

The current state of health of the Bay of Ranobe Reef System, S.W. Madagascar

1.0. Introduction:

Coral reefs are important ecosystems and are often referred to as the 'rainforests of the sea' due to their high biodiversity. 25% of marine fish species are found on coral reefs; a high percentage, given that coral reefs occupy less than 1% of the World's Oceans. Despite their high biodiversity, these unique ecosystems are extremely fragile and can only maintain such a high biodiversity through their extremely efficient use of all available nutrients in the nutrient sparse tropical waters. The distribution of coral reefs is limited to the 20°C isotherm, usually 30° latitude North and South of the equator (see Figure 1.) The distribution is limited due to the corals specific requirements of high light intensity for photosynthesis, a temperature of no less than 18°C for extended periods and a salinity of 32-42 parts per thousand.

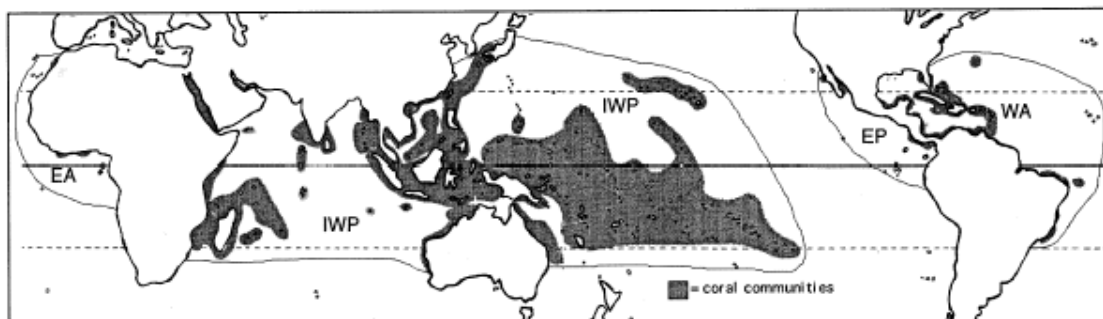


Figure 1. The distribution of coral reefs in the four tropical biogeographic regions: the Indo-West Pacific (IWP); Eastern Pacific (EP); Western Atlantic (WA); and the Eastern Atlantic (EA).

Coral reefs provide an important source of food and services for vast numbers of people, as well as having important cultural and aesthetic benefits (Moberg & Folke, 1999). They have been estimated to annually provide €30 billion in net benefits in goods and services to world economies, including tourism, fisheries and coastal protection (Cesar *et al.* 2003). However, despite their importance they are under serious

threat from both anthropogenic and environmental factors. As human populations and coastal pressures increase coral reefs are becoming more heavily exploited.

Many uses of coral reefs are unsustainable, and in this respect many of the assets of reefs are also the cause of their decline (Weber, 1993). Destructive activities include coral mining for lime production; collection of reef organisms for the curio trade; destructive fishing methods (such as cyanide or dynamite fishing); fishing with small sized seine nets; unregulated tourism activities and oil extraction (e.g. Hawkins and Roberts, 1994). In addition to these stresses, reefs are also affected by decisions made in their drainage basins. For example, intensified land use and urbanization increases run-off of sediment, nutrients and pollutants and often causes major problems for the coral reefs (Grigg and Dollar, 1990). Humans are therefore responsible for much of the change in the nature of disturbances in reef environments (Moberg & Folke, 1999).

ReefDoctor, a marine conservation NGO, is based in Ifaty, Toilara region of S.W. Madagascar, and currently monitors the health of the Bay of Ranobe reef system. The Bay of Ranobe reef system can be classed as an average productivity reef adjacent to two major river outflows. It supports the local Vezo population who are by tradition skilled sea-farers and totally dependant on the sea. As with many areas of Madagascar there is a rapidly growing population, high unemployment and low agricultural productivity due to the arid climate. Unfortunately the reef here is in a poor condition due to many factors, usually resulting from human activity. Destructive fishing is a major cause of coral reef degradation and is often associated with Malthusian over-fishing, a condition related to poverty and coastal crowding. In the context of immediate survival, small scale fishermen are not the lowest income group and more people are turning towards fishing activities (Laroche & Ramananarivo, 1995). Over-fishing is a major threat to coral reefs; it disrupts the balance of the ecosystem leading to catastrophic changes as seen with the extinction of many large vertebrates, such as manatees and sharks from most coastal ecosystems (Jackson *et al.* 2001). One of the most serious threats to The Bay of Ranobe reef system results from activities in its drainage basin. Deforestation leaves the land vulnerable to large scale soil erosion resulting in vast amounts of sediment being carried into the lagoon by the Fiherenana and Manombo rivers. High sediment levels are a serious threat to corals as they reduce the light intensity required for photosynthesis by the symbiotic zooxanthellae. Corals are sensitive to sedimentation, especially organic rich, silt sized sediments; these have direct physiological effects on the corals health.

Generally areas with increased nutrient inputs also have increased sediment and pollutant loads (Szmant, 2002). The use of fertilizers and pesticides for agricultural purposes inland results in a nutrient influx in the lagoon causing algae blooms that can ultimately out-compete the corals. This is also true for untreated sewage pumped into the sea from the city of Toliara and a lack of sewage facilities in the surrounding smaller coastal villages; this is becoming a greater problem and will continue to be so as the population increases. Anthropogenic nutrient enrichment has a greater affect on coral reefs closer to shore and within lagoons (Szmant, 2002), as found here in the Bay of Ranobe. A further problem for the coral reefs in the Bay of Ranobe is the uncontrolled exploitation of mangroves. Mangroves are important ecosystems, providing a nursery habitat for many species, (including those which are commercially important such as shrimps and lobster). Mangrove wood is extremely hard and insect resistant. The harvesting of mangroves for timber and fuel has been practised for thousands of years. Unfortunately vast areas of mangrove forest have been removed and destroyed with little or no replanting. Current rates of mangrove depletion are likely to have serious negative effects for the ecosystem function, fisheries production and reef resilience (Mumby *et al.* 2003). Human impacts on coral reefs can have serious consequences on adjacent ecosystems, such as mangroves, seagrass beds, the Open Ocean and vice-versa. Therefore it has to be realized that in order to maintain the resilience of these complex systems an ecosystem approach has to be adopted. The above mentioned negative impacts accumulate meaning that the coral reef has a reduced buffer capacity and will be less likely to be able to adapt and recover from future catastrophes.

Coral reefs are highly sensitive systems and extensively used in monitoring recent changes in the marine environment and the effects of human disturbances. This report provides an assessment of the current state of health of the Bay of Ranobe reef system, as shown from survey data collected in 2006.

[2.0. Methodology](#)

[2.1. Study Sites:](#)

ReefDoctor currently surveys a total of ten sites in the Bay of Ranobe. (See Figure 2). Three are located within the Lagoon with an average depth of three to five metres and a high fishing pressure. Three are located on 'Spur and Groove'; the reef crest area, with an average depth of twelve meters and a moderate fishing pressure. Three are located in the 'Deep' region; at the edge of the fringing reef with an average depth of eighteen meters and a low fishing pressure.

Reef Doctor also surveys the Rose Garden within the lagoon. This site is a designated Community MPA and is included in the results separately due to its high percentage of live coral cover and low fishing pressure.

Lagoon	Spur & Groove	Deep	MPA
Ankarandava	Canyons	The Wall	Rose Garden
Aquarium	SOSP	Dippy	
Fanemotse	NOSP	Humphead Hole	

Figure 2. Reef Doctors study sites in the three different regions.

[2.2. Methods:](#)

Data was collected by Transient Transects, a method known to provide rapid assessments of fish biodiversity and abundance, benthic biodiversity and abundance and enable assessments of overall reef ecology and health.

The surveys are conducted by a buddy team of two using SCUBA. The 10m transect line is placed at random and the fish are recorded to species level, (minimum family) in a belt 2.5m to either side of the transect line and up to 5m above (total volume 250m³). Benthic data is recorded as a point line intersect transect along the line at every 20cm, between 20cm to 1000cm. Thus providing 50 data points per transect. Substrate type, coral morphologies, overgrowth are all recorded where present. Invertebrates are recorded within a corridor of 50cm either side of the transect line producing a 10m² survey area. Any disease or damage to the corals is also noted.

3.0. Results:

Substrate type:

Table 1. The average percentage of substrate types at the different regions.

Substrate Type	Lagoon	Spur & Groove	Deep	Rose Garden
Bleached Coral	0.07	0.10	0.10	0.60
Dead Coral	8.67	1.55	2.19	15.60
Live Coral	2.60	16.43	19.33	37.60
Rubble	52.13	0.10	0.86	42.20
Rock	30.13	71.54	60.19	3.40
Soft Coral	0.07	6.55	10.76	0.00
Sand	3.64	2.26	5.62	0.00
Silt	3.40	1.26	0.86	0.60

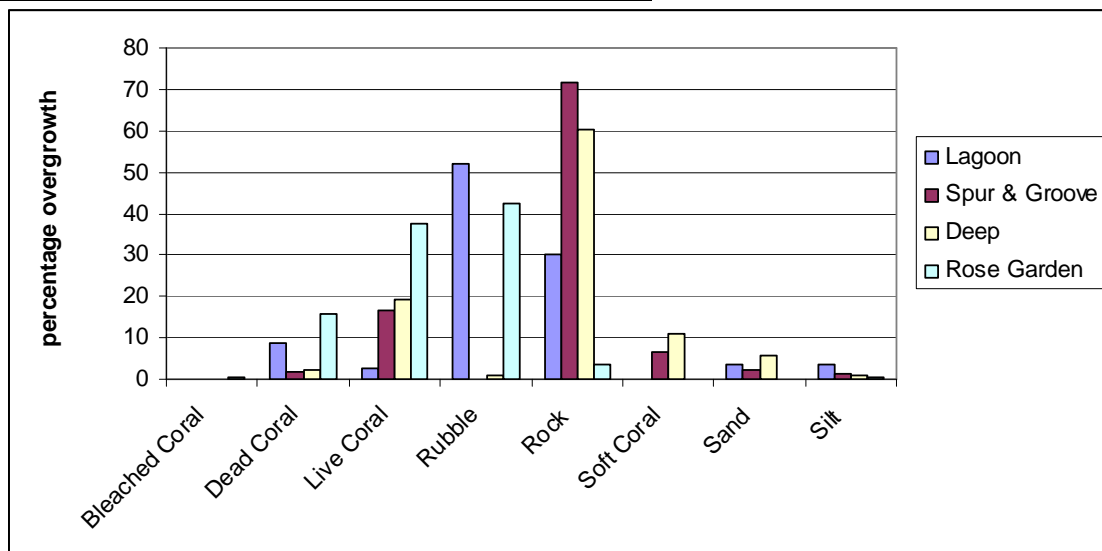


Figure 3. The average percentage of substrate types at the different regions

Overgrowth:

Table 2. The average percentage of overgrowth type at the different regions.

Overgrowth	Lagoon	Spur & Groove	Deep	Rose Garden
Macro Algae	23.17	47.12	15.33	5.01
Turf Algae	38.73	9.10	28.10	42.49
Coralline Algae	17.12	10.20	18.19	9.04
Filamentous Algae	0.64	0.32	0.19	1.39
Turbinara	1.48	1.96	0.00	0.10
Halimédia	0.33	0.10	0.10	0.00
Sea Grass	0.06	0	0.00	0.00
Absent	13.02	30.55	37.81	38.29

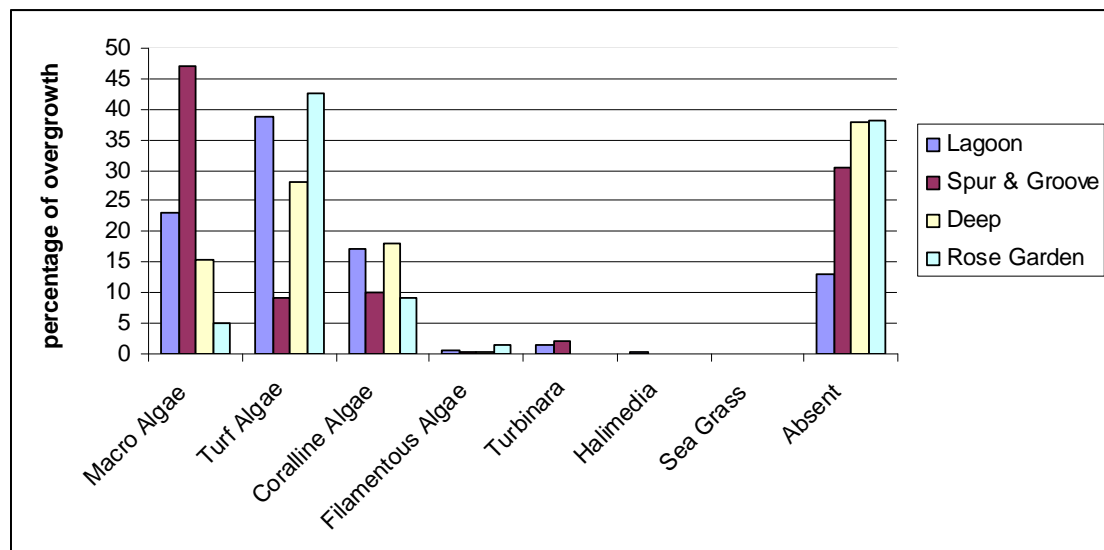


Figure 4. The average percentage of overgrowth type at the different regions.

Fish:

A total of 219 species of reef fish were recorded in the Bay of Ranobe during 2006. The highest diversity of species was recorded in the lagoon with a total of 126, followed by 122 species in the Deep region. The lowest number was recorded in the Spur and Groove with 82 species. The average density of individuals per 250m³ was lowest for the Lagoon with 60, whilst the Spur and Grove region contained an average of 73 individuals per 250m³. The highest density of individuals was found in the Deep region with an average of 77 individuals per 250m³.

The most common trophic group was herbivore for Lagoon and planktivore for both the Spur and Groove and Deep regions.

The most abundant species in the Lagoon was *Acanthurus nigrofuscus* with 172 individuals, followed by *Plectroglyphidodon lacrymatus* with 170 individuals. The most abundant species in the Spur and Groove region was *Chromis dimidiata* with 131 individuals and *Chromis weberi* with 119 individuals. The most abundant species in the Deep region was *Pseudanthias parvirostris* with 1000 individuals and *Pseudanthias squamipinnis* with 523. *Chromis dimidiata* was the 3rd most abundant species with 228 individuals recorded. *Chromis dimidiata* is abundant in all regions.

Indicator species: In the Deep region 5 species of grouper (Serranidae) were recorded, totalling 24 individuals. 4 species were recorded in the Spur and Groove and 3 species recorded in the Lagoon with a total of 5 individuals at each region.

11 species of Chaetodontidae were recorded in the Deep region, including 2 species that feed exclusively on coral polyps: *Chaetodon trifasciatus* and *Chaetodon meyeri*. 8 species were recorded in the Spur and Groove region and 7 species recorded in the Lagoon with one species that feeds exclusively on coral polyps *Chaetodon trifasciatus*.

3.1. Data Analysis:

Significant differences in fish assemblages, substrate and overgrowth between all 3 regions.....

4.0. Discussion:

Madagascar is often recognised for its wealth of terrestrial wildlife whilst its marine counterparts are often overlooked. This omission is quite unjustified since the third largest barrier reef in the world is located in South-West Madagascar; the 'Grand Recife' at Toliara. It is important that the marine life is recognised here as it is currently under serious threat from both anthropogenic and environmental factors.

The results show that the reef in the Bay of Ranobe has been affected by the negative stresses, including increased sedimentation and intensive reef flat gathering. The collapse of many Caribbean reefs was long preceded by ecological symptoms such as loss of macro-fauna, reduced fish stocks, a shift from fish dominated to echinoid-dominated herbivory and reduced coral recruitment (Bellwood *et al.*, 2004). These features were well documented but the forecast of the reefs eventual demise was not recognised (Sheffer & Carpenter, 2003). A similar change of events is occurring here in the Bay of Ranobe. There is already a distinct lack of macro-fauna such as sharks and turtles, and reduced fish stocks (Laroche & Ramananarivo, 1995). These symptoms should be recognised as signs of instability and warning signs of collapse and actions taken as soon as possible to reduce the stresses upon the reef to preserve this vital ecosystem.

The low coral cover recorded in the Lagoon could suggest marked demographic changes including decreased reproductive output and lower rates of recruitment. Whilst coral settlement studies conducted by ReefDoctor showed the presence of reproductive coral within the lagoon, after colonization the coral often suffered and early mortality as it was out-competed by algae. A feature indicating increased instability within the ecosystem (Bellwood *et al.*, 2004). The higher percentages of dead coral found within the Lagoon are likely due to physical damage by humans; including intensive reef flat gathering at low tide and anchoring of boats for fishing. The dead coral at the Rose Garden is caused by poor tourism practises; tourists treading and pirogues dropping anchor on the fragile foliose coral. Both problems should be alleviated with the implementation of the protected area laws however, which will provide education to tourists and mooring buoys for boats. Soft coral is found in higher percentages in the Spur and Groove and Deep regions. Soft corals lack a rigid internal skeleton and instead pump water through the mouths of the polyps into the canal system creating a hydroskeleton. This can be quickly dismantled in response to disturbances such as severe wave stress, making them suitable for the environmental conditions found in

these regions which can be exposed to severe wave action. The lack of bleached coral suggests that the Bay of Ranobe was not seriously affected by the bleaching event of 1998 that caused large scale bleaching in other areas of the East Africa eco-region (Mohammed *et al.*, 1999). There is a higher percentage of silt found within the Lagoon, due to soil erosion caused by deforestation in the Bay of Ranobe's water basin. Impacts of human decisions taken elsewhere (e.g. in forestry or in cities) are impairing functions at the cellular level of reef corals.

Healthy reefs have high coral cover and low algal cover. However here in the Bay of Ranobe there is a high percentage of fleshy macro-algae in all three regions showing the reef to be in a degraded state. Any factor that kills coral, such as storms, bleaching, disease and predation opens up the substrate for algal colonization and can lead to gradual and potentially permanent coral reef degradation if corals are not able to recover or grow back (Szmant 2002). Elevated nutrients can supposedly tip the competitive balance in favour of macroalgae, especially if herbivore densities are low. Nutrient overloading usually comes hand in hand with increased sediment, especially if it is caused by run-off from agricultural land. Sediment deposits can smother small coral colonies and recruits by restricting gas exchange between colonies and the water column. Sediments also negatively affect rates of photosynthesis due to stress and due to the light absorption by the particles deposited on the colonies or suspended in the water. Algal colonization success may be increased due to reduced herbivory resulting from over-fishing (Ostrander *et al.*, 2000). The increased algal cover leased to a greater susceptibility of the remaining part of the coral colony to algal growth (Szmant 2002). Algal-dominated reefs usually have lower fish stocks, less tourism appeal and lower coral biodiversity (McCook 1999). It is therefore important that these stresses are recognized and reduced in order to protect this vital ecosystem and the livelihoods of the people who depend upon it.

126 different species of fish were recorded in the Lagoon and 122 in the Deep region. The similar number of fish species found in these regions suggests that there is a 'mobile link' or movement between the two regions, with the Lagoon possibly acting as a nursery area for many juvenile fish. The difference in density of individuals reflects the differences in fishing pressure within the three regions. The lowest density of individuals seen per 250m³ was in the Lagoon; the area with the highest fishing pressure. The Deep

region has the highest density of individuals and the lowest fishing pressure. The Spur and Groove region had the lowest species richness; it also contained the highest percentage of rock substrate and macro-algae overgrowth. The lack of diversity in habitats in this region is limiting the diversity of fish.

Of the fish on the reef, 50-70% are carnivorous (Sale 1991). Herbivores and coral grazers are the second most important category with dominant families such as Scaridae (parrotfish) and Acanthuridae (surgeonfish). The rest of the fish are classed as omnivores (Sale 1991). However, this was not shown to be true in the Bay of Ranobe showing that there has been a shift in the fish composition. The most common trophic group was herbivore for the Lagoon comprising 40% of the fish population, with carnivores comprising only 17% of the population. In the Deep region Planktivores were the most common trophic group comprising 82% of the fish population recorded. Carnivores and Herbivores made up only 8% and 7% respectively. Planktivores were also the most common trophic group in the Spur and Groove region making up 59% of the population despite the high percentage of macro-algae available for herbivores.

In the Lagoon herbivores make up most of the fish composition. Abundant herbivore populations can buffer and protect reef communities against changes in algal production (McCook, 1999). Overfishing, by reducing grazing pressure, can affect the ability of reefs to recover from disturbance and lead to degradation (Szmant 2002). If fishing continues at its current high rate in the Lagoon then it is likely to have serious consequences for the reef system; reducing the number of herbivores (and therefore grazing pressure) allowing increased algae growth and resulting in an irreversible phase shift.

The concept of using certain key species as indicators of ecological conditions is well established (Soule and Kleppel, 1988; Jones and Kaly, 1996). Corallivorous butterflyfishes have coevolved with, and are intimately related to the corals on which they fed (Reese, 1991; Roberts *et al.*, 1988). The distribution and abundance of these fishes should be directly correlated with the distribution and abundance of the corals. If the corals are adversely affected by stressful environmental conditions their health will deteriorate. This deterioration should be detected by the fishes which feed on them. The corals are sessile and cannot avoid the stress, whereas the fishes are mobile, and can emigrate to healthier regions of the reef. The low numbers of corallivorous butterflyfishes found in the Bay of Ranobe indicates there is a lack of suitable food and habitat for these fishes. The low numbers suggests that they require large territories in order to gain their

energy requirements as the size of corallivorous butterflyfishes territories are determined by the amount of coral food contained therein (Crosby & Reese, 1996). These species should be monitored over time to see if there is any further decrease in numbers.

Commercially important reef fish such as Lutjanidae (Snapper) and Haemulidae (Sweetlips) were absent from the Spur and Groove region and found in low numbers in the other regions. Only one snapper species and individual (*Lutjanus monostigma*) was recorded in the Deep region. Grouper (Serranidae) are predatory fish, and were also found in very low numbers here in the Bay of Ranobe. This shows the ecosystem to be unbalanced with a lack of top predators and thus in an unstable state. Biodiversity in coral reefs and its influence on maintenance of ecosystem function is highlighted in the literature but comparatively little is known about the diversity of these systems and how changes in diversity might result in system instability and potential threshold effects (Done *et al.*, 1996). Reef systems often show poor recovery when affected by natural disturbances if they have already been exposed to persistent human disturbances (Brown, 1997). This is thought to be a consequence of loss of resilience (buffer capacity), making the coral reef ecosystem more susceptible to natural disturbance that otherwise could have been absorbed.

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everything possible should be done to help reduce the stresses on the reef and preserving this vital ecosystem that supports not only a vast amount of marine life but also many human populations and their way of life.

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