The Coral Reefs of the Indian Ocean: An Overview

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Abstract

This paper provides a brief overview of the coral reefs of the Indian Ocean as presented to the Census of Marine Life (CoML) Indian Ocean regional workshop in Goa, India. The theme of the workshop was to document, in relation to marine biodiversity, *" ... the known, the unknown and the unknowable"*. The distribution, species richness, endemism and threats to coral reefs of the Indian Ocean are briefly outlined from a global perspective. A description of coral reefs in Western Australia, current programs to conserve these ecosystems and local institutional marine research capacity are also summarized. Recommendations for future CoML research programs are presented. Detailed summaries of the current state of knowledge of the marine biodiversity of Western Australia, human capacity, institutional capacity and marine biodiversity resources, relevant to the CoML, are included in the appendices.

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Introduction

This paper provides a brief overview of the coral reefs of the Indian Ocean and was presented as a contribution to a Census of Marine Life (CoML) regional workshop in Goa, India on 12-15 December 2003. Invitations were extended to all of the counties bordering the Indian Ocean and most countries sent representatives to participate in the workshop. The CoML is a ten-year international initiative to promote and fund research assessing and explaining the diversity, distribution and abundance of marine life throughout the world's oceans. The P. Sloan Foundation (New York) is the major financial supporter of the CoML.

A series of regional workshops were convened around the world during 2002 and 2003 to 'benchmark' the current state of knowledge of the marine biodiversity of the world's oceans. The universal theme of the workshops was to document, in relation to marine biodiversity, *" ... the known, the unknown and the unknowable"*. In addition, workshop participants were requested to provide a detailed summary of the human capacity, institutional capacity and biodiversity resources from their respective countries. This information would then be summarized in workshop proceedings, published and made available to participant countries in each Region. The collective information would then provide a basis for the development of regional research plans, targeted at major 'gaps' in our understanding, and to promote regional collaboration and co-operation in relation to the conservation of marine biodiversity in the world's oceans.

As mentioned above this paper provides a brief overview of the coral reefs and associated ecosystems of the Indian Ocean. The distribution, species richness, endemism and threats to the coral reefs of the Indian Ocean region are outlined from a global perspective. The information presented, unless otherwise stated, is drawn from Veron, 2000; Spalding *et al*, 2001; Roberts *et al*, 2002 and Bryant *et al*, 1998. A description of coral reefs in Western Australia, current programs to conserve these ecosystems and local institutional marine research capacity are also summarized. Recommendations for future CoML research programs are presented. Detailed summaries of the current state of knowledge of the marine biodiversity of Western Australia (Appendix I), human capacity (Appendix II), institutional capacity (Appendix III) and marine biodiversity resources, relevant to the CoML, (Appendix IV) are appended.

Global Perspectives

Distribution, species richness and endemism

Worldwide the majority of coral reefs are found in shallow (< 50 m depth) tropical waters between the Tropic of Cancer and the Tropic of Capricorn. Poleward ocean currents off the east and west coasts of Australia and the east coasts of Japan and Africa significantly extend the distribution of coral reefs beyond these broad boundaries. Tropical waters cover over 75% of the Indian Ocean and, as a result, well-developed coral reefs are widespread in this region. Coral reefs occur as fringing or barrier reefs along the length of the Indian Ocean rim countries and as oceanic atolls, particularly in the central and western Indian Ocean. The coral reefs of the Indian Ocean are part of the Indo-West Pacific biogeographic region that is the global center of shallow water tropical marine biodiversity (Roberts *et al*, 2002). The species richness of the marine flora and fauna of this region, relative to the Eastern Pacific, Western Atlantic and the Eastern Atlantic, is shown in Table 1. Species endemism follows the same broad pattern as species richness and is highest in the Indonesian Archipelago and declines rapidly with distance from this region.

Table 1: Regional diversity of species diversity in coral reefs and related ecosystems (modified from Spalding *et al*, 2001).

Taxonomic Group	Indo-West Pacific	Eastern Pacific	Western Atlantic	Eastern Atlantic
Scleractinian corals	719	34	62	
Alcyonarian corals	690+	0	6	
Bivalves	2000	564	378	427
Echinoderms	1200	208	148	
Fish	4000	650	1400	450
Seagrasses	34	7	9	2
Mangroves	59	13	11	7

Threats
Coral reefs are highly productive ecosystems and, as such, are a major source of food and other resources for hundreds of millions of people. Their proximity to areas of high human populations make these ecosystems vulnerable to direct anthropogenic activities such as over-fishing, mining and coastal development as well as to indirect impacts resulting from poor land management practices such as deforestation. Other major impacts on coral reefs include coral bleaching as a result of the warming of the world's oceans and destructive fishing methods. The incidence of coral disease, possibly as a result of chemical pollution, is also increasing.

Global risk assessments of coral reefs (Bryant *et al*, 1998) have indicated that many of the reefs of the Indo-West Pacific are at high risk of degradation from human activities, particularly those reefs that are adjacent to areas of high population such as Indonesia, Philippines, India and some parts of the Red Sea and eastern Africa. Areas of low population such as Australia and the oceanic atolls of the Maldives are at significantly lower risk. Table 2 summarises the relative risk of Indian Ocean coral reefs to reefs in other parts of the world.

Table 2: Risks to Indian Ocean coral reefs relative to other parts of the world (from Spalding *et al*, 2001)

Region	Percentage of coral reef areas at different levels of risk (%)		
	Low	Medium	High
Middle east	39	46	15
Caribbean	39	32	29
Atlantic (excl. Caribbean)	13	32	55
INDIAN OCEAN	**46**	**29**	**25**
Southeast Asia	18	26	56
Pacific	59	31	10

In the recent report on the status of coral reefs of the world Wilkinson (2002) outlined a 'health' prognosis for coral reefs worldwide. A modified version of a table in this report is presented below (Table 3) for selected Indian Ocean countries.

Table 3: Prognosis for coral reefs for selected countries in the Indian Ocean region (modified from Wilkinson, 2002)

Country	Coral reef area (km^2)	World total (%)	Prognosis
Indonesia	51020	18	Mostly poor, somefair/good
Australia	48960	17	Good, bleaching only threat
Maldives	8920	3	Good, bleaching big threat
Saudi Arabia	6660	2.5	Good, bleaching threat
India	5790	2.2	Some good, many very poor
Egypt	3800	1.3	Good/fair, bleaching threat
Malaysia	3600	1.3	Fair to poor and threatened
Tanzania	3580	1.3	Fair to poor and threatened
Eritrea	3260	1.2	Good, bleaching threat

Western Australian coral reefs

Coral reefs and associated shallow water ecosystems occur along much of the north-western and western coastlines of Western Australian (between 10-29 degrees south) and can be separated into two main groups: reefal and non-reefal (Veron and Marsh, 1988). Reefs in the macrotidal Kimberley region (up to 10 m tidal range) are largely confined to offshore atolls and reef platforms because of the high turbidity of inshore waters. Further south, along the Pilbara coast, extensive reefs are associated with the numerous island groups found in this area. The Ningaloo Reef, extending for about 300 km south of Northwest Cape, is Australia's largest fringing coral reef. Coral reefs also occur around the offshore islands of the Shark Bay World Heritage Area. High latitude (28-29 degrees S) coral reefs, with over 200 hermatypic coral species, occur at the Abrolhos Islands. Non-reefal coral communities occur south of the Abrolhos Islands and are often associated with islands or temperate reef outcrops.

The southward extension of coral reefs into temperate regions off Western Australia occurs as a result of the Leeuwin Current, a poleward current of tropical water that flows along the coastline. This current is generated partly from water flowing southward through the Indonesian Archipelago from the western Pacific Ocean and partly from water flowing eastward from the northern Indian Ocean. These hydraulic connections are reflected in the biogeographic affinities that the tropical marine flora and fauna of Western Australia has with both the western Pacific Ocean and northern Indian Ocean.

The coral reefs of Western Australia are, on a global scale, relatively undisturbed largely because of their remoteness and the low population (<2 million) of the State. To conserve the biodiversity and manage human usage of these areas, the Government of Western Australia is establishing a comprehensive, adequate and representative (CAR) statewide system of marine protected areas (MPAs), as part of the National Representative System of Marine Protected Areas. A regional network of coral reef MPAs is being developed in the northern and central part of the State as part of the statewide CAR system of MPAs.

Knowledge, human and institutional capacity and resources

The state of knowledge of the marine biodiversity of Western Australia is outlined in detail in Appendix I. Like many countries throughout the Indian Ocean, the diversity and biogeographic distributions of the more visible tropical taxa, such as hermatypic corals, macroalgae, mangroves, seagrasses, sponges, molluscs, fish and echinoderms, are reasonably well described. However, the distributions and abundances and natural variability, on a local scale, are poorly known and life history information is largely confined to the species of major commercial interest. Other taxa are poorly described. The traditional knowledge of the marine environment by indigenous groups is high but is poorly documented.

The marine scientific expertise of the State relevant to the CoML is largely found in State and Commonwealth Government departments in Western Australia, local Universities and private consultants. A detailed summary is provided in Appendix II.

Institutional capacity and marine biodiversity resources, relevant to the CoML, are outlined in detail in Appendix III and Appendix IV respectively.

Recommendations for the CoML Research Program

The CoML research program should:

- Acknowledge and be integrated with existing global marine research initiatives;
- Focus on gaining knowledge to support conservation and sustainable management programs such the development of MPAs, sustainable fisheries and bioregional planning initiatives;
- Focus on knowledge ‘gaps’;
- Undertake comprehensive marine biodiversity inventories in ‘undisturbed’ locations that are representative of the Indian Ocean region;
- Establish an Indian Ocean regional network of long-term reference sites (in the same areas as the above) to provide the essential baseline information on natural variability; and
- Document the indigenous marine knowledge of the Indian Ocean region.

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