and many of the main turtle nesting beaches are also protected.

Priority Areas and Recommendations

The East African coast and Indian Ocean islands have tended to be overlooked by international donor agencies when compared with regions such as Southeast Asia and the Caribbean. However, in recent years increasing attention has been paid to these countries. WWF International has recently identified marine conservation priorities for the East African countries and Madagascar (Gawler and Agardy 1994); this report was not available at the time of writing and should be consulted for further information on priorities. The EC has recently initiated a regional program for the Indian Ocean islands that involves coastal zone management and the establishment of MPAs, and further information is required on the priorities that have been identified under this project. Marine conservation efforts are also

under way through the IUCN Eastern Africa Regional Technical Office and through the UNEP Eastern African Regional Seas Programme.

National Priority Areas for the Establishment and Management of MPAs

The following sites are proposed as priority areas for the establishment or improved management of MPAs in the countries of the East African Marine Region (see Map 12). The proposals have been identified through a revue process but do not necessarily have the support of governments. Areas that have been identified as being of highest regional priority are noted by an asterisk (*), with justification for their selection provided.

Comoros

A National Policy for the Environment was adopted in December 1993 and new environmental legislation should be adopted in June 1994 (Jeudy de Grissac 1994, in litt.).

Existing MPAs that require management support:

There were no MPAs identified.

Proposed new MPAs:

- South coast of Mohéli, to include the Nioumachoua Islets: Dugong occur all around Mohéli. The area includes the country's best coral reefs, with good populations of black coral and mangrove. I. Magnoungui and I. M'Chaco have important seabird colonies. There are at least six turtle nesting beaches with green and hawksbill turtles including three on I. Ouenefou. Important fishing area. A feasibility study has been completed with the support of FAO and UNDP (Beudels-Jamar de Bolsée and Soimadou Ali 1993) and designation is expected in 1994; completion and implementation of the management plan may be carried out under the EC Regional Program for the Indian Ocean. Recommendations include the management of the area as a Biosphere Reserve and the designation of the islets as a strict reserve, with a surrounding buffer zone in which artisanal fishing would be permitted (UNEP/IUCN 1988; WCMC 1993b).
- Grand Comore (Chindini-Malé Marine Park and Bangoi Kouni—Ivoini Marine Park): Two sites on Grand Comore, from Bangoi Kouni to Ivoini in the north and from Chindini to Male in the south, are identified in UNEP/IUCN (1988) and World Bank (1993b).
- Chiroroni in south Anjouan is identified in UNEP/IUCN (1988) and World Bank (1993b).

Other priorities include marine habitats of importance to the coelacanth (Stuart, Adams, and Jenkins 1990), notably around Anjouan and Grand Comore, and the western tip of Mohéli including La Selle Island (Jeudy de Grissac 1994, in litt.).

Kenya

Several of the most important sites in Kenya for marine biodiversity are already protected, such as the Malindi/Watamu area and the Kisite/Mpunguti area, and are not currently considered as conservation priorities.

Existing MPAs that require management support:

- Kiunga Marine National Reserve and Biosphere Reserve*: Although protected, this is the least developed of all the marine parks and reserves, and given its international importance, is a high priority, although recently improved management measures have been undertaken (see above).
- Diani/Chale Marine National Reserve (described above).

Proposed new MPAs:

- Tana River Delta: This area covers about 20,000 hectares southwest of Kipini; it is a largely undisturbed wetland area that is being considered for nomination as a wetland of international importance under the Ramsar Convention. The delta has high diversity and is a haven for numerous species of migratory and sedentary birds, fish, marine turtles and other species; traditional forms of small scale agriculture. Pastoralism and fishing have maintained the ecological balance of the delta; protection of the area would ensure the continuation of such practices to benefit both the local community and the integrity of the ecosystem. High level discussions between government ministries, NGOs and local communities are in progress to decide on the priorities for conservation and development.
- Ras Tenewi: This proposed Marine National Park, located between Lamu Town and the Tana River Delta, will cover approximately 351,000 hectares (105,000 hectares of land and 245,000 hectares of sea) and protect the complex interface of marine and terrestrial ecosystems, including reefs and mangroves. Several small rocky offshore islands support dense breeding populations of seabirds, mainly gulls and terns. The area is internationally important as nesting beaches for olive Ridley, green and hawksbill turtles, and regionally important as a breeding site for dugong. Terrestrial fauna include elephants, buffaloes, waterbuck, duiker, warthogs, lions, and bushpigs. The area is of considerable ornithological interest.

Madagascar

National priorities for the creation of protected areas have been defined by the Association Nationale pour la Gestion des Aires Protegees, supported mainly by USAID (ANGAP/DEF 1992).

Existing MPAs that require Management Support:

- Nosy Atafana Marine Park: This area is part of Reserve de la Biosphere du Mananara (see above).

Proposed New MPAs:

- Lokobe Strict Nature Reserve (740 hectares): In the southeast corner of Nosy Be, this terrestrial reserve includes a small area of mangrove; it is adjacent to Nosy Tanikely, which is run as a voluntary marine reserve and is an area recommended for statutory protection and is included in the ANGAP list of priorities (IUCN/UNEP 1987; Stuart, Adams, and Jenkins 1990; Jenkins 1987; ANGAP/DEF 1992).
- Grand Recif and coastal zone of Toliara*: This reef is 25 kilometers long and 3 kilometers wide. These are up to 200 kilometers of reefs in total in the region, over 500 species of fish (Harmelin-Vivien 1977), mangroves, and seagrass beds. The area is important for artisanal fisheries (Laroche and Ramananarivo N.d.). These are the most well-studied reefs in Madagascar (Thomassin 1987), and there have been numerous recommendations for protection and management of this area (for example, Rabesandratana 1984, in litt.; Vasseur and others 1988). WWF has funded surveys and the groundwork for a project through joint work by the Institut Halieutique et des Sciences Marines and the Toliara Coral Reef Expedition (a British group). Studies of the area were carried out by the Station Marine under the University of Marseille in the 1960s and 1970s, and there has been ongoing work by the Station Marine funded by FAO and the

Cooperation Francaise (Andrew Cooke, personal communication). The area is rated highest priority marine site by ANGAP and third overall (ANGAP/DEF 1992). Two sites have been recommended as MPAs for biodiversity protection and ecotourism: Passe Sud d'Ifoty and Nosy Ve I. (which supports Madagascar's only recorded colony of the red-tailed tropic bird *Phaeton rubricaudata* (WWF 1993).

- Baie de Bombetoka: This is 46,000 hectares of mangrove on the Betsiboka River; WWF and the protected areas administration provide forest guards (ANGAP/DEF 1992; Nicholls 1994, in litt.).
- Baie de la Mahajamba: The area has extensive mangroves in northwest and is the best known Malagasy area for the Indo-Pacific humpback dolphin *Sousa chinensis* (ANGAP/DEF 1992; Nicholls 1994, in litt.).

Other large areas of mangrove, particularly on the west coast, have been identified as being of conservation priority: ANGAP/DEF (1992) lists those at Tambohorano and the Baie de Baly; World Bank (1993b), IUCN/UNEP (1987) and Jenkins (1987) also list Ambodibonara, Antsohihy, Cap Saint-Andre, Loza (18,000 hectare mangroves around a large lagoon), Mangoky River estuary, Rodo Bay (2,220 hectares of mangroves) and the Tsiribihina River estuary; Vasseur (1994, in litt.) recommends protection of mangroves at Mamombo (about 400 hectares), Baie des Assassins (2,500 hectares), Baie St. Vincent/Tsingilofilo (5,500 hectares) and Belo-sur-Mer (6,000 hectares).

Island sites recommended for MPAs in ANGAP/DEF (1992) also include Nosy Mitsio, Nosy Boraha and Nosy Barren; Jenkins (1987) recommends the offshore sand cays of Nosy Anambo, Nosy Faho, Nosy Fasy, Nosy Faty, Nosy Foty and Nosy Langna, with their surrounding reefs and seagrass beds on the northwest continental shelf.

Mauritius

An Environmental Investment Program (EIP) has been prepared by the World Bank and the Mauritius Government. EIP projects being developed include the preparation of a Marine Environmental Management Plan, marine ecosystem and marine and estuarine pollution monitoring, oceanography data collection, and the establishment of a Marine Conservation Centre.

Existing MPAs that require management support:

No areas were identified.

Proposed New MPAs:

- The Cargados Carajos Shoals*, particularly I. Perle for turtles
- Le Chaland Blue Bay MP (to be established under the EIP)
- Balaclava MP, Turtle Bay (to be established under the EIP)

Marine areas around the shelf islands (Gabriel, Flat, Round, Serpent and Coin de Mire) and the lagoon and reefs of the southwest coast are also considered worthy of protection (la Hausse de Lalouvière 1994, in litt.).

Several sites are also identified in UNEP/IUCN (1988) and WCMC (1992) such as Arsenal/Pointe aux Canonniers (where the marine habitats are now largely degraded (la Hausse de Lalouvière 1994, in litt.).

Mayotte

There was insufficient information to identify priorities for Mayotte.

Mozambique

Existing MPAs that require management support:

- The Bazaruto Archipelago* (Bazaruto Marine National Park): This is one of the richest sites for marine biodiversity

in Mozambique, with the last viable population of dugong in East Africa, four species of nesting turtle, coral reefs and seagrasses (Dutton 1992; Mendelssohn 1992). Conservation measures under way are described above. All the islands of the archipelago plus a large marine area have been proposed as the Greater Bazaruto Archipelago National Park, and legislation for this is currently with the Ministry of Agriculture (Dutton 1994, in litt.; Elder 1994).

- Inhaca Island (Ilhas da Inhaca e dos Portugueses Faunal Reserve): The area is important for the southernmost fringing reefs on the East African coast, extensive seagrass beds, turtles, sabellariid reef, and important dune forest (IUCN/UNEP 1984a) (see above).

Proposed new MPAs:

- The Primeiras and Segundos Islands: These islands, with fringing reefs, 200 nesting green turtles, seagrass beds, mangroves, dune forest and dugongs (Mendelssohn 1992) and the Quirimba Islands, with reefs, sea grass beds, turtles, and a large, tern colony, have been recommended as MPAs (Stuart, Adams, and Jenkins 1990; World Bank 1993a; Dutton and Ramsay 1992). The Quirimba Islands were reportedly surveyed in 1992, and protection is being sought as a National Park (Dutton 1994, in litt.).
- Nacala-Mossuril: Proposed as a National Park, the area is important for islands, nesting seabirds, seagrass beds, turtle nesting beaches, coral reefs (IUCN/UNEP 1984a; Stuart, Adams, and Jenkins 1990; World Bank 1993a). A two-week survey was carried out in 1992 by IUCN with support from FINNIDA. The issue of salt production in Nacala Bay has become very controversial, particularly about any resulting environment damage. The area has good potential for tourism (Burbridge, Couto, and Massinga 1992; Hatton 1994).
- Bartolomeu Dias area (21°15'S, 35°06'E): This is a spectacular sandspit where the Govuro River enters Bartolomeu Dias Bay; it is deeply dissected with mangrove (World Bank 1993a).

Other areas identified include: Porto Amelia Bay (World Bank 1993a), Rio Save Mangroves (Hughes and Hughes 1992; World Bank 1993a), and San Sebastian Peninsula proposed National Park (20,000 hectares of mangroves, sandspit, bay, nesting marine turtles and flamingoes) (Tinley and others 1976; World Bank 1993a). Further information is available in Gove (1993).

Ile de la Réunion

Apart from the area mentioned below, specific recommendations have not been available. Socioeconomic and funding requirements are currently being identified for a new marine park that would encompass all the reefs around the island and would include specific reserve areas (Waller 1994, in litt.).

Existing MPAs that require management support:

- Ile de Europa: This island supports the largest green turtle nesting colony in the Indian Ocean and is therefore probably of global significance. Improved protection for the turtle nesting beaches on Europa Island are required.

Proposed new MPAs:

No new areas were identified as priorities.

Seychelles

A GEF program that includes a component on marine biodiversity is already under way

in the Seychelles as part of a larger Environmental Management Plan for the Seychelles (EMPS) (Government of Seychelles 1990; GEF 1992). Under EMPS Projects G5, G9 and G10, a range of activities are being carried out to improve management of marine national parks, establish a conservation and national parks service, and develop a conservation strategy and national parks management plans (with funding from the EU). The two priorities being supported under this, and thus not identified as priorities in this report, are: (a) Aldabra, a World Heritage Site for which a long-term management plan is to be prepared, and b) preparation of management plans for green and hawksbill turtles.

Existing MPAs that require management support:

- Curieuse National Park: This is EMPS Project G.4 for rehabilitation, financed by the Government of France.
- Baie Ternay: (see above).
- Port Launay: (see above).
- St. Anne: As described above, this area is already receiving considerable support.

Proposed new MPAs:

It has been strongly recommended that new MPAs should not be designated in the Seychelles until financial, logistical and personnel constraints that are affecting the implementation and management of existing MPAs have been overcome (Shah 1994, in litt.).

Somalia

Somalia has a highly interesting coastline, particularly given the proximity of the seasonal upwelling close to coral reef habitats. Its marine habitats and resources are still poorly known, however, and when the political situation allows further work, the country will become a high priority.

Existing MPAs that require management support:

No areas were identified.

Proposed new MPAs:

- Bajuni Archipelago and adjacent coastal area: The Lac Badana National Park (0°25′–1°30′S; 42°30′–43°30′E) could be extended to include part or all of the archipelago (UNEP 1987). This area, from Kismayo to Kaambooni on the southern coast, is probably of highest priority; it is important for coral reefs, marine turtles and other marine resources although it is still poorly known (UNEP/IUCN 1988). The Bay of Buur Gaabo to the south has dense mangrove stands around estuaries (Hughes and Hughes 1992).
- Maydh Island (about 11°35′N, 47°30′E): This island is located in the Gulf of Aden, adjacent to Daalo Forest Reserve. Nothing is known about its marine habitats but considering the close proximity to the Red Sea and the seasonal coastal upwelling, the marine habitats are likely to be biologically and geologically important. There are major seabird colonies in this area.

WCMC (1992) also lists the following coastal sites as proposed protected areas: Zeila (important seabird colonies on offshore islets), Jowhar-Warshek, and Awdhegle-Gandershe.

Tanzania/Zanzibar

Existing MPAs that require management support:

- Mafia Island and the Rufiji Delta*: This area includes Chole Bay and Tutia Island Marine Reserves (see above).
- Tanga area: This area includes Tanga Coral Gardens Marine Reserve (see above).

Proposed new MPAs:

- Kilwa Kisiwani (about 9°05'S, 49°10'E): This area is important for turtles and coral reefs (which have been little studied) and possibly dugongs. UNEP (1989) proposes a multiple use zoned area to extend from just south of the Kilwa Islands northward to Ozuka Island.
- Mbegani proposed MPA (06°34'S, 39°07'E): Extending from Ras Mbegani to a point south of Kitapumbe reefs, the area is important for unique dune formations, mangroves and islands, coastal banks and reefs including Kitapumbe Reefs and Mohingwi Reef (UNEP 1989).
- Ras Buyuni proposed MPA: The area extends from Ras Kunzi to Ras Pembamnasi, and includes reefs, bays, beaches, and mangrove forests (UNEP 1989).
- Lindi proposed MPA (09°41'S, 39°45'E): Extending north from Lindi Bay to Mchinga Bay, the area includes mangroves and reefs (UNEP 1989).
- Mtwara/Ruvuma proposed MPA: On the border of Mozambique, this area includes reefs and islands, with a northern Ruvuma estuarine and mangrove complex (UNEP 1989).
- Latham Island (6°50'S 39°50'E): Tanzania's nearest proximation to an atoll by virtue of its isolation and surrounding deepwaters, this island is uninhabited and undisturbed, as it has no freshwater. There is a narrow fringing reef and a turtle nesting beach, and the area is internationally important as a seabird nesting site for Greater Crested Tern (*Sterna bergii*), masked booby (*Sula dactylatra*), brown noddy (*Anous stolidus*), sooty terns (*Sterna fuscata*), and others. It is the only major seabird island in East Africa (UNEP 1989).

Zanzibar (the islands of Unguja and Pemba) has a number of sites of regional, and probably international importance for marine biodiversity. There is a proposal to develop a coastal zone management plan for the island through a UNEP initiative (Dight, personal communication).

- Pemba (Misali, Mtangani, Matumbe and N Pemba) (5°8'S, 39°46'E): The marine habitats of Pemba, which is surrounded by deepwater and strong ocean currents, are likely to be particularly significant; the waters are unusually clear and the reefs are well developed and very diverse with exceptional fish life. Four subareas have been identified:
  - Misali Island (5°15'S, 39°36'E), off the southwest coast of Pemba: The island has a 9.4 kilometer ring of exceptional coral growth, extending down to 64 meters, with diverse corals (40 genera) and fish (244 reef species). Strong tidal currents may mean that this is a source reef for reefs elsewhere on the mainland coast. Two species of turtle nest on the island and there are extensive seagrass beds. The island and reefs are important for artisanal fishing and have great potential for tourism (Horrill 1992a; UNEP 1989). Management is to be based on community participation. UNEP (1989) suggests designation as a reserve and marine park.
  - Mtangani (about 5°35'S, 39°55'E) on the southeast coast of Pemba: There is a mangrove forest in the inlet separating Mtanga Island from Pemba. The channel between the two islands is about 15 meters deep and may be a breeding site for finfish species. The mangroves have not been cut recently and are a habitat for a highly varied bird fauna. UNEP (1989) suggest designation as a marine reserve.

- Reefs of north Pemba: These are located off Ras Kiuyu and at Njao Gap in the northwest and have potential for dive tourism development.
- Matumbe reef complex off southwest Pemba.

- Unguja (Mnemba Island, Islets off Zanzibar) (approximately 5°49'S, 39°22'E): A number of important sites have been identified around Unguja Island. Mnemba Island and reefs, off the northeast coast of Unguja, have a large reef with diverse corals (47 genera) and fish; the deep reefs have large adult fish now rare elsewhere in Zanzibar. It is a feeding station for migratory shorebirds. The area is also important for tourism (Horrill 1992b; Ngoile and others 1990). UNEP (1989) suggests designation as a marine reserve. Also identified are Islets off Zanzibar town—Bawe, Changuu (Prison) and Chapwani (Grave)—that are less important biologically than some areas, but the reefs are of major value to tourism (Ngoile 1990). A draft management plan was prepared in 1989 by the Institute of Marine Sciences. UNEP (1989) suggests designation as a marine park and multiple use area.

Other areas identified include Jozani Forest/Chwaka Bay (mangroves, seagrass beds and adjacent terrestrial habitats) and the mangroves, reefs and islets of Menai Bay and the Fumba peninsula.

Regional Priorities for the Establishment and Management of MPAs

The areas listed below are considered to be those of highest regional priority for the establishment or improved management of MPAs, according to the criteria outlined in the introduction to this report. These areas were identified after regional and national representatives reviewed a short list of sites prepared by Sue Wells. Justification for the selection of these areas is outlined below. Sources of information are cited in the main report.

- Mafia Island and Rufiji Delta (Tanzania): The reefs around Mafia Island, with 350 reef fish and 40 genera of corals, are among the best on the East African coast and certainly within Tanzania. With the reefs around the islands of Zanzibar, it is possible that these reefs are important sources of larvae for other reefs along the mainland coast of East Africa. The Ruaha/Rufiji Delta, where the confluence of the two rivers forms a massive floodplain, is one of the most important coastal wetlands in East Africa (Hughes and Hughes 1992) and has about 3,200 hectares of mangrove. A small population of dugong may occur, and turtles are known to nest on some remote beaches on Mafia Island. One of the country's main prawn fishing grounds is at the mouth of the Rufiji Delta.

  The international importance of the area has been known for many years. Chole Bay and Tutia already receive legal protection as marine reserves but are not managed in practice and are not large enough to protect the biodiversity of the location. There have been many proposals and recommendations for management, including designation of the area as a Biosphere Reserve (UNEP 1989; Ngoile 1989). Work over the last five years on Mafia Island by the organization Frontier, in collaboration with Tanzanian institutions, means that implementation of a management plan for the island (to become Tanzania's first marine park) is now feasible (Horrill and others 1992). There is good local support, and legislation is in the pipeline. WWF and NORAD have reportedly offered funding for this site (Bensted-Smith 1993, in litt.).

- Parque Nacional do Bazaruto (Mozambique): The Bazaruto archipelago supports a diverse range of marine habitats including pelagic areas, coral reefs, rocky intertidal areas, sandy beaches, tidal sand flats, seagrass meadows and mangroves communities (see Elder 1994 and WWF, SANF and ORI 1989). The fish fauna is representative of East African coastal species with the total species count in excess of 2,000. Diverse crustacean and mollusk assemblages are also present. These and other resources are important to the local populations.

  The archipelago provides highly suitable habitat for marine mammals with a number of species present, including humpback whales (which feed in the area), bottlenose dolphin, common dolphin, spinner dolphins, humpback dolphins and a significant population of dugong. Five species of marine turtle are recorded, the green, hawksbill, loggerhead, olive Ridley and the leatherback. All of these except the olive Ridley are reported to nest on the islands.

  The archipelago is an important spawning, nursery and recruitment area for a variety of marine organisms. Its high diversity and relatively undisturbed condition make it of regional and probably global significance. It has been suggested as a possible site for World Heritage status. Significant progress has already been achieved in developing a community-based, multiple-use management plan under a WWF/Southern African Nature Foundation project, and these efforts should be supported as a high priority. The expansion of the existing protected area to create a "Greater Bazaruto Archipelago National Park" should also be a priority. The area would provide an ideal opportunity as a demonstration site for integrated coastal zone management.

- Kiunga Marine National Reserve and Biosphere Reserve (Kenya): The area includes coral reefs, islets with nesting seabirds, dugong, nesting turtles, and relatively pristine stands of mangroves. The inaccessibility of the area has meant that pressures from tourism and other forms of use have been low, and as a result the marine environment has not suffered the degradation experienced in other areas.

  Although this area has been established as a MPA it lacks infrastructure and management. Technical and financial support is required to provide for training of personnel, development of a management plan, purchase of equipment to ensure that management can be effectively implemented. It is proposed that management of this reserve should be integrated with that of the adjacent Dodori Coastal Reserve that has important tidal swamps.

- Grand Recif and coastal zone of Toliara (Madagascar): The barrier reefs of southwest Madagascar are the most extensive in the Indian Ocean and among the largest in the world, with about 200 kilometers of true barrier including the 18–25 kilometer long, 3 kilometer wide Grand Recif de Toliara. Five hundred reef fish species have been recorded in the area (Harmelin-Vivien 1977), and there is a high diversity of other marine life. These are the most well-studied reefs in Madagascar (Thomassin 1987). The area in the vicinity of the reef includes significant stands of mangroves, with at least seven species, and there are extensive seagrass beds to the north. There are major artisanal fisheries (Laroche and Ramananarivo 1993).

  There have been numerous recommendations for protection and management of this area (for example, Rabesandratana 1984, in litt.; Vasseur

and others 1988), and WWF has funded surveys and the groundwork for a project through joint work by the Institut Halieutique et des Sciences Marines and the Toliara Coral Reef Expedition (a British Group). French scientists have also been working in the area through the EC regional program for the Indian Ocean. The area is rated as the highest priority marine site in the country (ANGAP/DEF 1992). Two sites have been recommended as MPAs for biodiversity protection and ecotourism within the area, Passe Sud d'Ifoty and Nosy Ve I. (which supports Madagascar's only recorded colony of the red-tailed tropic bird (*Phaeton rubricaudata*) (WWF 1993). Although its importance has been recognized, at present there is no implementation of management in the area. The entire reef system should be a high priority for fisheries and tourism management within the context of coastal zone management.

It is now a high priority to implement this project and provide this area with formal protection.

- South coast of Mohéli, including the Nioumachoua Islets (Comoros): The area includes the country's best coral reefs, with good populations of black coral, mangroves and dugong. I. Magnoungui and I. M'Chaco have important seabird colonies. There are at least six turtle nesting beaches with green and hawksbill turtles including three on I. Ouenefou and the area may be among the most important turtle nesting sites in the western Indian Ocean. It is also a very important fishing area.

  A feasibility study has been completed with the support of FAO and UNDP (Beudels-Jamar de Bolsée and Soimadou Ali 1993) and designation is expected in 1994; completion and implementation of the management plan may be carried out under the EC Regional Program for the Indian Ocean. Recommendations include the management of the area as a Biosphere Reserve and the designation of the islets a strict reserve, with a surrounding buffer zone in which artisanal fishing would be permitted (UNEP/IUCN 1988; WCMC 1993b). Feasibility and likelihood for success is fairly high as a National Policy for the Environment was adopted in December 1993 and new environmental legislation should be adopted in June 1994.

- Cargados Carajos Shoals (Mauritius): This area of several thousand square kilometers has received little attention in the conservation literature. However, it is one of the most productive marine areas in the region and is extremely important for commercial and artisanal fisheries. It includes a 100 kilometer long crescent-shaped reef covering over 190 square kilometers, behind which lies a vast area of shallows and sandbanks averaging less than 20 meters in depth, with about 20 islets and cays. The reef itself has not been studied, but appears to have rather low diversity due to high natural sedimentation, but there is a broad reef flat with a massive algal ridge that is thought to be the largest in the Indian Ocean. Endemic Mauritian mollusks have been recorded from some of the reefs.

  The islets are regionally important for their seabird populations, and there have been many recommendations for protection of the more important colonies (see UNEP/IUCN 1988). Some of the islands have regionally important green turtle nesting beaches such as Ile du Nord (St. Brandon) and Perle; and the coconut crab may still occur on some islets. In the 1980s, the area was leased to a fishing company and this is presumably still the case. The com-

pany has reportedly enforced national and local regulations well.

The following notes pertain to the selection process:

- Sites in Somalia have been excluded as at present there is little chance of successful implementation.
- Protection and management of the coelacanth is a regional priority (principally Comoros, but also Mozambique), but there is insufficient data available to make recommendations relating to protected areas.
- In the Seychelles, GEF funds are already being used to assist protection of the marine environment at Aldabra and turtle conservation, and additional sites have therefore not been recommended. St. Anne Islands Marine National Park has been suggested as requiring support for ongoing management, but since this site is already receiving the bulk of attention of the conservation and national parks service, Baie Ternay and Port Launay are listed as the highest priorities in the main report. However, it would be difficult to justify any of these sites as internationally or regionally important.

Other Recommendations

In several countries, particularly the island nations, there is a need to develop policy on integrated coastal zone management, within which MPAs would play an important role. Many countries have an insufficient legal and institutional framework and lack sufficient trained personnel, suitable equipment and logistical support for the development of either integrated CZM or an adequate marine protected areas system. Improved public awareness of the purpose of MPAs, at the level of both local people and tourists is also required. A more formalized involvement of NGOs, especially in the island states, is also required. These issues must be tackled if efforts to protect the sites that have been identified for marine biodiversity protection are to be successful in the long term. Many of these issues were discussed at a workshop and policy conference on integrated coastal zone management in the region held in March 1993 in Arusha, Tanzania.

Expertise in MPA planning and management is unequally distributed throughout the region. Networks designed to share experiences and to enable temporary secondment of personnel to states and institutions in need would go a long way to advancing marine biodiversity conservation. There is an urgent need for training programs in MPA planning and management, including natural history, practical techniques (diving, boat handling and maintenance, mooring buoy design, installation and maintenance, trail).

To date there has been a lack of a strong regional approach to marine conservation in the region. This is now changing through initiatives being taken by the EC, the UNEP Regional Seas Programme, and IUCN's Eastern Africa Regional Office. The latter is embarking on a project to strengthen the capacity of the National Parks authorities in the region to prepare and implement management plans for MPAs, and a regional training course for MPA planners and managers is to be developed (Salm, personal communication).

Bibliography

Ahmed, O.H. 1988. Coastal fisheries development in Somalia. Paper presented at workshop on Ecology and Bioproductivity of the Marine Coastal Waters of East Africa, University Dar es Salaam, Tanzania.

Aleem, A.A. 1984. Seagrasses in the Indian Ocean. *Deep Sea Res.* 31:919–33.

Alusa, A.L., and L.J. Ogallo. 1992. *Implications of expected climate change in the Eastern African Coastal Region: An overview.* UNEP Regional Seas Reports and Studies 149. Nairobi.

Andrill, J.D. 1984. *Tuna fisheries in the Southwest Indian Ocean.* Proceedings seminar to review the marine fish stocks and fisheries in Tanzania. Bergen, Norway: Tanzania Fisheries Re-

search Institute/Norwegian Agency for Development/Institute of Marine Research.

Association Nationale pour la Gestion des Aires Protegées (ANGAP) and Direction des Eaux et Forets (DEF). 1992. *Manuel de Procedure pour la Creation des Aires Protegées.* Association Nationale pour la Gestion des Aires Protegées, Direction des Eaux et Forets, Antananarivo.

Beudels-Jamar de Bolsée, R.C., and A. Soimadou Ali. 1993. *Etude de faisabilité pour la creation d'un parc marin à Mohéli.* Rome: FAO/UNDP.

Briggs, J.C. 1974. *Marine biogeography.* New York: McGraw-Hill Book Company.

Burbridge, P., M. Couto, and A. Massinga. 1992. Nacala Bay and Peninsula, Mozambique. Unpublished report of field observations.

Commission of European Community (CEC). 1992. *Mangroves of Africa and Madagascar.* Brussels: Directorate-General for Development, Commission of the European Communities, ECSCC-EEC-EAEC.

Collar, N.J., and P. Andrew. 1988. *Birds to watch: The ICBP world checklist of threatened birds.* ICBP Technical Publication 8. Cambridge, U.K.

Cooper, J., A.J. Williams, and P.L. Britton. 1984. Distribution, population size and conservation of breeding seabirds in the Afrotropical region. In J.P. Croxall, P.G.H. Evans, and R.W. Schreiber, eds., *Status and conservation of the world's seabirds.* ICBP Technical Publication No. 2. Cambridge, U.K.

Dutton, P. 1992. Bazaruto Archipelago: Mozambique's fragile paradise. Unpublished report.

———. 1994. *Past and present status of Dugong Dugong dugon in the Bazaruto Archipelago and other known habitats on the Mozambique coast.* Paper presented at the First International Manatee and Dugong Research Conference. Gainesville, FL.

Dutton, P., and S. Ramsay. 1992. The Quirimbas Archipelago. *Endangered Wildlife* 12:16–7.

Elder, D.L. 1994. *Evaluation of WWF Project Bazaruto Archipelago Conservation Master Plan (BACP).* ZA 243. Report to IUCN.

Fagoonee, I., and D. Daby. 1993. Mauritius country report. Workshop and Policy Conference on Integrated Coastal Zone Management in East Africa and Island States, Arusha, Tanzania (April).

Fay, M.B. 1992. *Maziwi Island off Pangani (Tanzania): History of its destruction and possible causes.* UNEP Regional Seas Reports and Studies No. 139. Nairobi.

Feare, C.J. 1984. *Seabird status and conservation in the tropical Indian Ocean.* In J.P. Croxall, P.G.H. Evans, and R.W. Schreiber, eds., *Status and conservation of the world's seabirds.* ICBP Technical Publication No. 2. Cambridge, U.K.

Ferguson, W. 1993. A landscape ecological survey of the mangrove resource of Kenya. Draft report, March.

Fisher, P., and M.D. Spalding. 1993. *Protected areas with mangrove habitat.* Unpublished report to World Conservation Monitoring Centre, U.K.

Gawler, M., and T. Agardy. 1994. *Developing WWF priorities for marine conservation in the Africa and Madagascar region.* Report to WWF International. Gland, Switzerland.

Gaudian, G., and others. 1993. Establishment of a coastal zone management program for Tanzania. Consultancy report to the Commission for European Communities, DG VIII.

———. 1992. *The development of a marine resource conservation plan for Mafia Island, Tanzania.* 4th World Congress on National Parks and Protected Areas, Caracas, Venezuela (February).

Gaudian, G., and M. Richmond. 1990. *Mafia Island Marine Park Project.* London: The People's Trust for Endangered Species.

Global Environment Facility (GEF). 1992. *Seychelles: Biodiversity Conservation and Marine Pollution Abatement Project.* Washington, D.C.: World Bank.

Gove, D.Z. 1993. Mozambique Country Report. Workshop and Policy Conference on Integrated Coastal Zone Management in East Africa and Island States, Arusha, Tanzania, April.

Government Notice No. 127. 1975. Fisheries Act, 1970. Supplement No. 30, Subsidiary legislation.

Government of Seychelles (1990). *Environmental management plan of Seychelles 1990–2000.* Ministry of Planning and External Relations, Department of Environment, Republic of Seychelles.

Halim, Y. 1984. *Marine Sciences in the Peoples Republic of Mozambique.* UNESCO Technical Report RP/1981.

Harmelin-Vivien, M.L. 1977. *Ecological distribution of fishes on the outer slope of Tulear reef (Madagascar).* Proceedings of 3rd International Coral Reef Symposium, Miami.

Hatton, J. 1994. *A avaliacao da situacao ambiental da ilha de Mocambique e zonas adjacentes.* Report to IUCN. Harare, Zimbabwe.

Hayden, B.P., B.C. Ray, and R. Dolan. 1984. Classification of coastal and marine environments. *Environmental Conservation* 11(3): 199–207.

Horrill, J.C. 1992a. *Status of the coral reefs of Misali Island, Pemba.* Zanzibar Environmental Study Series No. 13. Zanzibar: Commission for Lands and Environment.

———. 1992b. *Ecological monitoring survey of the coral reefs around Mnemba, Chapwani, Changuu and Bawe Islandsof Misali Island, Pemba.* Zanzibar Environmental Study Series No. 11. Zanzibar: Commission for Lands and Environment.

———. 1992c. *Status and issues affecting marine resources around the Fumba Peninsula.* Zanzibar Environmental Study Series No. 12. Zanzibar: Commission for Lands and Environment.

Horrill, J.C., and others. 1992. *The proposed Mafia Island Marine Park Tanzania.* Report prepared for WWF/TZ for the Ministry of Tourism, Natural Resources and Environment.

Hughes, R.H., and J.S. Hughes. 1992. *A Directory of African Wetlands.* Gland, Switzerland and Cambridge, U.K.: IUCN; Nairobi: UNEP; Cambridge, U.K.: WCMC.

Iqbal, M.S. 1992. *Assessment of the Eastern African Action Plan and the effectiveness of its legal instruments.* UNEP Regional Seas Reports and Studies 150. Nairobi.

IUCN. 1987. *The coastal resources of Tanga region Tanzania.* IUCN East Africa. Nairobi.

IUCN and United Nations Environment Program (UNEP). 1984a. *Marine and coastal conservation in the East African region.* UNEP Regional Seas Reports and Studies 39. Gland, Switzerland.

———. 1984b. *Marine and coastal conservation in the East African region: National reports.* UNEP Regional Seas and Studies 50. Gland, Switzerland.

———. 1985. *Management and conservation of renewable marine resources in the Eastern African region.* UNEP Regional Seas Reports and Studies 66. Gland, Switzerland.

———. 1987. *The IUCN Directory of Afrotropical Protected Areas.* Gland, Switzerland and Cambridge, U.K.

Jenkins, M.D., ed. 1987. *An Environmental Profile of Madagascar.* Gland, Switzerland and Cambridge, U.K.: IUCN/WWF/UNEP.

Jiddawi, N.S., and C. Muhando. 1990. *Summary of marine resources in Zanzibar.* Zanzibar Environmental Study Series No. 1. Zanzibar: Commission for Lands and Environment.

Kurien, J., and S. Mathew. 1992. *Technological change in fishing: Its impacts on fishermen.* Trivandrum, India: Special Study for International Centre for Development.

Laroche, J., and N. Ramanarivo. N.d. Seasonal changes in the fish catches from coral reefs of the Tulear region (Southwest Madagascar) with an estimate of annual yield. *Aq. Living Resources.* Forthcoming.

Lebigre, J-M. 1990. *Les marais maritimes du Gabon et de Madagascar.* Thèse de Doctorat e'Etat. Institut de Géographie, University de Bordeaux III.

Mauritius Marine Conservation Society (MMCS). 1991. *The Whales and Dolphins of Mauritius.* Mauritius Marine Conservation Society.

McAllister, D.E., F.W. Schueler, C.M. Roberts, and J.P. Hawkins. 1993. Mapping and GIS analysis of the global distribution of coral reef fishes on a equal-area grid. In R. Miller, ed., *Mapping the diversity of nature.* London: Chapman and Hall.

McClanahan, T.R. 1989. Kenyan coral reef associated gastropod fauna: a comparison between protected and unprotected reefs. *Marine Ecology Prog. Ser.* 53:11–20.

McClanahan, T.R., and N.A. Muthiga. 1988. Changes in Kenyan coral reef community structure and function due to exploitation. *Hydrobiologia* 166:269–76.

McClanahan, T.R., and D. OburaD. 1993. *Status of Kenyan coral reefs.* Global Status of Coral Reefs, Miami (June).

Mendelssohn G. 1992. Mozambique Transfrontier National Parks and Institution Strengthening Project. Report to GEF from first preparatory mission (January).

Montaggioni, L.F., and G. Faure. 1980. *Les récifs coralliens des Mascarèignes (Océan Indien).* Université francaise de l'Océan Indien, Centre Universitaire de la Réunion.

Moorjani, S.A., and B. Simpson. 1988. *Seaweeds of the Kenya Coast.* Nairobi: Oxford University Press.

Mshigeni, K.E. 1985. Report on CSC Workshop on Marine Algal Resources of East Africa: Indian Ocean States.

Ngoile, M.A.K. 1989. *The development of a marine national park, Mafia Island, Tanzania; Current state of the marine environment of the South Mafia Channel.* Zanzibar: Shell Petroleum Development (TZ) Ltd, UDSM/IMS.

Ngoile, M.A.K., and others. 1990. *Ecological baseline surveys of coral reefs around Mnemba I. and Zanzibar Town.* Zanzibar Environmental Study Series No. 9. Zanzibar: Commission for Lands and Environment.

Nhwani, L.B. 1988. *The pelagic fish resources of East Africa coastal waters.* Paper presented at workshop on Ecology and Bioproductivity of Marine Coastal Waters of East Africa. Dar es Salaam, Tanzania: University Dar es Salaam.

Ntiba, M.J. 1993. *The ecological role of the mangroves in the capture marine fisheries of Kenya.* Paper presented at the National Workshop for the Improved Management Conservation of the Kenyan mangroves, Mombasa, Kenya (19–23 July).

Olendo, D. 1993. Survey of sea turtles and dugongs in Kenya. Report to Kenya Wildlife Service, Nairobi, Kenya.

Polunin, N.V.C., and J.G. Frazier. 1974. Diving reconnaissance of twenty seven western Indian Ocean coral reefs. *Environmental Conservation* 1(1): 71–2.

Salm, R. 1976a. The dynamics and management of the Ponta Torres coral reef, Inhaca Island, in Mozambique. Mems. Inst. Invest. Cient. Mocamb. 12 Serie A.

———. 1976b. The structure and successional status of three coral reefs at Mauritius. Proc. *Royal Society of Arts and Sciences of Mauritius* 3(2): 227–40.

Samoilys, M. 1988a. *A survey of the coral reef fish communities on the Kenyan coast.* WWF Project 3797 Kenya. Technical Report prepared for the Ministry of Tourism and Wildlife.

Samoilys, M.A. 1988b. *Abundance and species richness of coral reef fish on the Kenyan coast: the effects of protective management and fishing.* Proceedings of the 6th International Coral Reef Symposium, Australia.

Scullion, J. 1989. *Assessment of the demersal fish resources of the deeper reef slopes of Lindi and Mtwara Regions, Tanzania.* Report to ODA, U.K.

Semesi, A.K. 1991. *Management plan for the mangrove ecosystem of mainland Tanzania: Vol. II Mangrove management plan of all coastal districts* (Part 1: An overview of mangroves and strategies and approaches essential for the implementation of the plan). Report supported by NORAD.

Semesi, A.K. 1990. *Conservation and utilization of mangrove plants along the Tanzania coast.* Proceedings of Workshop on Marine Sciences in East Africa, Dar es Salaam.

Semesi, A.K., and K. Howell. 1989. *The mangroves of the East African Region.* Nairobi: UNEP.

Shah, N.J. 1991. Nature and tourism in Seychelles. In *Tourism of quality: A concept of tourism development compatible at the same time to economic, social and environmental aspects.* Switzerland: AIEST Press.

———. 1993. *Seychelles Country Report.* Workshop and Policy Conference on Integrated Coastal Zone Management in East Africa and Island States, Arusha, Tanzania, April.

Sheppard, C.R.C. 1987. *Coral species of the Indian Ocean and adjacent seas: A synonymous compilation and some regional distribution patterns.* Washington, D.C.: National Museum of Natural History, Smithsonian Institution.

Stuart, S.N., R.J. Adams, and M.D. Jenkins. 1990. *Biodiversity in Sub-Saharan Africa and its Islands.* IUCN/SSC Occasional Paper 6. Gland, Switzerland.

Thomassin, B.A. 1987. *Bibliographie des travaux sur la géologie et le bios marin de la région de Tuléar* (S.W. de Madagascar). Atelier AIRDOI "Récifs Coralliens." Univ. de la Réunion.

Tinley, K.L., A.J. Roshina, J.L.P. Tello, and T.P. Dutton. 1976. Wildlife and wild places in Mozambique. *Oryx* 13(4): 344–50.

United Nations Environment Program (UNEP). 1987. *Coastal and marine environmental problems of Somalia.* UNEP Regional Seas Reports and Studies 84. Nairobi: ESCWA/FAO/UNESCO/IMO/IAEA/IUCN/UNEP.

———. 1989. *Coastal and marine environmental problems of the United Republic of Tanzania.* UNEP Regional Seas Reports and Studies 106. Nairobi.

United Nations Environment Program (UNEP) and World Conservation Union (IUCN). 1988. *Coral Reefs of the World: Vol. 2 Indian Ocean, Red Sea and Gulf.* UNEP Regional Seas Directo-

ries and Bibliographies. Gland, Switzerland and Cambridge, U.K.: IUCN; Nairobi: UNEP.

Vasseur and others. 1988. *State of the coral reefs and mangroves of the Tulear region: assessment of human activities and suggestions for management.* Proceedings of the 6th International Coral Reef Symposium.

Wamukoya, G.M. 1992. Species composition, distribution and zonation of marine algae and seagrasses along the Kenyan coast with special reference to the marine protected areas. Report to Kenya Wildlife Service, Nairobi, Kenya.

Watson, M., and R.F.G. Ormond. N.d. The effect of an artisanal fishery on the fish community structure of a Kenyan coral reef. Mar. Ecol. Prog. Ser. Forthcoming.

World Conservation Monitoring Centre (WCMC). 1992. List of marine/coastal protected areas in East Africa. Information request. WCMC Database printout 16.07.1992.

World Bank. 1993a. *Ecologically Sensitive Sites in Africa: Vol. VI Southern Africa.* Washington, D.C.: World Bank.

———. 1993b. *Ecologically Sensitive Sites in Africa: Vol. III South-central Africa and Indian Ocean.* Washington, D.C.: World Bank.

World Wildlife Fund. 1993. *Coral reefs and coastal zone of Toliara: Conservation and development through ecotourism.* Pre-Project. Gland, Switzerland: WWF.

World Wildlife Fund (WWF), Southern African Nature Foundation (SANF), and Oceanographic Research Institute (ORI). 1989. *A Conservation Master Plan for Sustained Development of the Bazaruto Archipelago.* A report to the Minister of Agriculture Mozambique. Washington, D.C.: WWF/SANF/ORI.

Wynter, P. 1987. Sea tenure and other management strategies for tropical fisheries resources: the case of East Africa. Paper presented at 5th Symposium on Ocean Management, Seattle.

Yarish, C., and G. Wamukoya. 1990. Seaweeds of potential economic importance in Kenya: field survey and future prospects. *Hydrobiologia* 204/205:339–46.

MARINE REGION 13
East Asian Seas

Chris Bleakley and Sue Wells, editors

BIOGEOGRAPHY AND MARINE BIODIVERSITY

The East Asian Seas Marine Region includes the following countries: Brunei Darussalam, Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam. Limited information was available for Brunei and no data were available for Cambodia.

Oceanography

The following description is extracted from Gomez and others (1990), who draw on the work of Soegiarto (1985).

The East Asian Seas Marine Region comprises the Andaman Sea, Straits of Molucca, Straits of Singapore, South China Sea, Java Sea, Flores Sea, Banda Sea, Arafura Sea, Timor Sea, Celebes Sea, Sulu Sea, and the Philippine Sea. The region includes shallow continental shelves, deep sea basins, troughs, trenches, continental slopes and volcanic and coral islands. The numerous large and small islands divide the waters into different seas connected by many channels, passages and straits.

The region is strongly influenced by monsoons. The north monsoon lasts from December to February and the south monsoon from June to August. The rest of the year represents the transition from the north to the south monsoons (March to May) and from the south to the north monsoons (September to November).

Surface current patterns in the region show that the water mass of the region originates from the Pacific Ocean. The North Equatorial Current flows westward across the Pacific Ocean and upon reaching the Philippine islands, splits into two main branches. The northward branch becomes the Kuroshio, and the southward branch, the Mindanao Current. The Kuroshio begins east of northern Luzon as a swift and narrow segment of the western boundary current and flows to the east coast of Taiwan, the East China Sea and the Japan Sea. During the north monsoon, the Kuroshio is deflected into the China Sea. The Mindanao Current flows southeast with a speed of 1–2 knots along the coast of Mindanao Island with its main part entering the Celebes Sea through the straits between Mindanao, Sangir and Talaut Islands.

The tides of the East Asian Seas are influenced by both the Pacific and the Indian Oceans. Diurnal tides predominate in the South China and Java Seas, whereas mixed tides prevail in the eastern Indonesian archipelago, Philippine waters, the Andaman Sea, Straits of Molucca, and the shelf areas northeast of Australia.

Surface waters in the region have high temperatures and are of low density and salinity. Annual temperature variations in surface waters are small. During the north monsoon, generally high surface temperatures of 28–30°C prevail on the west coast of Sumatra and the eastern waters of the Indonesian archipelago. However, the inflow of colder water masses from high latitudes, results in lower water temperatures in the South China Sea. Temperatures of 26–27°C also prevail in the Arafura Sea and the south coast of Java. In other waters, temperatures range between 27°C and 29°C. The average annual range of sea surface temperature in the equatorial region is less than 2°C but is slightly higher, 3°C to 4°C, in the Banda Sea, the Arafura Sea and Timor Sea as well as in the waters south of Java.

The salinity in the East Asian Seas is extremely variable as a result of the effects of high rainfall, runoff from many large rivers, and the geographical subdivision of the seas. The distribution of discharges from land, presence of large bays and channels with little water exchange contribute to the general lowering of the salinity. The large excess of rainfall overevaporation results in an average salinity of less than 34°/oo within most parts of the region. The monsoon cycle results in rainy and dry seasons that also affect annual salinity variations.

Several factors influence the water transparency—silt content, plankton and other particulate matter in the water. Low water transparency (less than 10 meters deep) is found in the areas of river mouths and in the coastal waters around Sumatra, Borneo and the Gulf of Thailand. In general, the transparency is high in the deepwater (between 10 and 20 meters) and in the open seas (20 to 30 meters).

Coastal Geography and Geology

The following description is adapted from Schwartz (1982).

The shores of eastern Asia largely follow the tectonically active zones where the Pacific and Indian Ocean plates collide with the mainland Asia plate (Inman and Nordstrom 1971). Along stretches of coast, structural trends are generally parallel to the coast. Outside these areas, away from the tectonically active collision zones, the coastal regions are generally more stable and the structural trends are usually not parallel to the coast. This is the case along most of the Asian mainland from Thailand to northern Asia.

Comparatively straight coasts, situated along mountain chains, sometimes with river deltas and local alluvial foreland, are found mainly in western Sumatra, southern Java and northern Viet Nam. A drowned, older topography with an irregular coastline is present in parts of southern Viet Nam, the mainland coast north of the Red River, on the islands of eastern Indonesia, on northern Kalimantan (Borneo), and the Philippines. These coasts are somewhat remodelled by the sea, with bays containing beaches, spits, and barriers, sometimes being filled up with sediment and partially surrounded by alluvial foreland. Elsewhere the coast is predominantly depositional, consisting of beaches, spits, barriers, tombolos, mudflats, marshes, mangrove swamps, and coral reefs.

The general direction of beaches, spits, and barriers is related to the direction of the swell; between the Philippines and Indonesia the swell comes chiefly from northern directions, and the beaches and spits face largely east to northeast. Where the swell is southerly, as in the Indian Ocean, the beaches face mainly southeast to southwest.

Coral reefs and beach rock are common in the region and mangrove dominates large

stretches of coast in Indonesia, Malaysia, Thailand, Viet Nam and Myanmar, especially in areas that are relatively sheltered from the ocean swell. An important part of the mainland coastline consists of substantial river deltas (such as the Mekong, Chao Phraya, and Red Rivers).

Ecosystem Diversity

The East Asian Seas Marine Region includes a rich array of marine animals and plants. An abundance of coral reefs, mangroves and seagrass beds support probably the most diverse marine flora and fauna in the world.

Coral Reefs

The region is the global center of diversity for coral reefs. Approximately 70 hard coral genera occur in the vicinity of eastern Indonesia, the Philippines and the Spratly Islands, while 50 are present in other parts of Southeast Asia (Veron 1986). Throughout the East Asian Seas fringing reefs are most common and are present around most small to medium-size islands. Reefs are less common on mainland coasts and on larger islands, particularly around rivers. The Philippines and Indonesia support the most extensive areas of coral reef in the region. Well-developed reefs are also found off the southern coasts of Myanmar and Thailand, on the offshore islands of Viet Nam, on the east coast of Peninsula Malaysia, and off Sabah (UNEP/IUCN 1988).

The reefs of the East Asian Seas support a rich assemblage of marine life. They provide the fish, mollusks and crustaceans on which many coastal communities depend and, with other coastal habitats, provide nutrients and breeding grounds for many commercial species (UNEP/IUCN 1988). In some cases the fish taken from reef communities provide over half the protein intake of the local communities. UNEP/IUCN (1988) noted that coral reef fisheries have been estimated to comprise 8–10 percent of the overall fishery production in the Philippines, five percent in Indonesia and in excess of 20 percent in Sabah, Malaysia. Tourism associated with coral reefs provides major economic benefits in the region.

Reefs and nonreef communities within 15 kilometers of shore are generally overfished, while offshore subsurface atolls and pinnacle reefs are often beyond the reach of small-scale fishermen. Major destructive forces include excessive sedimentation and nutrients related to deforestation and agricultural activities and various forms of destructive fishing, especially blast fishing and poisoning.

Mangroves

In comparison with the mangrove flora of equivalent latitudes on the Atlantic shores of Africa and the Americas, the mangroves of the Indo-Pacific region, and Southeast Asia in particular, are extremely diverse. Mangrove is the dominant coastal community in tropical Asia, with the Malay-Indonesian region its center of distribution.

Indonesia has the greatest area of mangroves in the region with 4.25 million hectares (WCMC 1992), of which about 2.9 million hectares is in Irian Jaya. The mangroves in the western parts of this country, particularly Java, have suffered heavily from human impacts that include illegal cutting, conversion to other uses (such as mariculture and other forms of coastal development) and possible land-based industrial pollution (ASEAN-Australia Marine Science Project 1992). The mangroves in the east are less affected, but signs of degradation have been recorded in some locations (eg Ambon Island and Halmahera Island).

Malaysia, with 650,000 hectares, has the second largest area of mangroves, while Thailand and Viet Nam have about 200,000 hectares, the Philippines 100,000, Brunei 7,000 and Cambodia 10,000 (WCMC 1992 and ASEAN-Australia Marine Science Project 1992). In Viet Nam mangrove cover has de-

creased by about 50 percent since 1943 (Thanh, personal communication).

About 91,000 hectares (46 percent) of the mangroves in Thailand are under some form of use (such as farming, mining, salt farming and infrastructure activities), and there was a 25 percent decrease in mangrove cover between 1979 and 1987. In the Philippines, mangroves are estimated to cover about 20 percent of their area in the 1920s, and about half the remaining forest is composed of secondary growth (ASEAN-Australia Marine Science Project 1992). The best stands occur on the islands of Palawan and Mindanao.

The values and importance of mangroves has been well documented (for example, Salm and Clark 1984; WCMC 1993). Mangroves in the East Asian Seas support numerous seabirds (155 species recorded in the region) and provide valuable breeding and nursery areas for species of fish and shrimp.

Seagrass Beds

Southeast Asia, with about 20 species of seagrass from seven genera, has the most highly diverse seagrass flora in the world. Both mangroves and seagrasses show a similar global pattern of generic richness, characterized by a maximum variety in the Indo-West Pacific and secondary centers of diversity usually in the Caribbean. Although the number of seagrass species is relatively small, their numbers are by no means proportional to their ecological and economic importance. They form dense beds that cover large areas of coastal waters and perform a wide spectrum of biological and physical functions, serving as habitat and nursery areas for fish, many invertebrates, turtles and dugong. They also provide alternative feeding sites for commercial and forage organisms (Fortes 1988).

Sandy Beaches

Sandy beaches occur extensively on the shores of coral islands and are interspersed among other shore formations throughout continental Asia. Steep beaches of coarse sand are built up on ocean-facing coasts exposed to strong surf. Intertidal flats of mixed sediments, with a narrow sandy fringe at high water mark, develop on more protected shores (Schwartz 1982).

Only a restricted fauna tolerates the surf forces and instability of an exposed sandy shore. Tropical organisms are further inhibited by high temperatures and desiccation. Most animals must burrow for protection or limit their surface activity to periods when sand is moist. The middle and lower beach animals are absent from shores with severe wave action.

The fauna of sheltered sandy beaches is much richer by comparison (Berry 1964; Vohra 1971). On sand flats containing a proportion of silt, burrowing polychaetes, echinoderms, and coelenterates become important components of the fauna and a seaward zone of the marine grass *Enhalus* is developed. Marine turtles nest on the sandy beaches throughout many areas of the East Asian Seas.

Rocky Shores

Rocky shores occur on the coasts of many Asian islands. The southwest coast of Sumatra and the Pacific coastline of the Philippines and Sulawesi have extensive rocky topographies. Smaller rocky outcrops and boulder formations are common above coral reef flats and on headlands bordering sandy bays. Wave erosion of limestone creates sheer or fissured cliffs with little or no beach formation (Schwartz 1982).

The zonation of organisms on rocky shores in the region follows the typical pattern with three major zones (supra-, mid-, and sub-littoral), characterized by key organisms (littorinid snails, barnacles, and algae, respectively). High surface temperatures and desiccation greatly limit the tropical fauna and flora in comparison to those of temperate rocky shores. Large seaweeds (such as

fucoids and laminarians) typical of cooler latitudes and the organisms they support are absent, and there is a general lowering of the zonation levels toward the equator. A rich assemblage of organisms occurs at the lowest tidal level and in crevices (Berry 1964; Chuang 1973) where the environment is less extreme. Tropical rock pools are subject to extreme heating and wide fluctuations in salinity and consequently support a poorer biota.

Islands and Submerged Banks

The East Asian Seas Marine Region includes the extensive archipelagos of Indonesia and the Philippines. There are also numerous islands off the coast of mainland Asia. Island types range from coral cays to raised limestone, volcanic and continental islands such as Java and Borneo.

Open Ocean, Deep Sea, Upwelling

Upwelling has been reported during the southwest monsoon in the South China Sea northeast of the Malay Peninsula, along the edge of the shelf southeast of Viet Nam, on the edge of the mainland shelf, west of Luzon and Palawan, and in the Timor and Banda Seas. During the northeast monsoon, upwelling occurs along the edge of the mainland shelf, east of Viet Nam, and off Sarawak (Meth and Helmer 1983).

Species Diversity

Despite the basic homogeneity caused by the occurrence of many wide-ranging species, there are great differences in diversity among the various parts of the Indo-West Pacific region. Many authors have noted the concentration of species in the East Asian Seas in the vicinity of the Philippines, the Malay Peninsula and Papua New Guinea/Irian Jaya. This area has been recognized as a faunistic center from which other subdivisions of the Indo-West Pacific have recruited their fauna. The presence of a concentration of species is supported by a number of studies of the fauna in general and for animal groups such as mollusks, crustacean and fish. As noted above, the pattern is also followed by seagrasses and mangroves. Moving away from the Indo-Malayan center and considering the fauna of the peripheral areas there is a notable decrease in diversity correlated with distance (Briggs 1974).

Seaweeds

The Asian and Pacific region contains 100 species of seaweeds of economic value. They constitute an important biological resource of the region as part of the food web of marine life. Additionally, they are used for human consumption, animal feed, pharmaceutical products, fertilizer, and industrial raw material for the production of a wide range of products. Wild seaweed resources have become limited due to extensive use and are being supplemented by cultivated resources (ESCAP 1990).

Invertebrates

The region is the global center of diversity for marine invertebrates, including mollusks and crustaceans (Briggs 1974). For the gastropod genus *Strombus*, Abbott (1960) found the greatest number of taxa in the vicinity of the Philippines (26), Okinawa (24) and Indonesia (23). The number of taxa decrease moving east across the Pacific and west across the Indian Ocean.

Giant clams used to be abundant, having their center of distribution in the region, but are now heavily depleted and have been placed on the CITES list.

Fish

The region is a center of diversity for marine fish. For example over 2,000 species of shore fish have been recorded in the shallow waters of the Philippines (Briggs 1974).

Springer (1982) and Abbott (1960) recorded approximately 160 shorefish families in the region (with a similar number present in southeast Africa and off the Great Barrier Reef). The number of families shows a decreasing trend moving east across the Pacific Ocean and away from these centers of diversity.

Gomez (1990) noted the general decline in fishery resources in the region as a whole, attributed to overexploitation, particularly in inshore coastal waters.

Marine Turtles

Six species of marine turtle nest in the region: the flatback (*Chelonia depressa*), the green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), olive Ridley (*Lepidochelys olivacea*) and the loggerhead (*Caretta caretta*). The last five are classed as vulnerable or endangered (Elder and Pernetta 1991).

Sea Snakes

East Asia is the center of the world's radiation of true sea snakes (*Hydrophiidae*). This family contains some 14 genera and 47 species. Of these, 14 genera containing about 30 species are found in the East Asian region. With the exception of the pelagic yellow-bellied sea snake (*Pelamis platurus*), which occurs in both coastal and oceanic waters from East Africa throughout the Indian and Pacific Oceans to the west coast of Central America, all other sea snakes are confined to tropical and warm-temperate regions extending from the Persian Gulf to the Fijian islands.

The number of species declines west of the East Asian region to about 20 species in India and 11 in the Persian Gulf (Voris 1972). The adjoining Australasian region has 31 species (Cogger 1994), rapidly declining in diversity in the western Pacific region.

The sea kraits (*Laticaudidae*) also occur throughout the region. This family contains only six species in a single genus (*Laticauda*); some taxonomists recognize a second genus, *Pseudolaticauda*). Three of the six species are found in the East Asian region.

Sea snakes are widely utilized in the region for their skins, and significant trading in skins is centered in Singapore and Thailand, although the total number of skins traded is uncertain (see Heatwole 1987). Sea kraits are also utilized for their skins, and large quantities are exported from the region to Hong Kong and Japan for food and oriental medicine.

Relatively little is known of sea snake biology and ecology, and therefore the impacts on wild populations of either trade or fishing by-catch mortality cannot be determined.

Marine Mammals

The dugong (*Dugong dugon)* is present in the region but is endangered by hunting and destruction of its natural habitat.

Balaenoptera edeni (Bryde's whale) is the most common cetacean in the region. Other species recorded are *Balaenoptera acutirostrata* (minke whale), *Balaenoptera borealis* (sei whale), *Balaenoptera musculus* (blue whale), *Balaenoptera physalus* (fin whale), and *Megaptera novaeangliae* (humpback whale). Dolphin and porpoise species include *Sousa chinensis* (Indo-Pacific humpbacked dolphin), *Orcaella brevirostris* (Irrawady dolphin), *Neophocaena phocaenoides* (finless porpoise), *Tursiops truncatus* (bottlenose dolphin), *Delphinus delphis* (common dolphin) and possibly also *Sousa borneensis* (white dolphin), *Sousa plumbea* (plumbeous dolphin) and *Stenella malayana* (Malayan dolphin).

Biogeographic Classification

The biogeographic classification scheme for the East Asian Seas Marine Region is shown in Map 13. This scheme was adopted by members of the IUCN-CNPPA working

group at the UNEP EAS 25 Workshop on Marine Protected Areas in the East Asian Seas.

The first order subdivisions (Coastal Realms, Marginal Seas and Archipelagos) are largely those identified by Hayden, Ray, and Dolan (1984). The second order subdivisions were identified by national representatives who contributed to this report, using classification schemes used at the national level. Some areas have yet to be classified to this level including part of the Eastern Subtropical Marginal Seas (I), and all of the Eastern Tropical Coastal (IV), Eastern Intertropical Coastal (V), Western Tropical Coastal (VII) and Western Intertropical Coastal (XIII) Realms.

Assessment of Existing MPAs

The lists of MPAs for each country were submitted by the national representatives who contributed to this report. The areas are those that have been identified as including a significant subtidal marine component (with the exception of Brunei, for which data are preliminary). There are also a large number of protected areas in the region that include intertidal or estuarine terrain. It has not been possible to assess these areas in this report.

A total of 92 MPAs have been established in the region (Table 13.1). The location of these MPAs is shown on Map 13. No information was available on MPAs in Cambodia.

Management Level

The national representatives on the IUCN/CNPPA Working Group for the East Asian Seas were asked to assess the management level (in terms of how well these areas achieve their management objectives) of each MPA in their country according to the following scheme:

- High (H): Generally meets management objectives/purpose.
- Moderate (M): Partially meets management objectives/purpose.
- Low (L): Generally fails to meet management objectives/purpose.

Table 13.1 Number of Existing MPAs in the East Asian Seas Marine Region

Country	*Number of MPAs*
Brunei	4
Cambodia	no information
Indonesia	30
Malaysia	21
Philippines	19 (160)[a]
Singapore	1
Thailand	15
Viet Nam	2
Total	92

a. Sources identify over 160 MPAs in the Philippines. Only the main ones have been included in this report although a complete list is included in the Appendix.

This assessment reveals that nine MPAs (about 13 percent of those for which data are available) were considered to have a "high" management level, 22 (31 percent) a "moderate" management level and 41 (57 percent) a "low" management level. No data were available for 20 areas. These figures suggest that the proportion of MPAs in the region that generally fail to, or partially, achieve their management objectives is likely to be close to 90 percent.

Description of National MPA Systems

The following section summarizes the major characteristics of the marine protected area system in each country, including lists of existing MPAs.

Brunei

Brunei Darussalam has established four MPAs, and due to lack of pressure for exploitation, a complete ban on firearms and spearguns, and minimal visitor numbers, these remain in relatively good condition. However, there is no authority with overall re-

sponsibility for the establishment and management of MPAs. Sectoral interests within the coastal zone afford a degree of protection to some areas in keeping with the interests of the particular department concerned.

The following is a preliminary list of MPAs for Brunei:

- Pulau Berembang Conservation Area
- Pulau Chermin Reserve
- Pulau Selirong
- Pulau Siarau Conservation Area

Cambodia

No information is available on MPAs in Cambodia.

Indonesia

As the world's largest archipelagic state with approximately 81,000 kilometers of coastline and widely recognized very high marine biodiversity values, Indonesia has a critical role in marine conservation in the East Asian Seas (Hutomo and others 1993). Indonesia has a large population and rapidly expanding economy, and there is a pressing demand for marine conservation within the context of sustainable use of natural resources (Salim 1988).

The Indonesian government is carrying out a Five Year Development Program that will see the establishment of 10 million hectares in MPAs by early 1995, with a target of 30 million hectares for the year 2000 (Hutomo and others 1993). The overall objective of Indonesian marine conservation is to achieve "controlled development of the marine environment, sustainable utilization of Indonesia's diverse marine resources and protection of habitats critical to the survival of commercially valuable, endangered, vulnerable and other selected marine species" (Soegiarto, Soewito, and Salm 1984). MPA management will give attention to the need of the local community to have access to marine resources on a sustainable basis. Community participation programs, training and ensuring coordination between institutions is essential to long-term management (Sumardja, personal communication). Thirty MPAs (about 2.6 million hectares) have been established in Indonesian waters.

Sedimentation and nutrient runoff caused by deforestation and agricultural activities, habitat destruction and localised overexploitation of fish and other groups such as sea turtles (Soegiarto, Soewito, and Salm 1984) have been identified as key issues, along with other unsustainable practices such as rock mining, blast fishing and land reclamation (Robinson and others 1981). Overcoming a lack of skilled manpower and the development of marine conservation education and awareness programs are two of the major challenges to the Department of Forestry in implementing the Five Year Program. A shortage of financial and human resources hampers the implementation of surveillance, enforcement and research programs (Haeruman 1988).

The following MPAs were recorded for Indonesia:

Central Java

- Kepulauan Karimun Jawa Marine National Park

East Java

- Perairan Kangean Game Reserve
- Baluran National Park (seaward extension)
- Bali Barat National Park (seaward extension)

West Java

- Pananjung Pangandaran Strict Nature Reserve (seaward extension)
- Ujung Kulon National Park (seaward extension)
- Kepulauan Seribu Marine National Park
- Pulau Dua Strict Marine Nature Reserve
- Pulau Rambut Strict Nature Reserve (seaward extension)
- Pulau Sangiang Strict Nature Reserve (seaward extension)

- Leuwang Sancang Strict Nature Reserve (seaward extension)

Central Kalimantan
- Tanjong Keluang Marine Recreation Park

East Kalimantan
- Pulau Semama Marine Wildlife Reserve
- Pulau Sangalaki Marine Recreation Park

West Kalimantan
- Kepulauan Karimata Strict Marine Nature Reserve

East Nusa Tengarra
- Teluk Maumere Marine Recreation Park
- Pulau Tujuh Belas (North Flores) Strict Marine Nature Reserve

West Nusa Tengarra
- Pulau Moyo Marine Recreation Reserve (Sumbawa)/Marine Wildlife Reserve

Irian Jaya
- Teluk Bintuni Nature Reserve
- Teluk Cenderawasih Strict Marine Nature Reserve/Marine National Park

Lampung, Sumatra
- Bukit Barisan Selatan Strict Marine Nature Reserve
- Kepulauan Krakatau Strict Marine Nature Reserve

Aceh, Sumatra
- Pulau Weh Marine Recreation Park

Maluku
- Pulau Kasa Marine Recreation Park/Marine Wildlife Reserve
- Kepulauan Aru Bagian Tenggara Strict Marine Nature Reserve
- Pulau Banda Marine Recreation Park/Strict Marine Nature Reserve
- Pulau Pombo Marine Recreation Park/Strict Marine Nature Reserve

North Sulawesi
- Arakan Wowontulap Strict Marine Nature Reserve
- Bunaken Menado Tua Marine National Park
- Kepulauan Take Bone Rate Marine National Park

Malaysia

Malaysia has recognized the need for integrated planning and management of both land and sea to control and minimize adverse impacts on the marine environment. The principal goal in the establishment of MPAs in Peninsula Malaysia is "to protect, conserve and manage in perpetuity, representative marine ecosystems of significance in order that they remain undamaged for future generations and to inculcate public understanding, appreciation and enjoyment of Malaysia's marine heritage" (Yaman 1993). The Sabah Conservation Strategy (WWF-Malaysia 1992) recently completed for the Sabah Ministry of Tourism and Environmental Development contains new policy recommendations relating to the conservation of marine resources of Sabah, including recommendations for new MPAs as part of a comprehensive system of conservation areas (Andau and others 1993).

Malaysia has established 21 MPAs, primarily through its marine parks program (14 MPAs) and through the Sabah Wildlife Department (7 MPAs). The former total includes a number of proposed Marine Parks that have been designated as Fisheries Protected Areas in the interim period before formal establishment as Marine Parks. Twenty-eight islands on Peninsula Malaysia and the surrounding marine waters have been identified for inclusion in MPAs under the Marine Parks Program.[1] Two groups of islands (the Pulau Payar Group and the Pulau Redang Archipelago) have been established as Marine Parks and in operation for several years. An additional two MPAs are under consideration by the Sabah Wildlife

Department to include the diverse marine habitats associated with the Sipadan and Semporna Islands.

In developing Malaysia's system of MPAs the major challenges will be to secure consensus among all levels of government (particularly state and local government, given that jurisdiction over the islands rests with the state government) and to address the relatively long time taken to implement management plans (four years on average) and shortcomings in Environmental Impact Assessment (EIA) procedures (Ch'ng 1992). Sectoral planning and a failure to incorporate environmental criteria into economic decisionmaking have also been identified as barriers to successful management of Malaysia's coastal waters (Yaman 1993). There is also a need for training of personnel in the planning and management of MPAs.

The following MPAs were recorded for Malaysia:

Peninsula Malaysia

- Kuala Selangor Nature Reserve
- Matang Forest Reserve (Muara Kuala Gula)
- Pulau Besar (proposed) Marine Park/Fisheries PA (includes the islands of P.Hujung, P.Tengah, P.Rawa, P.Gual, P.Menserip and P.Harimau)
- Pulau Kapas (proposed) Marine Park/Fisheries PA
- Pulau Lang Tengah (proposed) Marine Park/Fisheries PA
- Pulau Perhentian Besar (proposed) Marine Park/Fisheries PA
- Pulau Sembilang and Pulau Seri Buat (proposed) Marine Park/Fisheries PA
- Pulau Sibu (proposed) Marine Park/Fisheries PA (includes P. Sibu Hujung)
- Pulau Tenggol (proposed) Marine Park/Fisheries PA (includes P.Nyireh)
- Pulau Tinggi (proposed) Marine Park/Fisheries PA (includes the islands of P.Mentigi)
- Pulau Langkawi (proposed) Marine Park/Fisheries PA
- Pulau Paya/P. Kaca/P.Lembu/Segantang Marine Park
- Pulau Redang Marine Park (includes P.Pinang, P.Lima, and P.Ekur Tebu)
- Pulau Tioman (proposed) Marine Park/Fisheries PA (includes P.Tulai and P.Chebeh)

Marine parks are also proposed for Pulau Aur and Pulau Permanggil although neither of these areas have been gazetted as Fisheries Protected Areas.

Sabah

- Kota Belud (Tempossuk Plains) Bird Sanctuary
- Kulamba Wildlife Reserve
- Pulau Mantanani Bird Sanctuary
- Pulau Sipadan Bird Sanctuary/(proposed) Marine Reserve
- Pulau Tiga Park
- Tunku Abdul Rahman Park
- Turtle Islands State Park

Philippines

According to information provided by the Department of Environment and Natural Resources (DENR), the Philippines has established more than 160 marine protected areas under the following designations: National Marine Park (one), National Marine Reserve (one), Marine Turtle Sanctuary (seven), Tourist Zone and Marine Reserve (65), Wilderness Area (52), Protected Landscape/Seascape (two), Seashore Park (one) and Fish Sanctuary (31). In addition to these areas other sources identify a number of areas established under municipal and other designations (UNEP/IUCN 1988; IUCN 1992; Gomez, personal communication).

Although a detailed assessment has not been possible, the management level of these areas, with a few exceptions, is considered generally low. In some cases effective management is provided by the DENR, through local efforts such as municipal councils and local resorts, or through support

from scientific institutions such as Silliman University, University of Philippines Marine Science Institute and the Tubbataha Foundation.

The Philippines has adopted a policy stating that "the management, protection, sustainable development and rehabilitation of protected areas shall be undertaken primarily to ensure the conservation of biological diversity and that the use and enjoyment of protected areas must be consistent with that principle" (Palaganas 1993). The Philippines Congress passed an act in July 1992 that provides for the establishment and management of what is known as the National Integrated Protected Areas System (NIPAS). In a supportive exercise, four areas have been identified representative of major marine biogeographic divisions (the Batanes Islands, Apo Reef, Siargo Island and the Turtle Islands). Feasibility studies have been completed and project documentation is being drafted to serve as guidelines for the development and management of these areas (Gomez, personal communication).

Primary threats to marine environments in the Philippines include coastal erosion, sedimentation and nutrient runoff from the land, coral mining and collection and destructive fishing techniques. In particular, dynamite fishing has caused extensive damage to coral reefs (UNEP/IUCN 1988) and remains prevalent although this and other destructive activities are prohibited by legislation.

The main MPAs in the Philippines are listed below (a complete list of MPAs provided by the DENR is included in the Appendix).

- Tubbataha Reefs National Marine Park
- Taklong Island National Marine Reserve
- Apo Island Marine Reserve/Tourist Zone
- Camiguin Island Marine Reserve/Tourist Zone
- Fortune Island Marine Reserve/Tourist Zone
- Fuga Island Marine Reserve/Tourist Zone
- Guiuan Marine Reserve/Tourist Zone
- Nasugbu Marine Sanctuary/Marine Reserve/Tourist Zone
- Panglao Island-Balicasag Area Marine Reserve/Tourist Zone
- Santa Cruz Island Marine Reserve/Tourist Zone
- Sombrero Islands Marine Reserve/Tourist Zone
- Malampaya Sound Marine Sanctuary
- Panguil Bay Marine Sanctuary
- Pollilo Island Marine Santuary
- Puerto Galera Biological Station
- Sumilon Islands Marine Reserve and Fish Sanctuary
- Guindolman Municipal Marine Park
- Carbin Reef Municipal Park
- El Nido Marine Reserve

Singapore

Singapore has established one MPA, the Sungei Buloh Nature Reserve, which includes mangrove habitat. A proposal has also been developed to protect and conserve some of the coral reefs associated with the southern offshore islands. Following surveys by volunteer sports divers, four areas containing reefs of better quality have been proposed for protection. The proposal was submitted to the National Parks Board of the Ministry of National Development in October 1991. The four areas have been included in Singapore's Green Plan of 1992, but the management and legislative framework have not been worked out (Chou, personal communication).

- Sungei Buloh Nature Reserve

Thailand

The Thailand Royal Forest Department has responsibility for protected areas under the National Parks Act. To date some 77 National Parks have been established, 15 of which are MPAs, with a further 5 areas proposed. These MPAs are largely concentrated in southern Thailand. There are also meas-

ures proposed by the Office of the National Environment Board (ONEB) for management of mangroves and coral reefs. A plan has been approved by the cabinet and has been distributed to the coastal provinces with a budget to assist with its implementation.

The following MPAs were recorded for Thailand:

- Ao Phangnga National Park
- Hat Chao Mai National Park
- Hat Nai Yang National Park (Ko Phuket reefs)
- Hat Nopharat Thara—Mu Ko Phi Phi National Park
- Khao Laem Ya—Mu Ko Samet National Park
- Khao Lam Pi—Hat Thai Muang National Park
- Khao Sam Roi Yot National Park
- Laem Son National Park
- Mu Ko Ang Thong National Park
- Mu Ko Chang Islands National Park
- Mu Ko Lanta National Park
- Mu Ko Phetra National Park
- Mu Ko Similan National Park
- Mu Ko Surin National Park
- Tarutao National Park

Viet Nam

Viet Nam's coastline spans 3,000 kilometers and is characterized by a wide range of geomorphological, climatic, hydrological, and socioeconomic conditions (Cheung 1992). Currently only a few coastal areas are included inside protected areas such as Cát Bá, Ha Long Bay, Son Tra, Côn Dảo and Camau. The Viet Nam National Conservation Strategy (1985), the Report on Review of the Nature Conservation System, National Parks and Protected Areas (Mackinnon 1990), and the National Plan for Environment and Sustainable Development 1991–2000 (SCS and others 1991) have all identified the urgent need for coastal and marine conservation in Viet Nam.

Two of these coastal protected areas included a marine component, with four additional sites proposed as being representative of the biogeographic characteristics of its marine environment. The problem of conserving Viet Nam's marine biodiversity is becoming urgent due to the overexploitation of marine resources and the heavy degradation of coastal ecosystems such as mangroves and coral reefs (Thanh, personal communication).

Almost all of Viet Nam's coastal coral reefs are threatened by siltation and destructive and excessive fishing, particularly those at Cát Bá and near to the shore of Nhatrang, but coral around the more remote islands off Nhatrang and Phu Quoc remains in good condition (Cheung 1992)

The following MPAs were recorded for Viet Nam:

- Cát Bá Islands National Park
- Côn Dảo Islands National Park

International and Regional Initiatives Relating to MPAs

Table 13.2 summarizes the participation of countries in the East Asian Seas region in major international initiatives relevant to marine protected areas (IUCN 1992).

Ramsar Sites

There are two Ramsar sites in the region that include coastal elements: Berbak protected area in Indonesia (intertidal terrain) and the Red River Estuary in Viet Nam (estuarine terrain).

World Heritage Sites

The Tubbataha Reef National Marine Park was listed as a World Heritage Site in November 1993. Ujong Kulon National Park (Indonesia) is also listed, as is the Komodo National Park (Indonesia) although available information suggests that this site includes

Table 13.2 Participation in International Initiatives by East Asian Seas Nations

Country	*World Heritage*	*Ramsar*	*UNESCO-MAB*
Brunei			
Cambodia			
Indonesia	✓	✓	✓
Malaysia	✓	•	✓
Philippines	✓	✓	✓
Singapore			
Thailand	✓		✓
Viet Nam	✓	✓	✓

• Malaysia attends all Ramsar meetings as an observer and is negotiating with state authorities about the possibility of becoming a party to the convention and establishing a Ramsar site.

coastal elements but no subtidal marine component.

UNESCO Man and the Biosphere Programme

There are several Biosphere Reserves in the region that include coastal elements. These are the Komodo National Park, Tanjung Puting National Park, Gunung Leuser National Park, Siberut Nature Reserve (Indonesia), Palawan and Puerto Galera Biosphere Reserve (Philippines). Of these areas only Puerto Galera has been identified as including a subtidal marine component.

UNEP Regional Seas Programme

The East Asian Seas Action Plan was adopted by Indonesia, Malaysia, the Philippines, Singapore and Thailand in 1981 for the development and protection of the marine environment and coastal areas for the promotion of the health and well-being of present and future generations. The Regional Coordinating Unit of the Coordinating Body for the Seas of East Asia (COBSEA) serves as a secretariat for the program. The participating countries have evolved generally efficient mechanisms for program management and project implementation with technical assistance from UNEP. They have also established a trust fund that provides partial support to the program activities (Gomez 1988). COBSEA undertakes a wide range of projects that aim to support management of the coastal marine environment and marine protected areas, including the EAS 19 and EAS 25 projects that provided training for marine park managers. Further activities are planned to address coastal zone management and sustainable use of marine resources in the East Asian Seas.

Other Regional Initiatives

The parties to the ASEAN Convention (Brunei, Indonesia, Malaysia, the Philippines, Singapore and Thailand) undertake a wide range of cooperative measures relevant to marine biodiversity conservation. Specific examples are the declaration of ASEAN Heritage Sites (Tarutao National Park in Thailand has been nominated) and measures aimed at avoiding or combatting oil spills, such as the ASEAN Oil Spill Preparedness and Response Action Plan (OSPAR).

There are also bilateral and multilateral agreements that address oil pollution, such as the Traffic Separation Scheme in the Straits of Molucca and Singapore, Tripartite Agreement to Combat Oil Spills in the Straits of Molucca and Singapore, ASCOPE Plan for the Control and Mitigation of Oil Pollution, and Regional Plan to Combat Oil in the Straits of Lombok/Makasar and the Celebes Sea. Gomez (1990) provides further details on the participation of nations in the region in other international and regional initiatives.

Assessment of Representation of Biogeographic Zones within MPAs

An assessment of representation of the major biogeographic subdivisions of the region

Table 13.3 Representation of First-Order Biogeographic Subdivisions of the East Asian Seas Marine Region

First-Order Zone	*Number of MPAs*
I	27
II	11
III	26 (1)
IV	2
V	1
VI	19 (8)
VII	4
VIII	2
Total	92

Note: The number of MPAs with a high management level is indicated in parentheses.

is shown in Table 13.3 (see Map 13 for their location).

All of the zones have at least one MPA, although their distribution is uneven. Zones IV, V, VII and VIII have fewer than five MPAs each, zone II has 11 MPAs, and zones I, III, and VI have around 20 MPAs or more each. Zones I, II, III and VI include 83 of the 92 MPAs in the region. Only two zones (III and VI) are represented by MPAs assessed as having high management level. Four zones include no MPAs with either high or moderate management level.

Under the biogeographic classification scheme adopted for this region several of the first-order biogeographic zones are further divided into second-order biogeographic zones. An assessment of these shows that within the relatively well-represented first-order zones (I, II, III and VI) there are disparities in the degree to which these second-order subdivisions are represented (Table 13.4).

Four of the 22 second-order zones are not represented in MPAs, four more have one MPA. Eleven of the zones have between two and six MPAs, while zone 22 has seven MPAs, zone 8 has eight MPAs, and zones 17 and 21 have 11 MPAs.

The implications of these figures are that while most of the zones have at least one MPA, there are some significant gaps with four zones with no MPAs. If management effectiveness is considered, the degree of representation of the zones by effectively managed MPAs is very low. Only three of the 22 zones include MPAs that were assessed as meeting their management objectives. These figures suggest that only a small proportion of the marine biodiversity of the East Asian Seas is currently being managed effectively.

PRIORITY AREAS AND RECOMMENDATIONS

National Priority Areas for Marine Biodiversity Conservation

The 20 areas listed below were selected by members of the IUCN-CNPPA Working Group for the East Asian Seas using the criteria outlined in the introduction to this report. Representation of biogeographic zones (see above) was an important, but not the only, criterion used. The assessment was carried out by the members of the working group by ranking existing and proposed MPAs in each country against the selection criteria listed in the introduction to this report. The areas that scored the highest were identified as national priorities, with up to four areas being selected for each country. For each priority area, the socioeconomic and political opportunities are such that establishment and management of an MPA is considered feasible and would make an important contribution to the conservation of marine biodiversity in the region. The group has emphasized the need to focus on supporting the management of existing MPAs, with 16 of the 20 national priority areas being established MPAs. Four of the priority areas are proposed new MPAs.

The areas identified represent key ecosystems for marine biodiversity conservation in

Table 13.4 Representation of Second-Order Biogeographic Subdivisions of the East Asian Seas Marine Region

First-Order	*Second-Order*	*Number of MPAs*
I	1. North Viet Nam	1
	2. South Viet Nam	0
	3. East Coast, Gulf of Thailand	2
	4. Inner Gulf of Thailand	0
	5. West Coast, Gulf of Thailand	2
	6. Northeast Coast, Peninsula Malaysia	4
	7. Southeast Coast, Peninsula Malaysia	4
	8. West Coast, Eastern Malaysia	8
	unclassified	6
II	9. Jawa Sea	6
	10. Makassar Sea	0
	11. Flores Sea (west)	5
	12. Flores Sea (east)	2
III	13. Banda Sea	3
	14. Arafura Sea	1
	15. Malaku Sea	1
	16. Sulawesi Sea	5
	17. Sulu Sea	11 (1)
	18. East Coast, Eastern Malaysia	3
VI	19. Indian Ocean	0
	20. Straits of Molucca	1
	21. Andaman Sea, Inner Coast	11 (5)
	22. West Coast, Peninsula Malaysia	7 (3)
	Total	83

a number of the biogeographic subdivisions of the East Asian Seas. Five of the eight first-order biogeographic subdivisions are represented by the areas proposed, the exceptions being regions IV, VII, and VIII, where no priority sites could be identified. These zones include the east coast of the Philippines, the southwest coast of Sumatra, and the south coasts of Java and the islands stretching around to Timor. These zones are poorly represented in existing MPAs and remain a significant gap. Further investigation will be required to identify potential sites for priority conservation action.

Most countries in the region are carrying out programs that are supporting the establishment and management of MPAs, and it is recognized that additional MPAs to those identified below will be required to adequately conserve all biogeographic types.

Brunei

The Brunei Darussalam Development Master Plan and the ASEAN-US Coastal Resources Management Project (CRMP) have recommended that several areas should be considered for protection or that current protection be further strengthened. CRMP suggested that all coastal islands should be managed under three broad categories: Islands for General Use, Islands for Conservation and Islands for Protection (De Silva, personal communication). Agbayani, De Silva, and Mohd (1992) provide further information on the classification of the 33 islands in Brunei according to this scheme. At this stage no specific areas have been identified as priorities for marine biodiversity conservation.

Indonesia

Descriptions of the following areas were provided by Dr. Achmad Abdullah of the Directorate of Forest Protection and Nature Conservation (Indonesia).

Existing MPAs that require management support:

- Teluk Cenderwasih Marine National Park (1,453,500 hectares): The park includes a wide variety of marine and coastal habitats including coral reefs, mangroves, seagrass beds and estuaries. The total area of coral reefs is approximately 80,000 hectares. Coral

diversity is high and several rare and endangered species are present, including green and hawksbill turtles, dugong, giant clam, *Trochus* spp. and *Charonia tritonia* (triton). The area supports rich fishery resources and has high potential for education and research.

- Pulau Banda Marine National Park (2,500 hectares): This park is located in the center of the Banda Sea. The islands are volcanic in origin with Banda Besar having the greatest reef development. Marine biodiversity values are high, coral reefs are largely undisturbed, and rare and endangered species such as the giant clam, horseshoe clam and hawksbill turtle have been recorded. The area has potential for tourism development.
- Take Bone Rate Marine National Park (530,765 hectares): Take Bone Rate, located in the Flores Sea, is the largest atoll in Indonesia. The area is considered a high priority for conservation of coral reef invertebrates. There are extensive coral reefs and seagrass beds that support a large number of grazing marine turtles. The green and hawksbill turtles both occur in the area and nest on uninhabited coral cays. The mollusk fauna is diverse although certain species such as trochus, green snail, pearl oysters, giant clams and horseshoe clams have been intensively harvested and are now rare. Marine resources are unmanaged and heavily exploited and there is an urgent need to implement a management plan.
- Karimunjawa Marine National Park (111,625 hectares): The park is located in central Java and includes coral reefs, nesting seabirds, green and hawksbill turtles and giant clams. The reefs support important fisheries including species of economic importance such as grouper and cod. The reefs are the second largest in north Java after Kepuluaun Seribu, but are in a better condition, although overexploitation of marine resources is becoming a threat.

Proposed new MPAs:

None was identified as priorities.

Cambodia

No information was available for MPA priorities in Cambodia.

Malaysia-Peninsula

Existing MPAs that require management support:

- Terengganu Group of Islands (P.Redang, P.Perhentian (5°47'N, 103°00'E)): This group of islands includes existing MPAs at Pulau Redang and Pulau Perhentian. The area has very high biodiversity with more than 50 species of coral identified, representing the best coral assemblage in Peninsula Malaysia. The area has been identified as a high priority for conservation and ecotourism by the State Government of Terengganu and the Federal Government of Malaysia. A multiple-use marine park was established around Pulau Redang in 1987. Pulau Perhentian has been established as a fisheries protected area in the interim before declaration of a marine park.
- Matang Forest Reserve (40,711 hectares (4°15'–5°0'N, 100°25'–45'E)): The reserve is located in the state of Perak from Kuala Gula to Panchor and is currently managed for sustainable production of fuelwood and poles. Management consists of a 30-year crop rotation with a working plan prepared and revised every 10 years. Management is considered to be generally effective (high) but further management support should be a priority.

Proposed new MPAs:
No new areas are proposed.

Malaysia-Sabah

Existing MPAs that require management support:

- Tunku Abdul Rahman State Park: The park is located off Kota Kinabalu on the west coast of Sabah and includes several islands and the surrounding sea. Fringing reefs occur around the islands and there are two small platform reefs off the northeast of Pulau Mamutik. Turtles have been seen around the islands but apparently do not nest within the park boundaries. Shallow reef areas support good fish populations, particularly damselfish, anemonefish and butterflyfish. Traditional subsistence fishing is carried out within the park but the major activity is tourism and recreation (UNEP/IUCN 1988).

Proposed new MPAs:

- Pulau Sipadan proposed State Park (710 hectares): The island of Sipadan is located in the southeast of Semporna Peninsula and is Sabah's only true oceanic island. Coral communities are largely pristine and support a diverse marine fauna. Green turtles nest on the island. A Bird Sanctuary was established in 1933 and the establishment of a State Park is proposed. There is some turtle egg collection and tourism use.
- Semporna Islands proposed Marine Park (4°37'N, 118°45'E): The islands are located in the Bodgaya group off the east coast of Sabah. Well-developed and extensive coral reefs are present surrounding the islands, and these support a high diversity of fish, soft corals, sponges, anemones, echinoderms, mollusks and other species. Diversity is greater than that of Sipadan Island and is reported to be comparable to that of Australia's Great Barrier Reef (Meagher 1992). Some of the islands are uninhabited, while others have long been occupied by fishing villages and small farms. Blast fishing has removed the larger, more conspicuous fish and caused damage to coral. Some areas are infested by Crown-of-Thorns starfish. Meagher (1992) recommends that the islands and associated marine life have substantial potential for tourism development and sustainable management as a state Marine Park.

Philippines

Descriptions are provided by Virgilio Palaganas of the Department of Environment and Natural Resources (Philippines).

Existing MPAs that require management support:

- Tubbataha Reef National Marine Park: The park includes relatively intact and extensive coral reefs, algal and seagrass beds and is an important turtle nesting site (at least five turtles come ashore to nest each night in the breeding season). Marine biodiversity is high with 46 hard coral genera, 379 species of fish, four seagrass species, five seabirds species and numerous algal species recorded. The area is exposed to the northeast (November–February) and southwest (July–October) monsoons that, although a destructive influence, in many respects assist management by preventing visitation and exploitation of the resources during eight months of the year. Social and political acceptability for the conservation of the park is high, and there is considerable community support from mainland Palawan. Tourism and recreational usage is high during the

summer and calm months. The area was included on the UNESCO World Heritage List in November 1993. A five-year management plan has been developed and approved by the DENR, and enforcement and patrolling is being undertaken by an NGO and the Philippines coast guard, with cooperation from tourist operators. Management is considered to be generally effective (high) but should be of priority for additional management support.

- Taklong Island National Marine Reserve (approximately 1,143 hectares): Taklong island is located on the southern tip of Guimaras Island, a subprovince of Iloilo within the Visayas Region. The marine reserve encloses 2 major islands and 10 small limestone islets. Relatively intact mangroves, coral reefs and seagrass beds are present, and the area serves as a feeding, breeding and nursery ground for fish and other marine species. Twenty-nine genera of hard coral have been recorded, as have 144 species of fish, seven species of seagrasses and three species of mangroves (Palaganas, personal communication).
- El Nido Marine Reserve (Bacuit Bay and surrounding islands): El Nido is located on the northwestern tip of mainland Palawan within Bacuit Bay. The reserve includes biogeographic features representative of the area, including mangrove forest, fringing coral reefs, extensive seagrass beds and white sand beaches. These ecosystems are largely intact, and the area serves as a feeding, breeding and nursery ground for fish and endangered marine turtles and dugong. The seagrass beds are known to be feeding grounds for dugong and turtles while the beaches are nesting sites for hawksbill, green, olive Ridley and leatherback sea turtles. The degree of community support for conservation is quite high and the area is accessible to tourism, recreational and education activities. The area was originally declared as a Marine Turtle Sanctuary in 1984 and was subsequently established as a Marine Reserve in 1991.

Proposed new MPAs:

No new MPAs are proposed.

Singapore

Descriptions have been provided by Dr. Chou Loke Ming of the National University of Singapore.

Existing MPAs that require management support:

- Sungei Buloh Nature Reserve: This reserve serves as an important feeding and nesting ground for numerous species of winter birds. It has been used in the past for prawn ponding, and as a result biodiversity is not comparable to that of pristine mangrove habitat. The management level is recorded as high, but additional management support is considered a high priority.Proposed new MPAs:
- Southern Islands: This area includes the only remaining coral reef ecosystem in Singapore. Biodiversity is high despite sedimentation. Mangroves and seagrass are also represented in the area. Four zones have been proposed for conservation by a governmental committee as part of the country's green plan.

Thailand

Existing MPAs that require management support:

- Mu Ko Surin National Park and Mu Ko Similan National Park: Description from UNEP/IUCN (1988). These two national parks are located in the Andaman Sea approximately 50 kilometers from the mainland. The parks

include marine components of 10,200 and 11,400 hectares, respectively, and fringing reefs are present, with more diverse corals present along the outer reef margins. The reefs at Surin have been assessed as the best-developed reefs in Thailand. Mangroves are present and hawksbill, leatherback and olive Ridley turtle have been recorded. Management is recorded as being generally effective (high). The area has been suggested as a possible World Heritage Site and should be of priority for additional management support.

- Hat Chao Mai National Park: Includes the last remaining habitat for dugong in Thailand.
- Mu Ko Chang Islands National Park: No information is available.

Proposed new MPAs:

No new MPAs are proposed.

Viet Nam

The following descriptions are provided by Professor Dang Ngoc Thanh of the National Centre of Scientific Research (Viet Nam).

Existing MPAs that require management support:

- Cát Bá Islands and Halong Bay National Park (20°50'N, 107°00'E): The park is situated in the Gulf of Tonkin and includes mangroves and fringing coral reefs. Halong Bay encloses about 3,000 small calcareous islands, with many historical, archaeological and other sites of tourism value.
- Côn Dảo Islands National Park (8°43'N, 106°37'): The area includes a group of 15 small islands situated in the southern part of the Viet Nam Sea, the largest being Côn Son, with typical fringing coral reefs, and mangroves. The area is of national historical significance.

Proposed new MPAs:

- Nam Du Islands (9°40'N, 104°20'E): Includes a group of small islands located in the Gulf of Thailand, including Nam Du, Thó Chu and An Thói Islands. Diverse and unexploited coral reefs are present.

The Spratly Islands

The Spratly Islands consist of some 600 coral reefs and associated structures scattered across an area north of Sabah and southern Palawan stretching for more than 300 nautical miles. The structures that protrude above the sea surface at high tide include at least 26 islands and seven exposed rocks. China, Taiwan and Viet Nam each claim all the offshore islands in the South China Sea, including the Spratlys. The Philippines claims most of the Spratlys and Malaysia claim islands in southern portions of the group. Historical claims include those by the Netherlands and France and recently Brunei has joined the list. The islands are of great strategic, political and potentially economic significance (McManus 1992).

The Spratlys fall within the highest diversity area of the East Asian Seas region and may support around 70 scleractinian coral genera. Marine turtles nest on the islands, and there are significant seabird populations. In comparison to other parts of the region the islands are relatively pristine, although there is some blast fishing and possibly other damage caused by troops of the military garrisons maintained by the Philippines, Taiwan, Viet Nam and Malaysia (McManus 1992). Over 200 ships pass through the area daily and oil wells are located nearby off western Palawan, Sabah, Sarawak, Brunei and the Natuna Islands. There is also the potential for oil drilling on the islands themselves.

Current patterns are such that the islands are likely to be an important source of larvae and juveniles for fish and invertebrates, including many species of economical importance such as tuna. Coastal reef fisheries of

the East Asian Seas are under severe pressure in many places, and the Spratlys could well play a vital role in supporting fish and invertebrate populations in other parts of the region.

The Spratly Islands are of regional and probably global significance for marine biodiversity conservation. However, in the face of such a larger number of competing territorial claims, establishing a comprehensive management regime will prove extremely difficult. McManus (1992) suggests that the Antarctic Treaty System and the Torres Strait Treaty between Papua New Guinea and Australia might offer models that would be applicable. Both these treaties provide for conservation of areas that were previously subject to jurisdictional dispute, particularly in the case of Antarctica.

Areas of Highest Regional Priority

The areas listed below are considered to be those MPAs of highest priority in the region, according to the criteria outlined in the introduction to this report. These areas were selected using the same procedure as that used to select those of national priority (see above) by ranking the national priority areas against the selection criteria and choosing those areas scoring the highest. An attempt has also been made to select at least one area from each country in recognition of the fact that all countries in the region must be involved if marine biodiversity is to be conserved and marine resources used sustainably. Description of these areas are provided above.

Existing MPAs that require management support:

- Teluk Cenderwasih (Indonesia)
- Pulau Banda (Indonesia)
- Karimunjawa (Indonesia)
- Tubbataha Reefs (Philippines)
- Mu Ko Surin and Mu Ko Similan (Thailand)
- Côn Dảo Islands (Viet Nam)
- Terengganu Group of Islands (Malaysia)

Proposed new MPAs

- Semporna Islands (Malaysia—Sabah)

Other Recommendations

The conservation and sustainable development of marine biodiversity in the East Asian Seas region is of great social, economic and ecological significance. The region is of global importance for marine biodiversity conservation as it is the global center of diversity for many marine ecosystems and groups of species. Their diversity and productivity support fisheries and tourism activities that are major sources of food, employment and foreign currency income and opportunities for other forms of economic development. In most countries the marine environment is also important for subsistence of local populations.

Marine habitats in the East Asian Seas are increasingly threatened by land-based development and overexploitation. Development in coastal areas, the impacts of sedimentation and nutrient runoff caused by deforestation and agricultural activities, unsustainable and often destructive fishing techniques, and the impacts of uncontrolled tourism activities are resulting in the degradation of marine habitats and the biological diversity that they support. These impacts may have severe economic, social and ecological consequences. There is therefore an urgent need to implement management of marine areas in the East Asian Seas to help prevent further degradation of marine biodiversity and depletion of marine resources.

Countries of the East Asian Seas region have recognized the importance of these issues and have collectively and individually taken steps to conserve the marine environment through the establishment of marine protected areas. All countries in the region have established MPAs (with the possible exception of Cambodia—for which no data

were available) and most have established programs for marine biodiversity conservation. In some areas, MPA management plans have already been formulated and implemented, while in others proposals are been drawn up for the establishment of MPAs. A total of 92 MPAs have been identified as established in the region. While this is encouraging, there is clearly still much to be done to ensure that these areas achieve the aims for which they are being established. It is estimated that close to 90 percent generally fail to achieve (57 percent) or partially achieve (31 percent) their management objectives. This reinforces the need to support the management of these existing areas. At the same time the established MPAs do not adequately represent all the biogeographic zones in the region, and a number of proposed new MPAs have been identified as priorities in this report. Additional areas will be required to develop a comprehensive regional system of MPAs.

The following factors are considered essential for the development of a system of MPAs that would represent and conserve the marine biodiversity of the East Asian Seas region.

Increased Management Capacity

The management of marine protected areas is a specialized undertaking and requires individuals with particular skills and expertise. Marine protected area management is a relatively recent field, and there is a shortage of management skills in East Asian Seas countries at all levels, including upper and middle managers and field personnel. This has contributed to a low management level of the majority of marine protected areas in the East Asian Seas region.

A basic requirement is that the institutions responsible for MPAs must have sufficient resources to effectively carry out their responsibilities. Such resources generally flow from political support. A further concern is that in some cases high level administrators and decisionmakers (particularly individuals in economic planning and finance ministries) are not fully familiar with the necessity, advantages and means of achieving effectively managed MPA systems, or with the adverse consequences resulting from mismanagement or neglect.

Consequently there is an urgent need in the East Asian Seas region for programs that support national governments in implementing effective management of marine protected areas through:

- Developing training programs for management staff
- Increasing the number of trained staff at all levels
- Increasing political awareness of the need for, and advantages of marine biodiversity Conservation, and translating this awareness into positive support
- Strengthening the institutions with responsibility for MPAs.

Such programs would be considerably strengthened if supported by networks of marine scientists and managers within the region to promote regional cooperation in marine management.

Sustainability of Investments

If MPAs are to function well in the long term, sustainable sources of financing for them must be developed. This will require innovative approaches, which might include taxes or "rent" from natural resource exploitation, as well as taxes on development projects that result in losses of marine or coastal biodiversity. In some countries the establishment of trust funds may prove a useful tool.

Legal and Administrative Jurisdiction over MPAs

Countries in the East Asia Seas region have a variety of legal and jurisdictional systems governing the management of marine resources and MPAs. As in other regions of

the world, overlapping responsibilities for components of the marine environment are common. In some instances there may be different jurisdictions over the resources of an area, such as in Malaysia where the Forestry Department is responsible for mangroves and the Fisheries Department is responsible for living marine resources around the mangroves. In a particular country several agencies may establish MPAs under a variety of different designations.

Usually there is little or no coordination between such agencies. This leads to conflicts in the use of marine resources in and around MPAs and resulting degradation of marine biodiversity. There is therefore a clear need for establishing clearer responsibilities for management of the marine environment or mechanisms to ensure coordination.

Data

There is a paucity of data on species and ecosystem dynamics, in particular the economic value of resources and activities carried out within MPAs. Such data are required for planning, monitoring and reviewing the effectiveness of management.

Managers and scientists must work together to identify data requirements for management and develop programs to meet these requirements. Data must be collected and presented in forms that are useful for planning and management. Mechanisms must be strengthened for sharing data, both nationally and regionally.

Public Support

Many local people rely heavily on the marine resources of the East Asia Seas and MPAs can provide benefits to local people, particularly through sustainable fishing and tourism activities. The present level of recognition of this fact is low and public support and awareness must be greatly increased. Public support for marine biodiversity conservation is essential for gaining political approval and support for MPAs.

Education in the region does not emphasize environmental concerns (Ch'ng 1993), and developing the public's interest in marine conservation will require a particular effort. This could be achieved through programs aimed at:

- Increasing public awareness, understanding and acceptance of the need for, and benefits of, marine biodiversity conservation and sustainable development
- Developing management approaches that integrate sustainable development and biodiversity conservation.

Managing Uses in Adjacent Areas

It is beyond the scope of this report to attempt to address issues relating to coastal zone management and marine biodiversity. However, the establishment and management of MPAs may prove to be a futile exercise unless this occurs within regimes that provide for management of the adjacent land and sea. Land-based activities such as forestry and agriculture result in increased turbidity and nutrient levels in the marine environment that pose a major threat, particularly to coral reefs. Coastal zone management initiatives are under way in some countries, and their successful implementation in all countries should be of high priority for marine biodiversity conservation.

Addressing these concerns will be essential to conserving marine biodiversity in the region, including the areas of high priority identified in this report. Without such programs is it likely that marine biodiversity in the East Asian Seas will continue to be degraded at an alarming rate.

NOTE

1. These areas were formally declared as marine parks in January 1995.

Appendix Updated List of Philippine Marine Protected Areas per Category

(submitted to IUCN Commission of National Park and Protected Areas as of July 1994)[1]

National Marine Park

Palawan Province	1. Tubbataha Reef (Presidential Proclamation No. 306 of Environment and Natural Resource (DENR)

National Marine Reserve

Iloilo Province	2. Taklong Group of Islands. Guimarae (Presidential Proclamation No. 525 dated February 8, 1990 under DENR)

Marine Turtle Sanctuary (by virtue of the former Minister of Natural Resources Administration Order No. 8. Series of 1982 now under DENR)

Tawi-Tawi Province	3. Bancauan Island 4. Baguan Island
Palawan Province	5. Halog Island 6. Tanobon Island 7. Panata Cay 8. Kota Island
Antique Province	9. Panagatan

Tourist Zones and Marine Reserve (Presidential Proclamation no. 1801 dated November 10, 1978 under Philippine Tourism Authority). These includes the coastal waters and resources surrounding the islands.

Batangas Province	10. Fortune Island 11. Maricaban Island 12. Caban Island 13. Sombrero Island 14. Ligpo Island 15. Balahibong Manok Island 16. Verde Island
Cagayan Province	17. Fuga Island
Mindoro Oriental Province	18. Port Galera 19. Balatero Cove 20. Medio Island 21. Buyayao Island 22. Aslom Island 23. Bating Peninsula 24. Maasim Island 25. Balatasan Cove 26. Pocanel Island 27. Opal Island 28. Buyallao Peninsula 29. Suguicay Island 30. Libago Island 31. Sibalat Island 32. Pambaron Island 33. Apo Island and Reef
Aklan Province	34. Boracay Island
Negros Province	35. Apo Island 36. Siquijor Island 37. Selinog Island 38. Aligway Island

Cebu Province	39. Caubian Island
	40. Olango Island
	41. Sulpa Island
	42. Hilatangan Island
	43. Lasuan Island
	44. Caohangan Island
	45. Pangan Island
	46. Buyong, Maribago, Mactan Island
	47. Sogod
Bohol Province	48. Panglao Island
	49. Cabilao Island
	50. Balicasag Island
Samar Province	51. Guiuan
Leyte Province	52. Gigantangan Island
Palawan Province	53. Busuananga Island
	54. Coron Island
	55. Puerto Princesa and vicinity
	56. Malampaya Sound and islands
	57. Canaron Island
	58. Solitario Island
	59. Bacuit Bay and islands
	60. Balabac Island
	61. Fort Burton Bay and islands
	62. Busuanga Island
Misamis Oriental Province	63. Al-Sulnuan Point
	64. Camigiun Island
Zamboanga Province	65. Big Sta. Cruz Island
	66. Small Sta. Cruz Island
	67. Sangali Cove
	68. Sacol Island
	69. Ayala/San Ramon
	70. Malanipa Island
Davao Province	71. Maliputa Island
	72. Talicud Island
	73. Ligig Island
	74. Samal Is (eastern side)

Wilderness Areas (Presidential Proclamation No. 225229 dated December 1981 under DENR: For the protection of foreshore areas and maintenance of estuarine and marine life including special forests for the exclusive habitats of rare and endangered Philippine flora and fauna)

Quezon Province	75. Alibijaban Island
Camarines Sur Province	76. Basot Island
	77. Quinalang Island
Masbate Province	78. Guinauayan Island
	79. Naro Island
	80. Chico Island
	81. Pobre Island
	82. Majaba Island
	83. Napayauan Island
	84. Dampalit Island

Cebu Province	85. Bantayan Island
Bohol Province	86. Catiil Island
	87. Calangman Island
	88. Lumislis Island
	89. Tabangdio Island
	90. Tintiman Island
	91. Pamasuan Island
	92. Budlangan Island
	93. Bugatusa Island
	94. Panga Island
	95. Silo Island
	96. Cabgan Island
	97. Cancostino Island
	98. Tabacon Island
	99. Maagpit Island
	100. Basihan Islet
	101. Bugatusan Islet
	102. Hayaan Islet
	103. Inanoran Islet
	104. Basilan Islet (Poom Point)
	105. Banson Island
	106. Bassan Island
	107. Saae Island
	108. Tambu Island
	109. Bambanon Island
Surigoa Del Norte Province	110. Lamagon Island
	111. Capaya Island
	112. Cobeto Island
	113. Rasa Island
	114. Siargao Island
	115. Pones Island
	116. Dahican Island
	117. Tona Laonan Island
	118. Abanay Island
	119. Bancuyo Island
	120. Awasan Island
	121. Cabilan Island
	122. Cabilan Island
	123. Capaquian Island
	124. Sugbuhan Island
	125. Tagboaba Island
Davao Del Sur Province	126. Pandasan Island

Protected Landscape/Seascape (under the National Integrated Protected Areas Act of 1992 (Republic Act 7586) of the DENR). The areas includes all the coastal waters, resources and islands found within the bay and between islands.

Zambales Province	127. Masinloo-Oyon Bay
Batanes Province	128. Batanes Group of Islands

Seashore Park under DENR

La Union Province	129. Ago-Damortis

Fish Sanctuaries declared under Bureau of Fisheries and Aquatic Resources (BFAR) Administration Orders. The sanctuary areas include the coastal waters and resources opposite the mentioned locality.

Leyte Province	130. Babatngon, Calangawan Island
	131. Barugo, Jalaba Point
	132. Capoocan, Culasian Point
	133. Mawodpawod, San Miguel
	134. San Antonio Fish Sanctuary
	135. Libas Merida
	136. Palo Reef
	137. Tabugon, Liloan
	138. Buenavista, Padre Burgos
	139. Banit, San Ricardo
Zamoanga Province	140. Tambulig
Bataan Province	141. Manila Bay
Cebu Province	142. Sumilon Island
Camarines Sur Province	143. Caranan, Pasacao
	144. Atulayan Island
	145. Cabcab, San Andres
Camarines Norte	146. Sapinitan, Siruma
	147. Quinapaguin, Mercedes
Quezon Province	148. Gerardo Point Perez
	149. Pinagsakayan, Calauag
	150. Catanauan
	151. Pagbilao
	152. San Francisco
	153. Unisan
	154. Perez
	155. Calauag
Sorsongon Province	156. Mulanawan
Samar Province	157. Badung-badung Island Marabut
Misamis Occidental	158. Locualan Shoal, Clarin
	159. Dinalooc Cove, Tangub City
Lanao del Norte-Zamboanba del Sur-Misamis Occidental Province	160. Panguil Bay

Environmentally Critical Area (Presidential Proclamation No. 156 dated March 25, 1992)

Pangasinan-La Union-Ilocos Province	161. Lingayen Gulf

Mangroves Swamp Forest Reserves (Presidential Proclamation No. 2152 dated December 29, 1981 declaring the entire province of Palawan and certain parcel of the public domain and/or parts of the country). These areas are withdrawn from entry, sale, settlement or other forms of disposition, subject to private rights for conservation and protection purposes by reason of values including flora and fauna and marine life found therein and other values.

Palawan	162. Entire provinces of Palawan
Quezon Province	163. Portion of Bondoc Peninsula
	164. Portion of Tayabas Bay
	165. Polillo Island
	166. Alabat Island
	167. Cabalete Island
	168. Jomalig Island
	169. Paenanongan Island

	170. Kalotkot Island
	171. Kalingkooan Island
	172. Palasan Island
	173. Calabao Island
	174. Icol Island
	175. San Rafael
Camatrines Norte	176. Del Pilar River to portion of Inuran and Sapnitan Bay
Camarines Sur	177. Portion of Cagraray Island
	178. Lahay Lucasuhin Island
	179. Haponan Island
	180. Quinabungan Island
	181. Malabungot Lamit Island
	182. Batan Island
Albay Province	183. Pigbucan to Paron Point
Sorsogon Province	184. From Putiao River to Mantay Point
Marinduque Province	185. Sta. Cruz Island
	186. Salomque Island
	187. Dapdap to Dating Bayan River, Calancan Bay
Masbate Province	188. Burias Island
	189. Basin Island
	190. Sibuyan Island
	191. Portion of Butan Bay
	192. Sta. Rosa River to Tinsgo Cove
	193. Banks of Balono and Pasil River, Toos Cove, Daraga, Diutag and Lomocab River
	194. Caroga Island
Mindoro Province	195. Banks of Manburao River to Ilin Island
	196. Sukol River to Soquicay Island
Leyte Province	197. Dupon Bay
	198. Apali Point to Bo. Manpagul
Cebu Province	199. Ponson Island
	200. Poro Island
	201. Pacihan Island
Bohol Province	202. Pamasuan Island
	203. Handayan Island
	204. Majanay Island
	205. Banoon Islet
	206. Lapinig Chico
	207. Soom River to Pampans
	208. Ambugan Island
	209. Pangangan Island
	210. Cavilao Island
	211. Sandigan Island
	212. Batas Islet
	213. Inabangan River to Pampans
	214. Agio Point to Kasag Point
Lanao del Norte	215. Liangan River to Lapayan River
Misamis Occidental	216. Bagumbang to Ozamis City

Davao Province	217. Baculin Point to Lakud Point
	218. Tanguip Point to Kinsblangan Island
	219. Samal Island
Surigao del Norte	220. Siargao Island
	221. Bucas Grande Island
	222. Middle Bucos Island
	223. East Bucos Island
	224. Dianagat Island
	225. Hikdop Island
	226. Sibale Island
	227. Hinigad Island
Surigao del Sur	228. Lavigan to Valencia to Barcelona
	229. Masopelid Island
	230. Mahaba Island
	231. Condona Island
	232. Bayagnan Island
	233. Bilabid Island
	234. Caye Island
	235. Tumalong Bay
	236. Baong River
	237. Pongao Bay
	238. Malubog Point to Smabalawan
	239. Pisan Island
	240. Sagayapan Island
	241. Tintauan Island
	242. Sacol Island
	243. Tagasilay to Tigbao River
	244. Vitali Island

Marine Reserve

Palawan	245. El Nido (by virtue of DENR Administrative order No. 14, April 12, 1991)

Municipal Coral Reef Park/Marine Park/Marine Reserve

Bohol	246. Guindulman
	247. Pamilacan Island (1985)
	248. Panglao-Balicasag Island
Negros Occidental	249. Sagay
Cebu	250. Sumilon Island
Mindoro	251. Ambulong-Ilin Island
Palawan	252. Oyster and Binussalina Bays Puerto Princesa (by virtue of City ordinance No. 13, 1992)

BIBLIOGRAPHY

Abbot, R.T. 1960. The Genus Strombus in the Indo-Pacific. *Indo-Pacific Mollusca* 1(2):33–146.

Agbayani, C.V., M.W.R.N. De Silva, and H.S.H. Mohamed Jaya. 1992. Island management strategy for Brunai Darussalam. In G. Silvestre, H.J. Matdanan, P.H.Y. Sharifuddin, M.W.R.N. De Silva, and T.E. Chua, eds., *The coastal resources of Brunai Darussalam: Status, utilisation and management.* ICLARM Conference Proceedings 34. Manila: Department of Fisheries, Ministry of Industry and Primary Resources, Bandar Seri Begawan, Brunai Darussalam and International Center for Living Aquatic Resources Management.

Andau, P.M., D.L.A. Alisaputra, J. Payne, and J.B. Sale. 1993. Marine Protected Areas in Sabah, Malaysia. Paper presented at the UNEP-COBSEA/MOSTS/DOF EAS-25 Workshop in Case Studies for the Planning and Management of Marine Protected Areas, held in Penang, Malaysia, 8–12 February.

Association of Southeast Asian Nations (ASEAN) and Australia Marine Science Project. 1992. *Newsletter of the ASEAN-Australia Marine Science Project* 19(April). Australian Institute of Marine Science, Townsville.

Berry, A.J. 1964. The natural history of the shore fauna of north Penang. *Malaysia Nature Journal* 18:81–103.

Briggs, J.C. 1974. *Marine zoogeography.* New York: McGraw-Hill Book Company.

Ch'ng, K.L. 1993. A marine protected areas system for the Asia-Pacific region. Paper presented to the Second Asia-Pacific Regional Consultative Meeting on Biodiversity Conservation, Bangkok, Thailand, February.

. 1992. Establishing Marine Parks Malaysia: Issues, problems and possible solutions. Paper presented at the 4th World Congress on National Parks and Protected Areas, Caracas, Venezuela, February.

Cheung, C.P.S. 1992. Report on a visit to the coasts of Vietnam. Paper prepared for WWF-Asian Region.

Chuang, S.H. 1973. *Ecology of Singapore and Malayan coral reefs—preliminary classification.* Proceedings of the 3d International Coral Reef Symposium.

Cogger, H.G. 1994. *Reptiles and Amphibians of Australia.* Fifth edition with revised appendix. Sydney, Australia: Reed Books.

Committee for Rational Utilisation of Natural Resources and Environmental Protection and World Conservation Union (IUCN). 1985. *Vietnam National Conservation Strategy.*

Elder, D., and J. Pernetta, eds. 1991. *Oceans.* London: Mitchell Beazley in association with IUCN.

Economic and Social Committee for Asia and the Pacific (ESCAP). 1990. *State of the Environment in Asia and the Pacific.* Bangkok.

Fortes, M.D. 1988. Mangroves and seagrass beds of East Asia: Habitats under stress. *Ambio* XVII(3).

Gomez, E. 1988. Achievements of the Action Plan for the East Asian Seas. In *UNEP 1988: Cooperation for environmental protection in the Pacific.* UNEP Regional Seas Reports and Studies No. 97. Nairobi.

Gomez, E.D., E. Deocadiz, M. Hungspreugs, A.A. Jothy, Kuan Kwee Jee, A. Soegiarto, and R.S.S. Wu. 1990. *The state of the marine environment in the East Asian Seas Region.* UNEP Regional Seas Reports and Studies No. 126. Nairobi.

Haeruman, H. 1988. Conservation in Indonesia. *Ambio* 17:218–22.

Hayden, B.P., G.C. Ray, and R. Dolan. 1984. Classification of coastal and marine environments. *Environmental Conservation* 11(3)(Autumn).

Heatwole, H. 1989. *Sea snakes.* New South Wales: New South Wales University Press in association with the Australian Institute of Biology.

Hutomo, M., H. Uktolseya, N.A. Sloan, A. Abdullah, R.H. Djohani, J. Alder, M.H. Halim, and Sutardjo. 1993. Marine conservation areas in Indonesia: Two case studies of Kepulauan Seribu, Java and Bunakan, Sulamesi. Paper presented at the UNEP-COBSEA/MOSTS/DOF EAS-25 Workshop in Case Studies for the Planning and Management of Marine Protected Areas, in Penang, Malaysia, 8–12 February.

Inman, D.L., and C.E. Nordstrom. 1971. On the tectonic and morphologic classification of coasts. *Journal Geology* 79:1–21.

Mackinnon, J.R. 1990. *Report on review of the nature conservation system, national parks and protected areas.* Forestry Sector Review—Vietnam Tropical Forestry Action Plan Project VIE/88/037. FAO/UNDP/MOF. Rome.

McManus, J.W. 1992. The Spratley Islands: A marine park alternative. *NAGA, The ICLARM Quarterly* (July):4–8.

Meagher, T.D., ed. 1992. Proposed Semporna Marine Park environment evaluation for expanded tourism development. Report prepared for Sabah Parks.

Meth, N., and R. Helmer. 1983. Marine environment and coastal resources in Southeast Asia: A threatened heritage. In E.M. Borgese and N. Ginsburg, *Ocean Yearbook 4.* Chicago and London: University of Chicago Press.

Palaganas, V.P. 1993. Tubbataha Reef National Marine Park: A case study in the planning and management of marine parks in the Philippines. Paper presented at the UNEP-COBSEA/MOSTS/DOF EAS-25 Workshop in Case Studies for the Planning and Management of Marine Protected Areas, in Penang, Malaysia, 8–12 February.

Robinson, A., N. Polunin, K. Kvalvagnaes, and M. Halmin. 1981. Progress in creating a marine reserve system in Indonesia. *Bulletin of Marine Science* 31:774–85.

Salim, E. 1988. Towards sustainable development of aquatic resources. In P.R. Burbridge, Koesoebiono, H. Dirschl, and B. Patton, eds., *Coastal Zone Management in the Strait of Molucca.* DESC/EMDI. Halifax, Canada: School of Resource and Environmental Studies, Dalhousse University.

Salm, R.V., and J.R. Clark. 1984. *Marine and coastal protected areas: A guide for planners and managers.* Gland, Switzerland: IUCN.

Shwartz, M.L. 1982. *The encyclopedia of beaches and coastal environments.* Stroudsburg, PA: Hutchinson Ross Publishing Company.

SRV State Committee for Sciences (SCS), United Nations Development Programme (UNDP), Swedish Development Agency (SIDA), United Nations Environment Programme (UNEP), and World Conservation Union (IUCN). 1991. *Vietnam national plan for environment and sustainable development, 1991–2000: Framework for action.* (Project VIE/89/021.

Soegiarto, A. 1985. *Oceanographic assessment of the East Asian Seas.* UNEP Regional Seas Reports Studies No. 69. Nairobi.

Soegiarto, A., Soewito and R.V. Salm. 1984. Development of marine conservation in Indonesia. In J.A. McNeely and K.R. Miller, eds., *National parks, conservation and development—The role of protected areas in sustaining society.* Washington, D.C.: Smithsonian Institution Press.

Springer, V.G. 1982. *Pacific plate biogeography, with special reference to shorefishes.* Smithsonian Contributions to Zoology No. 367. Washington, D.C.: Smithsonian Institution Press.

United Nations Environment Programme (UNEP). 1993. *Report of the UNEP-COBSEA/MOSTE/DOF workshop on case studies on marine protected areas in the East Asian Seas.* Penang, Malaysia, 8–10 February. Nairobi.

United Nations Environment Programme (UNEP) and World Conservation Union (IUCN). 1988. *Coral reefs of the world. Volume 2: Indian Ocean, Red Sea and Gulf.* UNEP Regional Seas Directories and Bibliographies. Gland, Switzerland and Cambridge, U.K.: IUCN; Nairobi: UNEP.

Vernon, J.E.N. 1986. Distribution of reef-building corals. *Oceanus* (Summer): 29.

Vohra, F.C. 1971. Zonation on a tropical sandy shore. *Journal Animal Ecology* 40:679–708.

Voris, H.K. 1972. The role of sea snakes (*Hydrophiidae*) in the trophic structure of coastal ocean communities. *Journal of the Marine Biological Association of India* 14(2): 429–42.

World Conservation Monitoring Centre (WCMC). 1992. *Global biodiversity: Status of the earth's living resources.* London: Chapman and Hall.

———. 1993. Protected areas with mangrove habitat. Draft. Cambridge, U.K.

World Conservation Union (IUCN). 1992. *Protected areas of the world: A review of national systems. Volume 1: Indomalaya, Oceania, Australia and Antarctic.* Gland, Switzerland and Cambridge, U.K.

World Resources Institute (WRI). 1992. *World resources 1992–93: A guide to the global environment.* Oxford, U.K.: Oxford University Press.

World Wildlife Fund (WWF)—Malaysia. 1992. *Sabah conservation strategy. Volume 2: Action plan.* Final report submitted to the Ministry of Tourism and Environmental Development.

Yaman, R.G. 1993. Planning and management of marine protected areas in Peninsula Malaysia: Case study for the Pulau Redang Marine Park. Paper presented at the UNEP-COBSEA/MOSTS/DOF EAS-25 Workshop in Case Studies for the Planning and Management of Marine Protected Areas, in Penang, Malaysia, 8–12 February.

Contributors

Many people and organizations contributed directly to these reports. The major authors or editors of each regional report in Volume III have prepared the following highlights of these contributions.

Marine Region 10: Central Indian Ocean

This report was produced from contributions provided by Sue Wells and Dwivedi, Singh, and Ivan (1994). Information used by these authors includes a series of country reports (Pernetta 1993a,b,c,d,e) for Bangladesh, India, the Maldives, and Sri Lanka. The country reports provide an overview of protected area needs in the South Asian Seas region; they were commissioned by UNEP OCA/PAC from IUCN and published in 1993 by IUCN. The main sources for these were Scott (1989), UNEP/IUCN (1988), and country reports published by the UNEP Regional Seas Programme in 1986. References cited in those reports have generally not been repeated here. Additional information was provided by CNPPA Working Group Leader, M.S. Swaminathan.

Lists of MPAs and national priority areas were compiled by Sue Wells based on information in Pernetta (1993a,b,c,d,e) and other sources as noted. The biogeographic classification presented was developed by Dwivedi, Singh, and Ivan (1994). Regional priority areas have also been identified by Dwivedi, Singh, and Ivan (1994).

Marine Region 11: Arabian Seas

This report has been compiled by Anthony W. Chiffings (Melbourne Water Corporation, Australia), with editorial assistance from Chris Bleakley (GBRMPA). Other contributors, through review, are noted below in the special acknowledgments.

Lists of MPAs, the biogeographic classification system, and proposed priority areas are those provided by Chiffings (1992) and other sources as noted. Descriptions of ecosystem and species diversity are adapted from Sheppard, Price, and Roberts (1992), from reports by Hanna (1983, 1991, 1994), Halim and others (1987), and other sources as also noted.

The draft report was forwarded for review to country representatives throughout the region and to scientific specialists. The author would like to gratefully acknowledge contributions and comments received from: Tom Berman (Israel Oceanographic and Limnological Research Ltd., Israel), David Cameron (University of Alaska, U.S.), Mike Evans (Birdlife International, U.K.), Rifaat G. Hanna (Australian Water Technology, Australia), Nazar Mulla Hussain (Kuwait Institute for Scientific Research, Kuwait), Ali Bin Amer Al Kiyiemi (Ministry of Regional Municipalities and Environment Muscat, Oman), Nazar Mulla Hussain (Kuwait Institute for Scientific Research, Kuwait), Gary Morgan (Kuwait Institute for Scientific Research, Kuwait), Jeff Miller (Queensland Department of Environment and Heritage, Australia), Richard Porter (Birdlife International, U.K.), Tony Preen (Queensland Department of Environment and Heritage, Australia), Andrew Price and Charles Sheppard (University of Warwick, U.K.), and Peter Symens (Wildlife Sanctuary for the Gulf Region, Saudi Arabia).

Particular acknowledgment is given to the authors, Charles Sheppard, Andrew Price and Callum Roberts, of *Marine ecology of the Arabian Region: Patterns and process in extreme tropical environments* (1992) for permission to use material from this publication. The assistance of the publishers

of this book, Academic Press (London, U.K.), is also gratefully ackowledged.

This report does not address the issue of priority sites for seabird conservation. A project has been carried out by an NGO, Birdlife International, to identify important bird areas throughout the Middle East (Birdlife International, N.d.).

Marine Region 12: East Africa

This section has been compiled by Gudrun Gaudian (Tropical Marine Research Unit, Fisheries Department, Grand Turk, Turks and Caicos Islands, British West Indies), Anderson Koyo (Kenya Wildlife Service, Nairobi), and Sue Wells (Cambridge, U.K.).

Additional information has been provided by: Robert Bensted Smith (Kenya Wildlife Service, Nairobi), Roseline Beudels-Jamar (Institut Royal des Sciences Naturelles de Belgique), Peter Burbridge (Stirling University, U.K.), Andrew Cooke (University of Newcastle, U.K.), M.E. Dulloo (Conservation Unit, Mauritius), Paul Dutton (Bazaruto Archipelago Conservation Project, Mozambique), I. Fagoonee (University of Mauritius), Domingos Gove (Marine Biological Station of Inhaca, Mozambique), Alain Jeudy de Grissac (IUCN Marine Programme), Paul la Hausse de Lalouvière (Mauritius Marine Conservation Society), Gaie Mendelssohm (Environment and Development Group, Mozambique), Martin Nicoll (WWF International), Rod Salm (IUCN East African Regional Office, Kenya), Nirmal Jivan Shah (ENVIRO, Seychelles), John Turner (Bangor University, U.K.), Pierre Vasseur (France), and O. Waller (Université de la Reunion).

The WCMC Protected Areas database and other sources as noted were used to compile the list of MPAs for each country. The biogeographic classification was developed by Gudrun Gaudian. Priority areas were selected by the authors using the criteria in the introduction to this report, bearing in mind existing recommendations in the literature including UNEP/IUCN (1988), World Bank (1993a,b), and other references cited in the text.

Marine Region 13: East Asian Seas

This report is the product of an IUCN/CNPPA working group that includes representatives of the countries of the East Asian Seas Marine Region. The report was edited by Chris Bleakley (GBRMPA) and Sue Wells. Where possible, each country was represented on the working group by a marine scientist and a marine resource manager and appointments were confirmed by relevant government authorities.

The Coordinator was Ch'ng Kim Looi—Malaysia (Ministry of Science, Technology and Environment). Working Group members were: Achmad Abdullah (Directorate General of Forest Protection and Nature Conservation, Indonesia), Porfirio M. Alino (Marine Science Institute, Philippines), Malikusworo Hutomo (Indonesian Institute of Sciences, Indonesia), Chou Loke Ming (National University of Singapore), Virgilio Palaganas (Department of Environment and Natural Resources, Philipines), Ridzwan b. Abdul Rahman (Universiti Pertanian, Malaysia), Jacques See (Jurong Bird Sanctuary, Singapore), Suraphol Sudara (Chulalongkorn University, Thailand), Dang Ngoc Thanh (National Centre of Scientific Research, Viet Nam), Somboon Wongpakdee (Royal Forest Department, Thailand), A. Rahim Gor Yaman (Department of Fisheries, Malaysia), and Nguyen Huy Yet (Institute of Oceanology, Viet Nam).

Additional information or comments have been provided by: Harold Cogger (Australian Museum), Ranjith De Silva (Department of Fisheries, Brunei), Edgardo Gomez (University of Philippines), Tim Meagher (Australia), John Sale (Sabah Environmental Management Plan, Malaysia), Effendy Sumardja (Ministry of Forestry, Indonesia), Clive Wilkinson (Australian Institute of Marine Science), Edward Wong (formerly Department of Fisheries, Malaysia). The authors

would like to acknowledge the strong support of Reza Amini, Coordinator of the Regional Coordinating Unit of the UNEP East Asian Seas Action Plan (RCU-EAS).

Except where noted the information and recommendations in this report are derived from written reports submitted by the contributors listed above and from discussions and papers presented at the UNEP-COBSEA (Coordinating Body for the Seas of East Asia) EAS 25 Workshop on Case Studies on Marine Protected Areas in the East Asian Seas, held in Penang, Malaysia, in February 1993 (UNEP 1993). The workshop was organized by the Malaysian Ministry of Science, Technology and the Environment (MOSTE) in cooperation with UNEP-COBSEA, IUCN-CNPPA, the World Bank, and the Great Barrier Reef Marine Park Authority (GBRMPA). The report has been compiled from these and other sources.

The biogeographic classification system used in this report has been adopted by the members of the IUCN-CNPPA Working Group for use in the East Asian Seas Marine Region. Lists of existing MPAs and priority areas were provided by IUCN-CNPPA Working Group members.

Index

Page numbers printed in *italic* type refer to tables or figures. Passim indicates that the topic is discussed intermittently within the given range of pages. Proposed MPAs of regional conservation priority are indexed by name. Other existing and proposed MPAs are grouped under given nations and marine regions.

Map Supplement

Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Bangladesh	Jinjiradwip	P		Y	10-1
	Naaf Estuary	P		Y	10-2
	Sundarbans	P	Y	Y	10-3
British Indian Ocean Territory	The Chagos Archipelago	P			
India	Andaman and Nicobar Islands	P		Y	10-15
	Bhitar Kanika Sanctuary	E		Y	10-4
	Chilka Lake Wildlife Sanctuary Extension	P		Y	10-16
	Chilka (Nalaban) Sanctuary	E			10-5
	Chorao Island Wildlife Sanctuary	E			10-6
	Gulf of Khambhat Wildlife Sanctuary	P		Y	10-17
	Kazhiveli Wildlife Sanctuary	P		Y	10-18
	Kundapar Sanctuary	P		Y	10-19
	Lakshadweep (Laccadive) Archipelago	P	Y	Y	10-20
	Malvan Sanctuary	E	Y	Y	10-7
	Marine (Gulf of Kutch) National Park	E	Y	Y	10-8
	Marine (Gulf of Kutch) S* Sanctuary	E			10-9
	Marine (Gulf of Mannar) National Park	E	Y	Y	10-10
	Marine (Wandur) National Park	E	Y	Y	10-11
	Pichavaram Sanctuary	E			10-12
	Point Calimere National Park	P		Y	10-21
	Pulicat Lake Sanctuary	E			10-13
	Sundarbans National Park	E			10-14
	Sundarbans National Park	P	Y	Y	10-22
Maldives	Maldives Atolls	P	Y	Y	10-23
Myanmar	Central Tenasserim Coast and northern Mergui Archipelago	P		Y	10-24
	Irrawaddy Delta	P		Y	10-25
	Lampi Island (and adjacent areas)	P		Y	10-26
	Moscos Island Wildlife Sanctuary	P		Y	10-27
	Sittang Estuary and the Gulf of Martaban	P		Y	10-28
	Thamihla Kyun Wildlife Sanctuary	P		Y	10-29
Sri Lanka	Bar Reef Marine Sanctuary	E		Y	10-30
	Basses Reef	P		Y	10-34
	Hikkaduwa Marine Sanctuary	E		Y	10-31
	Jaffna Peninsula and Lagoon	P		Y	10-35
	Kokilai Sanctuary	E			10-32
	Negombo Lagoon	P		Y	10-36
	Palk Bay and Gulf of Mannar	P	Y	Y	10-37
	Puttalam Lagoon	P		Y	10-38
	Rekawa Lagoon	P		Y	10-39
	Ruhuna (Yala) Block 1 National Park	E			10-33

Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Djibouti	Maskali Sud Integral Reserve	E			11-1
	Musha Territorial Park	E			11-2
Egypt	Abu Gallum Multiple Use Management Area	E			11-3
	Abu Monqar and Gaftun Islands	P		Y	11-32
	El-Ghardaqa	P		Y	11-34
	Gebel Elba Conservation Area	E		Y	11-4
	Nabq Multiple Use Management Area	E			11-5
	Ras Mohammed National Park	E			11-6
	Ras Mohammed Sector—additional marine areas Marine and Coastal Park	E		Y	11-7
	Southern Egypt (proposed) Marine Park: Mersa Alam—Sudanese Border	P	Y	Y	11-9
	Tiran-Sanafir Islands Protected Area	E		Y	11-8
Egypt, Saudi Arabia	Northern Red Sea: Straits of Gubal	P	Y	Y	11-10
	Northern Red Sea: Tiran Islands Area	P	Y	Y	11-11
Eritrea	Dahlac Marine National Park	E			11-12
Iran, Islamic Republic of	Shidvar Wildlife Refuge	E			11-13
Iraq	Marshes of the Tigris and Euphrates	P	Y	Y	11-14
Kuwait	Kuwait Bay	P		Y	11-33
	Qaru Marine Park	P		Y	11-15
Oman	Daymaniyat Islands National Nature Reserve	E		Y	11-16
	Khawr Salalah BS Managed Nature Reserve	E			11-17
	Quru Managed Nature Reserve	E			11-18
	Ra's al Hadd (Turtle Reserve) Managed Nature Reserve	E			11-19
	Ra's al Jumayz National Nature Reserve	E			11-20
Pakistan	Outer Indus Delta	P	Y	Y	11-21
Saudi Arabia	Farasan Islands Protected Area	E			11-22
	Farasan-Gizan Area	P	Y	Y	11-24
	Qishan Islands-Ras al Askar	P	Y	Y	11-25
	Ras Suwahil	P	Y	Y	11-26
	Um Al-Qamari Island Protected Area	E			11-23
	Wejh Bank	P	Y	Y	11-27
Saudi Arabia, Bahrain, Qatar	The Persian Gulf: Gulf of Salwa	P	Y	Y	11-28
Somalia	Maydh Island	P		Y	12-65
Sudan	Abraq, El Deib and Gebel Elba area Conservation Area	E			11-29
	Sanganeb Atoll Marine National Park	E			11-30
Yemen, Republic of	Socotra Island	P	Y	Y	11-31
Comoros	Chiroroni	P		Y	12-1
	Grand Comore (Chindini-Malé MP, Bangoi Kouni-Ivoin MP)	P		Y	12-2
	South Coast of Mohéli, including Nioumachoua	P	Y	Y	12-3

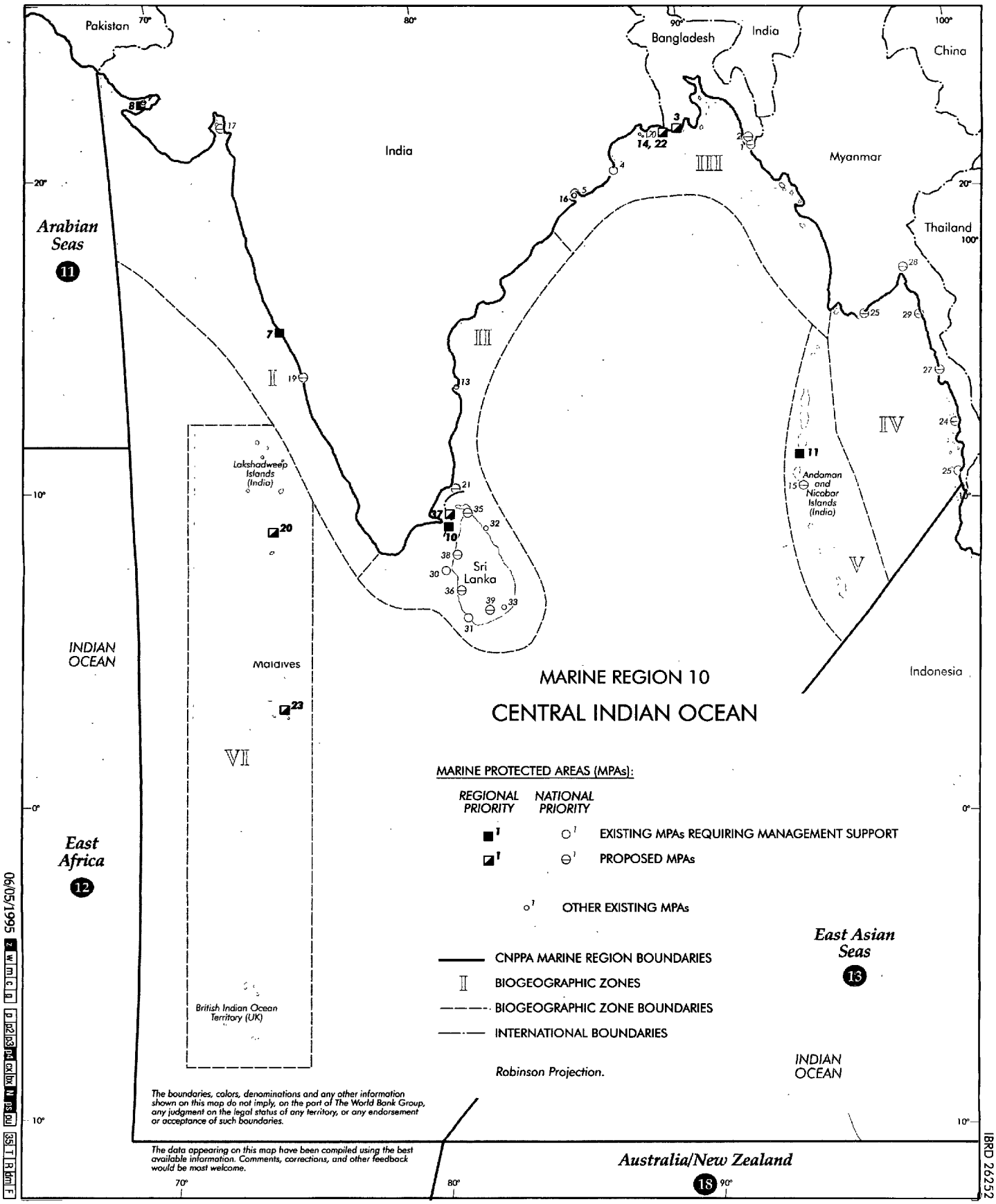
Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Kenya	Diani MNP Complex Marine National Park	E		Y	12-4
	Kisite/Mpunguti Marine National Park	E			12-5
	Kiunga Marine National Reserve	E	Y	Y	12-6
	Malindi Marine National Park	E			12-7
	Malindi Marine National Reserve	E			12-8
	Mombasa Marine National Park	E			12-9
	Mombasa Marine National Reserve	E			12-10
	Mpunguti Marine National Reserve	E			12-11
	Ras Tenewi (proposed) Marine National Park	P		Y	12-14
	Tana River Delta	P		Y	12-15
	Watamu Marine National Park	E			12-12
	Watamu Marine National Reserve	E			12-13
Madagascar	Baie de Bombetoka	P		Y	12-17
	Baie de Mahajamba	P		Y	12-18
	Grand Recif at Toliara	P	Y	Y	12-19
	Lokobe Strict Nature Reserve	P		Y	12-20
	Mananara Marine National Park	E		Y	12-16
Mauritius	Balaclava Marine Park, Turtle Bay	P		Y	12-27
	Black River Fishing Reserve	E			12-21
	Carjados Carajos Shoals	P	Y	Y	12-28
	Flacq Fishing Reserve	E			12-22
	Grand Port—Mahebourg Fishing Reserve	E			12-23
	La Chaland Blue Bay Marine Park	P		Y	12-29
	Port Louis Fishing Reserve	E			12-24
	Riviere du Rampart—Poudre d'Or Fishing Reserve	E			12-25
	Shelf Islands (Gabriel, Flat, Round, Serpent, Coin de Mire)	P		Y	12-30
	Trou d'Eau Douce Fir Fishing Reserve	E			12-26
Mayotte	Passe en S Strict Fishing Reserve	E			12-31
Mozambique	Bartolomeu Dias area	P		Y	12-36
	Bazaruto MNP National Park	E	Y	Y	12-32
	Ilhas da Inhaca e dos Portugueses Faunal Reserve	E	Y	Y	12-33
	Marromeu Game Reserve	E			12-34
	Nacala-Mossuril	P		Y	12-37
	Pomene Game Reserve	E			12-35
	Primeiras and Segundas Islands	P		Y	12-38
Réunion	Cap la Houssaye Fishing Reserve	E			12-39
	Ile Tromelin Nature Reserve	E			12-40
	Iles Glorieuses Nature Reserve	E			12-41
	Ilot d'Europa Nature Reserve	E		Y	12-42
	Ilot de Bassas Da India Nature Reserve	E			12-43
	L'Etang Fishing Reserve	E			12-44
	Saint-Leu Fishing Reserve	E			12-45

Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Réunion	Saline l'Hermintage (lagoon) Fishing Reserve	E			12-46
	Saline l'Hermintage (reef) Fishing Reserve	E			12-47
	St Pierre Fishing Reserve	E			12-48
Seychelles	African Banks Protected Area	E			12-49
	Aldabra Special Nature Reserve	E			12-50
	Anse-Boudin-Pointe Zanguilles (marine mollusc)	E			12-51
	Aride Island Special Nature Reserve	E			12-52
	Baie Ternaie Marine National Park	E		Y	12-53
	Brulee-Pointe au Sel Reserve (marine mollusc)	E			12-54
	Cousin Island Special Nature Reserve	E			12-55
	Curieuse Marine National Park	E		Y	12-56
	Desnoeufs island SR Reserve	E			12-57
	Ile Cocos Protected Area	E			12-58
	La Passe-Grosse Roche Reserve (marine mollusc)	E			12-59
	Northeast Point Reserve (marine mollusc)	E			12-60
	Port Launay Marine National Park	E		Y	12-61
	Silhouette Marine National Park	E			12-62
	St. Anne Marine National Park	E		Y	12-63
Somalia	Bajuni Archipelago	P		Y	12-64
Tanzania	Mafia Island	P		Y	
	Bongoyo & Pangavini Islands Marine Reserve	E			12-72
	Chole Bay Marine Reserve (Mafia Island)	E	Y	Y	12-73
	Fungu Yasini Marine Reserve	E			12-74
	Kilwa Kisiwani	P		Y	12-66
	Latham Island	P		Y	12-67
	Lindi	P		Y	12-68
	Maziwi Island Marine Reserve	E			12-75
	Mbegani	P		Y	12-69
	Mbudya Marine Reserve	E			12-76
	Mtwara/Ruvuma	P		Y	12-70
	Pemba (inc. Misali, Mtangani, Matumbe, N. Pemba)	P		Y	12-79
	Ras Buyuni	P		Y	12-71
	Tanga Coral Gardens Marine Reserve	E	Y	Y	12-77
	Tutia Marine Reserve (Mafia Island)	E	Y	Y	12-78
	Ujunga (Mnemba, Islets off Zanzibar Town)	P		Y	12-80
Brunei Darussalam	Pulau Berembang WS Wildlife Sanctuary	E			13-1
	Pulau Chermin Reserve Reserve	E			13-2
	Pulau Siarau Nature Reserve Forest Reserve	E			13-3
	Selirong (Productive Production) Forest Reserve	E			13-4
Indonesia	Arakan Wowontulap Marine Nature Reserve	E			13-5
	Bali Barat (Bali) National Park	E			13-6

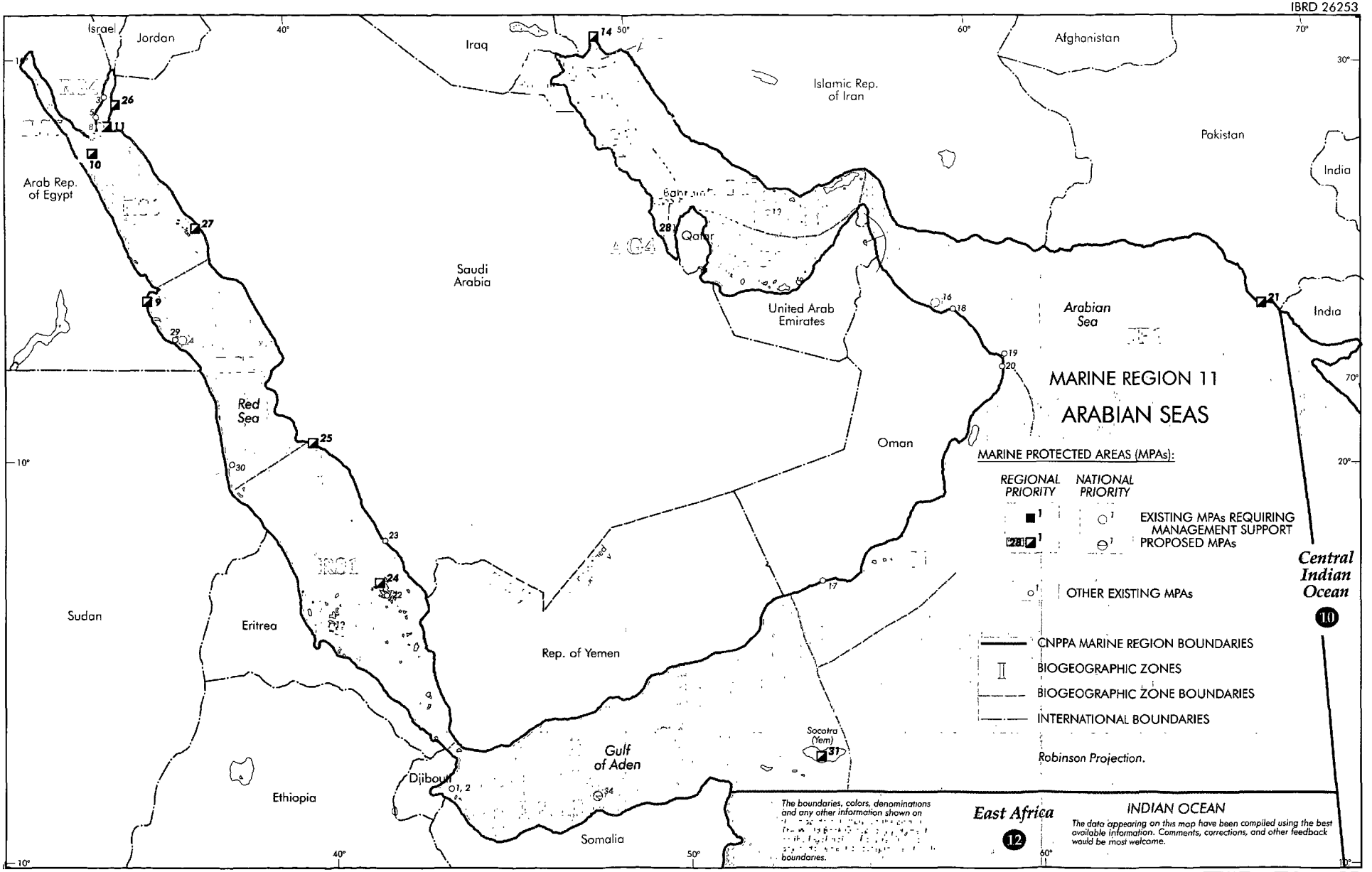
Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Indonesia	Baluran National Park	E			13-7
	Bukit Barisan Selatan National Park	E			13-8
	Karimata Nature Reserve	E			13-9
	Kepuluan Aru Baggian Tenggara Marine Park	E			13-10
	Laut Banda Marine Park	E	Y	Y	13-11
	Leuwang Sancang Nature Reserve	E			13-12
	Marine Bunaken Menado Tua National Park	E			13-13
	Marine Kepulauan Karimun Jawa National Park	E	Y	Y	13-14
	Marine Kepulauan Seribu National Park	E			13-15
	Marine Kepuluan Take Bone Rate Marine Nature Reserve	E		Y	13-16
	Marine Teluk Cendrawasih National Park	E	Y	Y	13-17
	Pangandaran National Park	E			13-18
	Perairan Kangean Game Reserve	E			13-19
	Pulau Dua Nature Reserve	E			13-20
	Pulau Moyo Hunting Park	E			13-21
	Pulau Pombo Marine Park	E			13-22
	Pulau Rambut Nature Reserve	E			13-23
	Pulau Sangiang Game Reserve	E			13-24
	Pulau Semama Game Reserve	E			13-25
	Pulau Weh Marine Park	E			13-26
	Sangalaki Marine Park	E			13-27
	Teluk Bintuni Nature Reserve	E			13-28
	Teluk Maumere Marine Park	E			13-29
	Tujuh Belas Pulau Nature Reserve	E			13-30
	Ujung Kulon National Park	E			13-31
Indonesia—Central Kalimantan	Tanjong Keluang Marine Recreation Park	E			13-33
Indonesia—Malaku	Pulau Kasa Marine Recreation Park	E			13-34
Indonesia—Sumatra	Kepuluan Krakatau Strict Marine Nature Reserve	E			13-35
Malaysia	Kuala Selangor Wildlife Reserve	E			13-36
	Matang Forest Reserve	E		Y	13-37
	Pulau Besar	E			13-38
	Pulau Kapas	E			13-39
	Pulau Lang Tengah	E			13-40
	Pulau Langkawi Marine Park	E			13-41
	Pulau Payar, Kacha, Lembu, Segatang Marine Park	E			13-42
	Pulau Perhentian Besar Marine Park	E	Y	Y	13-43
	Pulau Redang Marine Park	E	Y	Y	13-44
	Pulau Sembilang	E			13-45
	Pulau Sibu	E			13-46
	Pulau Tenggol	E			13-47
	Pulau Tiga Park	E			13-48
	Pulau Tinggi proposed Marine Park	E			13-49
	Pulau Tioman Wildlife Reserve	E			13-50

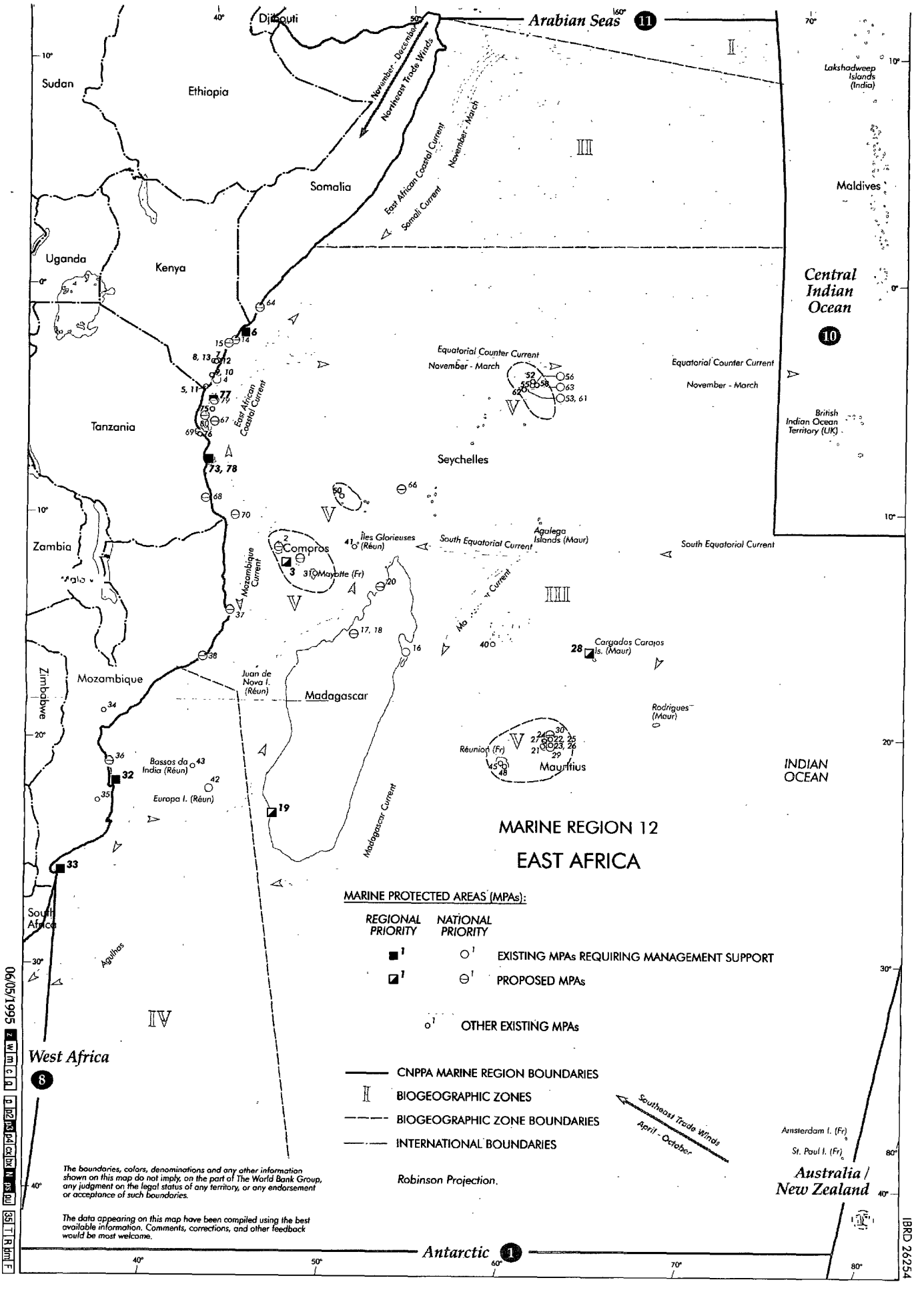
Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Malaysia—Sabah	Kota Belud Bird Sanctuary	E			13-51
	Kulamba Wildlife Reserve	E			13-52
	Pulau Mantanani Bird Sanctuary	E			13-53
	Pulau Penyu (Turtle Islands) Park	E			13-54
	Pulau Sipadan Bird Sanctuary	E			13-55
	Pulau Sipadan Marine Reserve	P		Y	13-57
	Semporna Islands	P	Y	Y	13-58
	Tunku Abdul Rahman Park	E		Y	13-56
Philippines	Apo Island Marine Reserve/Tourist Zone	E			13-59
	Camiguin Island TZ/MR Marine Reserve/Tourist Zone	E			13-60
	Carbin Reef (Sagay) Municipal Park	E			13-61
	El Nido Marine Reserve Marine Sanctuary	E		Y	13-62
	Fortune Island Marine Reserve/Tourist Zone	E			13-63
	Fuga Island Marine Reserve/Tourist Zone	E			13-64
	Guindolman Other area	E			13-65
	Guiuan Marine Sanctuary	E			13-66
	Malampaya Sound MS/TZ Other area	E			13-67
	Nasugbu Marine Sanctuary	E			13-68
	Panglao Island-Balicasag Area Marine Reserve/Tourist Zone	E			13-69
	Panguil Bay Marine Sanctuary	E			13-70
	Pollilo Island Marine Sanctuary	E			13-71
	Puerto Galera Marine Biological Station	E			13-72
	Santa Cruz Island (Big & Small) NP/MR/TZ Marine Reserve/ Tourist Zone	E			13-73
	Sombrero Island Marine Reserve/Tourist Zone	E			13-74
	Sumilon Island Marine Park	E			13-75
	Taklong Island National Marine Reserve National Marine Reserve	E		Y	13-76
	Tubbataha Reefs National Marine Park	E	Y	Y	13-77
Singapore	Southern Islands	P		Y	13-79
	Sungei Buloh Bird Sanctuary	E		Y	13-78
Thailand	Ao Phangnga National Park	E			13-80
	Hat Chao Mai National Park	E		Y	13-81
	Hat Nai Yang National Park	E			13-82
	Hat Nopharat Thara—Mu Ko Phi Phi National Park	E			13-83
	Khao Laem Ya—Mu Ko Samet National Park	E			13-84
	Khao Lam Pi—Hat Thai Muang National Park	E			13-85
	Khao Sam Roi Yot National Park	E			13-86
	Laem Son National Park	E			13-87
	Mu Ko Ang Thong National Park	E			13-88
	Mu Ko Chang National Park	E		Y	13-89
	Mu Ko Lanta National Park	E			13-90
	Mu Ko Phetra National Park	E			13-91
	Mu Ko Similan National Park	E	Y	Y	13-92

Country or Region	Name	Existing or proposed	Regional priority	National priority	Map reference
Thailand	Mu Ko Surin National Park	E	Y	Y	13-93
	Tarutao National Park	E			13-94
Viet Nam	Cat Ba National Park	E		Y	13-96
	Con Dao National Park	E	Y	Y	13-97
	Nam Du Islands	P		Y	13-98


Pakistan
India
Bangladesh
China
Myanmar
Thailand
Arabian Seas
11
INDIAN OCEAN
East Africa
12
East Asian Seas
13
Australia/New Zealand
18
Lakshadweep Islands (India)
Maldives
British Indian Ocean Territory (UK)
Sri Lanka
Andaman and Nicobar Islands (India)
Indonesia
I
II
III
IIII
IV
V
VI
VII
MARINE REGION 10
CENTRAL INDIAN OCEAN
MARINE PROTECTED AREAS (MPAs):
REGIONAL PRIORITY
NATIONAL PRIORITY
EXISTING MPAs REQUIRING MANAGEMENT SUPPORT
PROPOSED MPAs
OTHER EXISTING MPAs
CNPPA MARINE REGION BOUNDARIES
BIOGEOGRAPHIC ZONES
BIOGEOGRAPHIC ZONE BOUNDARIES
INTERNATIONAL BOUNDARIES
Robinson Projection.
The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
The data appearing on this map have been compiled using the best available information. Comments, corrections, and other feedback would be most welcome.
IBRD 26252
06/05/1995

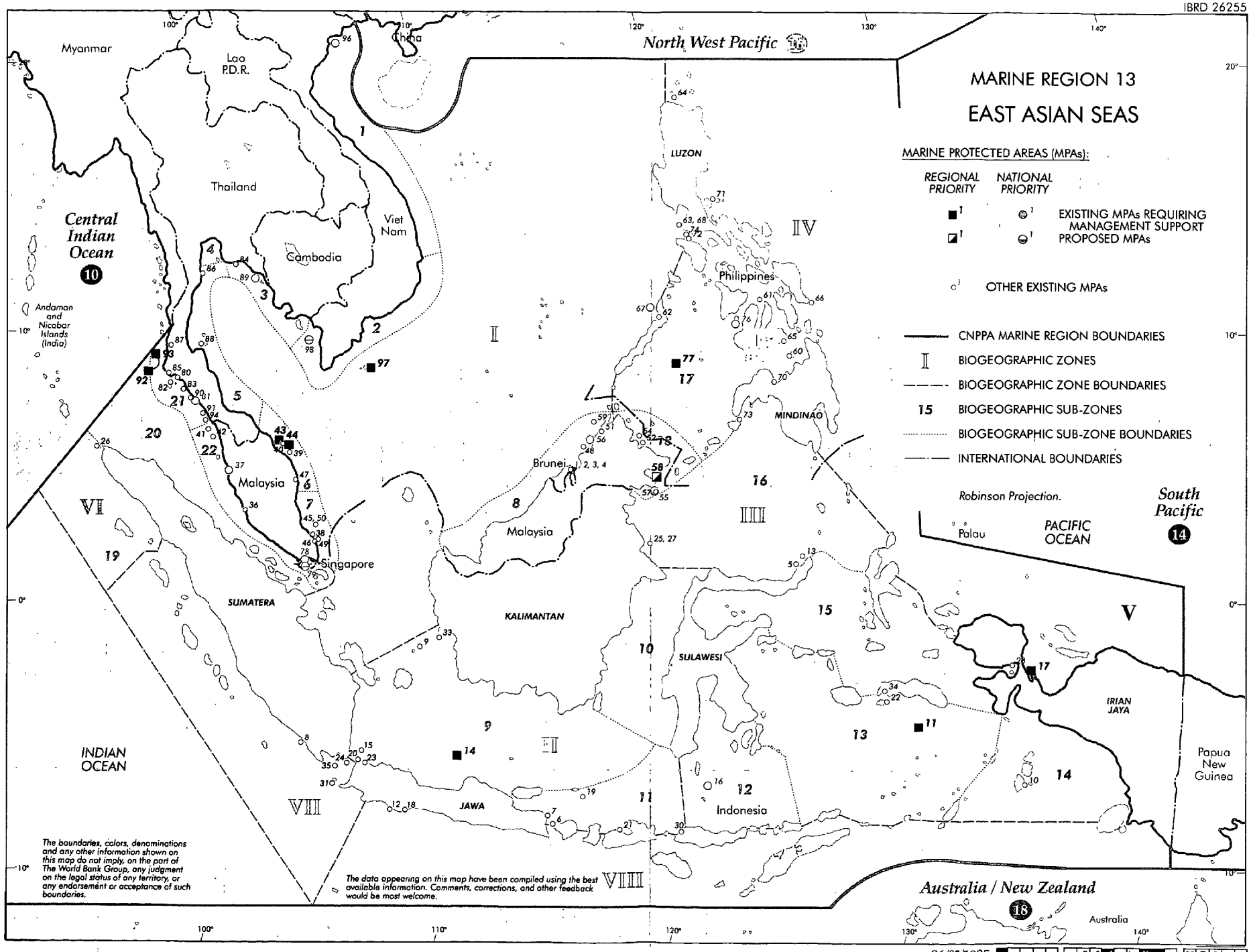
Map 10


Israel
Jordan
Iraq
Islamic Rep. of Iran
Afghanistan
Pakistan
India
Arab Rep. of Egypt
Saudi Arabia
Qatar
Bahrain
United Arab Emirates
Oman
Red Sea
Arabian Sea
India
Sudan
Eritrea
Rep. of Yemen
Ethiopia
Djibouti
Somalia
Gulf of Aden
Socotra (Yem)
Central Indian Ocean
10
MARINE REGION 11
ARABIAN SEAS
MARINE PROTECTED AREAS (MPAs):
REGIONAL PRIORITY
NATIONAL PRIORITY
EXISTING MPAs REQUIRING MANAGEMENT SUPPORT
PROPOSED MPAs
OTHER EXISTING MPAs
CNPPA MARINE REGION BOUNDARIES
BIOGEOGRAPHIC ZONES
BIOGEOGRAPHIC ZONE BOUNDARIES
INTERNATIONAL BOUNDARIES
Robinson Projection.
The boundaries, colors, denominations and any other information shown on boundaries.
East Africa
12
INDIAN OCEAN
The data appearing on this map have been compiled using the best available information. Comments, corrections, and other feedback would be most welcome.
06/05/1995


Arabian Seas 11
Djibouti
Sudan
Ethiopia
Somalia
Uganda
Kenya
Tanzania
Zambia
Zimbabwe
Mozambique
South Africa
Madagascar
Seychelles
Comoros
Mayotte (Fr)
Îles Glorieuses (Réun)
Juan de Nova I. (Réun)
Bassas da India (Réun)
Europa I. (Réun)
Agalega Islands (Maur)
Cargados Carajos Is. (Maur)
Rodrigues (Maur)
Réunion (Fr)
Mauritius
Lakshadweep Islands (India)
Maldives
British Indian Ocean Territory (UK)
Central Indian Ocean 10
INDIAN OCEAN
West Africa 8
Australia / New Zealand
Antarctic 1
Amsterdam I. (Fr)
St. Paul I. (Fr)
Northeast Trade Winds
November - December
November - March
East African Coastal Current
Somali Current
Equatorial Counter Current
November - March
South Equatorial Current
Mozambique Current
Agulhas
Madagascar Current
Southeast Trade Winds
April - October
MARINE REGION 12
EAST AFRICA
MARINE PROTECTED AREAS (MPAs):
REGIONAL PRIORITY
NATIONAL PRIORITY
EXISTING MPAs REQUIRING MANAGEMENT SUPPORT
PROPOSED MPAs
OTHER EXISTING MPAs
CNPPA MARINE REGION BOUNDARIES
BIOGEOGRAPHIC ZONES
BIOGEOGRAPHIC ZONE BOUNDARIES
INTERNATIONAL BOUNDARIES
Robinson Projection.
The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
The data appearing on this map have been compiled using the best available information. Comments, corrections, and other feedback would be most welcome.
IBRD 26254
06/05/1995

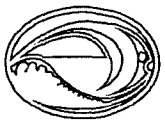
Map 12

IBRD 26255



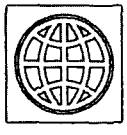
06/05/1995 z w m c g p p2 p3 p4 cx bx N ps pu 35 T R dm F

Map 13



GREAT BARRIER REEF MARINE PARK AUTHORITY

GPO Box 791, Canberra, ACT 2601, Australia
Telephone: (06) 247-0211, A/H (61) (6) 250-5597
International: (61) (6) 247-0211,AH (61) (6) 251-5597 GMT + 10hrs.
Facsimile: (06) 247-5761, International (61) (6) 247-5761



THE WORLD BANK

Land, Water & Natural Habitats Division
Environment Department
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.
Telephone: (202) 458-2715
Fax: (202) 477-0568

IUCN The WORLD CONSERVATION UNION

Rue Mauverney 28
CH–1195 Gland, Switzerland
Telephone: 41-22-999-0273
Fax: 41-22-999-0025
Telex: 419624 inch ch

Toward Environmentally Sustainable Development

Cover photographs by Mr. Jan C. Post
except "Walruses" by Dr. G. Carleton Ray