

7. STATUS OF THE CORAL REEFS OF THE SOUTH-WEST INDIAN OCEAN ISLAND STATES: COMOROS, MADAGASCAR, MAURITIUS, REUNION, SEYCHELLES

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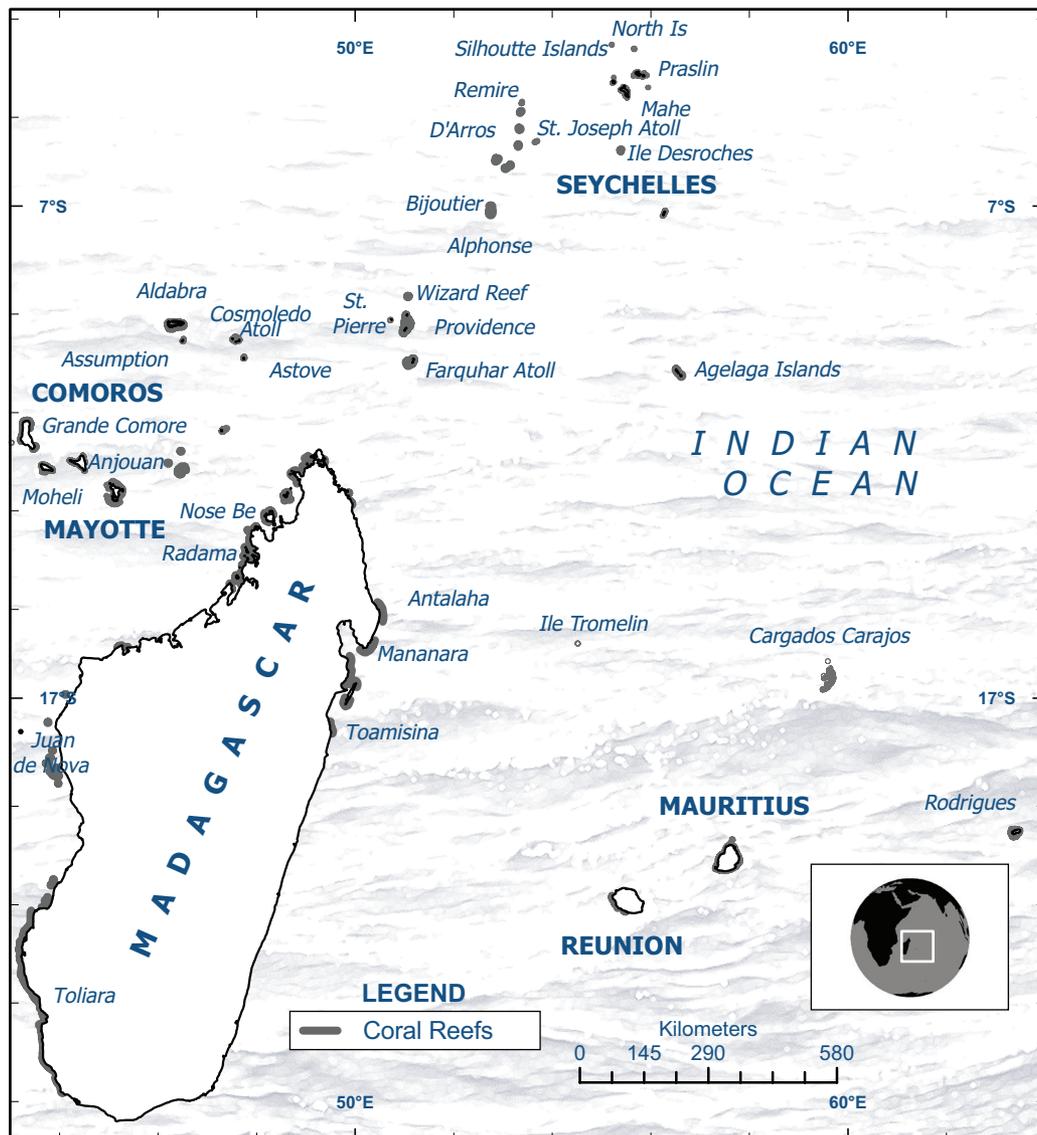
ABSTRACT

- Many reefs are recovering well from 1998 mass coral bleaching damage with all countries having some areas with good coral cover, and other areas with slow or little coral recovery;
- Mean live coral cover has continued to increase on some reefs of the Seychelles and Comoros, but has decreased on some reefs in Mauritius and La Réunion;
- The stresses causing low coral cover are mostly from human activities, such as trampling, pollution, chronic sedimentation and over-fishing;
- Cyclones and coral bleaching are the most important natural stresses damaging the reefs, with some bleaching recorded annually since 2000 in parts of the region;
- There is little information on the status of seagrass and mangrove areas in many countries, due to poor or no monitoring programs;
- Most countries have no active socio-economic monitoring, and ecological and socio-economic monitoring results are not reported regularly to reef managers;
- Recommendations include increasing efforts to reduce human impacts and increase monitoring within and outside MPAs, and especially on more remote reefs;
- Cooperation between the regional network and global or regional programs is needed to increase awareness in coastal communities of coral reef issues, and to make monitoring of coral reefs financially sustainable with regular mechanisms to feed ecological and socio-economic monitoring results into management processes.

INTRODUCTION

The SWIO node of the Global Coral Reef Monitoring Network consists of countries of the Indian Ocean Commission (COI) which includes the Comoros, Madagascar, Mauritius, La Réunion (France) and the Seychelles. Most of these countries have significant areas of coral reefs, which play an important role in the socio-economic well-being of their coastal communities. Monitoring throughout the node uses GCRMN methodologies, but with some modifications made in the Seychelles.

The **Comoros** has 430 km² of reef area, with those on the Comoros volcanic islands being young and fringing the newer islands. The AIDE (Association d'Intervention pour le Développement et l'Environnement) NGO, with support from the Indian Ocean Commission, has conducted coral



reef monitoring using protocols recommended by the GCRMN since 1998 on 3 islands: Grande Comore; Moheli; and Anjouan. Monitoring of barrier reefs of Mayotte, which is under French administration, is carried out by the Agriculture and Forestry Department. Socio-economic monitoring is currently conducted under CORDIO supervision and should be cross-analysed with the ecological data through GIS tools to assist in adaptive and integrated management of the reefs and associated resources.

Madagascar's spans 14° of latitude, harbouring over 3500 km of coral reefs in widely differing oceanographic settings. The most extensive reefs are found in the north-east, north-west, and south-west coasts, have the highest richness of coral species in the central and western Indian Ocean. Almost all accessible reefs are exploited by traditional artisanal fisheries with fishing effort increasing considerably over the past decade due to rapidly expanding commercial demand from fisheries enterprises. The growth of fishing effort has coincided with diversification of the range of species targeted by fishers and collectors. In addition to the negative impacts of unsustainable and largely unmonitored biomass removal, reef degradation is attributable to the chronic impacts of hyper-sedimentation from rivers discharge as well as organic enrichment and pollution of coastal waters. Cyclonic activity in Madagascar is high, with severe localised damage to coral reefs attributable to cyclones and tropical storms on an approximately annual basis.

Mauritius has a coastline of 200 km with 243 km² of lagoon area enclosed by 150 km of fringing reef that almost completely surrounds the island, except at major river mouths and on the south and west coast. Mauritius has rich coral diversity with a total of 159 hard corals in 43 genera. Recent coral bleaching in 2003–2004 affected some corals; however the reefs have since recovered and new recruits are increasing, especially on the reef slopes. The back reef is mostly dominated by branching and tabular *Acropora*, whereas encrusting corals dominate the fore-reef. Algae have been observed seasonally and a few soft corals and other colonial animals such as zoanthids are relatively common. The physico-chemical and bacteriological parameters are within the Coastal Water Quality Guidelines at all sites. The major threats to coral reefs are cyclones, coral diseases, crown-of-thorns starfish, coral bleaching and human damage from extensive coastal development, land-based pollution, sewage outfalls and anchor damage.

The Mauritian island of **Rodrigues** is surrounded by a fringing reef, which forms an almost continuous band approximately 90 km long. The reef encloses a shallow lagoon of 240 km² (twice the area of the island). The reefs are covered mainly by hard corals, with *Acropora* species dominant on both the reef flat and slope. Coral cover on the reef slopes around Rodrigues is relatively high and the reefs are healthy. Lower coral cover on the more heavily impacted reef flats is attributable to coral bleaching and fishing pressure (particularly trampling by octopus fishers).

La Réunion has 12 km² of fringing and platform reefs, restricted to the west and south of the island. Since the 1980s, these reefs have come under increasing pressure from both human and natural factors such as excessive trampling on the reef flat, over-fishing, excessive sedimentation from the land, cyclones and coral bleaching (which has been recorded annually from 2001 to 2005). There are 14 monitoring sites (7 on the reef flat, 7 on the reef slope) in 4 distinct sectors along the west and south coast at St. Gilles, St Leu, Etang Salé and St Pierre which include annual monitoring of bottom communities and reef fishes. The site at St Gilles

has been monitored since 1998. A Marine National Reserve was created along 40 km of the west coast in 2007 but is not fully operational due to delays in implementation caused by conflicts between traditional fishermen and the authorities, inadequate planning and poor integrated coastal zone management.

The **Seychelles** islands have an estimated 1690 km² of coral reef, which is about 13.1% of the total coral reef area of the Eastern Africa and the South West Indian Ocean islands. The inner islands, where most people live, have only 40 km² of coral reef, and fishing remains the most important economic reef activity. Reefs around the granitic islands are heavily fished and yield around 50% of the total annual demersal catch. In 2003, it was estimated that 19% of visitors to Seychelles participated in SCUBA diving and 65% in some form of snorkelling activity. Prior to the mass coral bleaching event of 1998, the coral reefs of the Seychelles were described as healthy with high coral cover, typically 60–90%. Coral cover after the bleaching event was reduced to less than 5% at most locations around the granitic islands. Between 2000 and 2004 mean live coral cover increased from 3.7% to 10.2% and is still increasing. Primary threats to coral reefs include dredging and reclamation, sedimentation, excessive fishing pressure, coral diseases, invasive species and climate change associated with global warming.

STATUS OF CORAL REEFS

There are two contrasting trends in the status of the reefs of the South West Indian Ocean. Reefs to the north (Comoros and Seychelles) that were seriously damaged in 1998 are showing slow but steady recovery, whereas reefs in the south that missed most of the bleaching losses are either stable (La Réunion) or declining (Mauritius and Rodrigues).

In the **Comoros** mean live coral cover at the monitoring sites was 77.5% in 1997, a year before the mass coral bleaching event. By 2002 mean live coral cover had dropped to 39%, but since then there has been a significant positive trend ($R^2=0.96$) and in 2007 cover was 66%; similar to the pre-bleaching level. Live coral cover has returned to pre-bleaching levels at many sites in the 10 years since the 1998 mass coral bleaching, and over 70% live coral cover is now present on the reef along Wani on Anjouan, Mitsamiouli at Grande Comore and Walla at Moheli. Some sites such as Bimbini at Anjouan and Chindini at Grande Comore are showing poor recovery and have low coral cover (about 24%). These reef sites are under high pressure from over-fishing, sedimentation and trampling. In the Moheli Marine Park the coral reefs are in good health with mean coral cover ranging between 50% and 72%. On unprotected reefs at the same island, such as Fomboni and Hoani, mean live coral cover is <30%. Minor coral bleaching (1–10%) was recorded in 2004 and 2005; however, the corals and reefs rapidly recovered, especially at sites with low human pressures.

There are few quantitative data for **Madagascar** to document coral reef responses to the bleaching events of 1998, 2001 and 2002 that devastated the reefs. With the exception of moderate bleaching on the north-eastern reefs in 2005, no subsequent widespread bleaching-related coral mortality events have been recorded in Madagascar over the past 6 years. Coral reef monitoring in the south-west started in 2003, and additional sporadic surveys have been carried out at sites in the north since 2004, where the reefs are generally considered to be in better condition. While annual reef assessments in the south-west provide an insight into reef condition and recovery responses, the absence of long-term quantitative reef assessments throughout the country means that the health and status of Madagascar's vast coral reef

systems cannot be determined. Madagascar's marine and coastal protected area network is currently being expanded, thus it is critical that reef monitoring efforts be enhanced to provide better information on ecosystem status, recovery and resilience to protected area managers and decision makers.

Monitoring in the south-west near Andavadoaka encompasses fringing, barrier and patch reef sites experiencing a range of fishing pressures. Most seaward fringing and barrier reefs in this region have undergone a phase shift from coral to algal-dominated communities. Typical seaward reefs in the region have <20% coral cover, with high or dominant levels (35–80%) of turf and macro-algae, particularly *Lobophora*, *Dictyota* and *Turbinaria* species. The dominant corals are faviids, poritiids, agaricids and mussids at all depths and on all reef types on an eroded coral framework, whereas branching *Acropora* species were previously dominant. The exposed seaward slopes have been planed smooth by wave action and hardened by encrusting turf and calcareous algae. Conversely, many sheltered fringing reefs and lagoonal patches consist of loose unconsolidated coral rubble. This rubble and the high cover of seaweeds are probably limiting reef recovery by inhibiting the recruitment of hard coral larvae.

Since 2004 coral cover at heavily-fished near-shore sites has remained stable at 5–10% showing no recovery trends, similarly seaweed and algal turf cover remains high, at 60–80%, showing no evidence of decline. Although these heavily-degraded reefs have not recovered, a number of less-exploited sites have shown substantial improvement in coral cover. Of note are several deep lagoonal patch reefs where coral cover has increased from about 30% to 70% between 2004 and 2008, accompanied by a reduction in algal cover from ~50% to ~20%. Clear differences in recovery between heavily-exploited and less exploited reef sites suggest that the reefs have significant resilience and recovery potential but this may be inhibited by high fishing pressure. This points to the tremendous potential for management strategies that prioritise the reduction of algal dominance on the reefs. Reducing the rate of removal of algal grazing fishes and decreasing terrestrial nutrient runoff could improve reef resilience against future disturbance events by enhancing coral recruitment and growth.

In **Mauritius**, there were no signs of coral bleaching between 2005 and 2007 at permanent back reef and fore-reef monitoring sites. In 2007 mean live coral cover was >50% at 5 of the 17 sites, 38% at 3, <38% at 7, and <2% at 2 sites. Algal cover was <20% at 13 of the 17 sites and was >30% at 3 sites. There has been a gradual decline in live coral cover at the 4 fore-reef sites, which is attributed to natural and human factors. Bleaching in 2003–2004 also contributed to reef degradation. Not all of fore-reef sites were monitored in 2001 and 2006 which explains the lower coral cover levels in the graph presented above. There has been an increase in abundance of invertebrates (sea-urchins) at sites where bare rock cover was highest. Holothurians (sea cucumbers) were commonly recorded at back reef stations while their distribution was sparse on the fore-reef. Territorial fish species (damselfish, surgeonfish and butterflyfish) were the dominant species recorded. The results of the water quality surveys at the sites have not shown any negative impacts and are within the standard norms. A detailed study on the effect of coral bleaching on the reef of Mauritius was carried out in 2006 with funding from CORDIO.

In the amended Fisheries and Marine Resources Act 2007 regulations prohibit the removal of coral and sea shells. A long-term monitoring programme is on-going in the Blue Bay and Balaclava marine parks and data are routinely collected on benthic cover, reef fishes, macro-

benthos and water quality. Activities in the parks are regulated by the MPA Regulations. The Blue Bay Marine Park was declared a Ramsar Site (a wetland of international importance) in 2008.

In the Mauritian island of **Rodrigues**, 9 fringing reef sites have been monitored since 2002: Riviere Banane, Passe Armand, Grand Bassin and Ile aux Fous (reef flat and reef slope sites); Passe Cabri, Trou Blanc and Passe L'Ancre (reef flat only); and Passe Demi and North Ile aux Sables (reef slope only). Mean live coral cover is high on reef slopes at Riviere Banane, Grand Basin and Ile aux Fous (>45%), but is low at Passe Demie, North Ile aux Sables and Passe Armand (<30%). Dead coral cover is low at all sites suggesting that they are generally healthy. Increases in the red macro-algae, *Asparagopsis taxiformis*, was recorded at some sites during October 2004 but cover returned to low levels the following summer, suggesting natural phenomenon. Coral cover was low at all reef flats sites (<30%). A large increase in dead coral cover was seen in March 2002 at Passe Armand and Grand Bassin, and again in October 2005 at Passe Armand, Trou Blanc and Ile aux Fous: these increases were due to coral bleaching. The fish community at all sites tended to be dominated by damselfish. Emperors, snappers, trevally and groupers were rare or absent and no triggerfish (ballistids) were observed at any site. The lack of large fish predators suggests fishing pressure is high. Sites have shown no obvious variation over time and occasional differences are due to large shoals of surgeonfish and fusiliers. Macro-invertebrate densities were low on the reef slopes with the urchin, *Echinometra mathaei*, dominating all reef slope and flat sites except Passe L'Ancre. There were temporal variations in the abundance of *E. mathaei* on the reef slope at Passe Armand and North Ile aux Sable and a general increase in urchin numbers from October 2005 on the reef flat at Rivière Banane, Passe Armand, Grand Bassin and Trou Blanc. The abundance of these urchins may be due to intense fishing pressure and the removal of predators, especially triggerfish (ballistids).

The coral reefs of **La Réunion** are seriously threatened with around 50% of the reef area considered as degraded. The status of coral reefs has remained relatively stable since 2004, with no significant changes or observed trends. At Alizés Plage in the St Pierre sector and Planch'Alizés in the St Gilles sector the coral communities are characterised by disturbed areas with high dominance of opportunistic sub-massive corals such as *Montipora circumvallata*, *Porites (synarea) rus* and *Psammocora contigua*. These sites have medium mean coral cover (40–50%) and are less sensitive to perturbations such as algal colonisation, coral bleaching and cyclones and have remained stable since their monitoring started. However these coral communities are generally less favourable as habitat for reef fishes and only a few omnivorous fish were observed.

The less disturbed stations (Trois-Chameaux in the St Gilles sector, La Corne and La Varangue in the St Leu sector, Bassin Pirogue in the Etang-Salé sector and Ravine Blanche in the St Pierre sector) have highly varied benthic populations dominated by the branching and digitate *Acropora* sp. corals. These sites are very sensitive to coral bleaching and colonisation by turf algae. As a result, coral cover has varied since monitoring started, with periods of good coral growth alternating with major mortality events, which were simultaneous in all 4 sectors in 2003 and 2004. The cause of wide spread coral mortality on the reef flats at La Réunion varies and includes elevated sea surface temperature, freshwater input and cyclones.

The status of the benthos on the reef slopes has undergone two different trends. Firstly, a continuous decrease in mean live coral cover at 3 sites: coral cover dropped from 56.8% in 1998 to 29.8% in 2007 at Trois-Chameaux, from 48.8% in 2000 to 26.3% in 2007 at Planch'Alizés, and from 57.8% in 2000 to 37.3% in 2007 at Etang-Salé. This decline is probably due to pollution coming from the catchment area. Secondly, coral cover has been stable at the St Leu and St Pierre monitoring stations: coral cover on the reef slope at La Corne in the St Leu sector has been around 74% since 1999. The reef slopes in the St Pierre sector at Ravine Blanche and Alizés Plages have high coral diversity and do not appear to be adversely affected by sedimentation from the nearby river.

The fish populations on the reef slopes are characterised by low abundance of high trophic level species such as the piscivores. Herbivores are generally the most dominant trophic group observed. The population structure of damselfish differs between sites. In areas where *Acropora* have been heavily over-grown by algae, *Stegastes* sp. are common, whereas *Chromis* sp. and *Dascyllus* sp. are more dominant at stations with healthy coral growth.

In the **Seychelles** inner islands, corals at the north of Mahé Island and the Curieuse Marine National Park indicate rapid recovery to a new mean cover of 24.6% by the end of 2007. However, recent surveys across the entire inner island group suggests that recovery is highly patchy, with some reefs exhibiting >20% coral cover while others have less than 5%. Mean live hard coral cover across the entire inner islands was 3.7% in 2000, 10.2% in 2004 and 11% in 2007.

In January 2005, live coral cover on the fore-reef slope of the Amirantes islands of Marie-Louise, Boudeuse, Poivre and Alphonse ranged from 7 to 26% and was dominated by *Porites* and *Pocillopora*. At Alphonse between 1999 and 2003 there was good coral recovery following the bleaching, with average live coral cover increasing from 10% in 1999, to 12–17% in 2001–2002, and to 23% in 2003. At the southern-most islands of Aldabra, Astove and Assumption recovery was minimal in the period between 1999 and 2006 with the exception of St Pierre Island where heavy recruitment of *Pocillopora eydouxi* has increased coral cover by 18%.

Coral recruitment on the granite based reefs of the inner islands is much better than on the carbonate reefs, with a strong linear increase in the number of corals recruiting onto the granitic reefs ($R^2 = 0.984$) and a weaker trend on the carbonate reefs ($R^2 = 0.438$). Levels of coral recruitment are greater in shallow areas than in deeper zones.

The trends for the coral reef fish population are less clear between 2002 and 2006: butterflyfish (Chaetodontidae)s population appear to be stable; damselfish (Pomacanthidae) show a gradual linear increase ($R^2 = 0.68$); 3 main herbivore families show signs of decline. The same downward trend was also observed in the main target fish, the snappers and groupers (Holocentridae, Lethrinidae, Lutjanidae and Serranidae). There have been no significant differences in fish-species diversity between 2002 and 2005 on Aldabra, Assumption, Astove, and St Pierre. The reef fish densities at these locations were all high and similar to one another, indicating equally productive systems with low fishing pressures.