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# Feasibility study on the protection and management of the Barren Isles ecosystem, Madagascar

blue ventures
discovery through research

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## Abbreviations and Acronyms

BCMM - Bureau du Cadastre Minier de Madagascar

BITCP - Barren Isles Turtle Conservation Project

BV – Blue Ventures

CBO – community-based organisation

CBM – community-based monitoring

CBNRM – community-based natural resource management

CMPA – coastal and marine protected area

COAP – Code des Aires Protégées

DPRH – Direction de la Pêche et de Ressources Halieutiques

DSRP – Document de Stratégie de Réduction de la Pauvreté

EIA - Environmental Impact Assessment

EPP – Ecole primaire publique

FAO – Food and Agricultural Organisation

GELOSE – Gestion Locale Sécurisée

INSTAT – Institut National de Statistique

ICZM – Integrated coastal zone management

IH.SM - Institut Halieutique et des Sciences Marines

IUU - Illegal, unreported and unregulated fishing

MAEP – Ministère de l'Agriculture, de l'Elevage et de la Pêche

MECIE – Mise en Compatibilité des Investissements avec l'Environnement

MMTD – Melaky Miaro ny Tontolo an-Driakany

MPA – Marine protected area

MSC – Marine Stewardship Council

NTZ – no-take-zone, an area closed to all extractive activities

ONE – Office National de l'Environnement

PIN – Project Idea Note

PSDR – Projet de Soutien au Développement Rural

PSP – Projet Sectoriel Pêche

RIPB - Reseau interdisciplinaire pour une gestion durable de la biodiversite marine - Region Melaky, Madagascar

SAF/FJKM - Sampan'Asa Fampandrosoana/Fiangonan'i Jesosy Kristy eto Madagasikara. Development arm of a protestant church.

SAPM – Système d'Aires Protégées de Madagascar

TEK – Traditional Ecological Knowledge

VA – the Velondriake Association

WCS – Wildlife Conservation Society

WWF – World Wildlife Fund

ZAC – Zone aménagement concertée

## Glossary

**Artisanal fishers** as defined by Malagasy fisheries law are fishers who use motorised vessels in mostly shallow depths. The power of the motor was initially limited to 25 hp, but was upgraded to 50 hp.

**Dina** A law, convention or contract established collectively by the people of the same community or village in order to govern a particular concern.

**Faly** A Vezo taboo or prohibition (fady in official Malagasy).

**Foko** A group sharing the same place of residence and having the same lineage guided by the elder of the group in the village.

**Fokonolo** Village assembly that brings together the different socio-political groups of the village.

**Fokontany** The smallest administrative level in Madagascar that consists of one or several villages within the boundaries of a commune.

**Human Development Index (HDI)** A composite index measuring average achievement in three basic dimensions of human development – a long and healthy life, access to knowledge and a decent standard of living.

**National poverty line** The poverty line deemed appropriate for a country by its authorities. National estimates are based on population-weighted sub-group estimates from household surveys.

**Income classifications** Countries are grouped by income using World Bank classifications: high income (gross national income per capita of US$11,116 or more in 2006), middle income (US$906–$11,115) and low income (US$905 or less).

**Karani** Malagasy of Indo-Pakistani descent.

**Nosy** Isle; island. This term also describes also permanently submerged coral cays.

**Traditional fisher** as defined by the Malagasy fisheries law is an individual or association of individuals who fish on foot or in non-motorised vessels.

**Velondriake** the Velondriake community-managed protected area, which encompasses 25 villages in the commune of Befandefa; many of these villages have a strong tradition of fisher migration to the Barren Isles.

# Summary


**Biodiversity conservation value**

The Barren Isles coastal and marine ecosystem is made up of a great diversity of habitats, from deep oceanic waters immediately off the continental shelf, to deep, far offshore reefs and several different forms of shallower coral reefs, to extensive mangrove forests, estuarine marshes, wetlands and coastal dunes backed up by dense semi-humid tropical forest. These habitats harbour several species of exceptional conservation value, including:

- Five of the world's seven marine turtle species. All five of these are globally threatened with extinction, four of them nest within the Barren Isles coastal and marine ecosystem;
- The endemic and endangered Madagascar heron (*Ardea humbloti*) and a regionally important nesting colony of the Roseate tern (*Sterna dougallii*);
- A number of charismatic mega-fauna, including sharks, humpback whales and several species of dolphin;
- The coelacanth (*Latimeria chalumnae*), which is a Critically Endangered species.

At the ecosystem level, the coral reef habitats of the Barren Isles are diverse and productive, considered to be representative of amongst the healthiest reefs in the country, and supporting a high coral reef fish biomass. In large part due to their remoteness and offshore isolation, the reefs of the Barren Isles have not suffered many of the stresses that have widely degraded coral reefs elsewhere in Madagascar and the Western Indian Ocean. The relative absence of direct anthropogenic stresses has enhanced the resilience of these ecosystems, and they have not shown the same vulnerability to bleaching as most other habitats in South West Madagascar.

**Socio-economic importance**

As well as harbouring an exceptional biodiversity, the Barren Isles are an economic and cultural lifeline to traditional fishers. The rich and diverse habitats within the Barren Islands coastal and marine ecosystem support a productive artisanal pelagic fishery. The islands are sacred to the local Sakalava Vezo people, who regard them as being a gift from their ancestors. The Barren Islands' extensive reef systems are an important fishing ground for the migratory Sara clan of Vezo as well as the local Sakalava Vezo fishers, of whom the latter travel the length of the west coast of Madagascar to exploit the shark and sea cucumber fisheries. Faced with the unabated decline of marine resources and deepening poverty in their home villages, increasingly large numbers of Vezo migrants are now arriving in the Barren Islands. For these migrants and the local traditional fishers, living a vulnerable and marginalised offshore existence on the very edge of Madagascar's economy and society, the still healthy waters of the Barren Islands ecosystem underpins some of the few remaining productive fisheries accessible to them and forms the bedrock of their livelihoods.

Unfortunately the fishery resources and biodiversity of the Barren Isles ecosystem are threatened by open-access to these resources and their uncontrolled exploitation. Local natural resource stakeholders have no

system of governance that would enable them to protect and manage their resources. They find themselves in a situation where their resources are over-exploited by outside artisanal fishers, where highly endangered species such as turtles are being killed-off, where keystone species such as sharks and sea cucumbers are being stripped out of the ecosystem and where outside interests are mining the isles for phosphate. All of these actions degrade the natural resources on which the local people depend and diminish their potential to cope with future climate change through ecosystem-based adaption.

**Conservation planning**

On the other hand the natural resources of the Barren Isles ecosystem present tremendous natural assets that, if properly capitalized on, could bring conservation financing and job opportunities to local people. Examples of this include: the business development of the already existing traditional pelagic fishery, the generation of carbon credits through the conservation of the extensive mangrove forests present, and the development of sustainable aquaculture businesses.

If the local communities are to be able to stop the degradation of their natural resources and realise the full value of them, effective local governance and management must first be put into place. This could be achieved through the establishment of a community- co-managed Marine Protected Area (MPA) that protects the Barren Isles. The creation and formalisation of the Barren Isles MPA will empower the local communities to combat the above threats and to become effective managers of their resources by developing community-based natural resource management within the larger Barren Isles ecosystem.

The establishment of a functioning local management structure with effective resource governance is a prerequisite to the establishment of the MPA. Such institutions will also enable the local communities, in the long term, to catalyse and develop other projects, such as sustainable fisheries, mangrove REDD projects and sea cucumber farming.

Over the last five years local actors have already been working with the local communities to protect the biodiversity of the Barren Isles, particularly that of the marine turtles, and have already made significant steps towards this. This began with the formation of the Barren Isles Turtle Conservation Project (BITCP, part of the Interdisciplinary network for the sustainable management of marine biodiversity) in October 2005, which had the specific goal of conserving the marine turtles of the Barren Isles. In 2008 the BITCP assisted the Maintirano community in establishing a community association- “Melaky Miaro ny Tontolo an-Driakany (MMTD) - which has as its main objective the protection of the marine biodiversity of the Melaky region.

It is recommended that the creation and management of the Barren Isles MPA should be made up of six community-based activities that will consolidate and build on the existing accomplishments of the local association MMTD and the BITCP:

**1. Community management structure** The establishment of an effective community management structure that has the capacity and motivation to manage the MPA and to enact effective natural resource management measures.

**2. Sustainable management of traditional fisheries** Four traditional fisheries exist that are key to fisher livelihoods as well as attaining biodiversity conservation objectives: the pelagic fishery targeting species such as Spanish mackerel and karange; sea cucumber collection by free-diving; shark fishing and the traditional turtle fishery. Through a participatory appraisal the project will enable the local communities to define threats to these fisheries and to develop local solutions to overcoming these. The project will assist the communities in implementing identified strategies.

**3. Implementation of biodiversity conservation actions** to protect key habitats and species (turtle, cetacean and seabird populations). These measures will form part of the sustainable management of the fisheries so as to gain community buy-in, but will also achieve biodiversity conservation objectives. Examples of such actions include: the establishment of NTZs on key reefs, the protection of turtle nesting beaches and fishing closures.

**4. Strengthening of traditional governance and local institutional support** to guarantee that the communities have the legal means to implement effective management. The fisheries management and biodiversity conservation measures will be enshrined in a local traditional law with the communities' consensus. Collaboration and engagement of local government authorities and the fisheries department will be undertaken to build institutional support for the MPA.

**5. Community-based natural resource monitoring** In the first instance this will establish the diversity and condition of the habitats and species present in the area. In the second it will monitor the evolution in the state of these, particularly those of key fisheries. This monitoring, done hand-in-hand with the fishers, will enable them to understand the state of their resources and the necessity of managing them. In the long term it will quantify the outputs of conservation actions and inform adaptive management.

**6. Monitor and enforce a ban on industrial fishing within the MPA** Intensive, near shore industrial trawling renders any local management efforts ineffective. In addition illegal, itinerant teams of sea cucumber divers equipped with scuba gear frequently pillage areas such as the Barren Isles. In socioeconomic surveying on the west coast, traditional fishers cited industrial trawling as the single biggest threat to their continued livelihoods. The MPA will have to work to overcome these problems by, for example: working with the industrial trawling sector and the Programme National de Recherche Crevettière (PNRC) to define boundaries for the MPA that accommodate all stakeholders; and develop a system of transparent reporting to facilitate the enforcement of the industrial fishing and illegal sea cucumber diving ban within the MPAs.

**Long term vision of conservation**

In addition to the above actions, in the long term the MPA will have to work with local people and private enterprise to create sustainable incomes for the MPA management and jobs for the local people. Most importantly this approach will have to ensure that conservation actions make business sense to local users, contribute to poverty alleviation and so guarantee that conservation is sustainable and broadly implemented. Potential projects that the feasibility study indentified include:

**1. Sustainable traditional pelagic fishery:** presently traditional fishers catch high-value pelagic fish but sell them as bulk, salt-dried fish on the local market. An opportunity exists to enhance the value of this fishery by enabling fishers to sell onto higher-value markets. This would require the development of a viable business plan so that a partnership with a private seafood export company could be developed.

**2. Village-based sea cucumber and seaweed aquaculture:** The variety of coastal habitats present in the protected area provide suitable conditions for these types of aquaculture project. The development of successful village-based aquaculture of sea cucumbers as well as seaweed within the Barren Isles could provide fishers with a valuable alternative income to fishing.

**3. Mangrove REDD project:** Significant mangrove forests exist within the Barren Isles ecosystem; the establishment of a carbon offsetting project that conserves these habitats could allow for the generation of carbon credits and consequently an income stream for the MPA. The project will have to examine the historical deforestation and degradation of the mangroves, carry out measurements to establish their potential carbon pool, as well as examine opportunities for restoration. These data will be included in a PIN with a view to obtaining carbon financing for mangrove conservation / restoration.

**4. Ecotourism:** with unspoilt natural beauty, pristine coral reefs, several charismatic marine mammals and game fishing, the Barren Islands has extraordinary eco-tourism potential. These natural assets will be leveraged to develop ecotourism in the Barren Isles as a means of providing sustainable income to the protected area. The inaccessibility of the Barren Isles poses a real barrier to the development of ecotourism and niche clients will have to be targeted.

In addition this project will be developed as a fully integrated Population, Health and Environment programme, to incorporate sexual and reproductive health services within conservation planning, in order to tackle a fundamental driver of poverty and threat to food security amongst fishing communities. This holistic and trans-disciplinary approach will ensure significant, immediate and long-lasting positive impacts for a range of stakeholders at local, national and global scales. Through working in close partnership with the local association MMTD and through local communities implementing the activities themselves, the project will build management capacity among local community groups and the next generation of Malagasy marine scientists and conservationists. The establishment of the Barren Isles Coastal and Marine Protected Area will help ensure the viability of one of Madagascar's most important marine and coastal ecosystems, thereby contributing to national and international biodiversity conservation goals.

**The cornerstone of a regional network of MPAs**

The Barren Isles MPA will complement several existing and proposed terrestrial conservation areas at an ecoregional and landscape level, including: the Bemamba Wetland Complex, the Wetland and Dense Dry Forest Complex of Tsimembo, the Manambolomaty Complex and the Menabe-Antimena Protected Area. Notably this would be Madagascar's first MPA to manage deep-water ocean habitats and populations of pelagic fish. SAPM – Madagascar's planning agency for protected areas - has long identified the Barren Isles

as a “future new protected area” - an area of very high conservation value, but for which there are currently no financial or material means to protect it.

On a regional level the MPA will form the cornerstone of a network of MPAs extending over the western coast of Madagascar that presently comprises the Velondriake MPA and Kirindy Mite MPA. Such a network will begin to contribute to the protection of an ecologically meaningful proportion of habitat, conserving threatened marine biodiversity as well as the fishing grounds of traditional migratory fishers. In doing so it will make a crucial contribution to the long-term economic viability of indigenous Vezo and Sara communities through forming a cornerstone of a regional marine protected area network that reflects their livelihood strategy of migration.

The number of migrant Vezo fishers from the South West of Madagascar frequenting the Barren Isles has increased since the early 2000s. In the last three years their number has increased dramatically, driven by the collapse of local fishing resources and population growth in the villages of origin. The implementation of the Kirindy-Mite marine extension has entailed Madagascar National Parks banning migrant fishers from certain isles there. The ever increasing number of migrants constitutes a real threat to the Barren Isles if it continues unabated. Consequently, the formation of a Barren Isles MPA – with proper consultation of traditional Vezo fishers – will be an essential step towards addressing this problem and achieving a coherent regional management approach.

The network will help to reinforce a culture of responsible resource management on a regional scale and significantly increase the effectiveness of efforts to build capacity and tackle over-population. Through the repeated protection of a diversity of representative ecosystems the MPA network will build a mutually replenishing marine and coastal landscape. This will lend it some degree of adaptability and resilience to climate change on a landscape level. The positive synergies that such a network will provide, both at an ecological and a human level, will be invaluable in halting the decline of marine resources regionally and alleviating poverty in resource-dependent fishing communities.

**Geographical area**

Province: Mahajanga

Region: Melaky

Main town: Maintirano

The project area would include the fishing villages of Maintirano and would extend south to Soahany (approx. 65 km south) and the Barren Isles (Nosy Marify is 15 km directly west of Maintirano, Nosy Lava is 55 km south of Maintirano).

The project will implicate approximately 3,000 persons comprising 480 families in 13 villages. The implicated villages are mainly isolated, small fishing villages located on the Barren Isles and the coast opposite the isles, but also include two fishing villages that are in the periphery of Maintirano town whose fishermen frequent the Barren Isles.

# 1. Introduction

The institutional context of a feasibility study in the creation of a CMPA is defined in the "Document d'orientation pour la création et la gestion des aires marines protégées à Madagascar" (Ranaivoson 2009). It details 14 steps in the process of creating a CMPA. After the first step of the initiative of creation/classification, two preliminary studies are carried out: firstly a feasibility study (art 9 of the COAP); and secondly an environmental impact assessment (Décret MECIE 99-954 du 15/12/99). The feasibility study has several objectives:

- to identify and quantify the fauna and flora, the resources and areas of particular value, as well as the threats;
- to evaluate the scientific, cultural and socio-economic value of the resources to be protected;
- to justify the creation of the CMPA at that site;
- to implicate and engender participation of the population in the process of creation;
- to propose the limits of the CMPA and initiate a consultative zoning process.

Outputs of the feasibility study include:

- Establishment of a proposed delimitation of the protected area;
- Description of the fauna and flora as well as the characteristics of the zone;
- Details of the present utilisations of the zone and developments with the regulations that govern these. ("les projets d'utilisation avec la réglementation à instaurer")

Similarly the "Manuel de procédure pour la création des aires protégées marines à Madagascar" (Resolve Conseil, 2009), specifies that the feasibility study should:

- "Establish the present context of the planned CMPA;
- Take a rapid inventory/synthesise data on the biology, geology, fisheries and potential mining, oil and gas developments;
- Describe the demographic occupation of the area as well as its uses; licensed industrial fishing zones and aquaculture zones;
- Establish the different pressures, present and potential, and levels of degradation;
- List the management/conservation options;
- Carry out socio-economic studies (existing activities and opportunities for economic development, identify stakeholders and the different sectors engaged in the initiative to create the CMPA);
- Identify in a participative way people affected by the CMPA, vulnerable populations and communities that are eligible for community projects;

- Carry out a social census of the people affected by the CMPA, vulnerable populations and eligible communities."

To fulfil the above institutional requirements of the feasibility study as well as the terms of reference of this consultancy, the report is divided into four sections:

1. Natural habitats and biodiversity of the Barren Isles: Using existing data and rapid surveys carried out for this study, this section provides a description of the marine and coastal habitats that make up the larger Barren Isles ecosystem. The fauna and flora, as well as natural resources that the ecosystem supports in the wider landscape, are presented. Through this the biodiversity value of the Barren Isles will be demonstrated, its protection justified and the foundation laid for its cultural and socio-economic evaluation.

2. Socio-economic context: The human occupation of the area is established by firstly presenting the population, demography and social infrastructure of the area. Stakeholders in the CMPA are identified, and vulnerable populations and communities specifically affected by the CMPA are characterised.

3. Present and future utilisation: Communities' present utilisations of the resources to be protected, as well as their socio-economic values, are examined. The occupation of the area by other present and potential economic actors is described; these include licensed industrial fishing, aquaculture, and potential mining, oil and gas developments. From this the different pressures, present and potential, and the levels of degradation, are assessed.

4. Conservation planning: The conservation value of the Barren Isles and the opportunity to establish a CMPA is assessed. The proposed limits of the CMPA and a preliminary zoning plan are presented. Objectives that the CMPA could fulfil and future conservation actions are briefly defined.

## 1.1 Existing data

There is very little published scientific data on the Barren Isles, as a thorough search of the following sources of data and academic databases showed:

The ISI Web of Science (consisting of the Science Citation Index, Social Sciences Citation Index, and Arts & Humanities Citation Index);

GreenFILE (EBSCO);

Thèses Malgaches en ligne (http://theses.recherches.gov.mg/accueil.jsp);

Association du Réseau des Systèmes d'Information Environnementale (http://www.arsie.mg/index.php);

Google Scholar.

Gabrie and colleagues noted that very little is known of the reefs between Morondava and Mahajanga within Malagasy waters (Gabrie *et al.*, 2000). The only detailed examination of the Barren Isles is a DEA thesis written by Géraud Leroux-Pinoesch in 1998: "Etude de l'écosystème d'une communauté de pêcheurs traditionnels Vezo aux environs de Maintirano (région septentrionale du littoral occidental de Madagascar)". There are a number of unpublished studies undertaken by MSc. students from the IH.SM, as well as for the BITCP. During the course of the feasibility study, the WCS (Tim Maclanahan) carried out reef surveys of a number of sites in the southern part of the isles. In early 2010, the University of La Rochelle carried out aerial surveying of marine species in the region. This study draws on the preliminary results of these two studies.

# 2. Natural habitats and biodiversity

## 2.1 Summary

There is an extensive geomorphological reef system associated with the Barren Isles that totals 869 km². The majority of this - 768 km² – is comprised of deep reef geomorphologies; shallower reef systems make up the rest and include: forereefs (37 km²), reef flats (38 km²), subtidal reef flats (26 km²).

Scuba surveying over a period of two-and-a-half days was undertaken for reef sites, including one barrier reef, one patch reef and three fringing reefs.

For all of the four sites where the benthos was surveyed, 39 genera of zooxanthellate scleractinia, comprising 16 families, were observed. This is clearly a function of the surveying effort, but constitutes 54% of the 72 genera and all but one of the 17 families known to occur in Madagascar (McKenna 2003). By way of comparison, 28 scleractinia genera were recorded across 10 sites within the Velondriake MPA.

The barrier reef site was turf algae dominated (62% cover), while the patch and fringing reefs were hard coral dominated with 56, 49 and 59% hard coral cover respectively. The turf algae cover for these sites ranges from 16% to 29%. Macroalgae cover is negligible on the barrier reef; for the other sites it ranged from a minimum of 3% to a maximum of 17%.

*Acropora* corals dominated the barrier reef site (14.1% of the total substrate cover). No single scleractinian genus dominated the hard coral cover of the patch and fringing reefs, though *Porites* corals contributed *ca*. 10 to 20% of the total substrate cover for all of them. *Echinopora*, *Favia* and *Lobophyllia* corals also made up *ca*. 10 – 15% of the total substrate cover of the fringing and patch reef sites; *Acropora* corals constituted less than 5% of the total substrate cover for all patch and fringing reef sites.

A total of 150 species of reef fish comprising 33 families were recorded over the five survey sites. This represents about 20% of the total coral reef fish fauna of Madagascar, which is determined to be 788 species in 91 families (McKenna 2003). The most species rich families were: Labridae (16% of the total reef fish species observed), Pomacentridae (15%), Acanthuridae (13%), Chaetodontidae (9%), Lutjanidae (6%), Pomacanthidae (5%) and Serranidae (5%). Together these seven families comprised about 70 % of the total reef fish species observed and were common to all five sites surveyed.

Acanthuridae were the most abundant family for the fringing and barrier reef sites, accounting for between 28% and 45% of fish observed on these reefs. Pomacentridae were most abundant on the patch reef site (35% of fish observed), and common to all of the other sites. Balistidae, Lutjanidae and Scaridae were also common on all of the sites.

The estimated reef fish biomass ranged from 1329 kg/ha (std. err. ±444) for the fringing reef, to 2270 kg/ha (std. err. ±902) for the barrier reef. The outer barrier, patch and outer fringing reefs had high proportions of herbivore biomass, ranging from 727 kg/ha (Site 4) to 905 kg/ha (Site 1). The fringing reef sites had lower herbivore biomasses of 470 and 764 kg/ha respectively. The biomass of carnivorous fish ranged from a maximum of 601 kg/ha (outer barrier reef) to a minimum of 182 kg/ha (outer fringing reef).

The mean fish biomass of the reefs surveyed in the Barren Isles is 1636 kg/ha ± 590 and is comparable to that of the mean of Velondriake MPA, 397 kg/ha ± 55. The data indicates that the Barren Isles experience a fishing pressure that is lower than other areas in South West Madagascar. This is expected given the lower population pressure and that virtually all fishers use techniques that do not target reef fish, with fishermen targeting shark, mackerel (*Scombridae*) and sea cucumbers.

**Table 1. Summary of fauna observed during the surveying**

| Faunal group | Number of families | Number of genera | Number of species |
|---|---|---|---|
| Zooxanthellate scleractinia | 16 | 39 | |
| Reef fish | 33 | 76 | 150 |

## 2.2 Oceanography

In the Indian Ocean, the main stream of the wind-driven South Equatorial Current (SEC) flows westward at about 10 degrees south of the Equator. The more southern flow of the SEC strikes the East coast of Madagascar between 17 and 20°S and splits into two branches, one flowing north, the other south. These branches comprise the Eastern Madagascar Current.

The ocean to the west of Madagascar lies in the slipstream created by the Madagascar landmass and has markedly different oceanic currents to the East coast that are complex and varied in nature. The more northern flow of the SEC passes over the tip of Madagascar (11°S) and continues towards the Comoros and the East coast of Africa. In the vicinity of the Comoros it begins flowing northward, forming the East African Coastal Current (EACC). Part of it all also passes southward, eddying into the northern reaches of the Mozambique Channel and forming the prevailing southerly Mozambique Current in the central area of the Channel. A slow, anti-clockwise rotation of surface water takes place that is centred on the Comoros.

The oceanic currents along the West coast of Madagascar are not well understood, but there is evidence for both north and south flows. Notably the convergence of the warmer waters of the northern part of the channel with the cooler waters of the southern part of the channel create a semi-permanent area of deep water up-welling off Cap St. Andre and the island of Juan de Nova (200 km to the NW of the Barren Isles).

Thanks to the warm waters of the SEC that envelope much of Madagascar, sea temperatures are higher than would be expected for what are mainly sub-tropical waters. The average annual surface temperature offshore ranges from 22°C in the south to 28°C in the north. In shallow waters, local seasonal extremes range from 19°C to 33°C. As throughout the Indian Ocean, sea surface temperatures reflect the influence of the El Niño Southern Oscillation (ENSO), with anomalously high SST occurring in 1998 and 2001 in association with ENSO events in the eastern Pacific.

Madagascar falls within the Agulhas Current Large Marine Ecosystem (ACLME). The ACLME is broadly characterised by warm water temperatures (20 - 30°C) and low primary productivity. The exceptions to this are a few nutrient-rich 'hotspots' associated with small upwelling areas (notably off Juan de Nova and South East Madagascar), oceanic eddies drifting southwards in the central Mozambique Channel and areas close to major estuaries. The Barren Isles could be considered to fall within such a nutrient-rich area, given their proximity to a number of river estuaries that bring high sediment loads to the coastal waters, as well as the Juan de Nova – Cap St. Andre area of upwelling.

## 2.3 Overview of the Barren Isles and associated habitats

Figure 1 illustrates the Barren Isles, which form an archipelago that stretches between 15 and 65 km west and south (18° S to 18° 40'S) offshore of Maintirano.

The isles consist of sand or coral cays formed on coral reef flats, seven of which are vegetated, though most are less than a kilometre in length. The archipelago also consists of a large number of coral reefs and sand cays that are submerged during spring tides and storms. In total fishermen recognize 12 isles and sand cays in the archipelago on which they can land, these are presented in Table 2.

**Table 2. The Barren Isles**

| Isle | Surface area (ha) | Observation |
|---|---|---|
| Nosy Manandra (Banc Bayfield) | 18 | sub-tidal sand cay (flooded during spring tides) |
| Nosy Abohazo (Nosy Androtra) | 30 | vegetated (grasses, trees) |
| Nosy Marify | 11 | sub-tidal sand cay (flooded during spring tides) |
| Nosy Maroantaly | 49 | vegetated (grasses, trees) |
| Nosy Mavony (Nosy Mboro) | 21 | vegetated (grasses) |
| Nosy Ampasy (Banc Simpson) | 4 | sub-tidal sand cay |
| Nosy Andrano | 44 | vegetated (grasses, trees) |
| Nosy Dondosy | 19 | vegetated (grasses, trees) |
| Nosy Lava | 77 | vegetated (grasses, trees) |
| Nosy Manghily | 17 | vegetated (grasses, trees) |

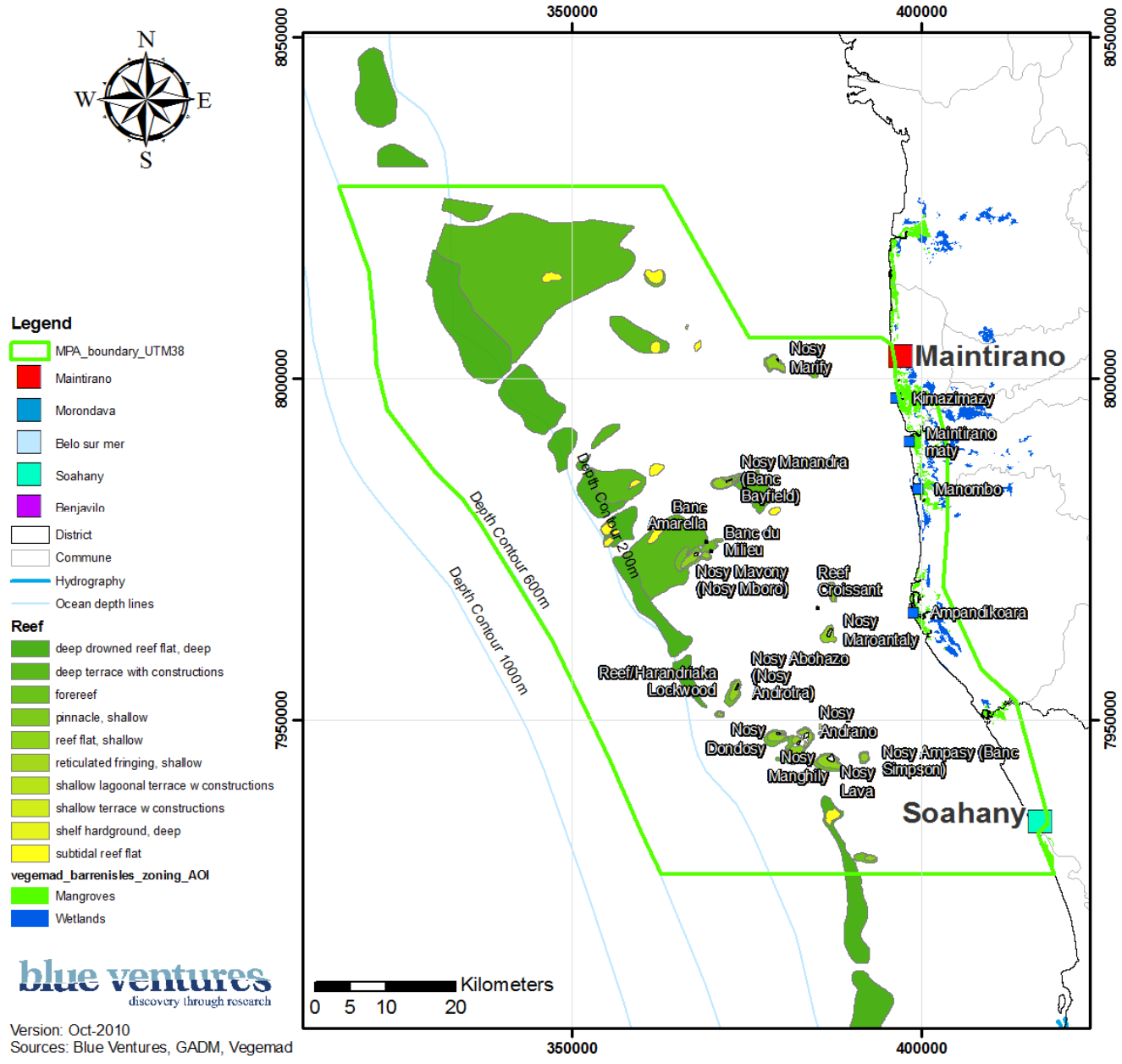


**Figure 1. The Barren Isles archipelago and neighbouring coastal habitats**

In Figure 1, an arbitrary boundary is defined around the reefs and coastal habitats that neighbour the Barren Isles. Note that this boundary has no management or ecological meaning, but simply defines a spatial domain to guide the analysis of the natural habitats that are likely to fall within the "Barren Isles ecosystem" and future conservation planning.

An extensive system of reef flats, submerged banks and rocky shoals that total 869 km², is associated with the Barren Isles (see Table 3). 'Deep drowned reef flats' (269 km²) and 'deep terraces with constructions' (499

km²) make up the major part of the geomorphology; shallower reef systems make up the rest and include: 'forereefs' (37 km²), 'reef flats' (38 km²), 'subtidal reef flats' (26 km²).

**Table 3. Summary of the reef geomorphology making up the Barren Isles ecosystem**

| Geomorphology classification | Area (km2) | % of total reef area |
|---|---|---|
| deep drowned reef flat | 268.9 | 30.9 |
| deep terrace with constructions | 498.7 | 57.4 |
| Forereef | 37.3 | 4.3 |
| reef flat | 38.1 | 4.4 |
| subtidal reef flat | 26.1 | 3.0 |
| ***Total reef area*** | ***869.1*** | ***100*** |

The isles exist within an extensive neritic zone / shelf seas, with the 200 m depth contour extending 30 to 60 km off shore and large extents of waters that are shallower than 30 m. A number of rivers with high sediment loads feed into this area and it would be a zone of high productivity for marine fisheries.

The different vegetation types present within the coastal area neighbouring the Barren Isles are presented in Table 4. (The terrestrial area is defined as a band that extends 1 km above the high tide mark and includes all linked mangroves and coastal wetlands. Where the latter extend further than 1 km inland, the boundary is drawn approximately 100 m from the edge of the mangrove/wetland.) Notable ecosystems include sand dunes, extensive mangroves, Western dry forest and croplands.

**Table 4. Summary of the coastal vegetation types present within the Barren Isles ecosystem**

| Vegetation classification | Area (km²) | % of total terrestrial area |
|---|---|---|
| Sand dunes /bare soil | 25.2 | 8.3 |
| Cultivation | 47.6 | 15.8 |
| Mangroves | 28.5 | 9.4 |
| Plateau grassland-wooded grassland mosaic | 69.9 | 23.2 |
| Water | 2.6 | 0.9 |
| Western dry forest | 53.4 | 17.7 |
| Wetlands | 22.8 | 7.5 |
| Wooded grassland-bushland | 51.8 | 17.2 |
| ***Terrestrial*** | ***301.7*** | ***100.0*** |

## 2.4 Coral Reefs

### 2.4.1 Geomorphology

The reef formations of the Barren Isles are part of a far larger, ancient submerged barrier reef that runs parallel to the western and north-western coast of Madagascar, stretching over 1,000 km from the Mangoky delta in the south to northeast of Mahajanga. The ancient reef is manifested today by a chain of scattered offshore banks that are generally at a depth of 15 – 30 m and are broken by passes, particularly in the vicinity of larger rivers. In places the reef rises to depths of 10 m and less and forms the foundation for sand cays, such as those of Belo-sur-Mer and the Barren Isles. Part of this reef system is shown in Figure 2. The ancient coral formations between Morondava and Mahajanga are divided into two large groups: the Barren Isles in the south, and the Pracel Shoal in the north.

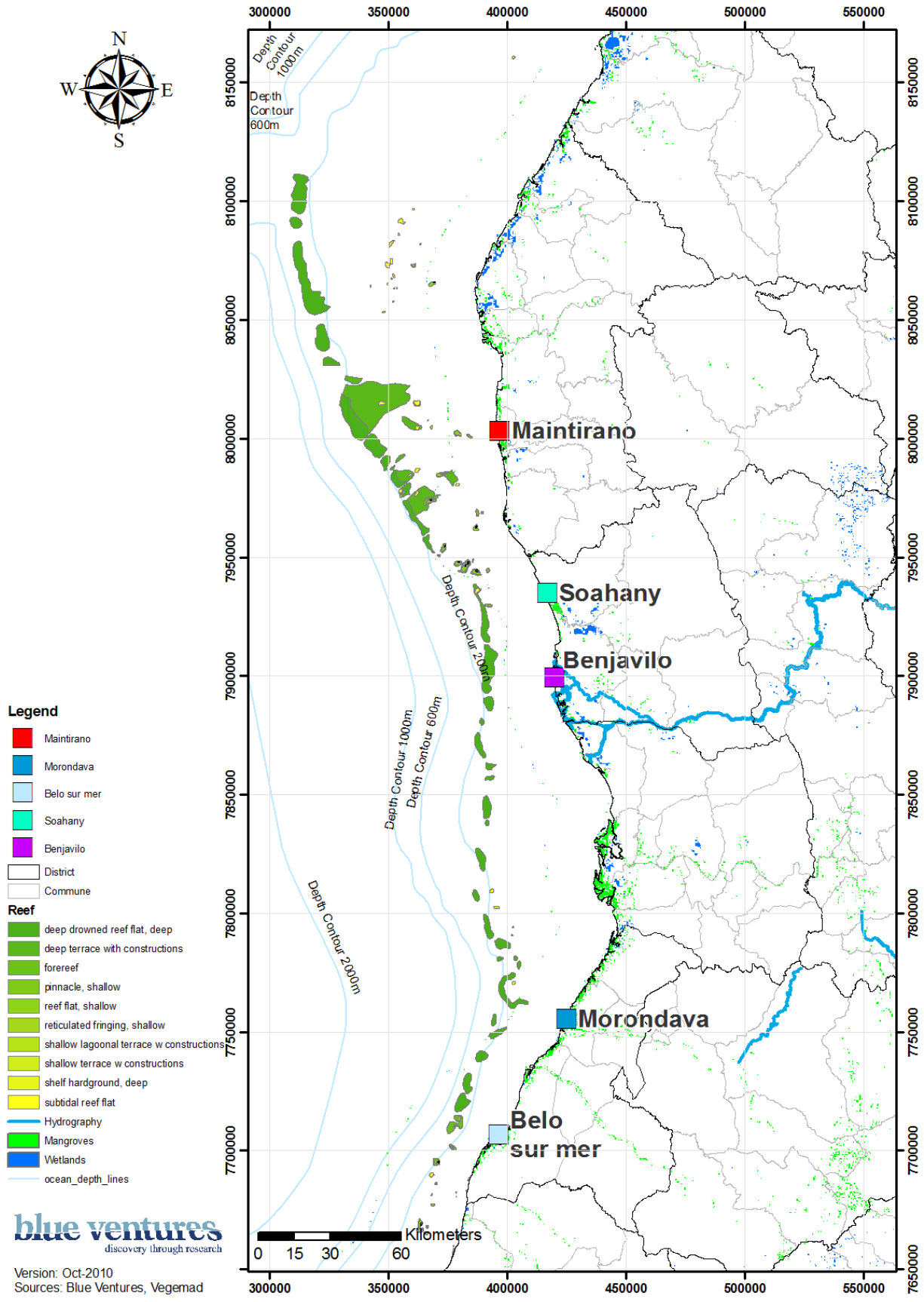


**Figure 2. The coral reef and coastal ecosystems of West Madagascar**

Several geomorphological coral reef and benthic formations make up the Barren Isles region, and are described in detail by Géraud Leroux-Pinoesch (1998). Starting from the west in oceanic water and moving eastwards towards the coast these are documented as the following.

#### *2.4.1.1 The outer slope and submerged barrier reef*

A submerged ancient barrier reef exists to the west of the archipelago, rising up from the outer slope of the continental shelf. The uppermost part of the submerged reef is found at approximately 60 m depth. At this depth coral communities are limited to a few species on the upper-reaches that are able to grow in the low light conditions. The external seaward slope falls away steeply to the deeper seafloor; frequently at 45° or steeper over several hundred meters. The internal slope of this ancient outer barrier reef is comprised of reef-derived material, typically calcareous sand (coral or shell sand, as well as larger coral pieces derived from the barrier and sometimes recolonised by living coral). This outer limit of the continental shelf is particularly rich in pelagic species, which forage within the shallow waters of the transitional shelf break. The barrier reef is little affected by the open sea swell because of its depth, even during storms. It provides little protection to the leeward reef systems, whose reef flats are exposed to the barely attenuated open sea swells.

Leroux describes a topographical cross-section of the seafloor moving in a landward west-east direction from the submerged barrier reef to the Banc de Vaudreuil (Figure 1). The leeward slope of the barrier reef continues with gradually decreasing depth the benthic environment covered with biodetritic material of different origins, brought by wave action and currents. The slope covers a distance of approximately 5 km, from the submerged barrier reef (at approximately 60 m depth), to exposed shallow waters of between 15 and 25 m. These shallower areas, exposed to the full ocean swell, are well-oxygenated and well-lit waters whose conditions are favourable to coral growth. These shallow areas harbour an abundance of coral formations, particularly compared to lagoonal areas further east. Closer to the Banc de Vaudreuil (minimum depth approximately 4 m), the isolated bommies are increasingly contiguous with the reef flat.

#### *2.4.1.2 The outer bank*

A submerged plateau, typically between 15 and 30 m depth, rises between the submerged barrier reef and the coast, stretching over 50 km in length (north-south) and being on average 38 km wide. It consists of a diversity of different habitats including coral patch reefs and isolated coral bommies, rubble ridges formed by wave action, large expanses of detritic sands; and coral rock formations, sand cays and coral reefs.

The substrate of the sand cays is formed by an accumulation of calcareous sand of biological origin. This sand consolidates into a calcareous cemented beach rock that forms layers sloping downwards from 3° to 15° on the seaward side. The form and location of the sand cays can change over time and after large storms, particularly those which are not vegetated. They frequently move in the direction of the prevailing wind, exposing the underlying beach rock, the remnants of which indicate the previous location of the cay.

Leroux suggests that the archipelago encompasses many of the different stages of formation of a sand cay, from shallow submerged coral banks to the beginnings of reef flats in the northern part, to vegetated sand cays in the southern part of the archipelago.

In the northern area of the archipelago there are numerous coral banks at a minimum depth of 2 – 5 m, formed by prolific growth of coral bommies without forming any coral reef flat. The Banc d'Ouest, the Banc du Vaudreuil and the Banc de la Surprise all represent this first stage of formation. Leroux remarks on the richness of the fish life around these coral banks, both in terms of diversity and abundance.

Then there are elements of coral reef flats that appear where the height of coral growth reaches or slightly exceeds the average level of the low tides. This is the case for Lockwood reef or the Banc du Milieu.

Where the coral reef flat is large enough, the accumulation of detritic coral material becomes sufficient for a bank to appear leeward of the reef flat. This is the embryonic, inter-tidal stage of the sand cay, the last stage before its becoming a distinct emergent island. Within the archipelago this formation is represented by the Croissant reef, Nosy Marify, the Banc Bayfield and the Banc du Nord.

The Banc Bayfield shows a classic coral cay zonation characterised by a coral reef flat, with a reef crest, internal and external slopes and a sandstone formation of beach rock.

The emergent cays are all formed on extensive coral reef flats which are typical of the south of the archipelago. The detritic sand is consolidated by vegetation growing on the cays. Nosy Lava, Nosy Andrano and Nosy Dondosy represent this ultimate stage in the formation of a sand or coral cay.

The seabed neighbouring and immediately east of Banc Bayfield varies in depth between 16 and 26 m. This zone is less exposed to alluvial sediments than the more easterly reefs because of its distance from the coast (a minimum of 15 km). However, despite their distance from river mouths, even these outer, western areas experience turbidity due to strong currents transporting sediment towards the edge of the continental shelf. These floods are not thought to affect the coral growth here, and the seabed in parts is carpeted with live coral. This is in contrast to other zones of the archipelago, such as the region immediately east of Nosy Maroantaly. This zone is sheltered from the open ocean swell by the vegetated islands to its south-west. The combination of this together with the island's relative proximity to the coast and resulting turbid conditions means that conditions retard coral growth.

#### *2.4.1.3 The internal slope*

A gentle slope forming a channel approximately 10 km wide runs between the reef flat and the edge of the coast, parallel to the coast. The coastal waters to the east of the channel are particularly turbid during the rainy season (November to April), when the rivers flood. High turbidity is observed at other times of the year depending on the local hydro-climatic conditions; for example, during the dry season strong southerly winds increase turbidity. The seabed is composed of very fine terragenous sand-mud sediments. As such, no coral life exists here.

Closer to the coast this zone is shallow (0 to 14 m), and its morphology very dynamic. The forces of the waves, the tides, the river currents and the drift of the coastal edge constantly change it. This continuous re-shaping of the seabed makes navigation through this area dangerous.

Between some of the coral banks a similar physical setting exists: moving west–east from the Banc de Vaudreuil towards the Banc Bayfield (Nosy Manandra), Leroux describes an area comprised of biodetritic material. Lateral currents carrying fine terrestrial sediments, coupled with a depth often greater than 25 m, mean that conditions are not favourable to coral growth, and there are only isolated bommies in this zone.

### 2.4.2 Benthic communities

Since little scientific data had been published on the coral reefs of the Barren Isles prior to this feasibility study, BV carried out rapid surveys on a sample of five reefs. The methods used studies the benthic communities and fish assemblages of these sites. The full details of the reefs surveyed as well as the methods used are presented in the Appendices. Table 5 summarises the sites surveyed, while Figure 3 presents their location.

**Table 5. Summary of the site surveyed**

| | **Site 1** | **Site 2** | **Site 3** | **Site 4** | **Site 5** |
|---|---|---|---|---|---|
| Reef type | Outer barrier | Patch | Fringing | Outer fringing | Fringing |
| Depth at top (m) | 9 | 8 | 6 | 2.5 | 7 |
| Depth at base (m) | 18 | 20 | 21 | 8 | 18 |
| Direction of slope | West | South West | South West | West | South |

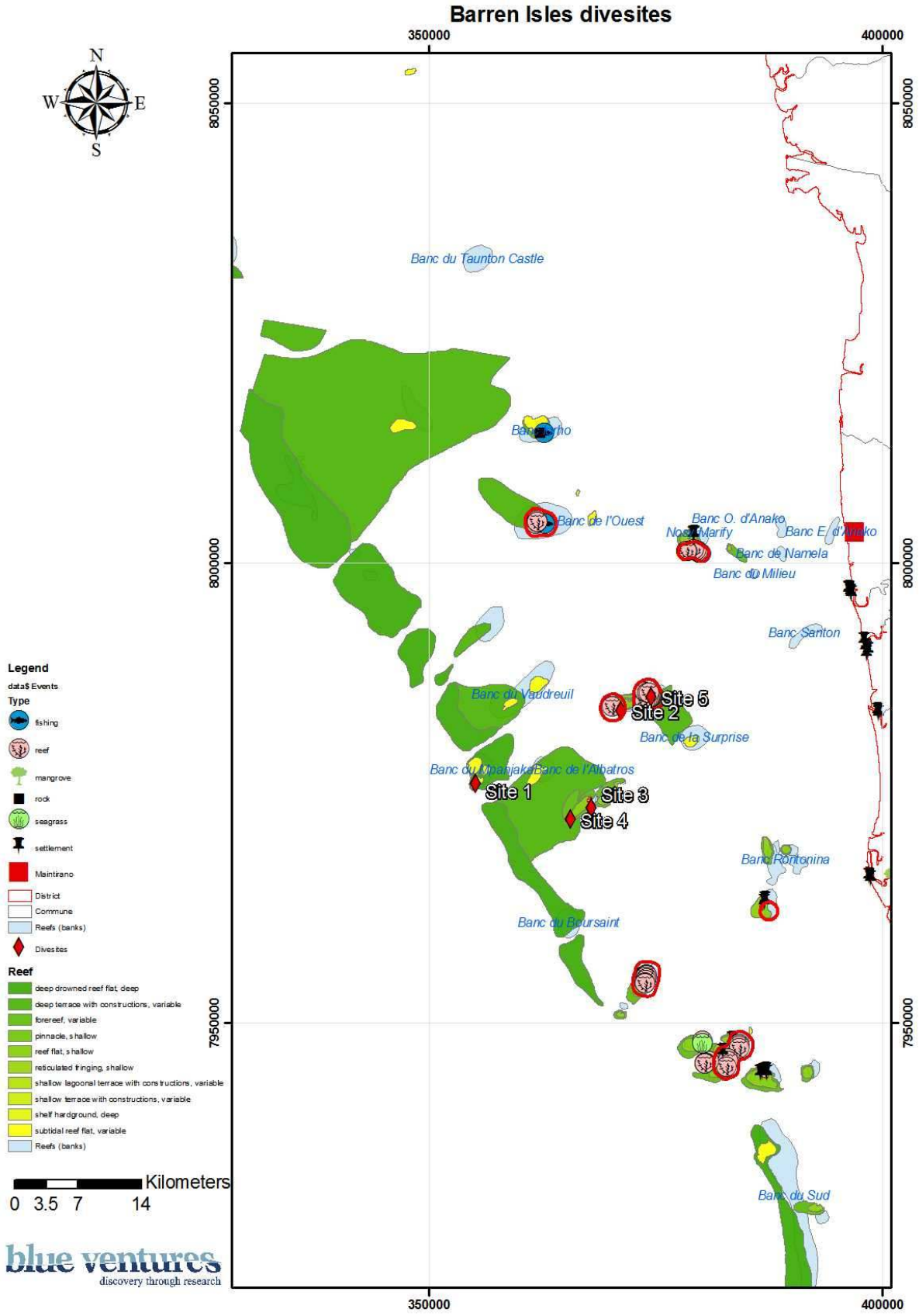


**Figure 3. Coral reef sites surveyed**

### *2.4.2.1 Hard coral (Scleractinia) diversity*

A total of 39 genera and 16 families of scleractinian corals were recorded at the four sites where the benthos was surveyed (Table 6 and Table 7). This is clearly a function of the surveying effort, but constitutes 54 % of the 72 genera and all but one of the 17 families that are known to occur in Madagascar (McKenna 2003). In comparison 28 genera were recorded across 10 sites within the Velondriake MPA.

**Table 6. Hard coral taxonomic diversity as represented by the number of hard coral genera and families observed. (Measured by 100 m transect.)**

| | Site 1 | Site 2 | Site 3 | Site 5 | All sites |
|---|---|---|---|---|---|
| Number of genera | 15 | 27 | 33 | 13 | 39 |
| Number of families | 9 | 12 | 14 | 9 | 16 |

Of the non-scleractinian hard corals the hydrocoral *Millepora* was recorded only on Sites 4 and 5. The azooxanthelate scleractinian *Tubastrea* and the organpipe coral *Tubipora musica* were not observed at any of the sites.

**Table 7. Hard coral genera observed at each survey site during a 100 m transect**

| Family | Genus | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|---|
| Acroporidae | *Acropora* | x | x | x | x | x |
| Agariciidae | *Gardineroseris* | | x | x | | x |
| | *Leptoseris* | | x | | | |
| | *Pachyseris* | | | x | | |
| | *Pavona* | x | x | x | x | x |
| Astrocoeniidae | *Astreopora* | | | | | x |
| | *Montipora* | x | x | x | x | x |
| Dendrophylliidae | *Tubastrea* | | | | | |
| | *Turbinaria* | | | | | x |
| Euphilliidae | *Physogyra* | | | | | |
| | *Plerogyra* | | | x | | |
| Faviidae | *Diploastrea* | | | x | | x |
| | *Favia* | x | x | x | x | x |
| | *Favites* | x | x | | x | x |
| | *Goniastrea* | | x | x | x | x |
| | *Hydnophora* | | x | x | | x |
| | *Leptoria* | | | x | | x |
| | *Oulophyllia* | | x | x | | x |
| | *Platygyra* | x | x | x | x | x |
| Fungiidae | *Cycloseris* | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *Fungia* | | x | x | | x |
| | *Herpolitha* | | x | x | | x |
| Merulinidae | *Merulina* | | | | | x |
| Montastreinae | *Cyphastrea* | | x | x | | x |
| | *Echinpora* | x | x | x | x | x |
| | *Leptastrea* | x | x | x | | x |
| | *Montastrea* | x | | x | | x |
| | *Plesiastrea* | x | x | x | | x |
| Mussidae | *Aacanthastrea* | | x | x | | |
| | *Blastomussa* | | | x | | |
| | *Lobophyllia* | | x | x | | x |
| Oculinidae | *Galaxea Green* | x | x | x | x | x |
| | *Galaxea red* | | x | | x | x |
| Pectiniidae | *Echinophyllia* | | x | x | | x |
| | *Mycedium* | | | x | | |
| Pectiniidae | *Oxypora* | | x | x | | |
| Pocilloporidae | *Pocillopora* | x | x | x | x | x |
| | *Seriatopora* | | | | | |
| | *Stylophora* | x | x | x | x | x |
| Poritidae | *Alveopora* | | | | | |
| | *Goniopora* | | | | | x |
| | *Porites branching* | | x | x | | x |
| | *Porites massive* | x | x | x | x | x |
| Psammocoridae | *Psammocora* | x | | x | | x |
| Siderastreidae | *Coscinarea* | | x | x | x | x |

Line Intercept Transects showed the barrier reef site was the least diverse, with 5 hard coral genera, while the patch and fringing reef sites showed similar numbers of genera, ranging from 19 to 22 (Figure 4, Table 8).

**Table 8. Hard coral richness and diversity as represented by the number of hard coral genera observed and the Simpson Diversity Index (measured by 10 m LITs).**

| | **Site 1** | **Site 2** | **Site 3** | **Site 5** | **All sites** |
|---|---|---|---|---|---|
| Number of genera | 5 | 21 | 19 | 22 | 33 |
| Number of families | 5 | 12 | 11 | 12 | 14 |
| Simpson Diversity Index (1-λ) | 0.392 | 0.891 | 0.865 | 0.853 | |

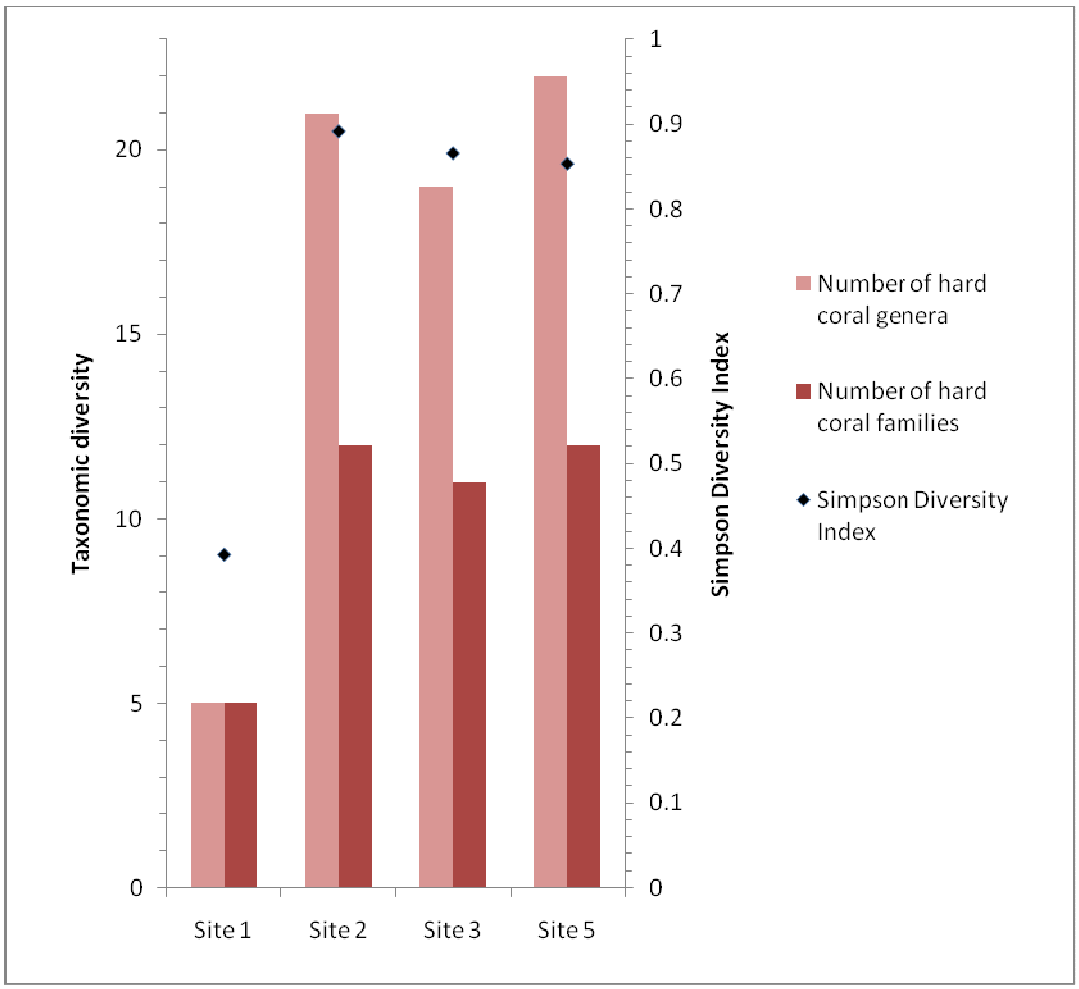


**Figure 4. Graphical representation of hard coral taxonomic diversity and Simpsons Diversity Index (SDI)**

### *2.4.2.2 Benthic composition*

The mean percentage covers recorded at each site for seven benthic categories are presented in Table 9 and Figure 6. The barrier reef (Site 1) is turf algae dominated (62 % cover), while the patch (Site 2) and fringing reefs (Sites 3 and 5) are hard coral dominated with 56, 49 and 59 % hard coral cover respectively. The turf algae cover for these sites ranges from 16 % for Site 5 to 29 % for Site 2. Macroalgae cover is negligible on the barrier reef Site 1 (0.6 %); for the other sites it ranges from a minimum of 3 % (fringing reef Site 3) to a maximum of 17 % (fringing reef Site 5).

**Table 9. Benthic composition presented by the percentage contributions of each substrate type**

| | **Site 1** | | **Site 2** | | **Site 3** | | **Site 5** | |
|---|---|---|---|---|---|---|---|---|
| | % cover | ±Std. error | % cover | ±Std. error | % cover | ±Std. error | % cover | ±Std. error |
| Hard coral | 18.5 | 2.5 | 56.1 | 2.4 | 48.8 | 2.3 | 59.0 | 5.0 |
| Turf algae | 61.8 | 3.4 | 28.7 | 3.2 | 25.7 | 4.8 | 15.8 | 2.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Calcareous algae | 1.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.3 | 0.0 | 0.0 |
| Macroalgae | 0.6 | 0.2 | 10.0 | 0.7 | 3.4 | 0.5 | 16.8 | 3.5 |
| Coralline | 8.7 | 3.4 | 3.6 | 1.3 | 4.3 | 1.1 | 5.6 | 2.5 |
| Soft coral | 6.8 | 0.4 | 1.0 | 0.7 | 8.5 | 3.9 | 0.0 | 0.0 |
| Sponge | 1.4 | 0.5 | 0.5 | 0.2 | 7.1 | 0.6 | 2.5 | 1.3 |

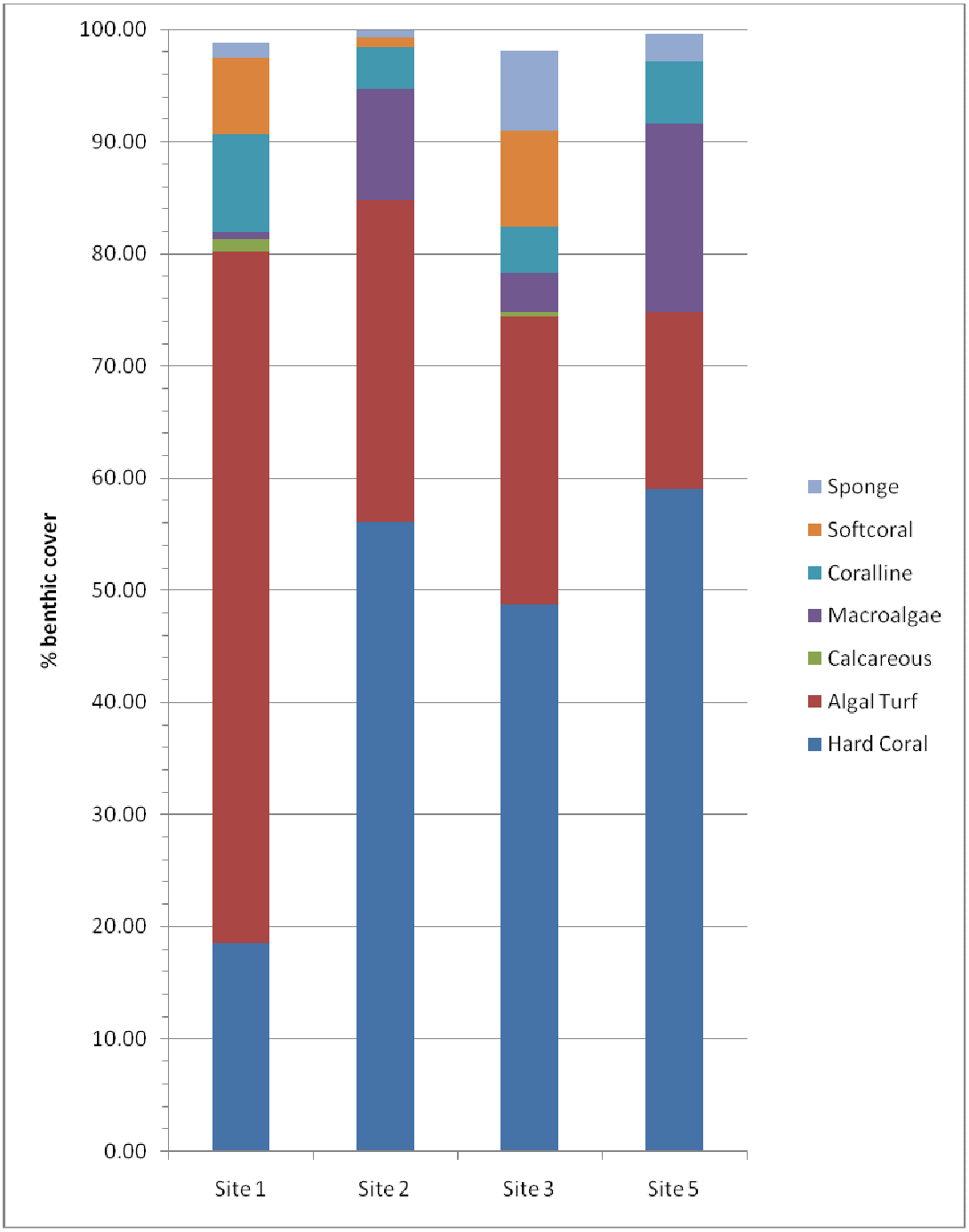


**Figure 5. Benthic composition, depicting percentage contributions for each substrate type**

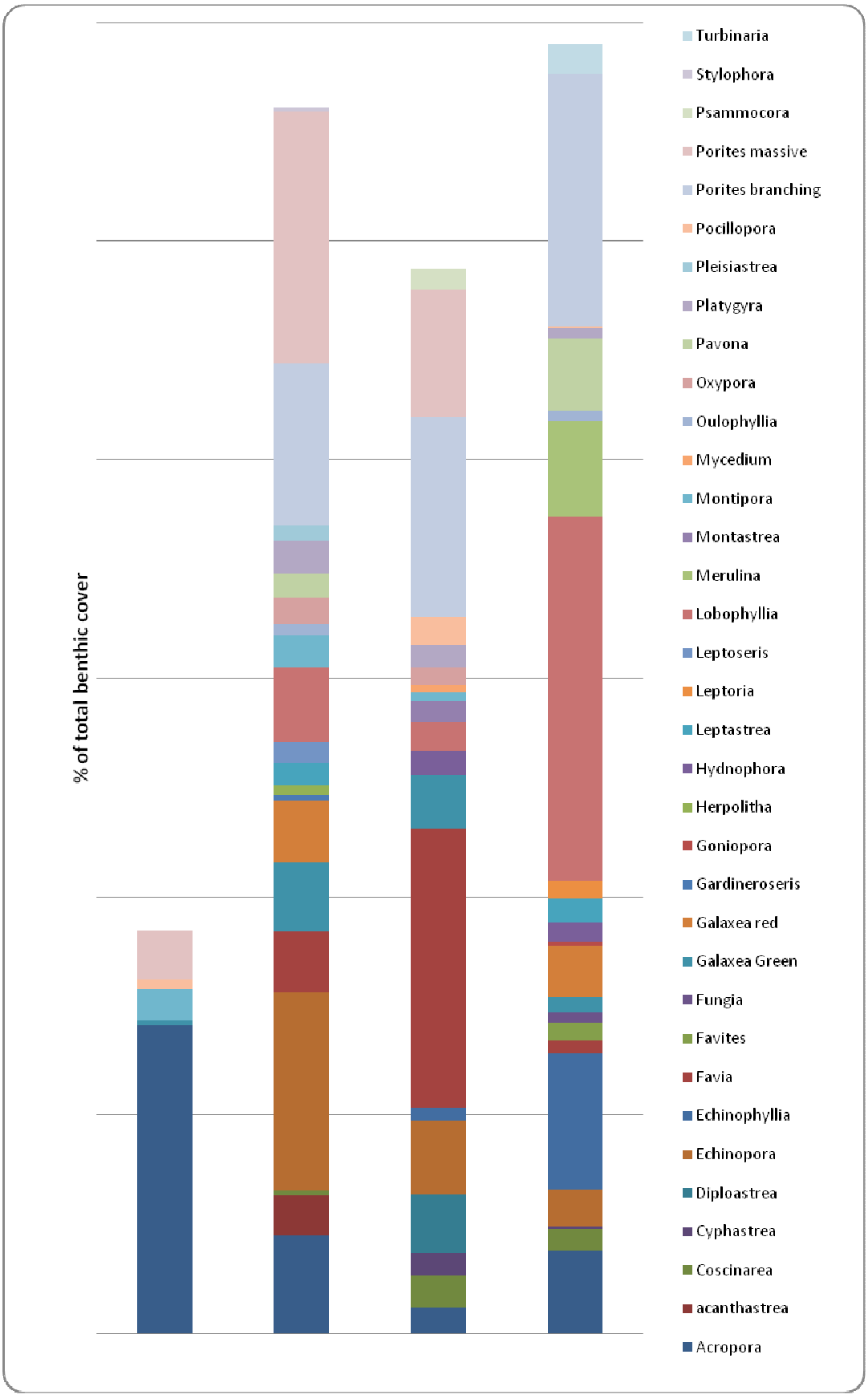


**Figure 6. Percentage contribution of each scleractinian genus to total benthic cover**

**Table 10. Percentage contribution of each scleractinian genus to total benthic cover**

| | % of total benthic cover | | | |
|---|---|---|---|---|
| **Genus** | **Site 1** | **Site 2** | **Site 3** | **Site 5** |
| *Acropora* | 14.1 | 4.5 | 1.2 | 3.8 |
| *Alveopora* | - | - | - | - |
| *Acanthastrea* | - | 1.9 | - | - |
| *Astreopora* | - | - | - | - |
| *Blastomussa* | - | - | - | - |
| *Coscinarea* | - | 0.2 | 1.5 | 1.0 |
| *Cyphastrea* | - | - | 1.1 | 0.1 |
| *Cycoloseris* | - | - | - | - |
| *Diploastrea* | - | - | 2.7 | - |
| *Echinopora* | - | 9.1 | 3.4 | 1.7 |
| *Echinophyllia* | - | - | 0.6 | 6.2 |
| *Favia* | - | 2.8 | 12.8 | 0.6 |
| *Favites* | - | - | - | 0.8 |
| *Fungia* | - | - | - | 0.5 |
| *Galaxea* green | 0.2 | 3.1 | 2.5 | 0.7 |
| *Galaxea* red | - | 2.8 | - | 2.3 |
| *Gardineroseris* | - | 0.3 | - | - |
| *Goniastrea* | - | - | - | - |
| *Goniopora* | - | - | - | 0.2 |
| *Herpolitha* | - | 0.4 | - | - |
| *Hydnophora* | - | 0.0 | 1.2 | 0.9 |
| *Leptastrea* | - | 1.1 | - | 1.1 |
| *Leptoria* | - | - | - | 0.8 |
| *Leptoseris* | - | 0.9 | - | - |
| *Lobophyllia* | - | 3.4 | 1.3 | 16.7 |
| *Merulina* | - | - | - | 4.4 |
| *Montastrea* | - | 0.0 | 1.0 | - |
| *Montipora* | 1.5 | 1.4 | 0.4 | - |
| *Mycedium* | - | - | 0.4 | - |
| *Oulophyllia* | - | 0.5 | - | 0.5 |
| *Oxypora* | - | 1.2 | 0.8 | - |

| | % of total benthic cover | | | |
|---|---|---|---|---|
| **Genus** | **Site 1** | **Site 2** | **Site 3** | **Site 5** |
| *Pachyseris* | - | - | - | - |
| *Pavona* | - | 1.1 | - | 3.3 |
| *Platygyra* | - | 1.5 | 1.0 | 0.4 |
| *Pleisiastrea* | - | 0.7 | - | - |
| *Pocillopora* | 0.4 | 0.0 | 1.3 | 0.1 |
| *Porites* branching | - | 7.4 | 9.2 | 11.6 |
| *Porites* massive | 2.3 | 11.5 | 5.9 | - |
| *Psammocora* | - | - | 1.0 | - |
| *Synarea* | - | - | - | - |
| *Seriatopora* | - | - | - | - |
| *Stylophora* | - | 0.2 | - | - |
| *Tubastrea* | - | - | - | - |
| *Tubipora* | - | - | - | - |
| *Turbinaria* | - | - | - | 1.4 |
| **Total hard coral cover** | **18.5** | **56.1** | **48.8** | **59.0** |

Three scleractinian genera constituted virtually all of the hard coral cover of Site 1 (a barrier reef): *Acropora* (14.1 % of the total substrate cover), *Porites* massives (2.3 %) and *Montipora* (1.5 %). While *Acropora* corals dominated Site 1, they constituted less than 5 % of the total substrate cover for all of the other sites surveyed (see Table 210 and Figure 6). No single genus dominated the hard coral cover of the patch and fringing reefs, though *Porites* corals contributed *ca*. 10 to 20 % of the total substrate cover for all of them. *Favia* corals comprised 12.8 % of the total substrate cover of the fringing reef Site 3, while *Lobophylia* made up 16.7 % of that of fringing reef Site 5.

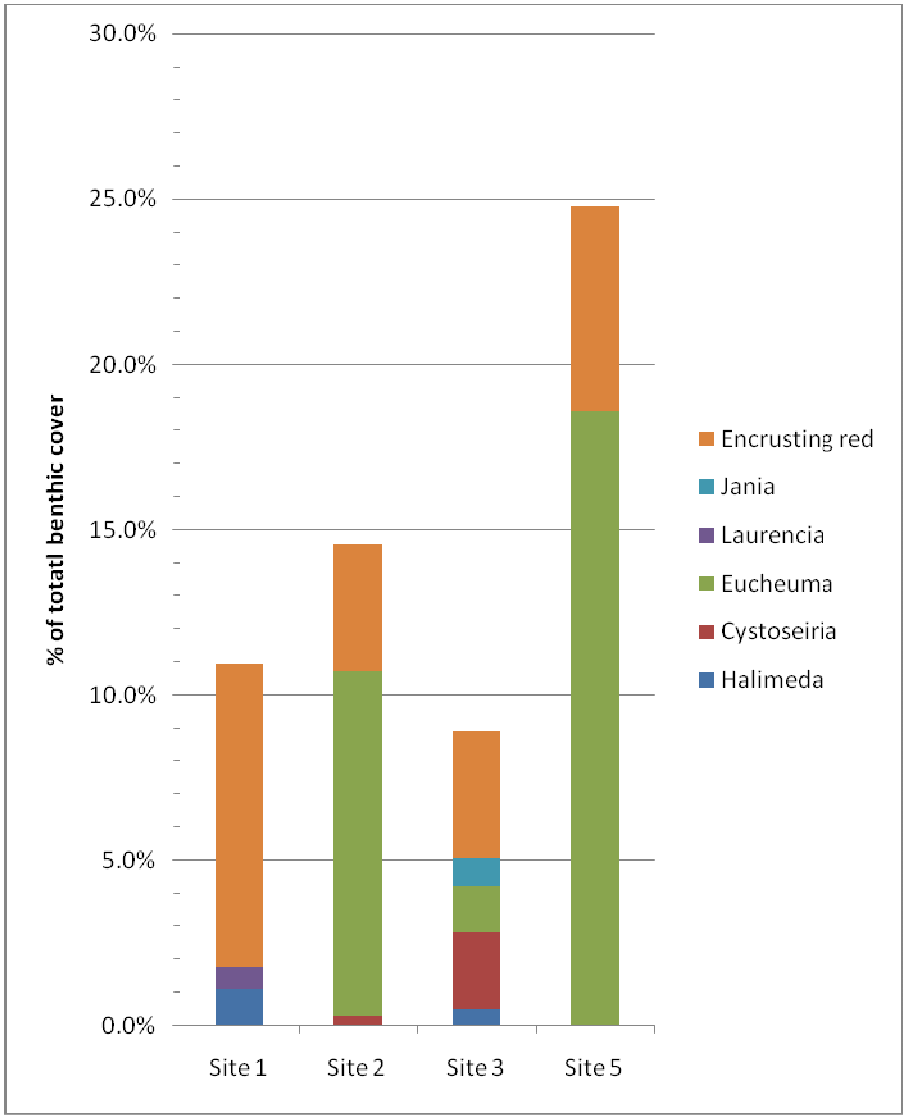


**Figure 7. Contribution of each algal genus to the total benthic cover**

Site 5, a fringing reef, showed the highest algal substrate cover (excluding turf algae), with this being largely made up of *Eucheuma* (18.6 % of the total substrate cover). The algal cover of Site 2, a patch reef, was also largely made up of *Eucheuma* (10.4 % of the total substrate cover). The algal substrate cover of the outer barrier reef site (Site 1) was dominated by encrusting red coralline algae (9.2 % of the total benthic cover) as would be expected for this habitat. Encrusting red coralline algae was also present in all of the other sites, making up *ca*. 4 % of the substrate cover for the Sites 2 and 3, and 6 % of total substrate cover for Site 5. Site 3, a fringing reef, was the most diverse in terms of algal genera.

**Table 11. Percentage contribution of each algal genus to the total benthic cover**

| | % of total benthic cover | | | |
|---|---|---|---|---|
| | **Site 1** | **Site 2** | **Site 3** | **Site 5** |
| **Calcareous Algae** | | | | |
| *Halimeda* | 1.1 | -- | 0.5 | -- |
| **Fleshy Algae** | | | | |
| *Asparagopsis* | -- | -- | -- | -- |
| *Caulerpa* | -- | -- | -- | -- |
| *Codium* | -- | -- | -- | -- |
| *Cystoseiria* | -- | 0.3 | 2.3 | -- |
| *Derbesia* | -- | -- | -- | -- |
| *Dictyospheria* | -- | -- | -- | -- |
| *Dictyota* | -- | -- | -- | -- |
| *Eucheuma* | -- | 10.4 | 1.4 | 18.6 |
| *Hydroclathrus* | -- | -- | -- | -- |
| *Hypnea* | -- | -- | -- | -- |
| *Laurencia* | 0.7 | -- | -- | -- |
| *Padina* | -- | -- | -- | -- |
| Red filamentous | -- | -- | -- | -- |
| *Sargassum* | -- | -- | -- | -- |
| *Turbinaria* | -- | -- | -- | -- |
| *Ulva* | -- | -- | -- | -- |
| **Coralline Algae** | | | | |
| *Jania* | -- | -- | 0.8 | -- |
| *Amphiroa* | -- | -- | -- | -- |
| Encrusting red | 9.2 | 3.9 | 3.8 | 6.2 |
| **Total % of benthic cover** | **11.0** | **14.6** | **8.9** | **24.8** |

### 2.4.3 Reef fish communities

#### *2.4.3.1 Reef fish diversity*

A total of 150 species of reef fish comprising 33 families were recorded over the five survey sites (see Table 12.). This represents about 20 % of the total coral reef fish fauna of Madagascar, which is determined to be 788 species in 91 families (McKenna 2003). It should be borne in mind that the surveying was rapid and is likely to have underestimated the true diversity of the site. The number of species observed ranged from a minimum of 57 for Site 4 (an outer fringing reef), to a maximum of 84 for Site 1 (a barrier reef site), with an

average of 67 species per site. A full list of fish species recorded at five sites in the Barren Isles is presented in Appendix 3.

**Table 12. Reef fish species richness and diversity**

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | All sites |
|---|---|---|---|---|---|---|
| Number of species | 86 | 64 | 64 | 57 | 64 | 150 |
| Number of families | 25 | 19 | 18 | 16 | 23 | 33 |

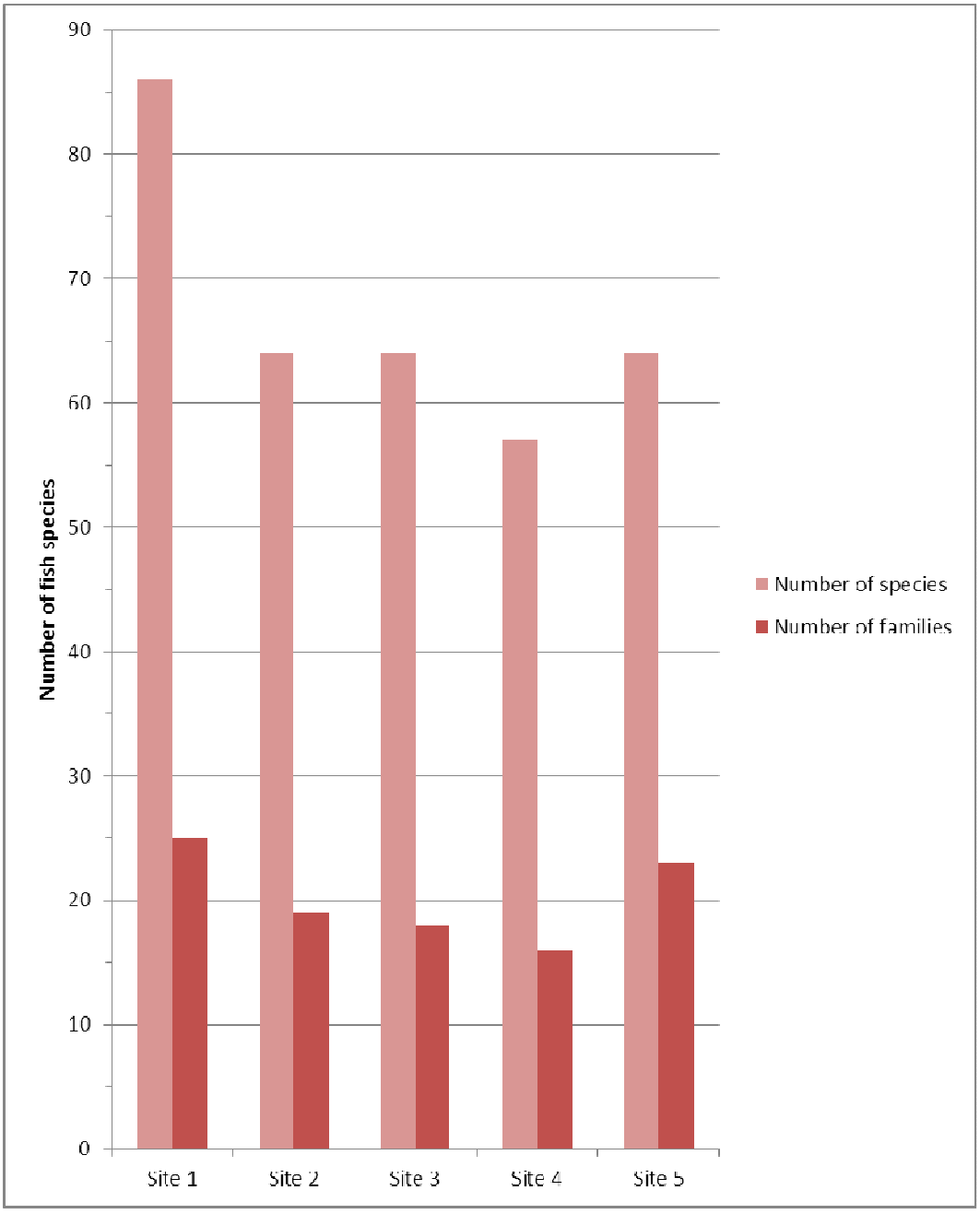


**Figure 8. Reef fish taxonomic richness and diversity (SDI)**

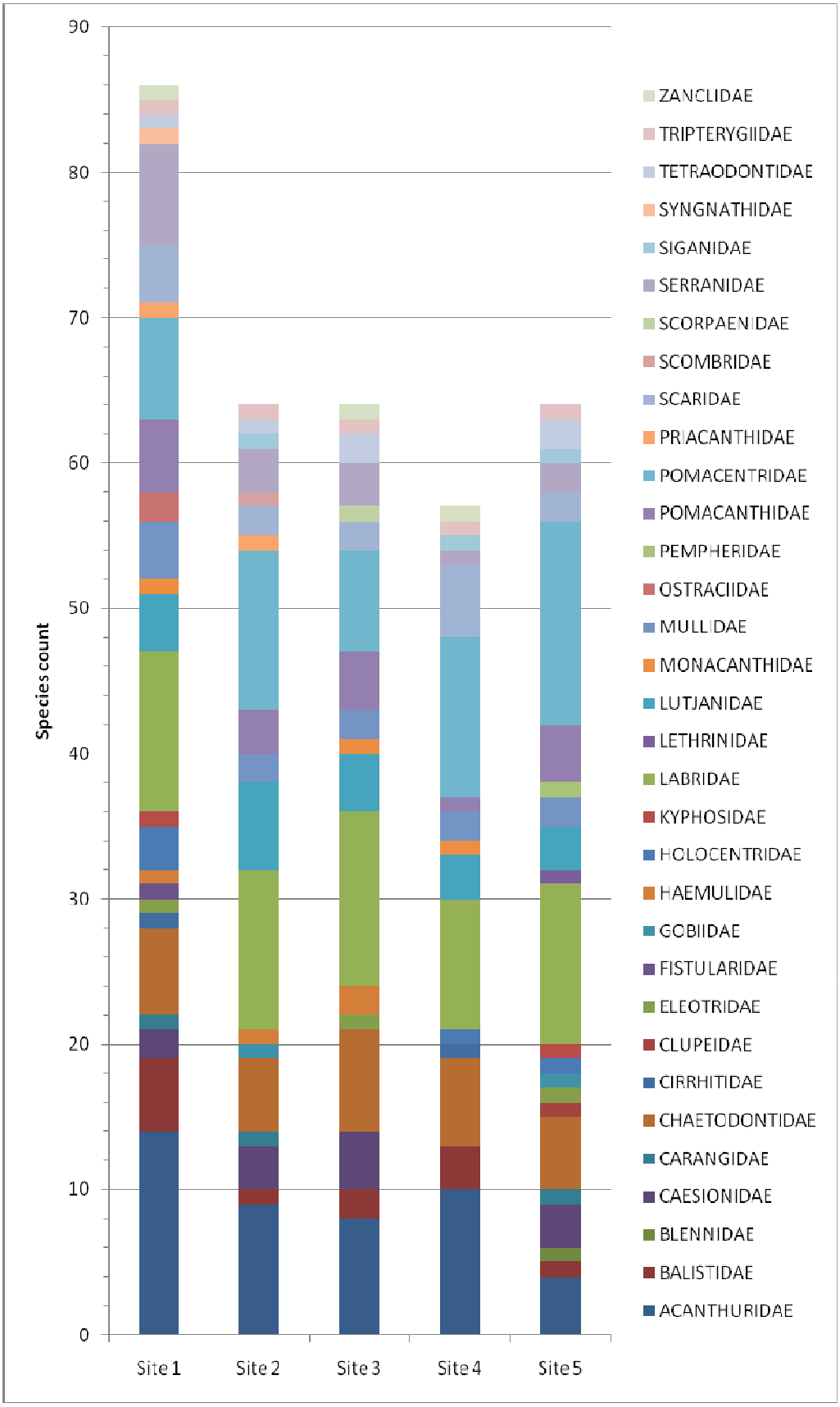


**Figure 9. Family contributions to the total count of fish species**

**Table 13. Contribution of families to the total fish species count**

| | Count of species | | | | |
|---|---|---|---|---|---|
| **Family** | **Site 1** | **Site 2** | **Site 3** | **Site 4** | **Site 5** |
| Acanthuridae | 14 | 9 | 8 | 10 | 4 |
| Balistidae | 5 | 1 | 2 | 3 | 1 |
| Blennidae | | | | | 1 |
| Caesionidae | 2 | 3 | 4 | | 3 |
| Carangidae | 1 | 1 | | | 1 |
| Chaetodontidae | 6 | 5 | 7 | 6 | 5 |
| Cirrhitidae | 1 | | | 1 | |
| Clupeidae | | | | | 1 |
| Eleotridae | 1 | | 1 | | 1 |
| Fistularidae | 1 | | | | |
| Gobiidae | | 1 | | | 1 |
| Haemulidae | 1 | 1 | 2 | | |
| Holocentridae | 3 | | | 1 | 1 |
| Kyphosidae | 1 | | | | 1 |
| Labridae | 11 | 11 | 12 | 9 | 11 |
| Lethrinidae | | | | | 1 |
| Lutjanidae | 4 | 6 | 4 | 3 | 3 |
| Monacanthidae | 1 | | 1 | 1 | |
| Mullidae | 4 | 2 | 2 | 2 | 2 |
| Ostraciidae | 2 | | | | |
| Pempheridae | | | | | 1 |
| Pomacanthidae | 5 | 3 | 4 | 1 | 4 |
| Pomacentridae | 7 | 11 | 7 | 11 | 14 |
| Priacanthidae | 1 | 1 | | | |
| Scaridae | 4 | 2 | 2 | 5 | 2 |
| Scombridae | | 1 | | | |
| Scorpaenidae | | | 1 | | |
| Serranidae | 7 | 3 | 3 | 1 | 2 |
| Siganidae | | 1 | | 1 | 1 |
| Syngnathidae | 1 | | | | |
| Tetraodontidae | 1 | 1 | 2 | | 2 |
| Tripterygiidae | 1 | 1 | 1 | 1 | 1 |
| Zanclidae | 1 | | 1 | 1 | |
| **Total species count** | **86** | **64** | **64** | **57** | **64** |

The most species rich families (in terms of the number of species observed) were Labridae (16% of the total reef fish species observed), Pomacentridae (15%), Acanthuridae (13%), Chaetodontidae (9%), Lutjanidae (6%),

Pomacanthidae (5%) and Serranidae (5%). Together these seven families comprised about 70% of the total reef fish species observed and were common to all 5 sites surveyed (Figure 9 and Table 13).

The Humphead or Napoleon Wrasse (*Cheilinus undulatus*), which ranges throughout the Indo-West and central Pacific, is one of the largest reef fishes, and is considered as an excellent indicator of fishing pressure in the Indo-Australian Archipelago (McKenna 2003). It has limited use for this purpose in Madagascar without knowledge of its previous abundance. Nevertheless, one small adult Napoleon Wrasse was sighted during the surveying on Site 1. In comparison, during a Marine RAP survey of northwestern Madagascar, which assessed 30 sites over a 16-day period, it was observed on only three occasions (one small adult and two juveniles) (McKenna 2003).

**Table 14. Inventory of holothuria and urchins**

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| **Holothuria** | | | | | |
| *Pearonothuria graffeii* | x | | x | x | x |
| *Holothuria edulis* | | | x | | |
| *Bohadaschia subrubra* | | | x | | |
| **Urchins** | | | | | |
| *Echinostrephus molaris* | x | x | x | x | |
| *Diadema savignyi* | | | x | x | x |
| *Echinothrix diadema* | | | x | | |

### *2.4.3.2 Reef fish biomass and abundance*

The estimated fish count, mean fish biomass and the most abundant family by count for the five survey sites are presented in Table 15.The estimated reef fish biomass ranged from 1330 kg/ha (std. err. ±444) for the fringing reef Site 5, to 2270 kg/ha (±901) for the barrier reef Site 1.

**Table 15. Summary table of coral reef fish biomass assessment**

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| **Transect 1** | | | | | |
| Approx. fish count | 157 | 263 | 148 | 262 | 216 |
| Biomass (kg/ha) | 3120 | 2120 | 1350 | 1749 | 1374 |
| **Transect 2** | | | | | |
| Approx. fish count | 168 | 227 | 145 | 237 | 164 |
| Biomass (kg/ha) | 1421 | 1495 | 1450 | 995 | 1285 |
| **Site average** | | | | | |
| Mean biomass (kg/ha) | 2270 | 1807 | 1400 | 1371 | 1330 |
| Std. error ± | 901 | 629 | 468 | 506 | 444 |
| Most abundant (% of total fish count) | Acanthuridae (35 %) | Pomacentridae (35 %) | Acanthuridae (28 %) | Acanthuridae (41 %) | Acanthuridae (28 %) |

The minimum fish count per transect was 145 for Site 3; the maximum was 263 for Site 2 (Table 15). The total fish count for both transects per site ranged from 293 (for Site 3) to 499 (for Site 4) (see Figure 10 and Table 16). Acanthuridae were the most abundant family for Sites 1, 3, 4 and 5, its count ranging from 82 (Site 3) to 204 (Site 4). Pomacentridae were most abundant on Site 2 (count 170) and were also common on all of the other sites, ranging from a minimum count of 43 (Site 3) to 100 (Site 4). Balistidae, Lutjanidae and Scaridae were also common on all of the sites.

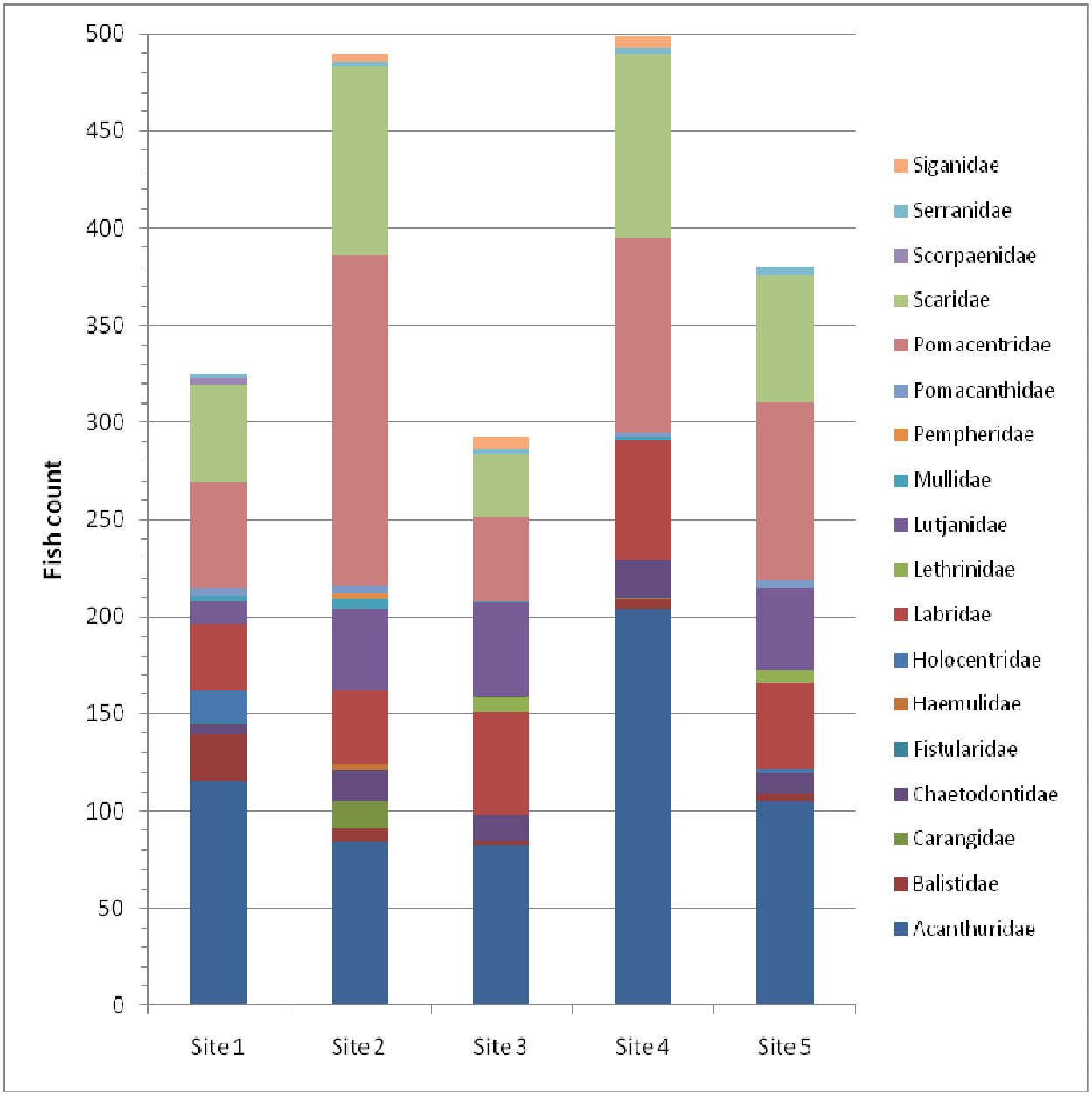


**Figure 10. Fish count by family for each surveying site, measured over 50 m biomass transects.**

**Table 16. Fish count by family for each survey site, measured over 50 m biomass transects.**

| Family | Estimated count of fish | | | | |
|---|---|---|---|---|---|
| | **Site 1** | **Site 2** | **Site 3** | **Site 4** | **Site 5** |
| Acanthuridae | 115 | 84 | 82 | 204 | 105 |
| Balistidae | 24 | 7 | 3 | 5 | 4 |
| Carangidae | 0 | 14 | 0 | 1 | 0 |
| Chaetodontidae | 6 | 16 | 13 | 19 | 11 |
| Fistularidae | 1 | 0 | 0 | 0 | 0 |
| Haemulidae | 0 | 3 | 0 | 0 | 0 |
| Holocentridae | 16 | 0 | 0 | 0 | 2 |
| Labridae | 34 | 38 | 53 | 62 | 44 |
| Lethrinidae | 0 | 0 | 8 | 0 | 6 |
| Lutjanidae | 12 | 42 | 48 | 0 | 43 |
| Mullidae | 3 | 5 | 1 | 2 | 0 |
| Pempheridae | 0 | 3 | 0 | 0 | 0 |
| Pomacanthidae | 4 | 4 | 0 | 2 | 4 |
| Pomacentridae | 54 | 170 | 43 | 100 | 91 |
| Scaridae | 51 | 97 | 33 | 95 | 66 |
| Scorpaenidae | 3 | 0 | 0 | 0 | 0 |
| Serranidae | 2 | 3 | 2 | 2 | 4 |
| Siganidae | 0 | 4 | 7 | 7 | 0 |
| **Total count** | **325** | **490** | **293** | **499** | **380** |

Herbivores along with carnivores constituted the major part of the fish biomass for all sites (see Figure 11, Table 18 and Table 18). Sites 1, 2 and 4 in particular had high proportions of herbivore biomass, ranging from 728 kg/ha (Site 4) to 905 kg/ha (Site 1). The fringing reef sites 3 and 5 had lower herbivore biomasses of 470 and 483 kg/ha respectively. Carnivore biomass ranged from a maximum of 602 kg/ha (Site 1) to a minimum of 182 kg/ha (Site 4).

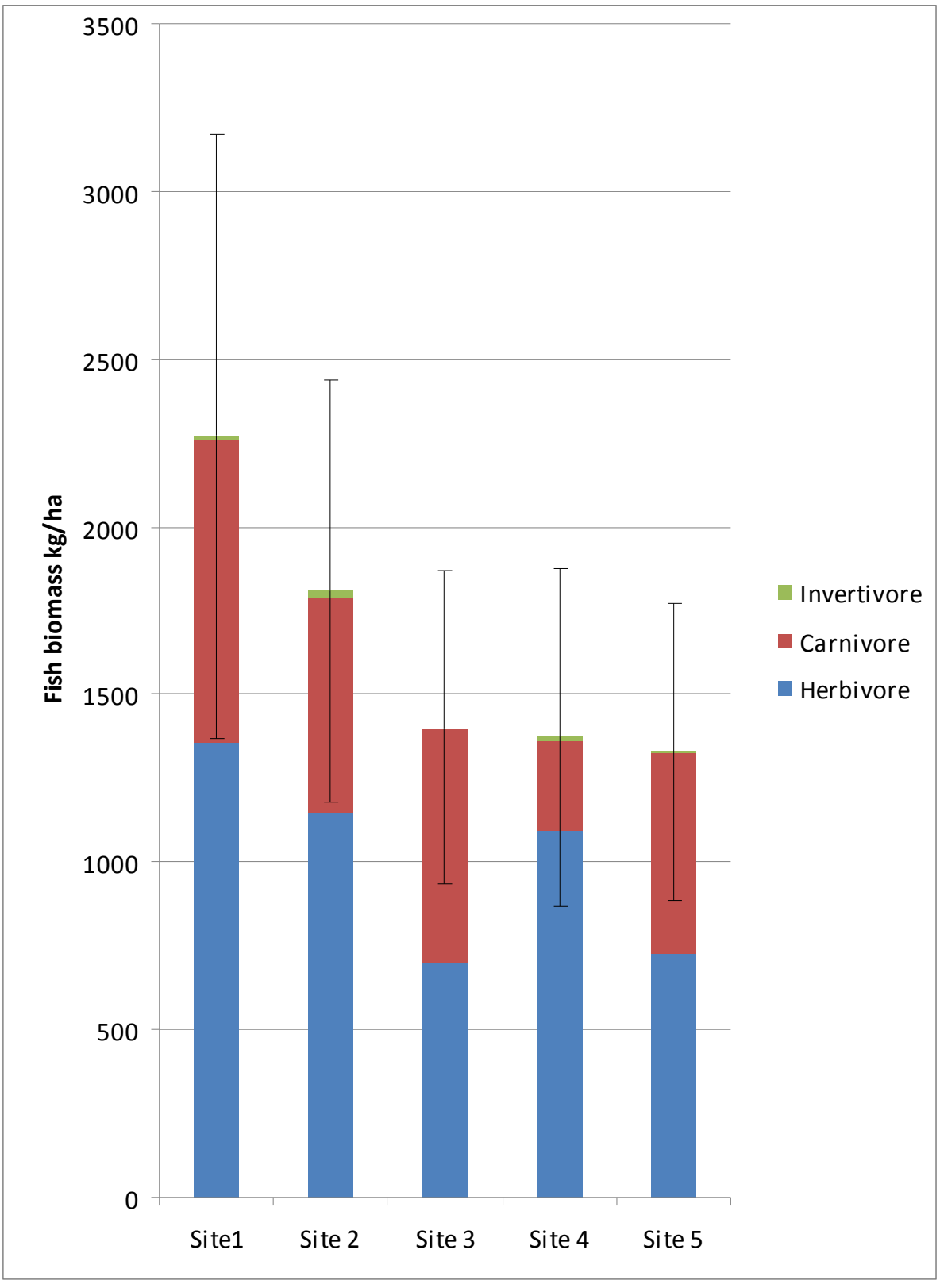


**Figure 11. Mean biomass of reef fish (Kg ha-1) depicting the proportion of each trophic guild (Error bars = ± Standard error of the mean total biomass).**

**Table 17. Reef fish biomass presented by trophic guild (Sites 1 -3).**

| | **Site 1** | | **Site 2** | | **Site 3** | |
|---|---|---|---|---|---|---|
| | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| Herbivore | 1357 | 284 | 1146 | 337 | 705 | 270 |
| Carnivore | 902 | 807 | 645 | 425 | 693 | 136 |
| Omnivore | 6 | 0 | 12 | 5 | 0 | 0 |
| Invertivore | 4 | 4 | 4 | 2 | 2 | 0 |
| **Total biomass** | **2270** | **901** | **1807** | **629** | **1400** | **468** |

**Table 18. Reef fish biomass presented by trophic guild (Sites 4 and 5).**

| | **Site 4** | | **Site 5** | | **Average for all sites** | |
|---|---|---|---|---|---|---|
| | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| Herbivore | 1091 | 570 | 725 | 177 | 1005 | 328 |
| Carnivore | 273 | 140 | 599 | 205 | 623 | 343 |
| Omnivore | 3 | 3 | 3 | 3 | 1.5 | 2 |
| Invertivore | 5 | 2 | 2 | 1 | 0.3 | 0.2 |
| **Total biomass** | **1371** | **506** | **1330** | **444** | **1636** | **675** |

The herbivorous fish families *Acanthuridae* and *Scaridae* frequently made a significant contribution to the total fish biomass (see Table 20, Table 20 and Figure 12). For example, for Site 1 *Acanthuridae* were 1,262 kg/ha of the total fish biomass of 2,270 kg/ha. *Lutjanidae* constituted a large part of the predator biomass for all sites with the exception of Site 4.

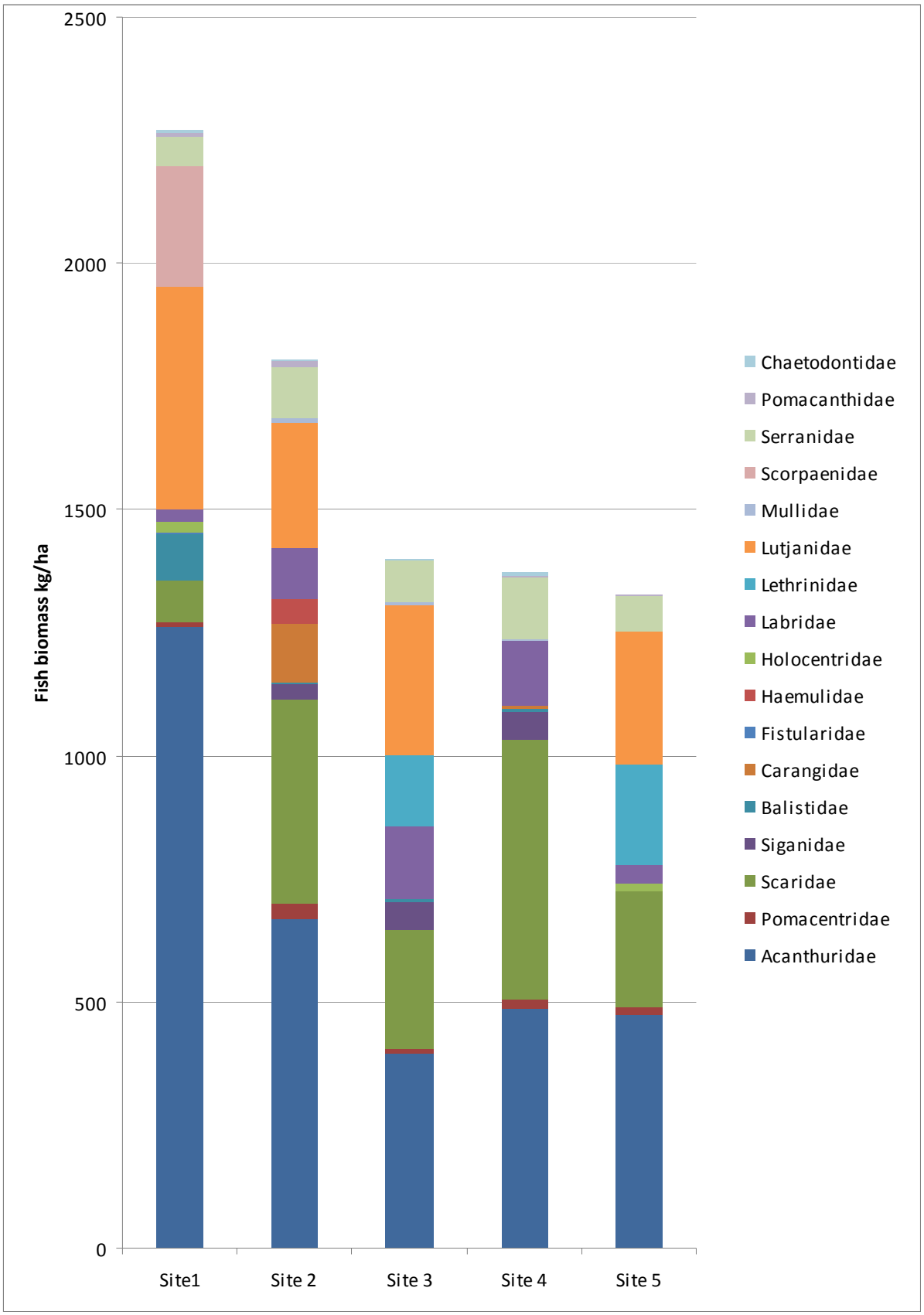


**Figure 12. Contribution of each fish family to the total reef biomass**

**Table 19. Contribution of each family to the total reef fish biomass (Sites 1 and 2)**

| Trophic guild | Family | Site 1 | | Site 2 | |
|---|---|---|---|---|---|
| | | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| Herbivore | Acanthuridae | 1262 | 271 | 669 | 275 |
| | Pempheridae | 0 | 0 | 0 | 0 |
| | Pomacentridae | 10 | 5 | 33 | 3 |
| | Scaridae | 85 | 8 | 412 | 25 |
| | Siganidae | 0 | 0 | 32 | 32 |
| Carnivore | Aulostomidae | 0 | 0 | 0 | 0 |
| | Balistidae | 96 | 86 | 3 | 1 |
| | Carangidae | 0 | 0 | 119 | 119 |
| | Fistularidae | 2 | 2 | 0 | 0 |
| | Haemulidae | 0 | 0 | 50 | 50 |
| | Holocentridae | 21 | 6 | 0 | 0 |
| | Labridae | 24 | 1 | 105 | 16 |
| | Lethrinidae | 0 | 0 | 0 | 0 |
| | Lutjanidae | 453 | 405 | 254 | 170 |
| | Mullidae | 1 | 1 | 10 | 5 |
| | Scorpaenidae | 243 | 243 | 0 | 0 |
| | Serranidae | 62 | 62 | 104 | 64 |
| Invertivore | Pomacanthidae | 6 | 0 | 12 | 5 |
| | Chaetodontidae | 4 | 4 | 4 | 2 |

**Table 20. Contribution of each family to the total reef fish biomass (Sites 3 - 5)**

| Trophic guild | Family | Site 3 | | Site 4 | | Site 5 | |
|---|---|---|---|---|---|---|---|
| | | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| Herbivore | Acanthuridae | 397 | 65 | 486 | 211 | 473 | 14 |
| | Pempheridae | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pomacentridae | 8 | 1 | 19 | 1 | 17 | 6 |
| | Scaridae | 243 | 163 | 529 | 302 | 234 | 157 |
| | Siganidae | 57 | 40 | 57 | 57 | 0 | 0 |
| Carnivore | Aulostomidae | 0 | 0 | 0 | 0 | 0 | 0 |
| | Balistidae | 6 | 2 | 4 | 4 | 1 | 0 |
| | Carangidae | 0 | 0 | 8 | 8 | 0 | 0 |
| | Fistularidae | 0 | 0 | 0 | 0 | 0 | 0 |
| | Haemulidae | 0 | 0 | 0 | 0 | 0 | 0 |

| Trophic guild | Family | Site 3 | | Site 4 | | Site 5 | |
|---|---|---|---|---|---|---|---|
| | | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| | Holocentridae | 0 | 0 | 0 | 0 | 17 | 0 |
| | Labridae | 147 | 9 | 130 | 0 | 36 | 12 |
| | Lethrinidae | 143 | 93 | 0 | 0 | 204 | 0 |
| | Lutjanidae | 307 | 27 | 0 | 0 | 270 | 162 |
| | Mullidae | 5 | 5 | 2 | 0 | 0 | 0 |
| | Scorpaenidae | 0 | 0 | 0 | 0 | 0 | 0 |
| | Serranidae | 85 | 0 | 128 | 128 | 71 | 31 |
| Invertivore | Pomacanthidae | 0 | 0 | 3 | 3 | 3 | 3 |
| | Chaetodontidae | 2 | 0 | 5 | 2 | 2 | 1 |

No large concentrations of commercially important species, such as *Carangidae* and *Scombridae*, were observed. The vast majority of fishers use large gill-nets, such as jarifa and ZDZD,[1] that would target these species and this probably accounts for their relative scarcity. Similarly, few sharks were observed throughout the surveying, with only 2 individuals including a juvenile hammerhead (*Sphyrna* sp.) being seen. Sharks in the area have been targeted for the Asian shark fin trade since the mid-1990s, and particularly intensively since 2006.

### 2.4.4 Condition of coral reefs

In Table 21 and Figure 13, a broad comparison is made between the mean percentage hard coral cover for all of the sites surveyed in the Barren Isles relative to that of other sites surveyed in the region. Clearly percentage hard coral cover depends on the reef type, but comparison of the average of a number of survey sites gives a broad indication of the health of the Barren Isles reefs relative to other areas.

**Table 21. Comparison of the mean percentage hard coral cover of different sites in Madagascar and East Africa**

| | Mean % hard coral cover | Standard Error | Count | Source |
|---|---|---|---|---|
| Barren Isles | 46 | 9 | 4 | This study |
| Tulear South All | 39 | 4 | 25 | Gough *et al.* 2009a; Gough *et al.* 2009b; Ory 2008 ; WWF 2006a ; WWF 2006b ; Walker and Fanning 2003 |
| NE Madagascar | 16 | 2 | 5 | Harding and Randriamanantsoa 2008 |
| Velondriake | 26 | 6 | 9 | Harding *et al.* 2006 |
| East Africa | 26 | 3 | 4 | McClanahan 2006 |

[1] Fishers' pronounciation of GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) – the development agency that first distributed this type of net.

The data show that reefs surveyed in the Barren Isles have a high percentage hard coral cover and attest to the healthy condition of these reefs. At 46 % ± 9, it is comparable to that of the reefs surveyed south of Tulear (which have a mean % hard coral cover of 39 % ± 4) and is much higher than that of the Velondriake MPA, approximately 500 km south of the Barren Isles, where a mean of 26 % ± 6 was recorded.

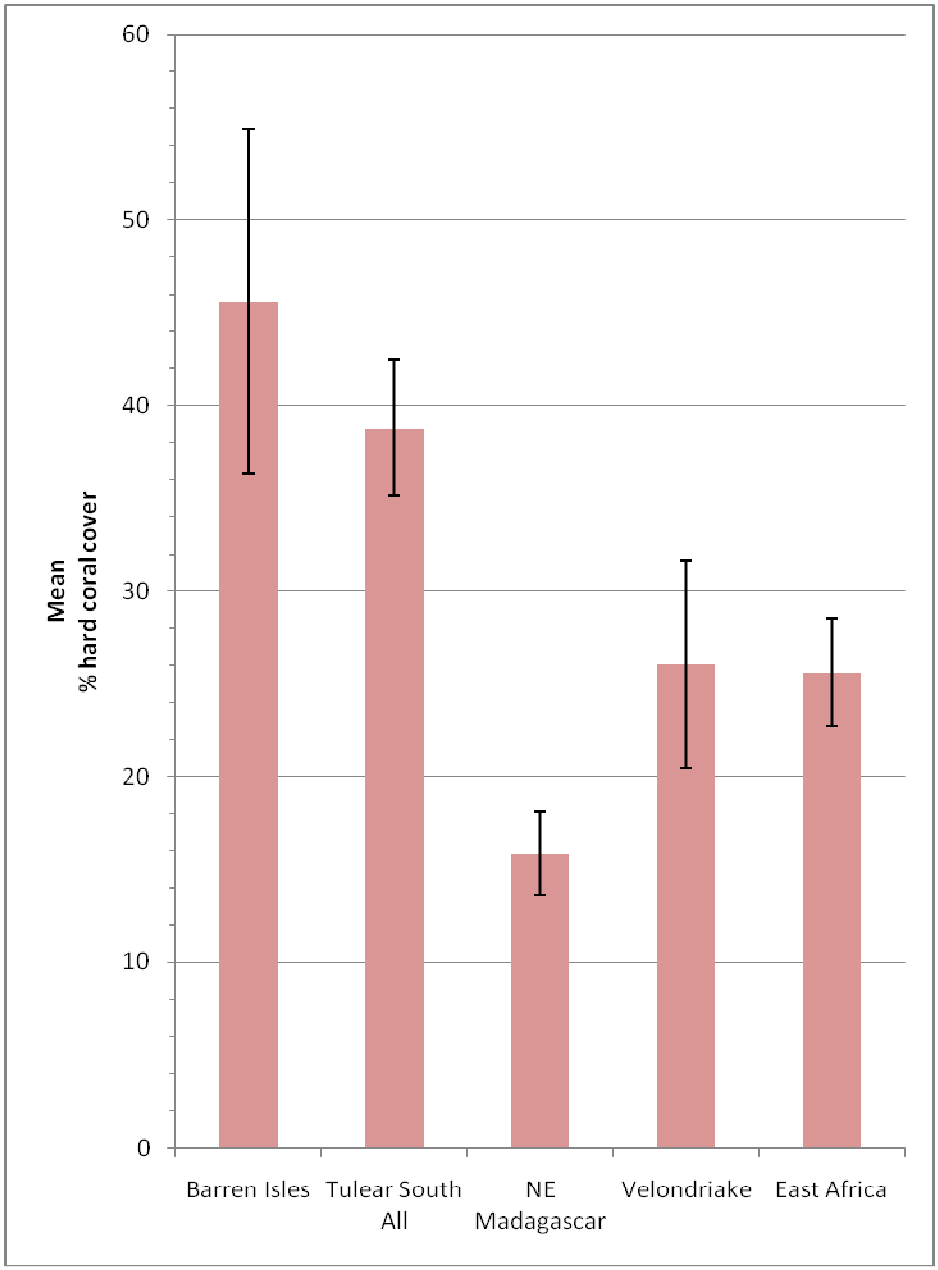


**Figure 13. Mean % hard coral cover of different sites in Madagascar and East Africa**

Table 22 and Figure 14 compare the mean reef fish biomass for site surveyed within the region. The mean fish biomass of the reefs surveyed in the Barren Isles is 1636 kg/ha ± 45 and is considerably higher to that of the mean of Velondriake MPA, 397 kg/ha ± 55. In comparison, the mean fish biomass of 1005 kg/ha ± 277 for "E Africa Managed" – reefs that are within marine reserves – is more similar to that of the Barren Isles and

Tulear south, while those of fished sites in E Africa and NE Madagascar are significantly lower. The data indicates that the Barren Isles experience a lower fishing pressure than other areas in South West Madagascar. This is expected given the lower population pressure and that virtually all fishers use techniques that do not target reef fish, with fishermen targeting shark, mackerel (*Scombridae*) and sea cucumbers.

**Table 22. Comparison of mean biomass of different sites in Madagascar and East Africa**

| | Mean fish biomass Kg/ha | Standard Error | Count |
|---|---|---|---|
| Tulear South | 1313 | 406 | 25 |
| Velondriake | 397 | 55 | 9 |
| Barren Isles | 1636 | 675 | 5 |
| NE Madagascar | 145 | 29 | 5 |
| E Africa | 82 | 9 | 1 |
| E Africa managed | 1005 | 277 | 3 |

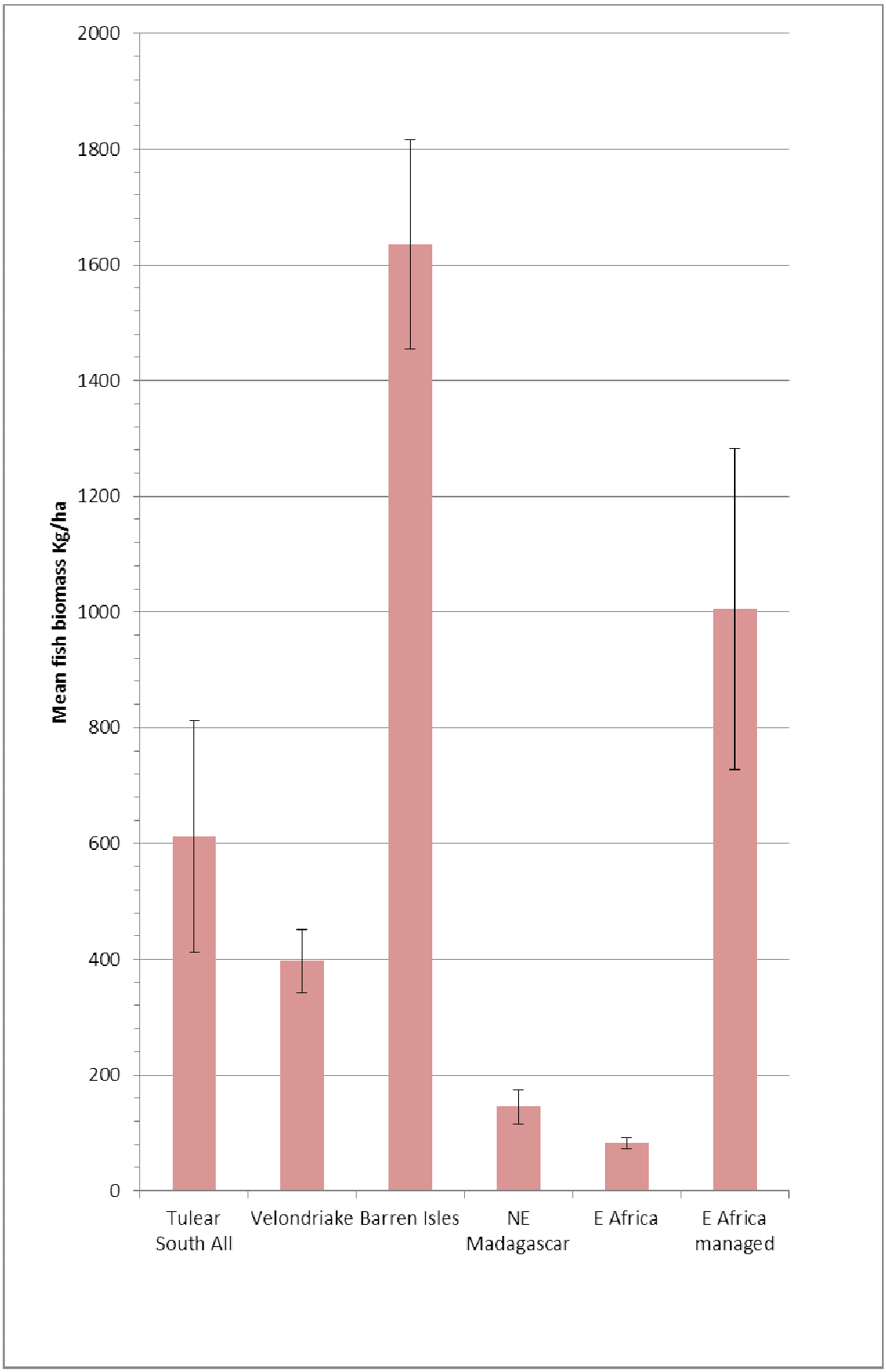


**Figure 14. Mean biomass of different sites in Madagascar and East Africa**

Throughout the study the general observation was that of a coral reef in good condition, taking into consideration levels of scleractinian coral cover, reef fish community structure and biomass and a number of qualitative indicators or reef health, relative to other areas of Madagascar (Figure 13, Figure 14, Table 22, Table 21, **Error! Reference source not found.**, and **Error! Reference source not found.**)

On the reef sites surveyed close to Nosy Manandra and Nosy Mboro, hard coral consistently constituted around 50% of the benthic substrate, and a qualitative estimation of certain reefs close to Nosy Marify, Nosy Maroantaly and the more southern isles of Nosy Mangily and Nosy Lava indicated them to be of poorer health in general (though there were still some smaller reefs of high hard coral cover in good condition in these areas).

The exception of low coral cover observed at Site 1 may be a more typical benthic community of this exposed outer reef.

The Association of South East Asian Nations (ASEAN) system for describing the health of coral reefs states that coral reefs with hard coral cover less than 25% are described as being in 'poor' health, whilst those of cover in excess of 25% are described as 'fair' (Wilkinson 1984). Using the ASEAN classification, all except Site 1 would be described as being of 'Good' or 'Excellent' health.

Scleratinian diversity on these reef sites is also high with 15 and 28 genera being observed on a single site, and low dominance of any single genera, although there were high contributions to total cover from *Porites, Favia* and *Lobophyllia*. While these large, slower growing 'massive' coral growth forms are often cited as being more resistant to heat induced bleaching, their physical form lowers the rugosity or complexity of the coral habitat, when compared with branching and foliose forms, and this has been reported to directly influence reef fish diversity (Graham *et al.* 2006, Wilson *et al.* 2006) as well as to reduce the height of the reef (pseudo sea-level change) and its ability to attenuate the force of the oncoming swell.

Scleractinian corals dominate the benthic community at most sites, but with turf and macro algae also being observed to be of high abundance (between 16 and 62%). Algae compete with recruiting corals for space on the reef, however as the level of these algae do not yet surpass that of the scleratinia it may be an indication that levels of herbivory, from both fish and urchins remain sufficiently high to control algal overgrowth.

Fish diversity was similar between all of the survey sites (0.5 SDI) and is comparable with the diversity seen at other sites in west and south west Madagascar (Gough *et al.* 2009), as well as that observed in managed areas in Kenya (McClanahan 2006).

Herbivorous fish families such as Labridae, Acanthuridae and Pomacentridae are the most abundant and account for a large proportion of the diversity and biomass of these reefs. This is similar to that observed in other fished regions of Madagascar and the WIO (Harding 2006, McClanahan *et al.* 2006, Graham *et al.* 2007, Ahamada *et al.* 2008), however what is noticeable here is that predatory species such as Lutjanidae and Serranidae also comprise a considerable proportion (35 to 50%) of the species richness and biomass, suggesting that these reefs are subjected to lower fishing pressure than observed in other areas of Madagascar. This result is somewhat unsurprising considering that the migrant fishing populations based on these isles' are small and primarily targeting shark (*akio*) and sea cucumber (*zanga*) (Cripps 2009). However, 'pristine' or 'un-fished' reefs in Kenya and Kingman island, south of Hawaii, have been shown to be dominated by

predatory species accounting for up to 70% of biomass (McClanahan *et al.* 2006, Pala 2007). The lower levels observed here may be an indicator that as shark catches decline fishers start to 'fish down the food web' targeting other profitable pelagic and reef fish (Pauly *et al.* 1998) whose also have slow growth rates and low fecundity, and make them more susceptible to over-fishing.

Growing populations of migrant fishers present one of the major threats to the reef systems of the Barren Isles. As local anthropogenic threats and stresses to the reefs increase, such as unsustainable biomass removal, the ability of the reef to adapt to natural disturbances is undermined, exacerbating the effects of natural stresses and causing more pronounced changes to community structure than would normally occur (McClanahan *et al.* 2002).

Sources and levels of damage and stress observed:

- The north westerly reefs showed a very low incidence of mortality and stress from sedimentation. In contrast some of the southern reefs near Nosy Andrano and Nosy Maroantaly showed evidence of high stress from sedimentation/eutrophication, with dead coral substrate overgrown by seagrass, macro algae or covered with silt.
- Evidence of stress from bleaching and coral pathogens was low for the north westerly sites surveyed.
- Damage resulting from the use of anchors and fishing nets was observed near Nosy Manghily and Nosy Manandra but the majority of sites showed no evidence of the impact of fishing actions.
- No evidence of recent physical damage from severe storms or cyclones was observed on the reef sites surveyed. However, there were vast expanses of rocky reef devoid of coral which would normally present suitable substrates for coral but for the constant and high attrition on these reefs caused by currents and swells of the open sea. Corals don't have the opportunity to establish themselves in places where they would be exposed to storms.

Several sources of damage or stress to the coral reefs of Madagascar have been documented elsewhere and include:

- Major bleaching events occurred in the Indian Ocean with the 1998 and 2001 ENSO events. Parts of the SW coast of Madagascar are thought to have been severely impacted by bleaching, particularly shallow fringing reefs.
- Over-fishing of near-shore habitats.
- Over-exploitation of marine resources (e.g. coral extraction, clearing of mangroves).
- Hyper-sedimentation from poor land-use practices (e.g. up-stream slash-and-burn agriculture),
- Destructive fishing practices (e.g. the use of beach seine nets, poison, destructive gleaning practices),
- Point sources of pollution (e.g. sewage from towns and sugar cane effluent),
- Predation by the Crown of Thorns starfish (COTS, *Acanthaster planci*).

In 1998 a global risk assessment of coral reefs found Madagascar's reefs to be at medium to high risk (Bryant *et al.* 1998). The reef surveying team made qualitative assessments of the resilience of the Barren Isle reefs to these stresses by recording qualitative estimates of important stresses and of characteristics that would lend the reefs inherent resilience. These are presented in Table 1.

**Table 23. Summary of qualitative indicators of reef resilience (scale 1-5 (low to high))**

| Site | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| Currents | 2 | 2 | 1 | 3 | 2 |
| Sedimentation | 1 | 1 | 1 | 1 | 1 |
| Micro Complexity | 2 | 4 | 4 | 2 | 4 |
| Macro Complexity | 4 | 3 | 4 | 4 | 4 |
| Wave Action | 3 | 2 | 1 | 4 | 1 |
| Exposure at low tide | 1 | 1 | 1 | 2 | 1 |
| Mortality (old) | 1 | 1 | 1 | 1 | 1 |
| Mortality (recent) | 1 | 1 | 1 | 1 | 1 |
| Fishing Pressure | 1 | 2 | 2 | 2 | 2 |

**Table 24. Comparison of the mean fish biomass and % hard coral cover for different sites within Madagascar and the region.**

Data sources: [1]This sudy; [2]Gough *et al.* 2009a; [3]Gough *et al.* 2009b; [4]Harding and Randriamanantsoa 2008; [5] Harding *et al.* 2006; [6]Ory 2008; [7]Walker and Fanning 2003; [8]WWF 2006a; [9]WWF 2006b; [10]McClanahan 2006.

| Country | Village | Site Name | Year | Mean Biomass Kg/ha | Std. error | Hard Coral % Cover | Std. error |
|---|---|---|---|---|---|---|---|
| Madagascar[1] | Maintirano | Site1 | 2009 | 568 | 212 | 18 | 2 |
| | Maintirano | Site2 | 2009 | 452 | 78 | 56 | 2 |
| | Maintirano | Site3 | 2009 | 350 | 13 | 49 | 2 |
| | Maintirano | Site4 | 2009 | 343 | 94 | - | - |
| | Maintirano | Site5 | 2009 | 332 | 11 | 59 | 5 |
| Madagascar[2] | Fanombosa | Beakio | 2009 | 175 | 17 | 43 | 6 |
| | Fanombosa | Rekitoto | 2009 | 19 | 6 | 62 | 7 |
| | Fanombosa | Berisitoaly | 2009 | 4603 | 1364 | 36 | 3 |
| | Ambohibola | Nosy Manitse | 2009 | 6 | 2 | 51 | 5 |
| | Ambohibola | Tsilomaitata | 2009 | 39 | 14 | 67 | 4 |
| | Androka Ela | Nosimboro | 2009 | 110 | 14 | 58 | 3 |
| | Androka Ela | Ambatovakivaky | 2009 | 186 | 42 | 39 | 3 |
| | Androka Ela | Lavabe | 2009 | 77 | 29 | 10 | 2 |
| | Itampolo | Tapikara | 2009 | 133 | 36 | 49 | 3 |
| | Ambola | Lovobato | 2009 | 110 | 35 | 59 | 3 |
| | Ambola | Ampiabaza | 2009 | 134 | 18 | 30 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ambola | Ampasimagnora | 2009 | 51 | 5 | 23 | 5 |
| Madagascar[3] | Ambohibola | Ankara Ambohoe | 2008 | 297 | 22 | 34 | 3 |
| | Ambohibola | Nosimbato | 2008 | 412 | 22 | 67 | 8 |
| | Ambohibola | Ambolafoty | 2008 | 1378 | 101 | 74 | 4 |
| | Itampolo | Ankara | 2008 | 387 | 14 | 53 | 8 |
| | Itampolo | Mahadrano | 2008 | 998 | 102 | 29 | 4 |
| | Itampolo | Belamiera | 2008 | 2202 | 284 | 19 | 3 |
| | Itampolo | Tambohoabo | 2008 | 474 | 56 | 19 | 3 |
| | Beheloke | Maromalinike | 2008 | 302 | 16 | 16 | 3 |
| | Beheloke | Ranolaly | 2008 | 1604 | 193 | 24 | 4 |
| | Beheloke | Tanyvao | 2008 | 135 | 21 | 24 | 4 |
| | Maromena/Befasy | Lavapano | 2008 | 479 | 51 | 20 | 4 |
| | Maromena/Befasy | Bezamba | 2008 | 153 | 6 | 37 | 3 |
| | Maromena/Befasy | Ankara MB | 2008 | 829 | 108 | 27 | 3 |
| Madagascar[4] | NW Madagascar | Sahamalaza (M) | 2008 | 252 | 16 | 16 | 3 |
| | NE Madagascar | Tanjona (M) | 2008 | 111 | 12 | 12 | 1 |
| | NE Madagascar | Cap Masoala (M) | 2008 | 96 | 13 | 13 | 2 |
| | NE Madagascar | Tampolo (M) | 2008 | 163 | 24 | 24 | 4 |
| | NE Madagascar | Mananara (M) | 2008 | 102 | 13 | 13 | 2 |
| Madagascar[5] | Andavadoaka | SA | 2006 | 403 | 105 | 23 | - |
| | Andavadoaka | NF | 2006 | 303 | 65 | 17 | - |
| | Andavadoaka | Valley | 2006 | 426 | 76 | 14 | - |
| | Andavadoaka | THB | 2006 | 660 | 446 | 40 | - |
| | Andavadoaka | OO7 | 2006 | 514 | 71 | 50 | - |
| | Andavadoaka | Recruitment | 2006 | 352 | 144 | 46 | - |
| | Andavadoaka | Coco beach | 2006 | 464 | 289 | 32 | - |
| | Andavadoaka | Andava Rock | 2006 | 396 | 242 | 9 | - |
| | Andavadoaka | HalfMoon | 2006 | 53 | 3 | 4 | - |
| Madagascar[6] | Ranobe | Ankaran-djelita | 2008 | - | - | 57 | 4 |
| | Ranobe | Cathédrale | 2008 | - | - | 19 | 1 |
| | Ranobe | Vato Be | 2008 | - | - | 12 | 6 |
| | Ranobe | Coral Garden | 2008 | - | - | 35 | 10 |
| | Ranobe | Massif des roses (M) | 2008 | - | - | 44 | 11 |
| | Ranobe | Beantsitsy | 2008 | - | - | 59 | 8 |
| Madagascar[7] | Anakao | Soalara/Anakao | 2002 | 1460 | - | - | - |
| Madagascar[8] | Salary | Salary North | 2006 | - | - | 33 | 4 |
| Madagascar[9] | Tulear South | Beheloke to Itampolo | 2006 | 1365 | 615 | 32 | - |
| East Africa[10] | Tanzania | Fishery managed | 2004 | 457 | 8 | 28 | 4 |
| | Kenya | Protected (M) | 2004 | 1354 | 89 | 33 | 6 |
| | Kenya | Fished Control | 2004 | 82 | 9 | 20 | 3 |
| | Kenya | Unfished Control | 2004 | 1205 | 35 | 22 | 4 |

(M - Managed)

## 2.5 Seagrass beds

In the vicinity of the isles, the tidal reef flats and the offshore shoals there are extensive areas of shallow seabed with clear waters that would provide the right conditions for sea grasses.

The study did not specifically survey for sea grasses, but stands were noted on the sub-tidal reeflats of Nosy Manghily (S and SW), Nosy Abohazo (S and SW) and Nosy Maroantaly (E). With the exception of the beds on the eastern reef flat of Nosy Maroantaly (which was particularly dense), all of these seagrass beds were characterised by a sparse growth and low biomass. Species of sea grass that are likely to occur in the Barren Isles include: *Syringodium isoetifilium*, *Thalassia hemprichii, Thalassodendron ciliatum*, *Halodule uninervis, Halodule wrightii*, *Cymodocea rotundata, Cymodocea serrulata*, *Syringodium* and *Halophila* spp.

## 2.6 Mangrove forests and coastal wetlands

Between Maintirano and Soahany there are three areas of mangroves with associated wetlands and salt flats (*flats)*, each separated from the other by higher areas of sand dunes, "grassland-wooded grassland mosaic" and Western dry forest. Figure 15 presents and overview of the coastal vegetation, while enlargements of each mangrove area are shown in Figure 16, Figure 17 and Figure 18. The largest mangrove and wetland complex stretches from Maintirano south to Manombo-Sakatay; another is centred around Ampandikoara; and a third, smaller mangrove forest is located further south near the village of Antsorosoro (just North of the Namakia point). The areas consist of a mosaic of mangroves, wetlands and flats and areas of cultivation. In total they comprise 29 km² of mangroves, 23 km² of wetlands and 48 km² of croplands. To the south there are more extensive mangrove-wetland complexes at Soahany and Mozambika-Benjavily. The coastline north of Maintirano continuing until Cap St. Andre is dominated by extensive mangroves and associated wetlands and flats.

The mangrove-wetland complexes are protected from the sea by sand dunes and the passages between the sea and the mangroves are relatively narrow compared to the length of the mangrove forests. Behind the sand dunes protected lagoons are formed where the alluvial sediment is deposited and mangroves are able to establish.

Seven species of mangrove occur in these forests: *Avicennia marina* (vernacular – Afiafy), *Rhizophora mucronata* (Tangalahy/honkolahy)*, Ceriops tagal* (Tangavavy/honkovavy)*, Bruguiera gymnorrhiza* (Tangampoly), *Heritiera littoralis* (Moromony), *Sonneratia alba* (Fobo) and *Lumnitzera racemosa* (Roneho).

The forests show a gradation of species moving from the seaward edge inland that is characterisitic of mangroves and is determined chiefly by salinity and the degree to which the substrate is anaerobic: The edge closest to the sea *Avicennia marina* and *Sonneratia alba* grow, with *A. marina* dominating. Behind this band occurs an intermediate zone of channels where *Rhizophora mucronata* occurs. It grows particularly on the convex banks of the channels where the salinity is lower than that of the inner concave banks. Here, *A. marina* dominates. Behind the channels, mangrove and non-mangrove plants are found: *Bruguiera gymnorrhiza* and

*Ceriops tagal* grow in equal proportions, interspersed by a few *Carapa obovata*. Finally, in the inner zones grow stands of *Heritiera littoralis* associated with a few *R. mucronata*. Beds of *Typha augustifolia* (vondro) also grow on the edges of the channels.

Salt flats frequently form an inland border to the mangroves. As the mangroves progress outwards towards the sea, the inland areas become less accessible to the movement of water, are only flooded during strong spring tides and are no longer flushed by water of lower salinity. The resulting build-up of salt eventually results in a substrate that is hostile to the growth of mangroves and consequently the inner mangrove border progresses towards the sea. The resulting salt flats are often bare of plant life. However, flats are also found in the area that have been colonised by halophytes, such as *Arthrocuenum nidium*, *Sporobulus virginicus*, *Fimbristylis abbreviata* and *F. ferruginea* (Leroux-Pinoesch, 1998).

The mangroves wetlands provide habitat for crocodiles *Crocodilus niloticus*, large numbers of juvenile Bull sharks during the rainy season, and may still support species of sawfish *(Pristidae)*, all three of which are Critically Endangered (IUCN 2009). Similar coastal wetlands in Soahany support the Critically Endangered Madagascar Fish Eagle (*Haliaeetus vociferoides*), and a number of threatened wetland species, including the Madagascar Teal (*Anas bernieri*), Madagascar Plover (*Charadrius thoracicus)*, Madagascar Pond-heron (*Ardeola idae)*, Madagascar Heron (*Ardea humbloti)* and Madagascar Crested Ibis (*Lophotibis cristata)* (REF). The mangrove-wetland complexes occurring between Maintirano and Soahany have not been scientifically surveyed, but they could constitute areas of high conservation importance.

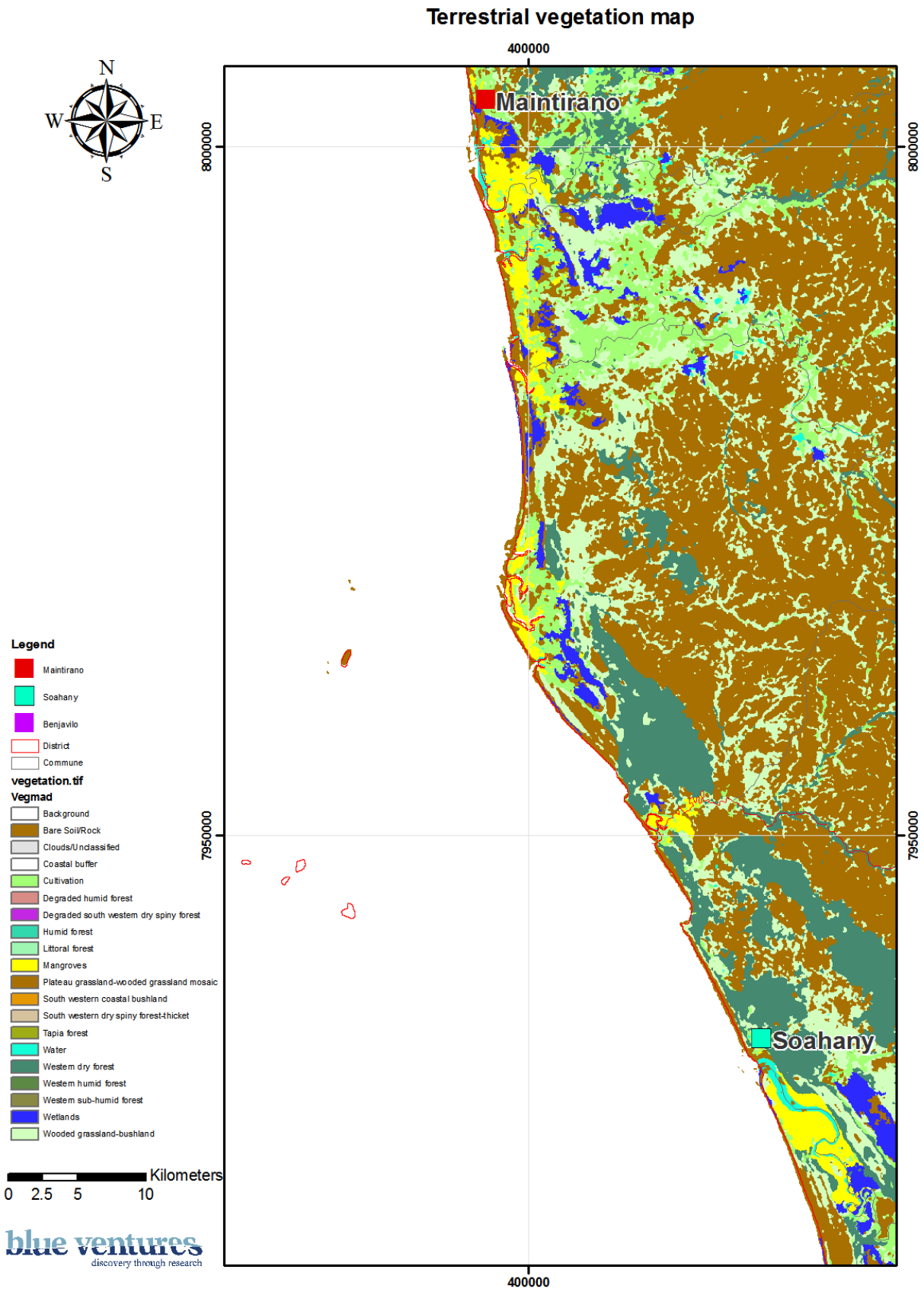


**Figure 15. Coastal vegetation of the coastland neighbouring the Barren Isles (adapted from CEPF Madagascar Vegetation Mapping Project, www.vegmad.org)**

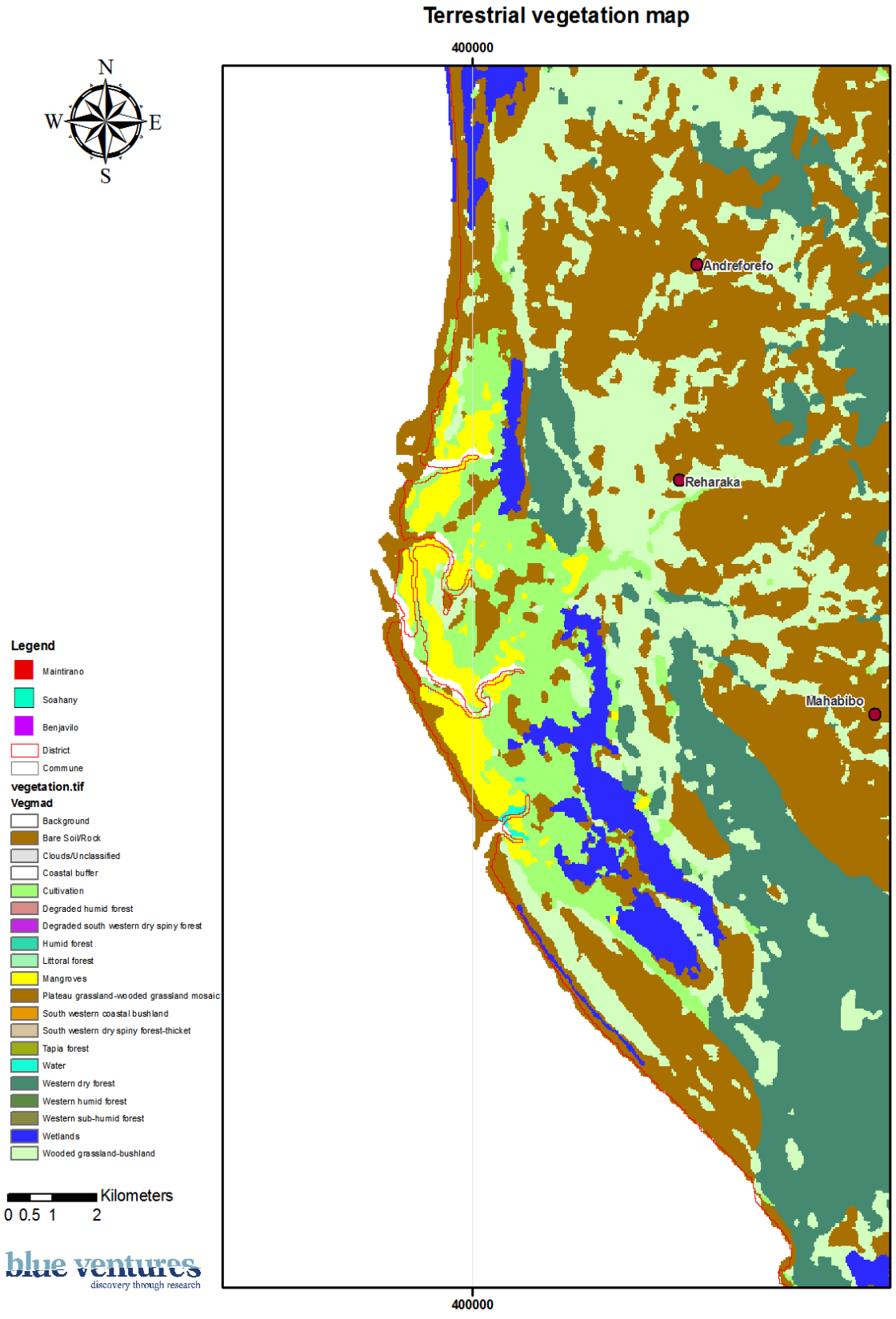


**Figure 16. Coastal vegetation of the Ampandikoara area (adapted from CEPF Madagascar Vegetation Mapping Project, www.vegmad.org)**

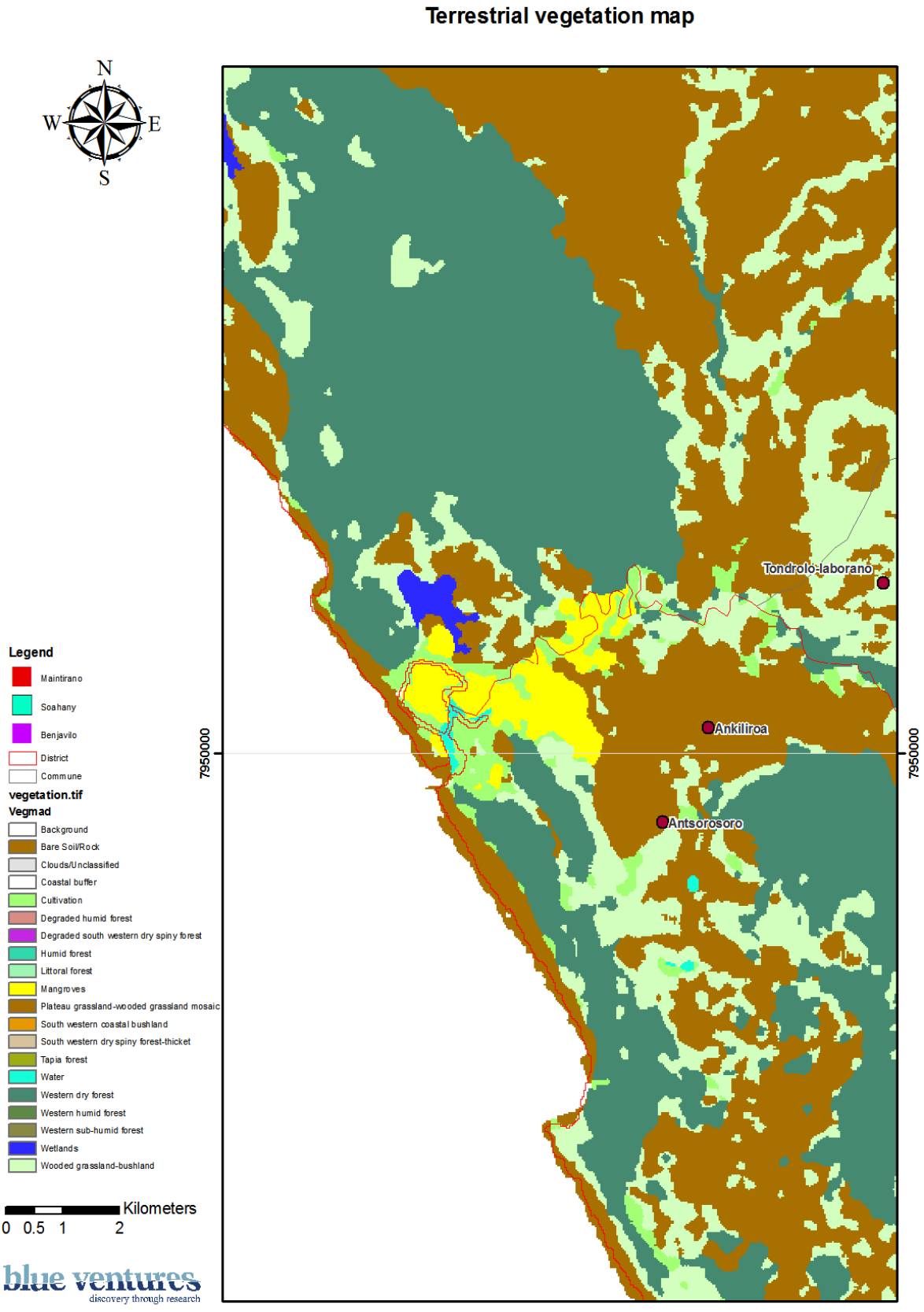


**Figure 17. Coastal vegetation map of the Namakia area (adapted from CEPF Madagascar Vegetation Mapping Project, www.vegmad.org)**

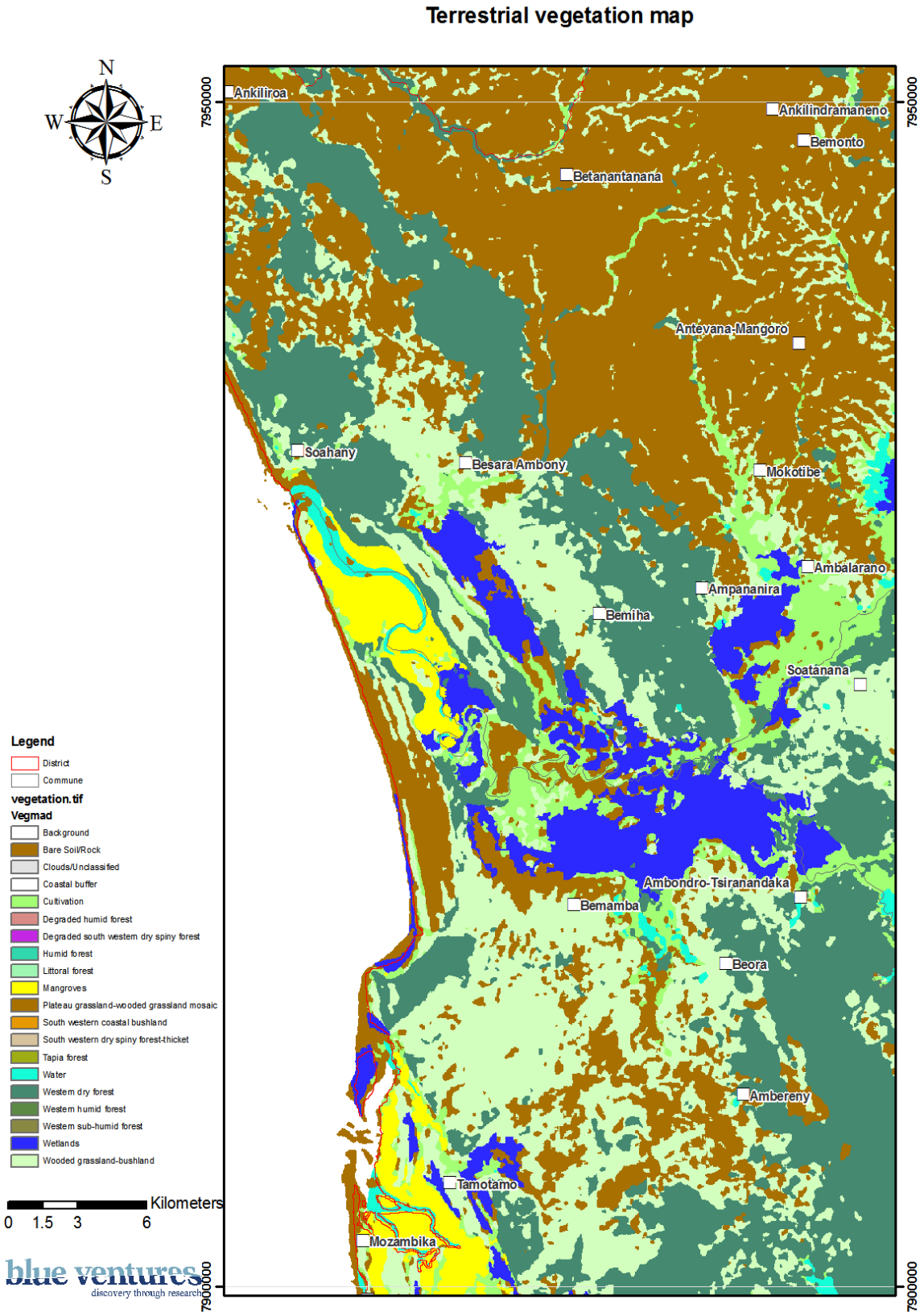


**Figure 18. Coastal vegetation map of the Soahany area (adapted from CEPF Madagascar Vegetation Mapping Project, www.vegmad.org)**

## 2.7 Littoral vegetation

In addition to mangroves, wetlands and cultivated areas, there are four habitats found in the littoral[1] zone that occur on the coastline opposite the Barren Isles: sand dunes (25 km²), plateau grassland-wooded grassland mosaic (69.9 km²), Western dry forest (53.4km²) and wooded grassland-bushland (51.8 km²)[2].

### 2.7.1 Sand dunes

Three chains of dunes, running approximately North to South, define the coastal ecosystem. They differ in age, with the most ancient found inland to the East and the most recent bordering the sea.

1. The most ancient dunes are vestiges of a Karimbolien chain and are made up of ocre and dark-grey sands. They are consolidated by a xerophytic vegetation and define the inland extent of the mangroves and flats.

2. The dunes of intermediate age (Flandrien) are interspesed as 'islands' within the mangroves and ridges and hillocks outside of them. The species here are halotolerant and adapted to dry conditions; typically they include: *Hyphaene shatan* (satra or satrana in Malagasy) a small, fire-tolerant palm characteristic of dry areas; *Scaevala plumieri* (barabaka), shrub-like plant that colonises the external border of the dunes; *Ziziphus jujuba* (enkonazy); *Poupartia caffra* (sakoa); *Commiphora simplicifolia* (fatsakatra); *Commiphora basiodioea* (arofi); *Flacourtia ramontchii* (lamoty); *Euphorbia stenoclada* (famatafotsy); and *Andansonia grandidieri* (renala, Grandidier's baobab).

3. Alluvial sediment and coral sand feed the most recent system of dunes; the prevailing winds, marine currents and river hydrodynamics define their form. They run in long stretches, broken only by the outlets of the rivers. They form a protective barrier for the estuaries, creating the conditions where alluvial sediment can build-up and where it is possible for mangroves to establish themselves. Here occurs littoral vegetation that is typical of the West coast of Madagascar. In addition to the species presented above in point 2, the following species are frequently found in proximity to the sea: *Ipomea pescaprae* (lalanda), the pan-tropical creeping vine that dominates the seaward slopes of the dunes; *Canavalia octucipholia* (ialandana); *Cynodon dactylan* (kidresy); and the coconut, *Cocos nucifera* (voanio).

The more recent system of dunes form long stretches of beach sand, cut only by the river mouths (vavarano), that run south form Maintirano until the rocky outcrops of Point Antsavaky and Point Namakia. Here the coastline is defined by small rock cliffs descending into the water, and ancient sand dunes that rise abruptly from the edge of the sea to ca. 120 m above sea level.

[1] Habitats occuring at the coastal fringe and that are above the high-tide mark.
[2] According to the classification of the Madagascar Vegetation Mapping Project

### 2.7.2 Western dry forest

The Western dry forests of Madagascar have suffered greater levels of deforestation than the humid eastern forests, with 97 % of dry deciduous forests having been lost (Whitehurst *et al.* 2009). These forests of western Madagascar are some of the world's richest and most distinctive tropical dry forests. They are characterized by very high local plant and animal endemism at the species, genus and family levels.

The dry deciduous forest ecoregion of Madagascar includes a narrow and fragmented band of coastal, or littoral, forests. Most of these littoral forests have already been degraded or destroyed, and the remaining remnants are highly fragmented. However, within them occur rare and locally endemic genera and species of plants. Littoral forests are particularly vulnerable to fragmentation, are presently poorly protected and are considered one of the most threatened ecosystems in Madagascar. Between Ampandikoara and Soahany there are two areas of Western dry forest that border the coast, descending right to the sea edge in parts. The study did not survey these areas, but they would be expected to support a number of species of high conservation value. The forests are reported to be relatively intact on the western side, but have been heavily exploited on the more accessible eastern sides.

### 2.7.3 Grassland-wooded grassland mosaic

Repeated burning of the Western dry forest quickly reduces the soil nutrients, prevents regeneration of native tree species and favours fire-resistant grasses. The secondary grasslands found along the coast arose from the frequent burning of forest in the area for cultivation. They have very low faunal and floral diversity, and are dominated by pan-tropical grass species. These grasslands are virtually sterile landscapes of low ecological value.

### 2.7.4 Island vegetation

Nosy Marify and Manandra are sand cays bare of any vegetation. The vegetation on the other isles is very similar to that growing on the outer sand dunes of the coast and is frequently comprised of salt-tolerant, psammophillous plants. Common speices include: *Hyphaene shatan*, *Ziziphus mauritania*, *Cryptostegia madagascariensis* and *Ipomea pescaprae*. In addition, Nosy Lava, Andrano, Maroantaly and Abohazo have a diversity of tree species growing on them that would suggest the availability of ground water. Nosy Manghily has far fewer trees and woody shrubs, and Nosy Dondosy is colonised only by *Hyphaene shatan* and thickets of *Flacourtia indica*. Nosy Mvory has no trees growing on it, being only vegetated by grasses and sedges (*Cyperus* spp.).

A previous study (Leroux-Pinoesch 1998) catalogued 78 species of plants that included a wide variety of trees, shrubs, grasses and vines on the isles of Nosy Lava, Andrano and Manghily. Nosy Lava had 58 species (17 of which were unique to that isle); 54 species on Nosy Andrano (14 unique to the isle); and 24 species on Nosy Manghily (4 unique to the isle). Not all of the specimens were reliably identified.

Nosy Andrano is colonised by the palm *Phoenix rectruata* (kelalo in Malagasy), *Aloe divaricata* (vaho), and *Casuarina equisetifolia* (akao). A small mangrove forest (*Avicennia marina*) exists near the centre of Nosy Andrano.

*Flacourtia indica* (lamoty), which produces edible fruit, has colonised most of the isles and thickets of it cover extensive areas of Nosy Maroantaly and Nosy Lava. *Casuarina equisetifolia* grow in groups or as dispersed individuals, particularly on Nosy Lava, Nosy Andrano and Nosy Maroantaly, but are absent from Nosy Dondosy. Other tree species that were noted on the wooded isles included: *Raphia farinifera*, *Tamarindus indica*, *Salvadora angustifolia*, *Azima tetracantha*, *Prunus* spp., and *Ziziphus mauritiana*.

Nosy Lava and Manghily have open areas of grasslands (e.g. Poaceae*, Cynodon dactylon*) in the central areas of the isles that are colonised groups of woody shrubs.

The invasive dominance of *Flacourtia indica* on large parts of Nosy Lava and Maroantaly and *Malvaceae* sp. (falorao) on the southern end of Nosy Abohazo, as well as the presence of stands of sisal *Agave sisalana* on Nosy Lava, indicates a strong human influence on the vegetation of these isles. Nosy Maroantaly was reported to be cultivated at the end of the 19$^{th}$ century; the French are said to have built an airstrip on Nosy Lava in the 1970s; and Nosy Andrano was mined for guano in the 1990s, with a permanent workforce living on the isle. Human presence would have brought rats and other alien invasives to the isles. Today Nosy Maroantaly is infested by feral cats, while on Nosy Abohazo a Vezo taboo prohibits killing or hurting rats and they can be seen in broad daylight. It is unlikely that much of the original fauna of the isles is still present.

## 2.8 Species of high conservation value

### 2.8.1 Ray-finned fishes

Seven teleost fish species associated with reefs are known from Madagascar and included in the IUCN Red List. This number is based on relatively little data and is likely to increase as new fish species are added to the Red List and as knowledge of Madagascar's marine fish fauna improves.

| Latin name | Common name | Occurrence in Madagascar | Distribution | IUCN Red List Category |
|---|---|---|---|---|
| *Epinephelus lanceolatus* | Giant grouper | Rare, occurs in all reef regions of Madagascar | Reefs, 0 to 100 m | VU |
| *Epinephelus marginatus* | Dusky grouper | Uncertain (IUCN); occurs according to FishBase; not reported in local research | Reefs, 0 to 300 m | EN |
| *Epinephelus fuscoguttatus* | Brown marbled grouper | Occurs in reefs of NW and SW Madagascar | Reefs, 0 to 60 m | NT |
| *Cephalopholis* | Bluelined coral | Occurs in all coral | Reefs, 0 to 60 m | LC |

| | | | | |
|---|---|---|---|---|
| *boenak* | cod | reef regions of Madagascar | | |
| *Dermatolepis striolata* | Smooth grouper | Uncertain occurrence according to IUCN but reported locally in NW and SW | Reefs, 0 to 60 m | DD |
| *Cheilinus undulatus* | Napoleon wrasse | Widespread on coral reefs of Madagascar but uncommon | Reefs, 0 to 60 m | EN |
| *Bolbometopon muricatum* | Bumphead parrotfish | Rare, reported from coral reefs in NNE, NW and SW reef regions | Reefs, 0 to 60 m | VU |

### 2.8.2 Sharks and rays

The sharks and rays (which include the sawfish and chimaeras) share the common characteristics of late age maturity, low fecundity and large size, making them particularly vulnerable to exploitation. Many sharks and rays are now vulnerable to extinction and they are of high conservation priority as a group of species.

What attracts migrant Vezo fishers to the Barren Isles are the still productive shark and sea cucumber fisheries. The composition of their catch gives an indication of what species commonly occur in the area. Fishermen on the isles report frequently catching: *Carcharinus melanopterus* (Akio mainty lambosy in Vezo), *Sphyrna lewini* (Akio viko), *Galeocerdo cuvier (*Akio kary), *Stegostoma fasciatum* (Akiodrangita), *Rhyncobatus sp.* (Soroboay), *Carcharhinus limbatus* (Akio fesoke), *Odontaspis noronhai* (Akio ragnaragna), *C. leucas* (Boriloha), *Triaenodon obesus* (Kivirovola) and an unidentified species, called Akio vantasy.

The distribution of the sharks and rays of Madagascar is not well-known, but given the diversity of productive marine and coastal ecosystems that the Barren Isles straddles, the diversity of Chondrichthyes in the region is likely to be high. A study of the traditional shark fisheries of southwest Madagascar listed 34 species of shark that are commonly caught by traditional fishers.[1] Many of these species have been recorded in the monitoring of shark fisheries in Mahajanga and it is very probable that they will occur in the Barren Isles area. They include the threatened scalloped hammerhead (*Sphyrna lewini)*, the zebra shark (*Stegostoma fasciatum)* and the bull shark (*C. leucas*).

Local fishers stated that sawfish *Pristis* spp. (vava in Vezo) were commonly caught near the mangroves and wetlands of the area until 8 to 10 years ago. Local people used the rostra as implements / tools and many fisher households were seen still have them as ornaments. However, presently it is extremely rare for them to be caught. Sawfish are Critically Endangered (IUCN, 2009) and are listed on Appendices I and II of CITES.

[1] The traditional shark fisheries of southwest Madagascar: A study in the Toliara region, Fisheries Research 82 (2006) 280–289, Angus R. McVean, Ryan C.J. Walker, Eibleis Fanning and references sited therein.

Five to seven species are recognized worldwide, of which up to three may occur in Madagascar - the large tooth sawfish *Pristis microdon*, the green sawfish *P. zijsron* and the knifetooth sawfish *Anoxypristis cuspidate*. The large tooth sawfish is (or was) the main species in Madagascar. In the 1960s, sawfish were commonly fished in the West coast estuaries of Madagascar. Today, they are very rare, probably due to a combination of shrimp trawling, the use of gill nets across rivers and the setting of estuarine fish fences (valakyra). They are particularly vulnerable to entanglement in nets. Sawfish may also have been adversely affected by sedimentation of their habitat due to inland deforestation.

There is evidence that sawfish still exist in reduced numbers, particularly in the West and North West of Madagascar around Nosy Be and the Mahavavy, Tsiribihina and Mangoky river deltas. West Madagascar may constitute a last stronghold in the Western Indian Ocean for sawfish.

The whale shark *Rhincodon typus* is listed as vulnerable and is on Appendix II of CITES. Whale sharks were recorded in the region of the Barren Isles on the edge of the continental shelf during aerial surveying in February 2010. Whale sharks migrate vast distances and are capable of trans-oceanic movements. The migratory routes and site-fidelity of whale sharks in the Western Indian Ocean are poorly understood.

The Madagascar skate *Dipturus crosnieri* is one of few marine fish species endemic to Madagascar. It is a relatively small and rare deepwater skate with a distribution limited to the continental slope off the west coast of Madagascar. Virtually nothing is known of the biology of the species.

The deep-water skate *Rostroraja alba* is Endangered and 17 other species are Vulnerable.

### 2.8.3 Coelacanth (*Latimeria chalumnae*)

During an expedition to the isles Leroux observed and photographed a coelacanth on 18 June 2006. It had been caught by shark fishermen to the south of Nosy Lava at a depth of 140 m. It measured 1.71 m and its stomach contained only the remains of jelly fish bathed in a white, viscous liquid. The fishermen reported that they had not caught such a fish before.

The Coelacanth (*Latimeria chalumnae)* - known as the "living fossil" occurs in the vicinity of the Grand Comoro and Anjouan islands, and the coasts of South Africa, Madagascar and Mozambique. It is a Critically Endangered species and in South African coastal waters is regionally extinct (Musick, 2000).

### 2.8.4 Marine turtles

Five of the world's seven marine turtle species are observed in the Barren Isles: the Leatherback, the Loggerhead, the Hawksbill, the Green turtle and the Olive Ridley. The IUCN Red List status of these species (and whether they nest in the Barren Isles) are summarized in Table 25. Marine turtles' long life span and complex life cycle make them vulnerable to a multitude of threats and all of these species are classified as threatened, ranging from Vulnerable (Olive Ridley) to Critically Endangered (Leatherback and Hawksbill). Two species nest on the Barren Isles (Green and Hawksbill), while two others nest (or once did) on the mainland (Loggerhead and Olive Ridley).

**Table 25. Summary of the sea turtles occurring in the Barren Isles**

| | Leatherback | Loggerhead | Hawksbill | Green | Olive Ridley |
|---|---|---|---|---|---|
| **Scientific name** | *Dermochelys coriacea* | *Caretta caretta* | *Eretmochelys imbricata* | *Chelonia mydas* | *Lepidochelys olivacea* |
| **Vezo name** | fano ronto, valo zoro | fano apombo | fano hara | fano zaty, fano omby | fano tsakoi |
| **Observations** | Within the region it is the rarest of the five species | Less appreciated because of the strong odour of the flesh | The only species whose carapace is locally traded on an *ad hoc* basis | The most common species in the region; prized for its fat and eggs; the most fished | |
| **IUCN status** | Critically Endangered | Endangered | Critically Endangered | Endangered | Vulnerable |
| **Interest to local fishers** | * | ** | ** | *** | ** |
| **Nests in the Barren Isles** | No | No, but does on the coast | Yes | Yes, the most frequent | No, but does on the coast |

Source: Leroux, http://www.tortuesilesbarren.org and http://www.iucnredlist.org/

Genetic analysis of Green turtle populations in the South West Indian Ocean showed that six distinct groupings exist (Taquet, 2007): La Réunion, Europa (Ponte), Cosmolédo, Tromelin, Mayotte and the Barren Isles. These different meta-populations constitute management units that would form the basis for the development of a conservation management plan for this endangered species. The management units are of importance because of both their genetic distinctiveness and diversity. The Barren Isles group is not considered to be of first-order priority, but is important nonetheless.

Research carried out in 2000 at three sites along the North West coast of Madagascar (Nosy Iranja, the Radama Islands and the Nosy Hara archipelago) suggested that North-West Madagascar may harbour regionally, perhaps globally, important nesting populations of Endangered Green turtles and Critically Endangered Hawksbill turtles (Metcalf *et al.*, 2007). Furthermore these areas may be of regional significance as foraging areas. The Barren Isles are separated from these areas by Cap St. Andre and approximately 700 km in distance. While the Barren Isles region (including the mainland beaches) may historically have had important nesting grounds, it now is more likely to constitute an important foraging and mating area. Despite the local fishers having long hunted turtles and harvested turtle eggs, there still are seemingly abundant populations of turtles in the area (particularly Green). This has given fishers the perception that they are an inexhaustible stock.[1] The oceanic islands situated in the central area of the Mozambique Channel (Europa,

[1] Monitoring of the turtle fishery in South West Madagascar shows that current catch levels are approximately at the same level as they were in the early 1990s. This would indicate that the area is not critical as a nesting ground; though more intensive fishing using more effective methods (such as jarifa and ZDZD nets) may also be the reason why catch levels have not decreased (Humber *et al.* 2010).

Bassas de India, Juan da Nova, Iles Glorieuses) are major nesting sites and no doubt the source of turtles along the western coast of Madagascar.

Aerial surveys of the area of West Madagascar and Juan de Nova recorded a number of leatherback turtles in the area, with an observation frequency that was one of the highest for the southern Western Indian Ocean at that stage of the surveying.

Leroux reported the capture of sea turtles in the Barren Isles afflicted by the disease fibropapillomonas. The disease causes tumours on the soft parts of the turtle and can eventually cause their death. 25 % of turtles captured around Nosy Maroantaly had the disease (though the incidence of it was less in turtles captured near the more westerly isles) and it is likely to be a significant cause of mortality for this population.

### 2.8.5 Cetaceans

A number of marine mammals have been observed in the Barren Isles and the coastal waters of Maintirano (Rosenbaum, 2003), including:

- Migratory humpback whales (*Megeptera novaeangliae*), which breed and calve in Malagasy coastal waters during the wintering season (May to December).
- In October 2000 a 14 m Sperm whale (*Physeter macrocephalus*) was found dead in Maintirano. Historically this whale existed in large concentrations and was hunted throughout Madagascar.
- Bottlenose dolphins (*Tursiops* sp.) are one of the most frequently sighted small cetaceans in Malagasy waters.
- Long-nosed spinner dolphins (*Stenella longirostris*): in Madagascar they are usually sighted in more off-shore areas, outside of barrier reefs or in nearby deeper water, often in large groups of 50 or more. They are frequently observed in mixed groups with pan-tropical spotted dolphins (*S. attenuata*), and, to a lesser extent, the striped dolphin (*S. coeruleoalba*).

Aerial surveying of the West coast of Madagascar and Juan de Nova (a block roughly including he Barren Isles and reaching westwards and northwards to include Juan de Nova) showed the area to be rich in cetaceans (REMMOA 2010). This was particularly true for the zone directly west and slightly north west of Maintirano towards the edge of the continental shelf. Rates of observation of cetaceans were higher than any other areas that had been surveyed: approximately twice as high as for the zones of the Comores, Mayotte, Glorieuses and NW Madagascar; and four times higher that for the zones of Tromelin, the NE coast of Madagascar and the Baie d'Antongil. Of the cetaceans observed, eleven were identified to species level. They included: small dolphins of the *Tursiops* genus (*T. aduncus/S. chinensis* in the shelf sea/neritic zone and *T. truncatus* in the oceanic zone), which were the most frequently sighted; *Stenelles* spp., the second most frequently sighted; 19 observations of Risso's dolphins (*Grampus griseus)*; beaked whales, of which 11 observations of Cuvier's beaked whale (*Ziphius cavirostris*); six observations of baleen whales, but it was not possible to identify the species (*Balaenoptera physalus* or *B. edeni* or *B. borealis*); small dolphins, *Peponocephala/Feresa* spp. and *Tursiops/Sousa* spp.; *G. griseus*; large dolphins (*Globicephala/Pseudorca*).

Rosenbaum (2003) infers the potential occurrence of other cetacean species from their probable ranges and anecdotal evidence. These species may potentially occur in the Barren Isles or oceanic waters in proximity to the isles and the observations of the aerial surveying above support the likelihood of this:

- The Indo-Pacific humpback dolphin (*Sousa chinensis*) occurs primarily near fringing reefs and in bays along the West coast of Madagascar and could occur in the Barren Isles.
- Southern right whales (*Eubalaena australis*) have been recorded in Malagasy waters and the Mozambique Channel and could potentially occur in the coastal waters off the Barren Isles.
- Unconfirmed reports, historical accounts and suspected ranges would also make the occurrence of some other large cetaceans here likely, including: the minke whale (*Balaenoptera acutorostrata*), Bryde's whale (*B. edeni*), and the fin whale (*B. physalus*). Similarly sporadic sightings of false killer whales (*Pseudorca crassidens*), pygmy killer whales (*Feresa attenuata*) and killer whales (*Orcinus orca*) have been made off the west coast of Madagascar and in the Mozambique Channel.

### 2.8.6 Avifauna

Continental islands on the West coast of Madagascar, such as the Barren Isles, are thought to have previously supported large populations of seabirds, but sustained human presence on the isles, the harvesting of eggs and the introduction of rats (on a number of isles it is taboo to kill rats) have greatly decreased the populations. These seabirds have largely retreated to the more inaccessible oceanic islands of the central Mozambique Channel.

However, a published survey recorded twenty-one species on the site, of which one is endemic to Madagascar (BirdLife International, 2009). The key species for conservation are:

- The Madagascar heron (*Ardea humbloti*), is an Endangered species with a very small population that is continuing to decline because of overexploitation and loss and degradation of its wetland habitats (BirdLife International, 2008). It thought to be restricted to western Madagascar, where it is sparsely distributed, with its stronghold being the Antsalova area. *Ardea humbloti* breeds only in Madagascar. It is represented on the isles by both winter and resident populations. The Barren Isles is a very important conservation site for the resident population of *Ardea humbloti* not only because this is a threatened species, but furthermore it is restricted to this particular biome. *Ardea humbloti* has been recorded on Nosy Dondosy and Nosy Manghily.
- The Roseate tern (*Sterna dougallii*). The Barren Isles are important for the conservation of this species in that they are a breeding and congregation site for a particular biogeographic population. *Sterna dougallii* is not globally threatened, but the tropical Indian Ocean may be the most secure region for it. Birdlife staff counted a total of 1,480 pairs of *Sterna dougallii*, of which 1,400 were on Nosy Mboro (Nosy Mavony), where they were nesting with ca. 100 *Sterna anaethetus*. In 1982, there were ca. 2,000 pairs of *Sterna dougallii* at the site.

Birdlife International surveyed the Barren Isles from 11 – 17 July 1998 and reported that Nosy Manghily had important bird populations on it, including *Ardea humbloti*. At this time Nosy Manghily was uninhabited. Fishers inhabited Nosy Mboro (Nosy Mavony) and collected the eggs of the seabirds nesting there (*Sterna dougallii* and *Sterna anaethetus*); consequently few hatched.

Other marine seabirds have been recorded on the Barren Isles, including: *Anous stolidus*, *Sterna fuscata* (nesting), and winter migrants that have been recorded passing through the isles - *Fregata minor* and *Fregata ariel*.

Aerial surveying of the West coast of Madagascar and Juan de Nova in February 2010, recorded a number of species in the vicinity of the Barren Isles, including: *Anous stolidus/tenuirostris*, *Fregata* spp., *Phaethon* spp., *Puffinus* spp., *Sterna dougalii*/*bergii* (about 850), *Sterna fuscata/anaethetus* (n=3,600) Sulidae spp., and *Diomedea* spp.

The Critically Endangered Madagascar fish eagle (*Haliaeetus vociferoides*) is observed in the mangroves of Soahany. Globally this species has an extremely small population which is probably declining rapidly. Recent surveys suggest that the Antsalova district is the main stronghold, with 12 pairs in the Manambolomaty complex and a further 15 pairs elsewhere in the district. The birdlife of the mangrove forests and wetlands occurring on the coast neighbouring the Barren Isles has not been surveyed. The presence of rare species such as *Haliaeetus vociferoides* in the Soahany mangroves, as well as the exceptional level of endemism and number of endangered bird species found in nearby areas such the Manambolomaty wetland complex and Tsimembo Classified Forest, could indicate that these unsurveyed areas will be rich in birdlife.

### 2.8.7 IUCN Red Listed species

Please see Appendix 8.

# 3. Socio-economic context

## 3.1 Summary

The Barren Isles are situated within the region of Melaky, a region that has a lower population density in comparison to the rest of Madagascar. The estimated total population is 158,919 and the average population density is 4.1 habitants/km². This is ascribed largely to the isolation of the area, as well as the presence of *dahalo* (armed bandits) in the rural areas. The isles are divided between the administrative districts of Maintirano and Antsalova. The only one true urban centre of the Melaky region – Maintirano – is therefore in proximity to the isles. This results in two distinct socio-economic environments:

- that of the urban centre, which has relatively good health, education and transport infrastructure, as well as a relative diversity of economic activities;
- and that of a rural, isolated area with poor social infrastructure and a population that is largely dependent on subsistence agriculture and fishing.

Fishers living on the Barren Isles live in a rural socio-economic context, but can readily sail to Maintirano and frequently go there in order to fetch drinking water, and access markets and health services.

Despite having a long history of frequentation and use – the French explorer Henry Douliot noted the presence of local people on the isles in 1892 - there are no large, permanent villages on the Barren Isles themselves. There is no officially recognised *chef de fokontany* resident on the isles, though some of the isles have a *de facto* leader who is looked upon as such by other fishers.

Fishers live on and frequent the isles year round, mostly from March to the end of November. Six of the isles were settled at the time of this study – Nosy Lava, Nosy Manghily, Nosy Abohazo, Nosy Maroantaly, Nosy Manandra and Nosy Marify. Nosy Andrano and Dondosy are also frequently settled by fishers. The isles have no health, education or drinking water infrastructure and fishers must come to Maintirano town to reach these.

The isles are lived on by traditional fishers who can be roughly divided into two groups[1]:

- Traditional fishers who live permanently in the fishing villages of Maintirano town (Ampasimandroro and Ambalahonko) ;
- Traditional migrant fishers who come from South West Madagascar (mostly from the Morombe town and the coastal villages of Befandefa commune).

Much of the population of the isles (particularly the Vezo migrants from the South West), is highly transitory and the population of a given isle can vary enormously from week to week, depending on the fishing and

[1] (The groups are not completely distinct because many of the "residents" of Maintirano are first generation children of migrants themselves; present day migrants also marry residents and settle in Maintirano themselves.)

weather conditions. A census carried out for this study in October 2009 showed the population of the Barren Isles to be 508. This should be taken only as an indication of the population of the isles; the true figure for a given year or month could vary significantly from this because the traditional fishers are so mobile. Vezo migrant fishers from the South West make up 66 % of the Barren Isles population; the other 34 % - mostly Sara, but also Vezo and Vezo Sakalava - originate from the fishing villages of Maintirano. The most populated isle was Nosy Manandra (164 persons), followed by Nosy Marify (90) and Nosy Lava (79). 83 % of the population of the isles was male, reflecting a population of active fishermen who are there specifically to fish.

In addition to the traditional fishers who live on the Barren Isles, two other populations could potentially be implicated in the creation of a protected area: the habitants of the coastline opposite the Barren Isles; and the traditional fishers who live in the urban fishing villages of Maintirano town

Only four small fishing villages exist on the coast between the town of Maintirano and Soahany, a village approximately 75 - 80 km south. The village of Ampandikoara is effectively a nucleated settlement, while Manombo (and the neighbouring area called Sakatay) and Kimazimazy are made up of dispersed households. Maintirano maty is not truly a village, consisting of a few isolated households dispersed over ca. 2.5 km. The present study estimated that in October 2009 little more than 250 persons lived in these four villages. Virtually all of them are Vezo Sakalava who are long residents to the area. Almost half of this population is situated in the village of Manombo (101 persons), while 70 persons live in the village of Kimazimazy. Similarly to the Barren Isles, a large proportion of this population is made up of fishers from Maintirano who move seasonally to the coastal fishing villages.

The traditional fishers of Maintirano town are centred in two villages located on the edges of the town: Ampasimandroro and Ambalahonko Ambany. Ampasimandroro has a distinct neighbourhood that was established by Sara migrants in the 1960s and remains predominantly Sara. Almost half of the households interviewed in Ampasimandroro are immigrants to the village. Two-thirds of the population of Ampasimandroro is Vezo Sakalava; first generation Vezo migrants from the South West make up approximately a third of the population. Fishers resident in Maintirano, particularly those of Ampasimandroro, move seasonally to fish around the Barren Isles as well as the coastal fishing areas opposite the isles.

The habitants of the Barren Isles and the coastal fishing villages were found to be totally dependent on fishing for their livelihoods, with not one of these fishers having a secondary occupation or alternative source of income or food. The fishers resident in the Maintirano fishing villages were not much less dependent on fishing, with this being the primary occupation for 97 % of respondents; 79 % had no secondary occupation, while 12 % named rice farming as a secondary occupation.

The Barren Isles, the coastal fishing villages and the fishing villages of Maintirano do not have any traditional dina originating from the fishers themselves that govern fishing or the use of natural resources in any way. The sea is regarded by resident and migrant fishers alike as an open access resource that all Malagasy are able to use to gain their livelihood. There has recently been, however, certain rules and a *dina* drawn up in Maintirano regarding the isles – these are presented in the Appendices.

Most of the villages do not have any form of association of fishers nor do most of the fishers see themselves as belonging to any larger association of fishers formed to promote their interests or to manage the resources. There are exceptions to this: the UPTM (Union des Pêcheurs Traditionnels de Maintirano) is an association of mostly Sara fishers from Ampasimandroro and includes fishers who frequent Nosy Lava and Maroantaly. This association is active and vocal. Some of the migrant fishers from Manandra have formed their own association and have sporadically been active in the management of the isles.

## 3.2 Introduction

The socio-economic section is divided into four parts: a presentation of the socio-economic conditions of the general population of the area within which the Barren Isles are located; followed by descriptions of the socio-economic conditions of the three populations that could be directly implicated in the management of the Barren Isles larger marine and coastal ecosystem. These three populations can be distinguished according to their location and are presented accordingly:

- That of the Barren Isles, of which six were settled at the time of this study – Nosy Lava, Nosy Manghily, Nosy Abohazo, Nosy Maroantaly, Nosy Manandra and Nosy Marify
- That of the coastal fishing villages south of Maintirano, comprising Ampandikoara, Manombo (including the settlement of Sakatay), Maintirano Maty and Kimazymazy.
- And that of the fishing villages of Maintirano town, comprising Ampasimandroro and Ambalahonko-Ambany.

## 3.3 Socio-economic environment of the general population

### 3.3.1 Administration

The Barren Isles occur in both the district (*fivondronas)* of Maintirano and Antsalova, as is summarised in Table 26 and presented in Figure 19. The chef de *fokontany* responsible for the Isles is from the village of Soahany in Antsalova. Maintirano and Antsalova are located in the Melaky region, the ex-province of Mahajanga. Maintirano is the administrative and only true urban centre of Melaky.

**Table 26. Summary of the administrative setting of the Barren Isles**

| Isle | Fivondrona |
|---|---|
| Nosy 283 | Maintirano |
| Nosy 284 | Antsalova |
| Nosy Andrano | Antsalova |
| Nosy Androtra | Maintirano |
| Nosy Dondosy | Antsalova |
| Nosy Lava | Antsalova |

| | |
|---|---|
| Nosy Manghily | Antsalova |
| Nosy Marify | Maintirano |
| Nosy Maroantaly | Maintirano |
| Nosy Mavony | Maintirano |

### 3.3.2 Population

Melaky has a low population density in comparison to the rest of Madagascar, with an estimated total population of 164,159. The average density is 4.1 habitants/km², which is noticeably less than the 6.2 habitants/km² average for the Mahajanga province. This is ascribed to the isolation of the area, as well as the presence of *dahalo* (armed bandits). The spatial distribution of the population in Melaky is presented in Table 27.

**Table 27. Spatial distribution of the population of the Melaky region**

| Fivondrona | Resident population | Area/km² | Population Density (habitants/km²) |
|---|---|---|---|
| Maintirano† | 41 481 | 9 456 | 4.4 |
| Antsalova† | 23 662 | 6 097 | 3.9 |
| Ambatomainty | 26 134 | 3 792 | 6.9 |
| Morafenobe | 15 356 | 8 215 | 2.0 |
| Besalampy† | 57 526 | 11 292 | 4.6 |

† Fivondrona bordered by the Mozambique Channel

The coastal population increased by 61 % on average between 2002 and 2004 (Table 28). This is largely due to the massive increase in the coastal population of Maintirano; on the other hand that of Antsalova increased by 23 %, while that of Besalampy decreased by -11 %.

**Table 28. Evolution of the coastal population in the region of Melaky**

| Fivondrona | Coastal population | | |
|---|---|---|---|
| | 2002 | 2004 | % increase |
| Antsalova | 23 662 | 29 008 | 23 |
| Besalampy | 57 523 | 50 997 | -11 |
| Maintirano | 41 481 | 117 023 | 182 |
| Total | 122 666 | 197 028 | 61 |

Source: UPDR 2003; ONE-Enquête communale 2005 (Région Melaky)

The population of the region as a whole has shown a rate of growth over ten years of 2.6%.

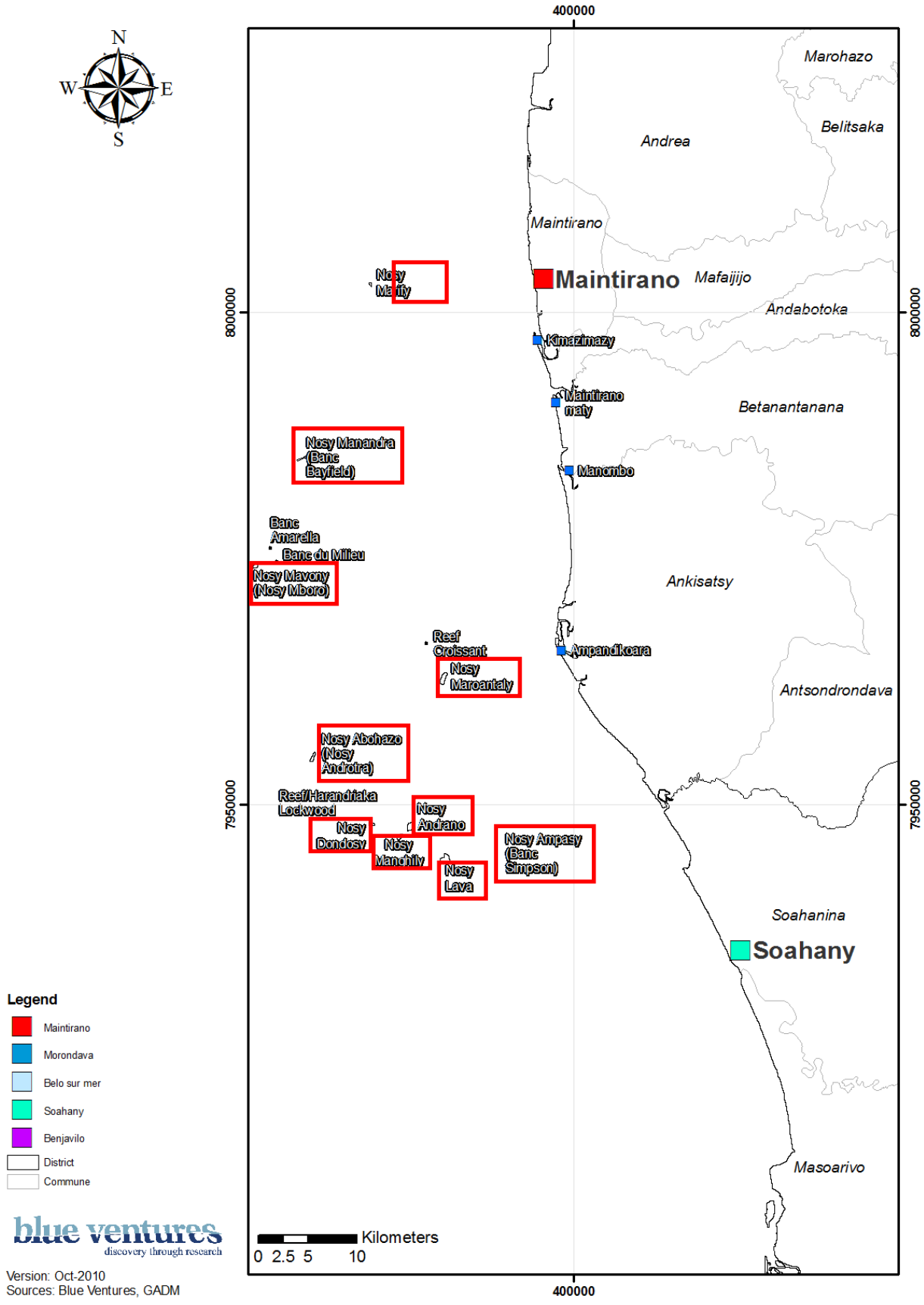


**Figure 19. Administrative map of the Barren Isles region**

### 3.3.3 Occupations

The occupations of the communes neighbouring the Barren Isles reflects a largely rural population who are dependent on agriculture, fishing and animal husbandry (see Table 29). Agriculture forms the principal occupation of the populations with the exception of Maintirano, where 55% of the population are fishers. Fishers form a minority of the other communal populations, ranging from a minimum of 0% for Andabotoka to a maximum of 20% for Masoarivo. In all of these communes animal husbandry (after agriculture), occupies a greater proportion of the population than does fishing.

**Table 29. Occupations of the populations within the coastal communes neighbouring the Barren Isles**

| Commune | Agriculture % population | Fishing % population | Animal husbandry % population | Manufactur-ing % population | Services % population |
|---|---|---|---|---|---|
| Soahany | 90 | 10 | 0 | 0 | 0 |
| Masoarivo | 54 | 20 | 23 | 0 | 3 |
| Betanatanana | 70 | 5 | 24 | 0 | 1 |
| Andabotoka | 85 | 0 | 13 | 0 | 2 |
| Ankisatra | 90 | 8 | 2 | 0 | 0 |
| Maintirano | 34 | 55 | 0 | 0.8 | 10.2 |

### 3.3.4 Social infrastructure

Table 30 summaries the existing social infrastructure within the communes neighbouring the Barren Isles. Thanks to the presence of Maintirano town, the only true urban centre of Melaky, this commune is serviced by a reasonable social infrastructure. The other communes are isolated and rural, lacking means of telecommunication, running water, banks and often even a daily market.

**Table 30. Summary of social infrastructure within the coastal communes neighbouring the Barren Isles**

| Commune | Perma-nent tribunal | Daily market | Inputs sales point | Tele-phone | BLU | Running water (JIRAMA) | Bank | Post office |
|---|---|---|---|---|---|---|---|---|
| Soahany | -- | -- | -- | -- | -- | -- | -- | -- |
| Masoarivo | -- | -- | XX | -- | -- | -- | -- | -- |
| Betanatanana | -- | XX | -- | -- | -- | -- | -- | XX |
| Andabotoka | -- | XX | -- | -- | -- | -- | -- | -- |
| Ankisatra | -- | -- | -- | -- | -- | -- | -- | -- |
| Maintirano | XX | XX | XX | XX | XX | XX | XX | XX |

### *3.3.4.1 Education*

Primary and secondary public education in the Melaky region is singularly lacking: 69% of the total schools are non-functional. Those public schools that are operational are concentrated in the towns of Besalampy and Maintirano. Private schools play an important role in primary schooling, with the number of schoolchildren in private schools exceeding those in government ones.

Only Maintirano and Besalampy have public high schools (lycée publique) where students can study for the bacalaureat. The number of students attending these schools is very high, particularly in Maintirano, where any students from the neighbouring Fivondrona who want to continue their education must come. The number of teachers is largely insufficient and poorly distributed. At "niveau 3", Maintirano has 8 teachers – 75 % of the total, while Besalampy has only one science teacher.

**Table 31. Educational infrastructure within the coastal communes neighbouring the Barren Isles**

| Fivondronana | Commune | Primary school | Secondary school (1st cycle) | Secondary school (2nd cycle) - lycée |
|---|---|---|---|---|
| Antsalova | Soahany | XX | -- | -- |
| | Masoarivo | XX | XX | -- |
| Maintirano | Betanatanana | XX | XX | -- |
| | Andabotoka | XX | -- | -- |
| | Ankisatra | XX | -- | -- |
| | Maintirano | XX | XX | XX |

### *3.3.4.2 Health*

Access to medical care in the rural areas is very poor, with only the urban commune of Maintirano being serviced by a hospital or private clinic (see Table 32). All of the other communes have only community health centres (CSB) or private dispensaries, which are only located in the main towns of these communes. Malnutrition has become a serious problem, particularly amongst women and children, and Tuberculosis and sexually transmitted diseases (STDs) continue to increase. The principal causes of morbidity are: Kidney failure: 7.02%[1]; Malaria: 5.8%; diarrhoea: 2.13%; skin infections: 1.59%; and accidents and traumatisms: 1,9%. The principal causes of death are: surgical pathology 30%; diarrhoea and dehydration: 26.66%; respiratory infections: 20%; and severe Malaria with complications: 13.3%.

**Table 32. Medical infrastructure within the coastal communes neighbouring the Barren Isles**

| Fivondronana | Commune | Hospital or Private Clinic | CSB or Private Dispensary |
|---|---|---|---|
| Antsalova | Soahany | -- | XX |
| | Masoarivo | -- | XX |
| Maintirano | Betanatanana | -- | XX |

[1] According to the "Monographie de la région de Melaky" (2003), Unité de Politique de développement Rural (UPDR), Ministère de l'Agriculture, de l'Elevage et de la Pêche.

| | | | |
|---|---|---|---|
| | Andabotoka | -- | XX |
| | Ankisatra | -- | XX |
| | Maintirano | XX | XX |

*3.3.4.3 Transport and access*

Until three years ago, the region of Melaky was characterised by its isolation and even the urban centre of Maintirano was difficult to access during the rainy season. More recently a surfaced road has been re-established that services Maintirano year round, an airport and a small sea port (see Table 33). During the rainy season the dirt road between Maintirano and Tsironomandidy can only be travelled in a 4x4 vehicle, while rough seas make access to the port difficult. With the exception of Maintirano, the only other communes with a regular taxi-brousse are Morafenobe, Betanatanana, Antsalova and Andrea. The "indicator or remoteness" for most of the rural communes is superior to the national average of 3.3 (see Table 33).

**Table 33. Transport infrastructure within the coastal communes neighbouring the Barren Isles**

| Commune | Indicator of remoteness | National road | Provincial road | Taxi-brousse | Airport | Fluvial port | Sea port |
|---|---|---|---|---|---|---|---|
| Soahany | 5 | -- | XX | -- | -- | -- | -- |
| Masoarivo | 5 | -- | XX | -- | -- | XX | -- |
| Betanatanana | 3 | XX | -- | XX | -- | -- | -- |
| Andabotoka | 2 | -- | -- | -- | -- | -- | -- |
| Ankisatra | 4 | XX | -- | -- | -- | -- | -- |
| Maintirano | 1 | XX | XX | XX | XX | -- | XX |
| National average | 3.3 | | | | | | |

A measure of the isolation of the Melaky region neighbouring the Barren Isles is given by the "duration of the voyage to reach the closest urban centre", presented in Table 34. Both in the dry and wet season this is a multiple of the national average - two- to eleven-times longer[1]. Consequently the cost of transport for people, food and goods is several times higher than the national average (see Table 34), or roads become impracticable and people are forced to transport items by foot. The inaccessibility of the Melaky region is a major limitation to its development.

**Table 34. Summary of indicators of accessibility to the coastal communes neighbouring the Barren Isles**

| Commune | Cost of transport for a person to reach the CUC – dry season | Cost of transport for a person to reach the CUC – wet season | Duration of voyage to reach the CUC –dry season (hours) | Duration of voyage to reach the CUC – wet season (hours) | Existence of a tarred road in the commune | Existence of a metalled road in the commune practicable year round |
|---|---|---|---|---|---|---|

[1] The information was taken from the national Ilo survey carried out in 2001; people in Maintirano found the figures exaggerated the cost and duration of travelling in the region. However, they do enable a comparison to the national average and there is little doubt that transport in the region is a barrier to development.

| | MGA (fmg) | MGA (fmg) | | | | |
|---|---|---|---|---|---|---|
| Soahany | 85,000 (425,000) | 142,000 (710,000) | 126 | 240 | yes | no |
| Masoarivo | 58,000 (290,000) | 58,000 (290,000) | 85 | 85 | no | no |
| Betanatanana | 33,000 (165,000) | 31,400 (157,000) | 72 | 76 | yes | yes |
| Andabotoka | 40,000 (200,000) | 31,500 (157,500) | 48 | 52 | no | no |
| Ankisatra | 34,000 (170,000) | 40,800 (204,000) | 50 | 55 | yes | no |
| Maintirano | 32,000 (160,000) | 32,000 (160,000) | 48 | 48 | yes | yes |
| National average | 10,784 (53,920) | 11,305.2 (56,526) | 17 | 21 | | |

CUC – closest urban centre

### 3.3.5 Food security

Table 35 presents community perception of food security (and consequently well being) gained through community focus groups evaluating to which of the following categories their population belongs:

**"Rich"** – those who have never experienced food shortages, even during years of poor harvest

**"Average"** – those who don't experience food shortages throughout the year, but who do experience difficulties during years of poor harvest (years when there is a cyclone, drought or another type of natural catastrophe)

**"Poor"** – those who experience seasonal food shortages, both during good and bad years

**"Completely destitute"** – those who never have enough to eat throughout the year

In addition the community focus groups estimated the **"Duration of the lean period"** – the period during which the majority of the population decrease the number of meals / the quantity of food that they consume

**Table 35. Perceptions of food security within the populations of the coastal communes neighbouring the Barren Isles (information was taken from the national Ilo survey carried out in 2001)**

| Commune | % of "rich" in the population | % of "average" in the population | % of "poor" in the population | % of "completely destitute" in the population | Lean period duration (months/year) |
|---|---|---|---|---|---|
| Soahany | 15 | 55 | 20 | 10 | 4 |
| Masoarivo | 0 | 60 | 40 | 0 | 4 |
| Betanatanana | 0 | 30 | 57 | 13 | 6 |
| Andabotoka | 10 | 60 | 20 | 10 | 3 |
| Ankisatra | 1 | 80 | 10 | 9 | 6 |

| | | | | | |
|---|---|---|---|---|---|
| Maintirano | 8 | 52 | 40 | 0 | 6 |
| National average | 9 | 39 | 44 | 8 | 4 |

The communes of Soahany, Andabotoka and Maintirano saw 15, 10 and 8 % of the population as never having experienced food shortages ("rich"), percentages that are comparable to the national average of 9%. On the other hand the percentage of rich people in the communes of Masoarivo, Betanatanana and Ankisatra were notably inferior to the national average (see Table 35).

For five of the six communes, the percentage of the population who only suffer food shortages during poor harvest years ("average") was superior to the national average of 39 %, ranging from a minimum of 52 % for Maintirano to a maximum 80 % for Ankisatra. The exception is Betanatanana, where only 30 % of the population were considered as "average", while well over half of the population were seen as "poor" - experiencing food shortages during both good and bad years. The other five communes had percentages of "poor" that were lower than the national average. The percentage of completely destitute for five of the communes was comparable to or lower than the national average, with once again that of Betanatanana being a quarter higher.

In summary, the communes neighbouring the Barren Isles have higher food security than Madagascar's national average, with the exception of Betanatanana. On the other hand only in the commune of Andabotoka is the duration of the lean period less than the national average of four months; for the other five communes it ranges from four to six months of every year.

### 3.3.6 Development priorities

Table 36 presents the development priorities for each commune that were ascertained through asking focus groups to rank seven different areas where development actions were needed, namely: 1. Health, 2. Education, 3. Security, 4. Transport, 5. Agriculture, 6. Environment, and 7. Water.

**Table 36. Perceptions of the development priorities within the populations of the coastal communes neighbouring the Barren Isles**

| Commune | First development priority of the commune | Second development priority of the commune | Third development priority of the commune |
|---|---|---|---|
| Soahany | Agriculture | Water | Transport |
| Masoarivo | Health | Security | Transport |
| Betanatanana | Security | Agriculture | Health |
| Andabotoka | Agriculture | Transport | Security |
| Ankisatra | Agriculture | Security | Transport |
| Maintirano | Security | Transport | Education |

Three of the six communes saw agriculture as the first development priority of the commune; two saw this to be security; while one saw it to health. Agriculture and security were also ranked as secondary development priorities, along with transport and water. No communes saw the environment as being a development priority.

## 3.4 Socio-economic environment of the Barren Isles

The socioeconomic surveying followed closely the methods of McClanahan, T.R. (Editor) 2008, 'Manual and field guide for monitoring coral reef ecosystems, fisheries, and stakeholders', Wildlife Conservation Society - Coral Reef Programmes. The surveying questionnaires of this manual were used after adapting them to suit the local context and the data needs of the study.

### 3.4.1 Population

A census carried out for this study showed the population of the Barren Isles to be 508 and that of the coastal fishing villages to be 250 (see Table 37 and Table 43).

Of the eight isles visited during October 2009, only six had fishers settled on them. Previously Nosy Mboro was a popular isle amongst fishers, but is no longer frequented because of a communal law forbidding this. Nosy Andrano is frequently lived on by two groups of fishers from the South West. In the past Nosy Dondozy was frequented by a small number of fishers, but presently is uninhabited. The most populous isle was Nosy Manandra (164 persons), followed by Nosy Marify (90) and Nosy Lava (79). Nosy Manandra and Nosy Marify are nothing more than sand cays that are submerged during large spring tides and big storms. Regardless of this, their relative proximity to Maintirano and the ready access they give to good fishing grounds makes them popular destinations.

It must be noted that much of the population of the isles is highly transitory and the population of a given isle can vary enormously from week to week, depending on the fishing and weather conditions. The Vezo fishers build only makeshift shelters and readily move between the isles, with Manandra, Marify and Nosy Vao (further to the north of Maintirano) being favoured destinations.

83 % of the population of the isles was male, with Marify and Manandra being 97% and 93 % male respectively. A small percentage of the population, 14 %, was 15 years old or younger; of the 69 children present on the isles, 68 % were male. Only on Nosy Manghily, which is settled by one large Vezo family, is there a larger proportion of females and children. The largely male, adult population of the isles reflects the seasonal frequentation of the isles by active fishermen who are there specifically to fish.

**Table 37. Population and basic demographics of the Barren Isles, October 2009.**

| Isles | Persons | Groups | Average Group Size | % =< 15 years | % females | % males |
|---|---|---|---|---|---|---|
| Nosy Lava | 79 | 12 | 6.6 | 16 | 28 | 72 |
| Manghily | 38 | 5 | 7.6 | 39 | 39 | 61 |
| Abohazo | 71 | 10 | 7.1 | 20 | 30 | 70 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Maroantaly | 66 | 16 | 4.1 | 6 | 24 | 76 |
| Manandra | 164 | 35 | 4.7 | 10 | 7 | 93 |
| Marify | 90 | 20 | 4.5 | 8 | 3 | 97 |
| **Total** | **508** | **98** | **5.2** | **14** | **17** | **83** |

#### *3.4.1.1 Habitation of the Barren Isles*

The Barren Isles have a long history of habitation (Battistini, 1964). Henry Douliot describes in his voyage that he made up the West coast in 1892 seeing people living on one of the Barren Isles (Cripps, 2009). In the 1940s Sara fishers from St. Augustin had a tradition of migrating up the entire west coast to fish large pelagic fish off the most westerly reefs in the north west. Most Vezo did not migrate such long distances; however, some Vezo from the Befandefa area are said to have accompanied them. This probably was one of the precursors to the Vezo migrating to the Barren Isles and is perhaps why many of today's migrants come from this area.

In the 1960s several families left Anakao in search of new fishing grounds; they stopped over in Belo-sur-Mer and Morondava, continuing until Maintirano. One group of Sara migrants lived on the isles (Nosy Lava, Nosy Drano, Mboro, Maroantaly, Dondozy, Abohazo), at first permanently, then from April/May until the end of November. Other Sara lived in Maintirano and fished around the isles for 2-3 days before returning. At this time the Vezo Sakalava residents went to the islands to hunt turtles, but only infrequently and they never stayed there as there were many *faly* on the islands. The Vezo Sakalavas' pirogues were also crudely made; the Sara showed them how to make more seaworthy pirogues and guided them to the islands.

In the early 1980s the resident Sara did not see migrants from the South on the islands, but by 1984 fishers from the South (Andavadoaka, Antsatsamoroy, Belavenoke, Bevohitse) camped on the islands (Nosy Lava, Nosy Manghily). In the late 1980s they also camped on Nosy Abohazo, Nosy Dondozy and Nosy Mboro. But they were still only few in number; probably an insignificant and temporary presence on the isles.

In the mid 1980s the Sara groups who lived in Maintirano began to live seasonally on Maroantaly, from March to November; the reason for this was that, though the fishing was good, they were no longer able to catch enough during a short period to justify frequent return trips to Maintirano.

In the late 1980s migrants from the South (Befandefa villages and Morombe) were already fishing shark and sea cucumbers in the Barren Isles, though they were still outnumbered by the resident fishermen. From 1990 to 1992 they began to come in larger numbers to the islands. By 1996 there was a definite increase in the number of migrants from the South. In the late 1990s, along with the Sara fishers from Maintirano, they lived on Nosy Lava, Anbohazo, Dondosy, Maroantaly and Nosy Mboro.

In about 1998 to 2000 migrants from the South started to live on the islands in significant numbers, and their numbers have increased continuously every year since, with the most arriving in 2008.

In 2000 Japanese Development Agency introduced the ZDZD kirara shark-fishing technique to Maintirano fishermen, particularly the Sara. Between 2003 and 2004 a number of these families, who had been resident in Maintirano, started living on Maroantaly during the fishing season as this is a well situated base from which to practise ZDZD kirara.

2006 was a turning point, with the number of migrant fishers settling on all of the islands becoming much larger; conflicts with the residents began at this time. These became more marked in 2007 and 2008, with still more migrants from the South arriving who did not respect the faly of the isles.

### 3.4.2 Migration

The population of the Barren Isles is made up of resident fishers from Maintirano and migrant fishers from South West Madagascar who seasonally settle the isles. The origins of the fishers who constitute the total population of the Barren Isles are presented in Table 38 and Figure 20. Migrant fishers make up 66% of the Barren Isles population. The majority of the migrant fishers are from South West Madagascar, specifically from the town of Morombe, the village of Andavadoake and other villages of the rural commune of Befandefa (Ambatamilo, Ampasilava, Antsatsamoroy, Belavenoke, Bevato, Bevohitse and Lamboara). 34% of the population originate from the fishing villages of Maintirano, the majority of whom are themselves first or second generation Sara migrants originally from Anakao (south of Tulear). As noted earlier, the migrant population is highly mobile, and the population of the Barren Isles could vary significantly from the 510 persons recorded in October 2009.

**Table 38. Origins of the people who constitute the total population of the Barren Isles.**

| Origin | Number of persons | % of Barren Isles population |
|---|---|---|
| Ambatomilo | 10 | 2 |
| Ampasilava | 17 | 3 |
| Andavadoake | 108 | 21 |
| Antsatsamoroy | 3 | 1 |
| Belavenoke | 8 | 2 |
| Belo-sur-Mer | 12 | 2 |
| Bevato | 23 | 5 |
| Bevohitse | 19 | 4 |
| Lamboara | 4 | 1 |
| Mahajunga | 8 | 2 |
| Maintirano | 174 | 34 |
| Morombe | 100 | 20 |
| Morondava | 16 | 3 |
| Salary Nord | 8 | 2 |
| **Total Barren Isles** | **510** | |

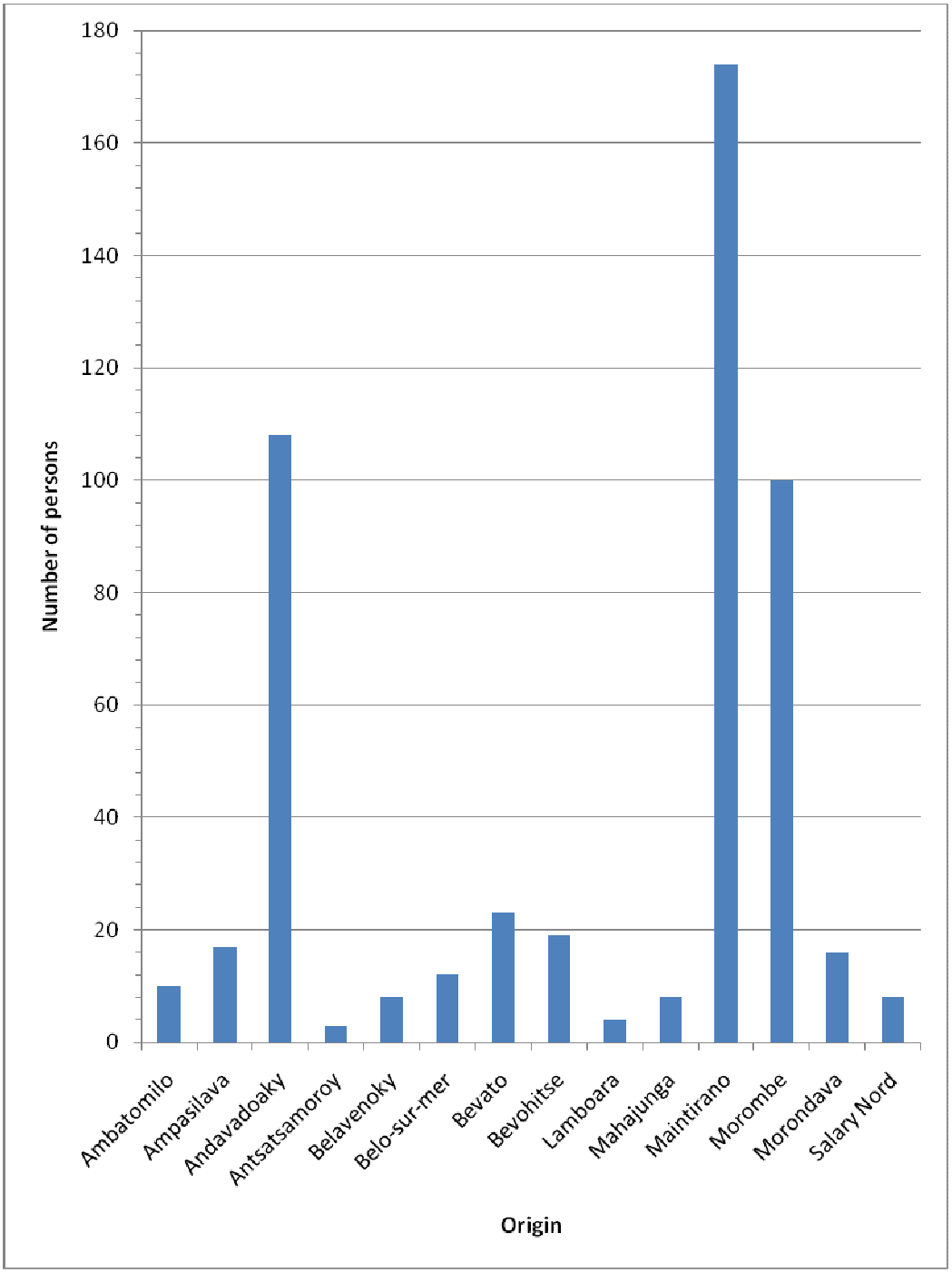


**Figure 20. Origins of the people who constitute the total population of the Barren Isles.**

Table 39 and Figure 21 present the origins of the fishers who constitute the populations of each of the individual isles.

Fishers from Maintirano are mainly present on three isles where they dominate the populations: Nosy Lava, Maroantaly and Marify. Nosy Lava and Maroantaly are predominantly settled by Sara fishers from Ampasimandroro, while Nosy Marify is frequented by fishers from both Ampasimandroro and Ambalahonko Ambany. Migrant fishers from the South West very rarely frequent Maroantaly because it is not a good location for their principal fishing targets – shark and sea cucumber. On the other hand the number of

migrants frequenting Nosy Lava is reported to increase dramatically when the conditions for free-diving for sea cucumber are favourable.

The other isles are predominantly frequented by migrant fishers from the South West, with Manandra being the most popular isle. A single extended family from Andavadoake has lived seasonally on Nosy Manghily since about 2006 and has come to be regarded as the "residents" of this isle by fishers frequenting the Barren Isles.

It is only in the last decade that Vezo Sakalava from Maintirano have begun frequenting the Barren Isles to fish and they are still mostly concentrated on Nosy Marify, with a few on Nosy Manandra. The few Vezo Sakalava present on Nosy Maroantaly are married to Sara families from Ampasimandroro, while all of the fishers from Maintirano settled on Nosy Lava are Sara families. The Sara are said to be the first fishers to regularly frequent the isles when they arrived from Anakao in the early 1960s. The local Vezo Sakalava are said to have rarely visited the isles (though Henry Douliot recounts local people farming on Nosy Maroantaly at the end of the 19th century). The wooden houses of the Sara families built on Nosy Lava and Maroantaly constitute the only permanent buildings on the Barren Isles.

**Table 39. Origins of the fishers who constitute the populations of each of the Barren Isles.**

| | **Barren Isles** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Origin** | Abohazo | Manandra | Manghily | Marify | Maroantaly | Nosy Lava | Nosy Andrano | **Total** |
| Ambatomilo | | 4 | | | | 6 | | **10** |
| Ampasilava | | 17 | | | | | | **17** |
| Andavadoaky | 25 | 20 | 38 | 19 | | 6 | | **108** |
| Antsatsamoroy | | 3 | | | | | | **3** |
| Belavenoky | | | | | | 7 | 1 | **8** |
| Belo-sur-Mer | 4 | 3 | | | | 5 | | **12** |
| Bevato | 7 | 16 | | | | | | **23** |
| Bevohitse | | 8 | | 11 | | | | **19** |
| Lamboara | | | | | | 4 | | **4** |
| Mahajunga | | | | 8 | | | | **8** |
| Maintirano | 5 | 10 | | 52 | 66 | 41 | | **174** |
| Morombe | 22 | 77 | | | | | 1 | **100** |
| Morondava | | 6 | | | | 10 | | **16** |
| Salary Nord | 8 | | | | | | | **8** |
| **Total** | **71** | **164** | **38** | **90** | **66** | **79** | **2** | **510** |

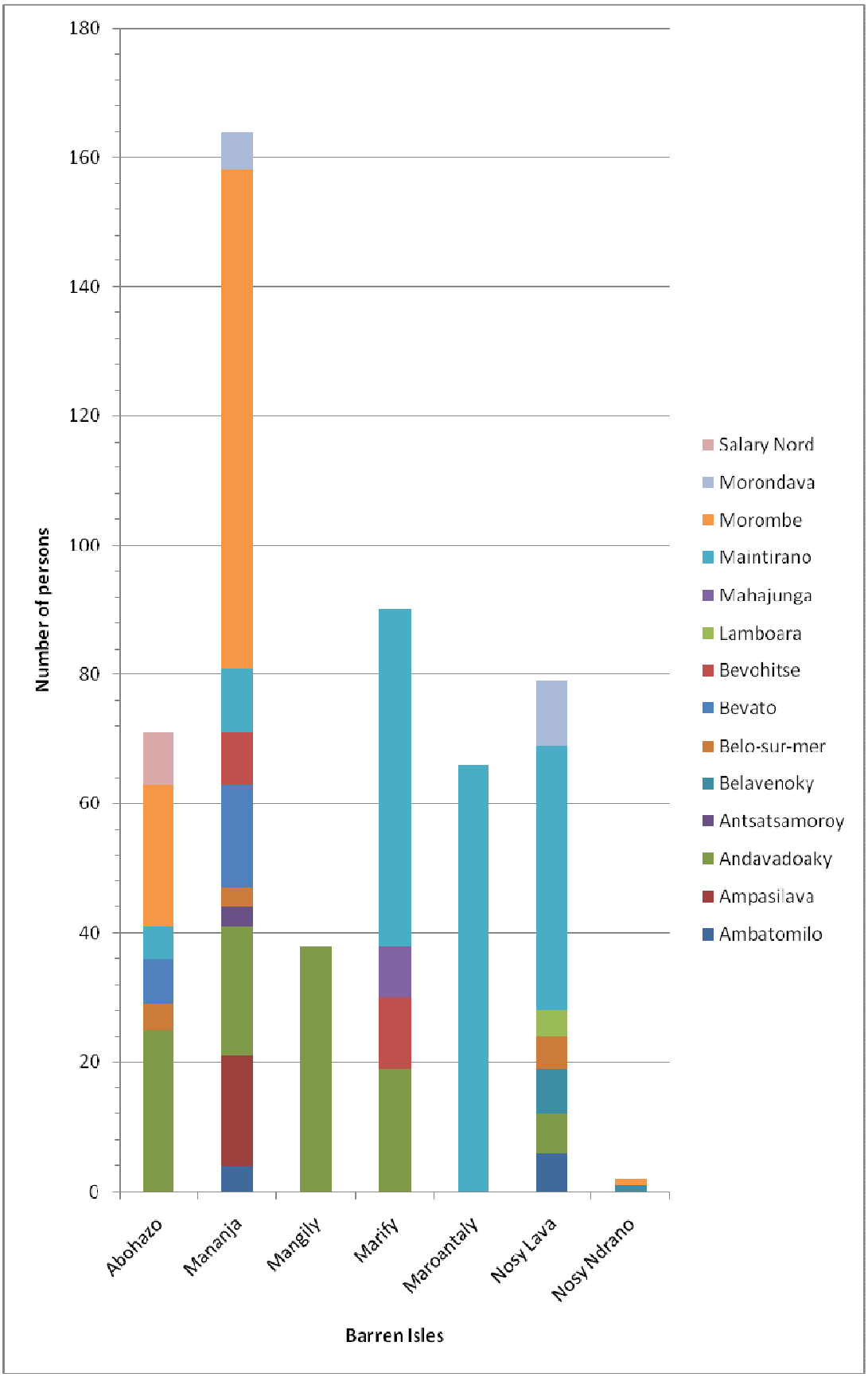


**Figure 21. Origins of the fishers who constitute the populations of each of the Barren Isles.**

In addition to the populations of the isles being recorded, the study also gained an estimate of the seasonal frequentation of the isles over the previous two years through "household" and key informant interviews. These data are presented in Table 40 and Figure 22.

**Table 40. Estimated number of fishers frequenting the Barren Isles by month of the year**

| | Population | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Isles** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **June** | **July** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** |
| Abohazo | 15 | 15 | 33 | 33 | 48 | 54 | 54 | 54 | 71 | 71 | 71 | 71 |
| Manandra | 41 | 41 | 72 | 79 | 113 | 151 | 151 | 161 | 164 | 164 | 164 | 151 |
| Manghily | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |
| Marify | 13 | 13 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 82 |
| Maroantaly | | | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 41 |
| Andrano | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Nosy Lava | 13 | 13 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 39 |
| **Total** | **120** | **120** | **467** | **474** | **523** | **567** | **567** | **577** | **597** | **597** | **597** | **424** |

The isles are mostly frequented from March to December, which corresponds broadly to the dry season. Over this period the prevailing southerly winds can frequently turn the sea dangerous after midday. Whilst during the rainy season there is the risk of depressions and cyclones coming in from the north, the sea is often calmer. It is probably the predictability of the prevailing southerly winds of the dry season rather than "good weather" that brings fishers to the isles at this time. Some fishers reported that they frequented the isles year-round, though during the cyclone season they stay for shorter periods on the isles and take refuge in Maintirano if a large storm is reported. The Sara from Ampasimandroro live on Nosy Lava and Maroantaly from March to November; most are based in Ampasimandroro from December to February and fish closer to shore. A first wave of migrant fishers from the South West arrives in March, followed by a second wave of about the same number in June (normally late June). The migrant fishers begin returning to their villages of origin in late November/early December. (While most migrant fishers with families return home each year, many of the unmarried migrants stay in Maintirano.) The number of fishers on the Barren Isles peaks between June and November – a period when conditions are most favourable to fishing.

In addition there are migrant fishers who pass through the Barren Isles en route to Nosy Vao, approximately 80 km north of Maintirano. They are estimated to be 100 in number and are not reflected in Table 40 and Figure 22. In 2010 many fishers also continued to a new and still productive fishing ground around Nosy Kely – a sand cay 50 km offshore of Cap St. Andre that the Sara of Ampasimandroro began fishing from in 2009 (or earlier).

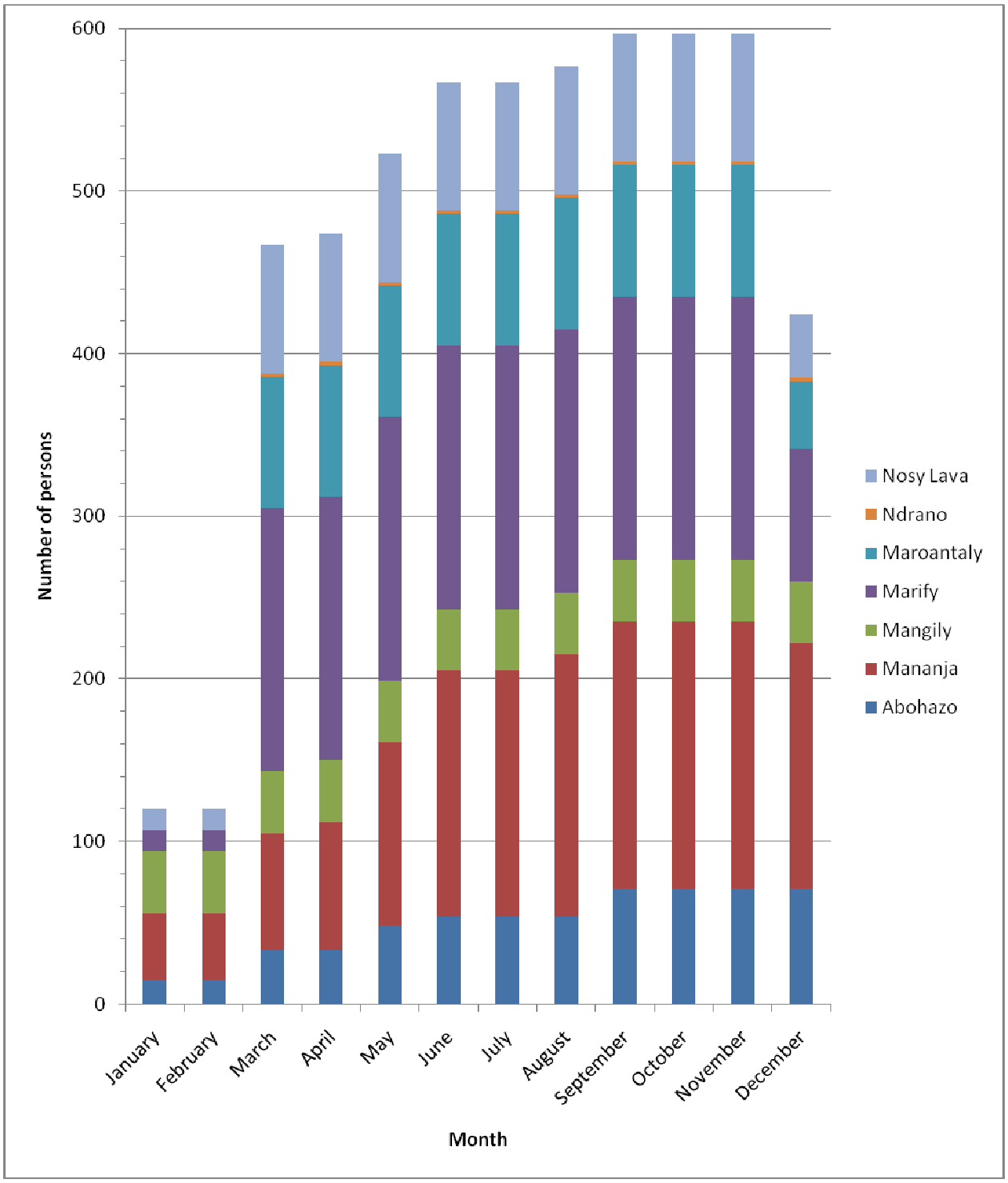


**Figure 22. Estimated number of fishers frequenting the Barren Isles by month of the year**

Since about 2000 migrant fishers have been settling on the Barren Isles in increasing numbers. Besides depleting the ecosystem of keystones species (shark and sea cucumber), the migrants have had a number of other negative impacts on biodiversity conservation, particularly of the isles, which include:

- The presence of migrant and local fishers have disturbed nesting colonies of seabirds. The mayor of Maintirano passed a local law to prevent fishers from frequenting Nosy Mboro to protect the nesting

colonies there. While this was respected for a while, with the advent of the political crisis in Madagascar many fishers began to disregard the law and in 2010 Nosy Mboro was frequented by migrant fishers (artisanal and traditional).

- Migrants actively hunt turtles and harvest their eggs; this is a particular problem in the Barren Isles, which encompass nesting grounds for green and hawksbill turtles.
- Migrant fishermen have cut down many of the trees that are reported to have once existed on certain islands.
- On isles such as Abohazo the migrants believe that it is *faly* to kill rats; these islands are infested with rats and this must have decimated a lot of the island fauna, particularly nesting seabirds. Likewise Maroantaly is completely infested with feral cats introduced by fishers living there.

### 3.4.3 Social infrastructure

The social infrastructure of the settlements on the Barren Isles is summarised in Table 41. The Barren Isles settlements have very limited health, education, sanitary and communication infrastructure, as would be expected from the lack of overall social infrastructure of the rural communes within which these villages fall (see section 0). The fishers living on the isles must go to Maintirano town in order to access basic health and education services, drinking water and markets.

**Table 41. Summary of the social infrastructure of the Barren Isle villages**

| | Nosy lava | Manghily | Nosy Andrano | Abohazo | Maroantaly | Manandra | Marify |
|---|---|---|---|---|---|---|---|
| Hospital, CSB | | | | | | | |
| Primary school | | | | | | | |
| Secondary school | | | | | | | |
| Drinking water (wells) | yes / no (1 brackish) | | | | | | |
| Latrines / toilettes | | | | | | | |
| Electricity (Jirama) | | | | | | | |
| Telephone network | | | | | yes | yes | yes |
| Access to closest urban centre | Maintirano (by sea) | Maintirano (by sea) | Maintirano (by sea) | Maintirano (by sea) | Maintirano (by sea) | Maintirano (by sea) | Maintirano (by sea) |
| Church | | | | | | | |
| Chef (de facto / traditional) | yes (Celestin) | yes | | yes (Besine) | yes (Gervais) | yes | yes (Velarison) |
| Rules / dina on fishing | | | | | | | |
| Market | | | | | | | |
| Association de pecheurs | | | | | yes (UPTM) | yes | |

None of the settlements on the Barren Isles could be considered of being made up of permanent houses, with the exception of most of the Sara homesteads on Nosy Lava and Nosy Maroantaly. Most fishers build only make-shift shelters on the isles close to sheltered landing beaches. All of these settlements are well dispersed along the length of the beaches, with no nucleated village. None of the settlements have any sanitary system and the only Nosy Lava has a well. The water in this becomes brackish during the dry season and is not drinkable by normal standards. Fishers living on the other isles must bring drinking water to the isles from Maintirano or, in the case of Nosy Maroantaly, from the well of Ampandikoara. Only those isles that are closest to Maintirano town have cell phone coverage. Fishers must go to Maintirano to access health and education services and markets as these are non-existent on the isles. All of the fishers from Maintirano leave their young children in Maintirano with their family and so these children attend school. In contrast virtually all the children of migrant fishers from the South West stay on the isles and none attend school. The Barren Isles do not have an administratively recognised chef de *fokontany* resident on the isles. However, some of the isles have a *de facto* leader who is looked upon by other fishers as being the isle's recognised leader. This is particularly true of those isles that have more stable resident populations, such as Nosy Lava, Manghily and Maroantaly. Though Manandra and Marify have more transient populations, there are fishers who have consistently frequented the isles over a number of years and are considered to be the elders of these isles.

The Barren Isles, the coastal fishing villages and the fishing villages of Maintirano do not have any traditional *dina* originating from the fishers themselves that govern fishing or the use of natural resources in any way. The sea is regarded by resident and migrant fishers alike as an open access resource that all Malagasy are able to use to gain their livelihood. There are however certain rules and a *dina* drawn up in Maintirano regarding the isles – these are described in more detail in Section 5.

Most of the villages do not have any form of association of fishers nor do most of the fishers see themselves as belonging to any larger association of fishers formed to promote their interests or to manage the resources. There are caveats to this: the UPTM (Union des Pêcheurs Traditionnels de Maintirano) is an association of mostly Sara fishers from Ampasimandroro and includes fishers who frequent Nosy Lava and Maroantaly. This association is active and vocal. Some of the migrant fishers from Manandra have formed their own association and have sporadically been active in the management of the isles. The local fisheries department requires fishers to hold a fisher's card; to do so they must belong to an association of fishers. However, the fisheries department mandates that the association can be no larger than 20 persons. Consequently a plethora of fishers associations were formed (about 25), mostly according to a fishers origin, that exist really only in name. In summary there are no fisher associations that have broad participation of fishers and that are active.

### 3.4.4 Livelihoods

Table 42 presents the primary and secondary occupations, on which the household is dependent for their livelihood, for the groups present on the Barren Isles, in the coastal fishing villages and in the fishing villages of Maintirano.

**Table 42. Primary and secondary occupations of the populations of the local fishing villages**

| | Maintirano fishing villages | | Coastal fishing villages | | Barren Isles | |
|---|---|---|---|---|---|---|
| **Occupation** | Primary | Secondary | Primary | Secondary | Primary | Secondary |
| Rice cultivation | 3 | 12 | -- | -- | -- | -- |
| Fishing | 97 | -- | 100 | -- | 100 | -- |
| Other | -- | 9 | -- | -- | -- | -- |
| None | -- | 79 | -- | 100 | -- | 100 |

Notes: 1. "Other" includes: tourist guide; epi-bar owner; and employee of the Barren Isles Turtle Conservation project. 2. In the coastal fishing villages and Barren Isles all household heads present were surveyed, while only a sample of 35 households was surveyed in the Maintirano villages.

The surveying shows a total dependence on fishing for all fishers present on the Barren Isles and in the coastal fishing villages, with not one of these fishers having a secondary occupation or alternative source of income or food. The fishers resident in the Maintirano villages were not much less dependent on fishing, with this being the primary occupation for 97 % of respondents; 79 % had no secondary occupation.

## 3.5 Socio-economic environment of the coastal fishing villages neighbouring the Barren Isles

### 3.5.1 Population

Only four small fishing villages exist on the coast between the town of Maintirano and Soahany, approximately 75 km to the south. Between Ampandikoara and Soahany to the south there are no nucleated settlements or what could be considered a village, but the area is frequented by isolated families of fishers. The village of Ampandikoara is effectively nucleated settlements, while Manombo (and the neighbouring area called Sakatay) and Kimazimazy are made up of dispersed households. Maintirano maty is not truly a village, consisting of a few isolated households that are dispersed over ca. 2.5 km.

The coast between the town of Maintirano and Soahany is sparsely populated, with little more than 250 persons over approximately 65 km of coastline. Almost half of this population is situated in the village of Manombo (101 persons), with the village of Kimazimazy comprising 70 persons. The demographics of this coastal population, presented in Table 43, are more of what one would anticipate for rural fishing villages when compared to the Barren Isles. But while a larger proportion of females and children make up the population, it is still predominately male. As for the Barren Isles, a proportion of this population is made up of fishers from Maintirano who move seasonally to the coastal fishing villages.

**Table 43.Populations and basic demographics of the coastal fishing villages, October 2009.**

| Coastal villages | Persons | Groups | Average Group Size | % =< 15 years | % females | % males |
|---|---|---|---|---|---|---|
| Ampandikoara | 54 | 8 | 6.8 | 39 | 37 | 61 |
| Manombo | 101 | 16 | 6.3 | 59 | 45 | 53 |
| Maintirano Maty | 25 | 7 | 3.6 | 28 | 44 | 56 |
| Kimazimazy | 70 | 13 | 5.4 | 50 | 47 | 53 |
| **Total** | **250** | **44** | **5.6** | **47** | **43** | **57** |

### 3.5.2 Migration

The populations of Ampandikoara, Kimazimazy and Maintirano maty originate principally from Maintirano. Virtually all of these fishers move seasonally between their base in Maintirano, which they consider as their permanent place of residence, and the fishing villages on the coast. During the cyclone season or when a large storm is announced on the radio, they return to Maintirano. Part of Ampandikoara does constitute a village that is habited year-round; a second, separate part of the village is habited seasonally. Kimazimazy is also more-or-less permanently settled because of its proximity to Maintirano, but families move back to Maintirano if dangerous weather threatens. Maintirano Maty comprises dispersed households that are seasonally occupied. Manombo is the only village with a sizeable resident population, with just over 50 % of the population being residents of the village. A further 32 % come from neighbouring Sakatay – a coastal area that is sometimes habited by fishers in isolated dwellings.

Fishers from Maintirano frequent the coastal villages principally from March to December, similar to the period over which they frequent the Barren Isles.

The fishers in the coastal fishing villages all considered themselves as Vezo Sakalava. At the time of the surveying (October 2009), there were no Sara or Vezo migrants from the South West in these villages, with the exception of 3 fishers from Morondava who had been resident in Ampandikoara for two years.

**Table 44. Origins of the fishers who constitute the populations of the coastal fishing villages**

| | Coastal villages | | | | |
|---|---|---|---|---|---|
| **Origin** | Ampandikoara | Kimazimazy | Maintirano maty | Manombo | **Total** |
| Maintirano | 50 | 70 | 25 | 12 | **157** |
| Manombo | | | | 53 | **53** |
| Morondava | 3 | | | 2 | **5** |
| Sakatay | | | | 32 | **32** |
| **Total** | **53** | **70** | **25** | **99** | **247** |

### 3.5.3 Social infrastructure

The social infrastructure of the settlements on the coastal fishing villages are summarised in Table 45. Health, education, sanitary and communication infrastructure are very limited, as would be expected from the lack of overall social infrastructure of the rural communes within which these villages fall (see section 0).

**Table 45. Summary of the social infrastructure of the coastal fishing villages neighbouring the Barren Isles**

| | Ampandikoara | Manombo | Maintirano Maty | Kimazimazy |
|---|---|---|---|---|
| Hospital, CSB | | | | |
| Primary school | | | | |
| Secondary school | | | | |
| Drinking water (wells) | yes (2) | yes (2) | yes (1) | yes (1) |
| Latrines / toilettes | | | | |
| Electricity (JIRAMA) | | | | |
| Access to closest urban centre | Maintirano (by sea) | Betanatana (by foot) | Maintirano (by molanga) | Maintirano (by molanga) |
| Church | | | | |
| Chef fokontany | | yes | | |
| Rules / dina on fishing | | | | |
| Market | | (Betanatana) | (Maintirano) | (Maintirano) |
| Association de pêcheurs | | | | |

Notes: molanga – small dugout canoe

Most of the coastal fishing villages are similar to the Barren Isles in their lack of social infrastructure. The village of Kimazimazy, however, is approximately three km south of Maintirano town and so residents of this village are able to access health and education services of the town even though these are not present in the village. In contrast to the isles all of the coastal fishing villages have wells with drinkable water. Villages of Manombo, Maintirano Maty and Kimazimazy are also able to readily access the markets of the neighbouring towns of Betanatanana and Maintirano by foot or by using dugout canoes to follow protected channels within the mangroves. Only children from Kimazimazy consistently attend school in Maintirano; no children resident in Ampandikoara attend school, nor do the vast majority in Maintirano Maty and Manombo (despite there being an EPP 3 km away from Manombo). Of these villages only Manombo has an administrative chef de fokotany.

### 3.5.4 Livelihoods

The surveying shows a total dependence on fishing for all habitants of the coastal fishing villages, with not one of the villagers surveyed having a secondary occupation or alternative source of income or food. See section 4.2 for more details.

## 3.6 Socio-economic environment of the fishing villages of Maintirano town

### 3.6.1 Migration

Random surveying of households within the fishing villages of Maintirano indicate that there is no immigration into Ambalahonko Ambany (Table 46). On the other hand, just under half of the households interviewed in Ampasimandroro originated from outside of the Melaky region. A family of Sara migrants from Anakao founded the Sara quartier of Ampasimandroro, which is separated from Ampasimandroro by a river channel, when the Vezo Sakalava allowed them to settle on this land in the 1960s. The majority of the quartier (73%) are now themselves residents of Maintirano, but the quartier also included fishers from Belavenoke, Morombe and Antsohihy who have married into Sara families. Similarly Vezo migrants from the South West have married into Vezo Sakalava families from Ampasimandroro and so gained the right to settle in the village.

**Table 46. Origins of the household heads interviewed within the Maintirano fishing villages**

| Origin | Ambalahonko Ambany | Ampasimandroro | Ampasimandroro Sara quartier |
|---|---|---|---|
| Anakao | - | 11% | - |
| Antsohihy | - | - | 9% |
| Belavenoke | - | - | 9% |
| Belo-sur-Mer | - | 22% | - |
| Morombe | - | - | 9% |
| Maintirano | 100% | 56% | 73% |
| Morombe | - | 11% | - |

The ethnic groups to which the fishers saw themselves as belonging reflected the immigration dynamics described above:

- 100 % respondents in Ambalahnko Ambany were Vezo Sakalava
- Ampasimandroro was constituted by 56 % Vezo Sakalava, 11 % Sara and 33 % Vezo from the South West
- The Sara quartier of Ampasimandroro was constituted by 60 % Sara, 10 % Vezo Sakalava and 30 % Vezo from the South West.

The movements of fishers who are resident in the Maintirano fishing villages to other local fishing sites are pertinent to the establishment of the PA. Table 47 summarises the percentages of households who do

habitually move each year to local fishing grounds that are not immediately accessible from their resident villages. The data indicates that the majority of fishers from Ampasimandroro and the Sara quartier of Ampasimandroro in particular, habitually move to other areas beyond Maintirano to fish. Comparatively fewer fishers from Ambalohonko Ambany do this; still, the surveying indicates that nearly a third of fishers from Ambalahonko Ambany move to other fishing areas.

**Table 47. % of respondents surveyed in the fishing villages of Maintirano who migrate to local fishing grounds**

| | % of respondents who migrate locally | |
|---|---|---|
| | **yes** | **no** |
| Ambalahonko Ambany | 31% | 69% |
| Ampasimandroro | 78% | 22% |
| Ampasimandroro Sara quartier | 91% | 9% |
| **For all sites** | 64% | 36% |

The shortest fishing trips were to sites close to Maintirano and lasted 2– 5 days; the more remote sites were visited over periods ranging from one to several months.

The destinations frequented by the fishers surveyed are summarised in Table 48 and Figure 23. While the data may well have been biased by the absence of fishers at the time of surveying (particularly for Ampasimandroro and the Sara quartier of Ampasimandroro) they do give an indication of the importance to Maintirano fishers of fishing areas that could be included in the PA.

In summary both the Barren Isles and the coastal fishing areas opposite them are important to fishers resident in Maintirano:

- The Barren Isles themselves are frequented by between 10 % (Ambalahonko Ambany) and 37 % (Ampasimandroro Sara quartier) of respondents.
- The coastal fishing villages opposite the Barren Isles are frequented by between 5 % (Ambalahonko Ambany) and 39 % (Ampasimandroro) of respondents.

The destinations frequented reflect the fishing methods and species favoured by the fishers of each village, described in detail in Section 4 Utilisation. For example, fishers of the Sara quartier of Ampasimandroro favour the Barren Isles, Nosy Vao and more remote villages known to have good shark fishing such as Benjavily. These fishers also frequent sites such as Maintirano Maty to fish close to shore, but only during the months when they are not able to fish the Barren Isles etc. because of bad weather.

**Table 48. Local fishing destinations frequented by fishers of the fishing villages of Maintirano and the % of the total respondents who move to them**

| | Village of Origing | | |
|---|---|---|---|
| **Destination** | **Ambalahonko Ambany** | **Ampasimandroro** | **Ampasimandroro Sara quatier** |

| | | | |
|---|---|---|---|
| Ambalahonko | - | - | 11% |
| Ambalambongy | 14% | - | - |
| Ampandikoara | 5% | 16% | - |
| Andalanda | - | - | 5% |
| Benjavily | - | - | 5% |
| Maintirano Maty | - | 23% | 16% |
| North to Magnomba | 10% | 16% | - |
| Nosy Barren | 10% | 23% | 37% |
| Nosy Vao | - | - | 11% |
| Tambohorano | - | - | 5% |

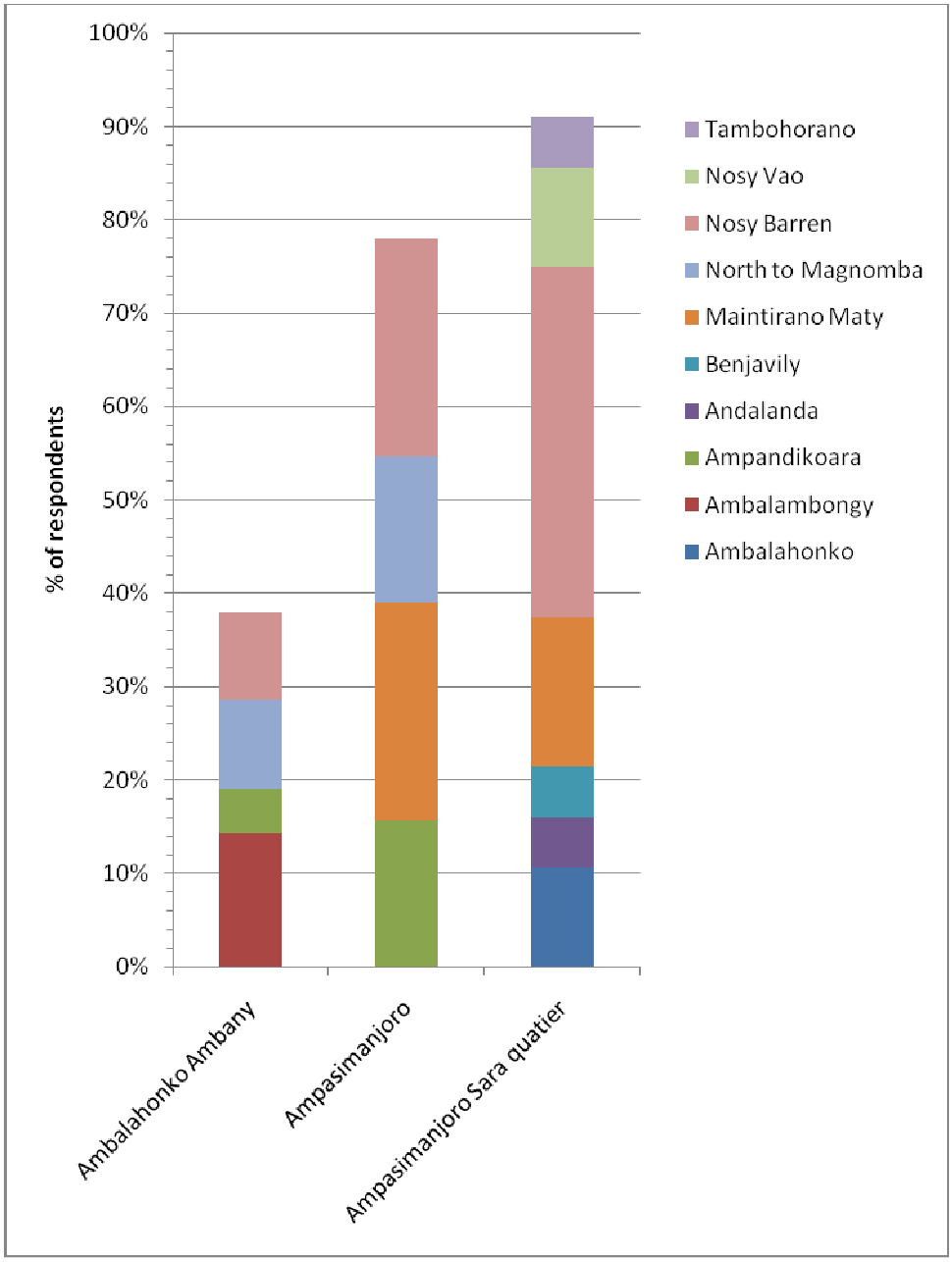


**Figure 23. Percentage of the total respondents from the three Maintirano fishing villages who move to a particular local fishing destination**

### 3.6.2 Livelihoods

The fishers resident in the Maintirano villages were not as reliant on fishing for their livelihoods as those living on the Barren Isles, but still had a high dependency on fishing. The primary occupation for 97 % of respondents was fishing; 79 % had no secondary occupation, while 12 % named rice cultivation as a secondary occupation. See section 4.2 for details.

### 3.6.3 Social infrastructure

The social infrastructure of the Maintirano fishing villages is summarised in Table 49. Thanks to their proximity to Maintirano, these urban fishing villages are able to access the infrastructure of the town and are consequently much better off than the rural fishing villages.

**Table 49. Summary of the social infrastructure of the fishing villages within Maintirano town**

| | **Ampasimandroro** | **Ambalahonko Ambany** |
|---|---|---|
| Hospital, CSB | yes (Maintirano) | yes (Maintirano) |
| Primary school | yes (1 EPP) | yes (Maintirano) |
| Secondary school | yes (Maintirano) | yes (Maintirano) |
| Drinking water (wells ) | yes (6) | yes (4) |
| Latrines / toilettes | no | no |
| Electricity (JIRAMA) | yes | no |
| Telephone network | yes | yes |
| Access to closest urban centre | yes | yes |
| Church | yes (Maintirano) | yes (Maintirano) |
| Chef fokontany | yes | yes |
| Rules / dina on fishing | no | no |
| Market | yes (Maintirano) | yes (Maintirano) |
| Association de pêcheurs | yes | no |

# 4 Utilisation

## 4.1 Summary

Presently there are three main active users of the isles: traditional fishers, artisanal fishers and a guano mining company. Shrimp trawlers are known to work the channel between the isles and the mainland, but only during certain months (mostly April and May). No significant tourism takes place on the isles. Oil and gas exploration is presently taking place immediately south of the isles and it is envisageable that exploration will take place west of the isles.

The creation of the Barren Isles marine protected area will essentially impact directly on the livelihoods of one group of people – traditional fishers.[9] As is noted in the previous chapter, this population is highly dependent on fishing for income and food. The study therefore investigated in detail how the traditional fishers used the isles.

The species targeted by traditional fishers and the area that they use depends largely on the origin of the fisher. Broadly speaking:

- Fishers from the Sara quartier of Ampasimandroro fish almost only for Spanish mackerel, and other pelagic fish species in this guild, in a large area falling between Nosy Lava, Maroantaly and the mainland between March and November; during the rainy season many of these same fishers free dive for sea cucumbers;
- Migrant fishers from the South West fish exclusively for shark and sea cucumbers over an extensive area that includes the outer submerged barrier reef and areas of the Mozambique channel immediate to this;
- A very small number of Vezo Sakalava fishers from Ambalahonko Ambany fish for shark and sea cucumber on the outer reefs that they access from Nosy Marify and Manandra (the vast majority of fishers from this village fish close to the shoreline or in the mangroves);
- And Vezo Sakalava fishers from the coastal and Maintirano fishing villages target species that occur within the mangroves and close to shore (normally less than 2 km). They don't fish near the isles nor do they frequent them for cultural reasons.

Shark, sea cucumber and Spanish mackerel (and other pelagic fish species in this guild) are by far the most important species targeted by traditional fishers around the Barren Isles. Though fishermen do use hand lines, spear guns and nylon mono-filament nets to catch reef and other shallow water habitat fish species, this is a secondary activity. The catch is for eating or to bait the jarifa shark nets. Women and children glean the extensive reef flats, mostly for octopus. Fishers prize turtle meat and will hunt marine turtles. Traditional

[9] At the time of writing of the report, guano mining did not employ any local people as the company was mostly transporting stockpiled guano that had been abandoned by a previous operator in the 1990s.

fishers fish the waters around the isles mostly from March to November, but it is noted that fishers from all of the groups frequent the isles year round.

More than half of the fishers from the Maintirano fishing villages and all of the fishers from the coastal fishing villages form a distinctive group of fishers who do not frequent the Barren Isles. They are Vezo Sakalava residents and fish for species that occur within the mangroves or close to the mainland shore. Their favoured fishing gears are nylon mono-filament nets, hand-lines and mosquito nets. Few of these fishers have large, seaworthy outrigger pirogues that would enable them to make long trips to the isles, in contrast to the Sara and Vezo migrants from the South West.

Guanomand, an exploiter of bat guano based in Antananarivo, is presently mining guano on the isles. In late 2009 they began mining on Nosy Andrano, despite no Environmental Impact Assessment (EIA) having been carried out – normally obligatory by law (decret MECIE) since small islands are classed as "sensitive zones". Four "permis d'exploitation" for the exploitation of "phosphorite" have been centrally issued to mine the following isles: Nosy Lava, Nosy Andrano, Maroantaly and Nosy Abohazo (also called Androtra).

The isles belong entirely to the Government of Madagascar and are classed as "domainial"; there are no legitimate ownership claims to the isles. The coastline opposite the Barren Isles is almost entirely public land with only one small parcel at Namakea belonging to a private individual. No current claims to private ownership or to change land tenure status have been lodged with the government cadastral services.

## 4.2 Traditional fishing

The area that would be effected by the establishment of a marine protected area is largely used by traditional fishers, though itinerant artisanal fishers also frequent the Barren Isles and some shrimp trawling takes place in the area.

The species that traditional fishers target, the techniques that they use and their spatial and temporal utilisation of the area all have an important bearing on future conservation strategies. Traditional fishers' use of the area was investigated in detail using a combination of household surveys, focus group interviews and participative mapping exercises. The species targeted by traditional fishers and the area that they use depends largely on the origin of the fisher. Broadly speaking:

- Fishers from the Sara quartier of Ampasimandroro fish almost only for Spanish mackerel (and other pelagic fish species in this guild) in a large area falling between Nosy Lava, Maroantaly and the mainland;
- Migrant fishers from the South West fish exclusively for shark and sea cucumbers over an extensive area that includes the outer submerged barrier reef and areas of the Mocambique channel immediate to this;
- Vezo Sakalava fishers from Ambalahonko Ambany fish for shark and sea cucumber on the outer reefs that they access from Nosy Marify and Manandra;

- And fishers from the coastal fishing villages target species that occur within the mangroves and close to shore (normally less than 2 km). They don't fish near the isles.

### 4.2.1 Barren Isles

Table 50 presents fishing techniques used within the entire larger Barren Isles ecosystem area and the ranking that fishers of the Barren Isles gave these. In addition Figure 24 and Figure 25 present the primary and secondary techniques fishers on the Barren Isles use. The fishing techniques frequently used in the vicinity of the Barren Isles are as follows:

*Manirike zanga* – free-diving for sea cucumbers. Rocky outer reefs are favoured areas for *manirike zanga*; sometimes fishers use a long, thin spear of wood so that they are able to gain extra depth, once the sea cucumber is stabbed the stick floats to the surface itself. More recently fishermen have begun diving at night with torches tied inside condoms – a technique that migrants have brought up from the south.

*Jarifa* – is a baited gill net used to target shark; it is set overnight in 100 -300 m depth, normally in shallower waters of the Mozambique Channel just off the edge of the submerged barrier reef. The bait fish are fished with small nylon nets or spearguns, often in the lagoons of the isles the afternoon before setting out to set the net.

*ZDZD kirara* – a 100 – 200 m long drifting gill net that is used to target Spanish mackerel and other pelagic fish species at night. Fishers set the net at the surface at dusk, fix one end to the pirogue and drift in the current, periodically checking the net until dawn, when it is brought in. Wealthier fishermen will attach a couple of *ZDZD kirara* nets together to form nets of substantial length.

*ZDZD* - a deep-water gill net similar to *jarifa*, but of smaller mesh and made of finer cord. It is normally bought manufactured, is more expensive than a *jarifa* and therefore less common.

*Basy* - spear fishing, mostly with spear guns fabricated from wood, car tyre rubber and a spear of steel reinforcing bar.

*Maminta* - hand-line fishing for large reef species and pelagics.

*Mihake* – gleaning on reef flats for octopus and some species of sea cucumber; practised mostly during spring tides.

*Horata tondro 2* - a small, handmade net of nylon fishing line and a 2-finger mesh size; 4 – 6 m in length; it is frequently used to fish in shallow, near shore areas.

It should be noted that in the ranking exercise migrant fishers often could not really prioritise between *manirike zanga* (free-diving for sea cucumber) and *jarifa* (shark fishing). They practise these techniques either concurrently or opportunistically when conditions favour one over the other, for example, when good visibility or the discovery of an unexploited fishing ground favours *manirike zanga*.

The fishers of the Barren Isles used seaworthy, large (6 – 8 m) outrigger sail pirogues to fish and to transport water, provisions etc. to the isles.

**Table 50. Fishing techniques used by fishers of the Barren Isles ranked by their relative importance**

(1 = most important; 6 = least important; gained by focus group interviews.)

| | Nosy Lava (Vezo) | Nosy Lava (Sara) | Nosy Manghily | Nosy Abohazo | Nosy Maroantaly (Sara) | Nosy Manandra | Nosy Marify |
|---|---|---|---|---|---|---|---|
| Manirike zanga | 2 | 4 | 2 | 2 | 6 | 1 | 1 |
| Rapala | -- | -- | -- | -- | -- | -- | -- |
| Jarifa | 1 | -- | 1 | 1 | 2 | 2 | 2 |
| ZDZD | 3 | -- | -- | -- | -- | 3 | 3 |
| ZDZD kirara | -- | 1 | | -- | 1 | -- | 3 |
| Jaoto | -- | -- | 3 | | | | |
| Palangre | -- | -- | -- | -- | -- | -- | -- |
| Basy | 5 | 2 | | 5 | | 4 | 5 |
| Harato tondro 2 | 4 | 3 | | -- | 3 | -- | 4 |
| Maminta | -- | -- | 4 | 3 | 5 | 5 | -- |
| Chasse en moustiquaire | -- | -- | -- | -- | -- | -- | -- |
| Mihake | -- | -- | 5 | 4 | -- | -- | 6 |
| Filet de crevette | -- | -- | -- | -- | 4 | -- | -- |
| Mila drakaky | -- | -- | -- | -- | -- | -- | -- |

The primary fishing technique of the Sara fishermen living on Nosy Lava and Manghily was exclusively *ZDZD kirara*. Key informant interviews and quantitative surveys revealed that this was by far the most important technique (see Table 50 and Figure 24). Fishing techniques of secondary importance to these fishers that they used on the isles included *jarifa*, *basy* (spear fishing) and *harato tondro 2* (net fishing, including filet de crevette) is practised not from the isles but close to the mainland during the cyclone season). In contrast to the migrant fishers from the South West, the Sara did not commonly practise *manirike zanga*; they did, however, fish for shark using *jarifa* and *ZDZD*.

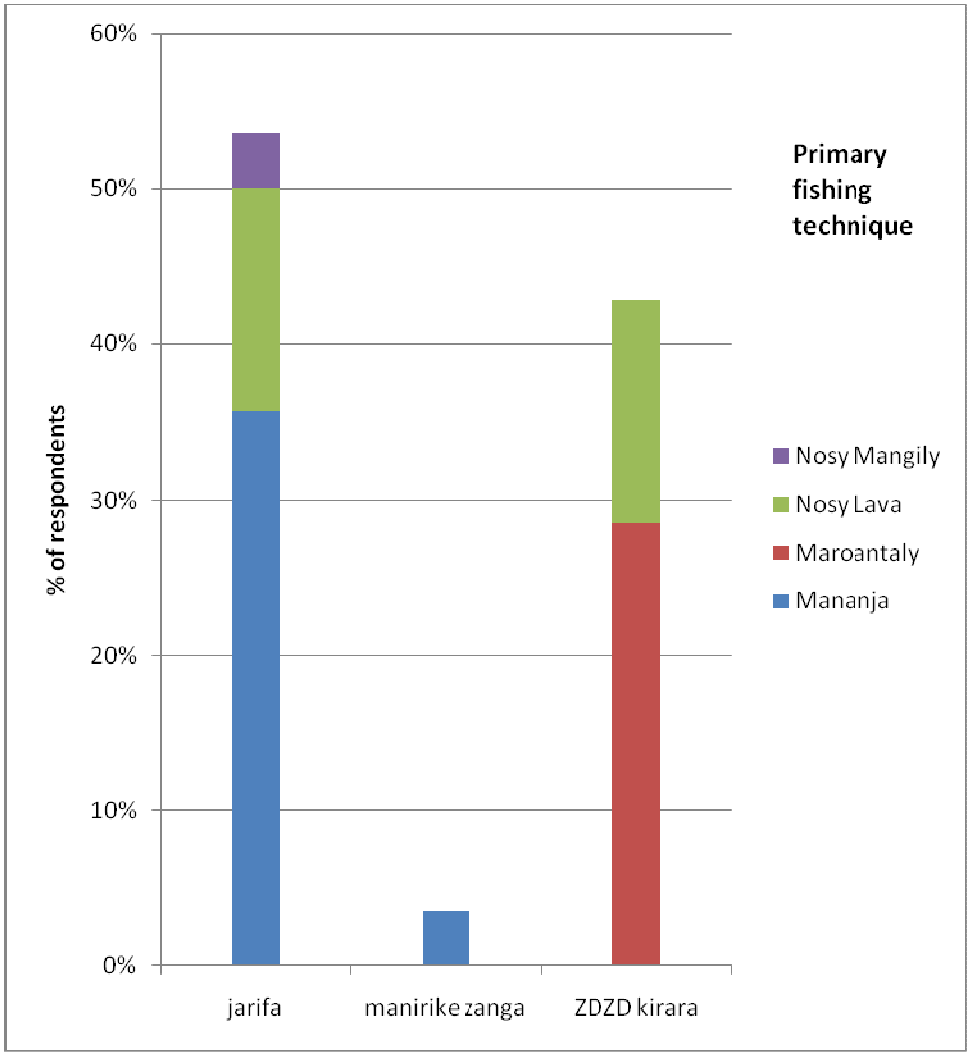


**Figure 24. Primary fishing techniques used and the percentage of total respondents using these for fishers living on the Barren Isles (from quantitative surveying of all group leaders present)**

The Vezo migrants who dominated the populations of the other isles consistently ranked *jarifa* or *manirike zanga* as their primary fishing technique. Nosy Manandra and Marify give access to reefs that have consistently superior visibility to the more southerly reefs; fishermen on these isles named *manirike zanga* as their primary fishing method. The visibility in the vicinity of the other isles, particularly Nosy Lava and Nosy Manghily is normally poorer than the northern Barren Isles and so *jarifa* is favoured here. Of tertiary importance to the migrants was another shark fishing net called *ZDZD*. Net and spear fishing for reef species were not considered important techniques and were not widely used (see Figure 26). These techniques were used only to catch fish for eating on the isles or to bait the *jarifa*. Only one fishing group, the Vezo family living on Nosy Manghily, use *jaoto* - a destructive beach seine net.

Fishermen from Maintirano based on Nosy Manandra and Marify used techniques similar to the Vezo migrants from the South West – *jarifa* and *manirike zanga*. In addition some of the Maintirano fishermen also practised *ZDZD kirara* from Marify, using the sand cay as a base and returning to Maintirano directly from fishing overnight to sell the catch on the Maintirano market.

*Mihake* (gleaning on the reef flats for octopus) was practised on a number of the isles (Nosy Manghily, Abohazo and Marify, but also Nosy Lava, Manandra and Maroantaly, see Figure 26) and was ranked as being of the least importance for these isles. The female and infant Vezo migrant fishers from the South West glean the reef flats of these isles during spring tides.

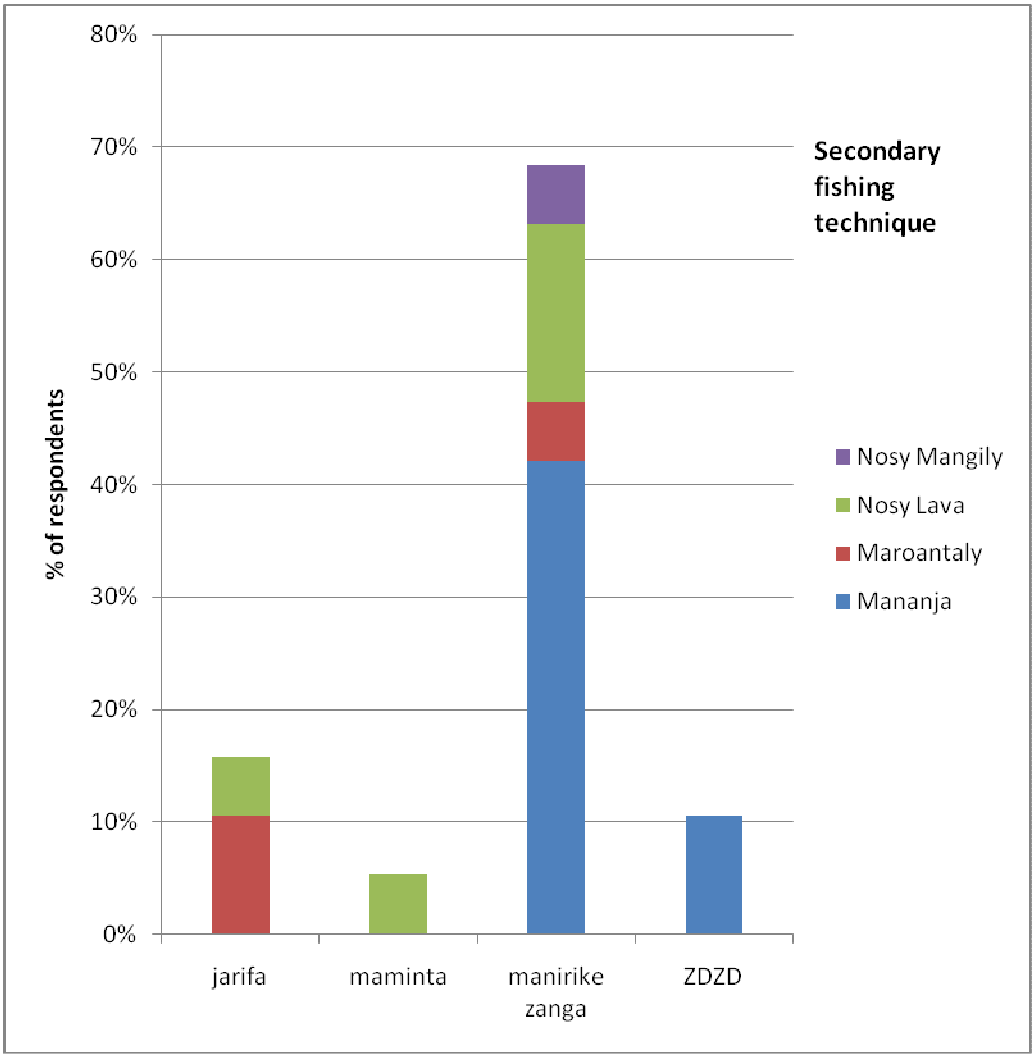


**Figure 25. Secondary fishing techniques used and the percentage of total respondents using these for fishers living on the Barren Isles (from quantitative surveying of all group leaders present)**

The total number of groups practising particular fishing techniques on the Barren Isles is presented in Figure 26. In terms of numbers, *jarifa* and *manirike zanga* are the primary techniques practised by a roughly equal number of fishermen; *ZDZD kirara* is the third most used technique. These three techniques are by far the the most commonly used. In addition, fishers use a number of other techniques that are less importance. These include, in order of importance: *maminta* (hand-line fishing), *mihake* (gleaning), *ZDZD* (shark fishing net) and *horata tondro 2* (a handmade net of 2 fingers mesh size made with nylon fishing line).

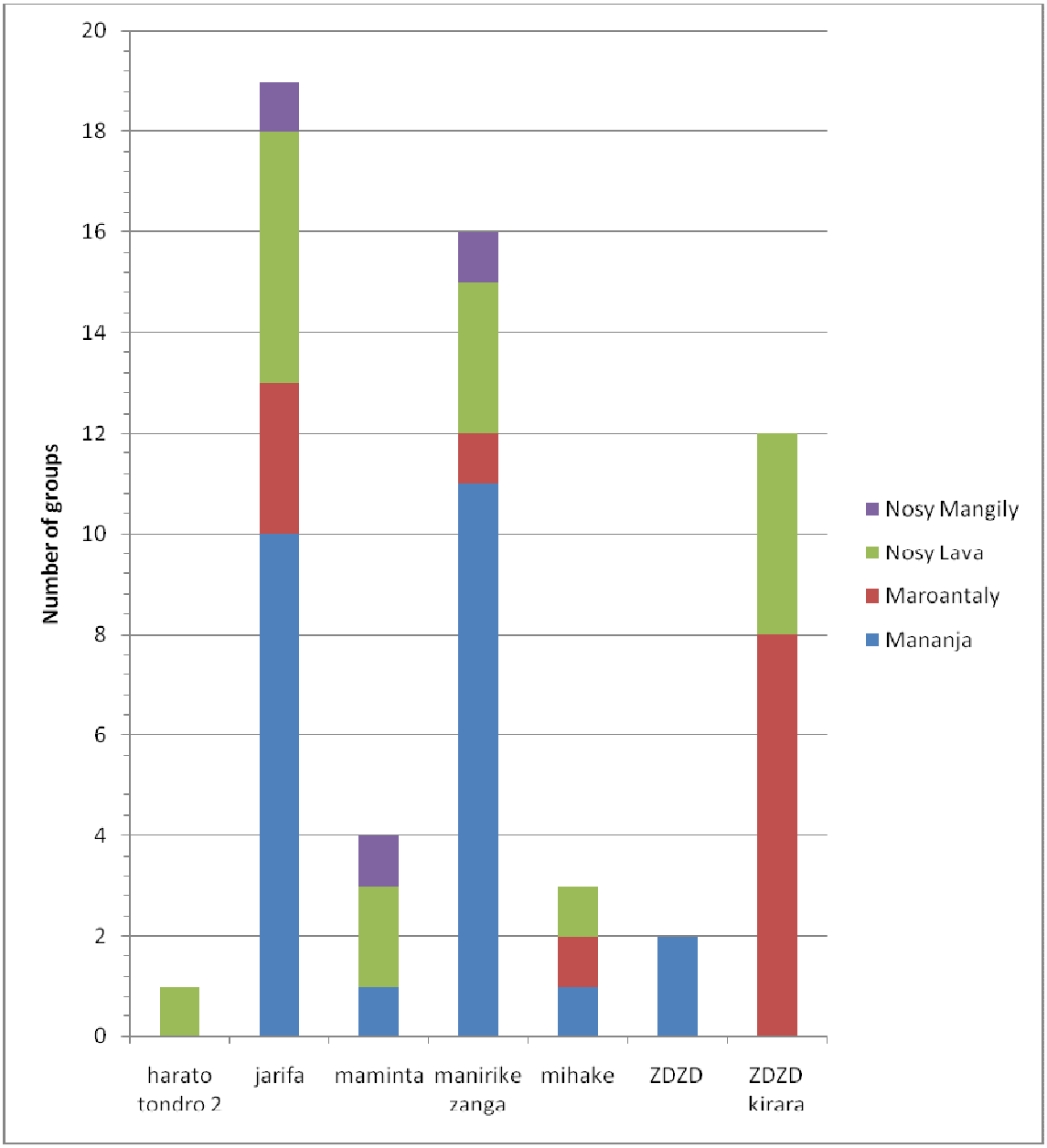


**Figure 26. The total number of fisher groups using particular techniques for the Barren Isles (from quantitative surveying of all group leaders present)**

An understanding of the seasons of particular fisheries is very useful in informing resource management measures, such as establishing temporary fishing reserves or global closures of particular fisheries. Table 51 presents calendars of use for the principal fishing techniques practised from the Barren Isles.

| Technique | Isles | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Jarifa** | Nosy Lava (Vezo) | All year | | | | | | | | | | | |
| | Manghily | All year | | | | | | | | | | | |
| | Abohazo | | | March - November | | | | | | | | | |
| | Maroantaly | | February - December | | | | | | | | | | |
| | Manandra | | | March - December | | | | | | | | | |
| | Marify | | | March - December | | | | | | | | | |
| **Manirike zanga** | Nosy Lava (Vezo) | Throughout the year when water clean | | | | | | | | | | | |
| | Manghily | Throughout the year | | | | | | | | | | | |
| | Abohazo | | | March - November | | | | | | | | | |
| | Maroantaly | Periodically when visibility permits | | | | | | | | | | | |
| | Manandra | | | March - December | | | | | | | | | |
| | Marify | Throughout the year | | | | | Best period June - November | | | | | | |
| **ZDZD kirara** | Nosy Lava (Sara) | | | March - November | | | | | | | | | |
| | Maroantaly | | | | | | June – November | | | | | | |
| | Manandra | | | | | | June – November | | | | | | |
| | Marify | | | | | | June – November | | | | | | |
| **ZDZD** | Nosy Lava (Vezo) | Throughout the year | | | | | | | | | | | |
| | Maroantaly | | | March - May | | | | | | | | | |
| | Manandra | | | March - December | | | | | | | | | |
| | Marify | | | March - December | | | | | | | | | |
| | Ampandikoara | | | March - December | | | | | | | | | |
| **Maminta** | Manghily | | | Periodically | | | | | | | | | |
| | Abohazo | | | Periodically | | | | | | | | | |
| | Maroantaly | | | Periodically | | | | | | | | | |
| | Manandra | | | Periodically | | | | | | | | | |
| **Mihake** | Manghily | Periodically throughout the year | | | | | | | | | | | |
| | Abohazo | | | March - November | | | | | | | | | |
| | Marify | Periodically throughout the year | | | | | | | | | | | |
| **Basy** | Nosy Lava | Throughout the year | | | | | | | | | | | |
| | Abohazo | | | March - November | | | | | | | | | |
| | Manandra | | | March - December | | | | | | | | | |
| | Marify | | | March - December | | | | | | | | | |
| **Harato tondro 2** | Nosy Lava (Vezo) | Throughout the year | | | | | | | | | | | |
| | Marify | Periodically throughout the year | | | | | | | | | | | |
| **Jaoto** | Manghily | Often throughout the year | | | | | | | | | | | |

**Table 51. Calendar of fishing technique utilisation for the Barren Isles (lighter green shading indicates less frequent use)**

Note: lighter green shading indicates that fishers still practice the method, but less than during the 'season', shown by darker green shading.

As would be anticipated, the use of particular techniques corresponds with the same period of the year that fishers favour living on the Barren Isles (see section 3.4). The most common fishing techniques, *jarifa* and *manirike zanga*, are chiefly practised from March to late November / early December, though on Nosy Lava and Manghily they are practised year-round. The third most popular technique, *ZDZD kirara*, is used chiefly from June to November, though the fishers of Nosy Lava begin using the technique in March.

### 4.2.2 Coastal fishing villages

The fishing techniques used by the fishers of the coastal fishing villages, as well as the order of importance of these to fishers, are presented in Table 52. The principal fishing techniques were as follows:

*Harato tondro* 1/2 - a small, handmade nylon net of a 1- or 2-finger mesh size; used to fish in channels within the mangroves or less than ca. 2 km offshore; the finer nets are sometimes used to fish shrimp, though few fishers specifically targeted shrimp.

*Maminta* - fishing with a nylon hand-line, either in channels within the mangroves or less than ca. 2 km offshore).

*Chasse en moustiquaire* - the use of a net made from mosquito nets to fish juvenile shrimp (*patsa*) or small, anchovy-like fish (*varilava*). It is used in both the mangroves and off beaches.

*Mila drakaky* - fishing/collecting crab within the mangroves.

*Harato*, *maminta* and *chasse en moustiquaire* are all carried out both within the mangroves and in the sea close to shore. Whether fishing is carried out in mangroves or the sea depends on the season but also equally on the weather – if conditions do not permit fishing at sea, the mangroves often present a sheltered alternative.

The majority of fishers from the coastal villages used *molanga* (small dug-out canoes) to fish from and as transport. A minority also have small dug-out sail pirogues (out-rigger sail canoes); though none of these fishers owned large, sea worthy pirogues as did the fishers living on the isles.

**Table 52. Fishing techniques used by the fishers of the coastal fishing villages neighbouring the Barren Isles ranked by their relative importance**

(1 = most important; 5 = least important; gained by focus group interviews.)

| | Ampandikoara | Manombo | Maintirano Maty | Kimazimazy |
|---|---|---|---|---|
| Manirike zanga | -- | -- | -- | -- |
| Rapala | -- | -- | -- | -- |
| Jarifa | -- | -- | -- | -- |
| ZDZD | 5 | -- | -- | -- |
| ZDZD kirara | -- | -- | -- | -- |
| Jaoto | -- | -- | -- | -- |
| Palangre | -- | -- | -- | -- |
| Basy | -- | -- | -- | -- |

| | | | | |
|---|---|---|---|---|
| Harato tondro 1/2 | 1 | -- | 2 | 1 |
| Maminta | 4 | 1 | 1 | 2 |
| Chasse en moustiquaire | 2 | 2 | 3 | 3 |
| Mihake | -- | -- | -- | -- |
| Filet de crevette | -- | -- | 4 | 4 |
| Mila drakaky | 3 | 3 | -- | -- |

The coastal fishing villages were characterised by fishers only using two or three techniques (and some fishers reported only using one) that required simple equipment. Fishers of Manombo, Maintirano Matay and Kimazimazy reported using four techniques, while those of Ampandikoara listed five (one of these, *ZDZD*, is only used by a single migrant fisher from Morondave).

*Harato tondro 2* and *maminta* were ranked as a primary or secondary fishing technique for all of the villages. *Chasse en moustiquaire* was ranked as a secondary or tertiary technique by all of the villages. *Mila drakaky* (crab fishing in the mangroves), was ranked as a tertiary fishing activity in Manombo and Ampandikoara.

Table 53 presents the calendars of utilisation for the techniques used by the fishers of the coastal fishing villages. In considering the principal fishing techniques, *maminta* and *harato*, there doesn't seem to be any global fishing seasons, with the preferred fishing habitat (mangrove or near-shore sea) and season varying from village to village. The use of mosquito nets is also carried out very much opportunistically throughout the year, with the high season for patsa and varilava varying from year to year. Likewise fishers collect crabs in the mangroves throughout the year.

Any fishery management measures taken amongst the coastal fishing villages would have to be very much at a village-level for a number of reasons: the fishers practise a very limited number of fishing techniques; fishing activities of these fishers are localised to small well-defined areas (see section 4.2.4); the villages are well separated; and each village has its own preferred fishing seasons.

**Table 53. Calendar of fishing technique utilisation for the coastal fishing villages neighbouring the Barren Isles (lighter green shading indicates less frequent use)**

| Technique | Village | Jan. | Feb. | Mar. | Apr. | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Moustiquaire** | Ampandikoara | Periodically throughout the year (Mangroves – varilava) | | | | | | | | | | | |
| | Ampandikoara | Periodically throughout the year (Sea – patsa) | | | | | | | | | | | |
| | Manombo | Throughout the year (Sea – patsa) | | | | | | | | | | | |
| | Kimazimazy | Periodically throughout the year, infrequent | | | | | | | | | | | |
| **Harato tondro 1 / Filet crevette** | Maroantaly | | | March - July when returning to Maintirano via coastal villages | | | | | | | | | |
| **Harato tondro 1/2** | Ampandikoara | Throughout the year (Mangroves) | | | | | | | | | | | |
| | Ampandikoara | Throughout the year (Sea) | | | | | | | | | | | |
| | Maintirano maty | | | March - December (Sea and mangroves) | | | | | | | | | |
| | Kimazimazy | | | March – June (Sea) | | | | | | | | | |

| Technique | Village | Jan. | Feb. | Mar. | Apr. | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kimazimazy | | | | | | June – October (Mangroves) | | | | | | |
| **Maminta** | Ampandikoara | Throughout the year (Sea) | | | | | | | | | | | |
| | Manombo | | | | April – October (Sea) | | | | | | | | |
| | Manombo | November – March | | | | | | | | | | | |
| | Maintirano maty | | | March – December (Sea and mangroves) | | | | | | | | | |
| | Kimazimazy | Throughout the year (Sea) | | | | | | | | | | | |
| **Mila drakaky** | Ampandikoara | Throughout the year (Mangroves) | | | | | | | | | | | |

### 4.2.3 Maintirano fishing villages

Table 54 lists the fishing techniques used by the fishers of Ampasimandroro and Ambalahonko. The focus groups had difficulty in ranking the techniques as these villages are comprised of three groups of fishers: those who fish around the Barren Isles and Nosy Vao; those who fish only in the mangroves and close to shore; and those who fish the isles, close to shore and the mangroves. Consequently fishers from these villages use a wider variety of techniques that those from the rural coastal fishing villages and those based on the isles. Techniques that have not already been described in the previous sections include:

*Palangre* – a form of baited long-line that is attached to an anchored buoy in about 30 m of water and left overnight. It is used to target certain shark species.

*Maminta* (small palangre) – fishing for small pelagic fish from a pirogue using a small long-line.

*Filet de crevette* – a fine net made from nylon monofilament and used to target shrimp.

**Table 54. Fishing techniques used by the fishers of the fishing villages within Maintirano ranked by their relative importance**

(1 = most frequently cited; 4 = least frequently cited; gained by focus group interviews.)

| | Ampasimandroro Sara quartier | Ampasimandroro | Ambalahonko Ambany |
|---|---|---|---|
| Manirike zanga | 3 | yes | Yes |
| Rapala | | | |
| Jarifa | 2 | yes | Yes |
| ZDZD | 5(=) | 3 (=) | Yes |
| ZDZD kirara | 1 | yes | Yes |
| Jaoto | | | |
| Palangre | | yes | |
| Basy | 5(=) | yes | Yes |
| Harato tondro 1 | 4(=) | | 1(=) |
| Harato tondro 2 | 4(=) | 1 | 1(=) |
| Harato tondro 3 | 4(=) | | 1(=) |
| Maminta | | 2 | 4(=) |
| Maminta (small palangre) | | | 4 (=) |

| | | | |
|---|---|---|---|
| Chasse en moustiquaire | 5(=) | 3 (=) | 3 |
| Mihake | | yes | Yes |
| Filet de crevette | | 4 | 2 |
| Mila drakaky | | yes | |

Since the focus groups could not reliably rank certain techniques these are simply noted as being used.

The fishers of both Ambalahonko Ambany and Ampasimandroro judged harato – net fishing close to shore or in the mangroves using a range of mesh sizes - to be the technique of primary importance. Maminta, chasse en moustiquaire and filet de crevette were all listed as being of importance to fishers of these villages.

Fishers of the Sara quartier of Ampasimandroro ranked ZDZD kirara as the primary technique, followed secondly by jarifa and thirdly by manirike zanga. In contrast to Ambalahonko Ambany and Ampasimandroro, harato was not of primary importance, but was ranked fourth.

Figure 27 and Figure 28 present the primary and secondary fishing techniques used by the fishers of the Maintirano villages as ascertained by quantitative household surveying. This would probably have been biased by the absence of fishers who were on the isles. Nevertheless the results largely support the relative importance of the fishing techniques gained from the focus groups and agree with what would be expected from the proportions of fishers moving out of these villages to the isles.

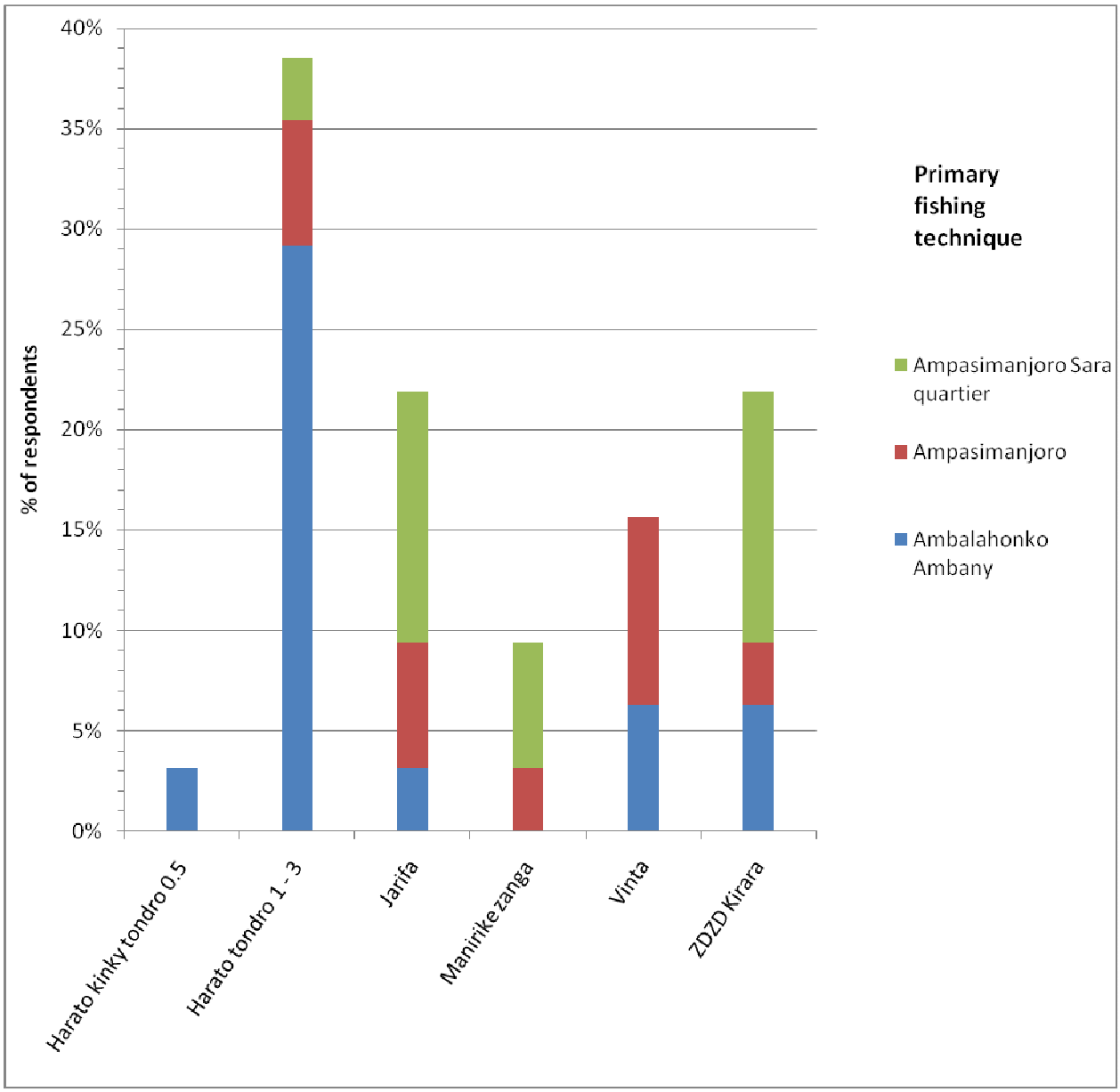


**Figure 27. Primary fishing techniques used and the percentage of total respondents using these for fishers living within the Maintirano fishing villages**

In summary:

- The majority of fishers of Ambalahonko Ambany target lower value fish species for local sale and consumption using nets of varying mesh-size. This type of net fishing is of importance both as a primary and secondary technique. Nets of this kind are relatively cheap and are made by the fishers themselves. Hand-line fishing is used as both a primary and secondary technique but is of far less importance than net fishing. A minority of fishers use *ZDZD kirara* and *jarifa*.

- Fishers of Ampasimandroro use mostly hand-line and net fishing to target species for local sale and consumption. These two activities are prevalent as both primary and secondary techniques. A smaller but still significant number of fishers also use *jarifa*, *ZDZD kirara* and dive for sea cucumbers.

- The fishers of the Sara quartier of Ampasimandroro target Spanish mackerel and other pelagic fish using ZDZD kirara, but an equal number also target high-value shark fin using jarifa. The ZDZD kirara (in particular) and jarifa nets are both expensive and large investments for a traditional fisher. The fishers also target sea cucumbers – another high-value product. Jarifa and manirike zanga are particularly important as secondary fishing techniques.

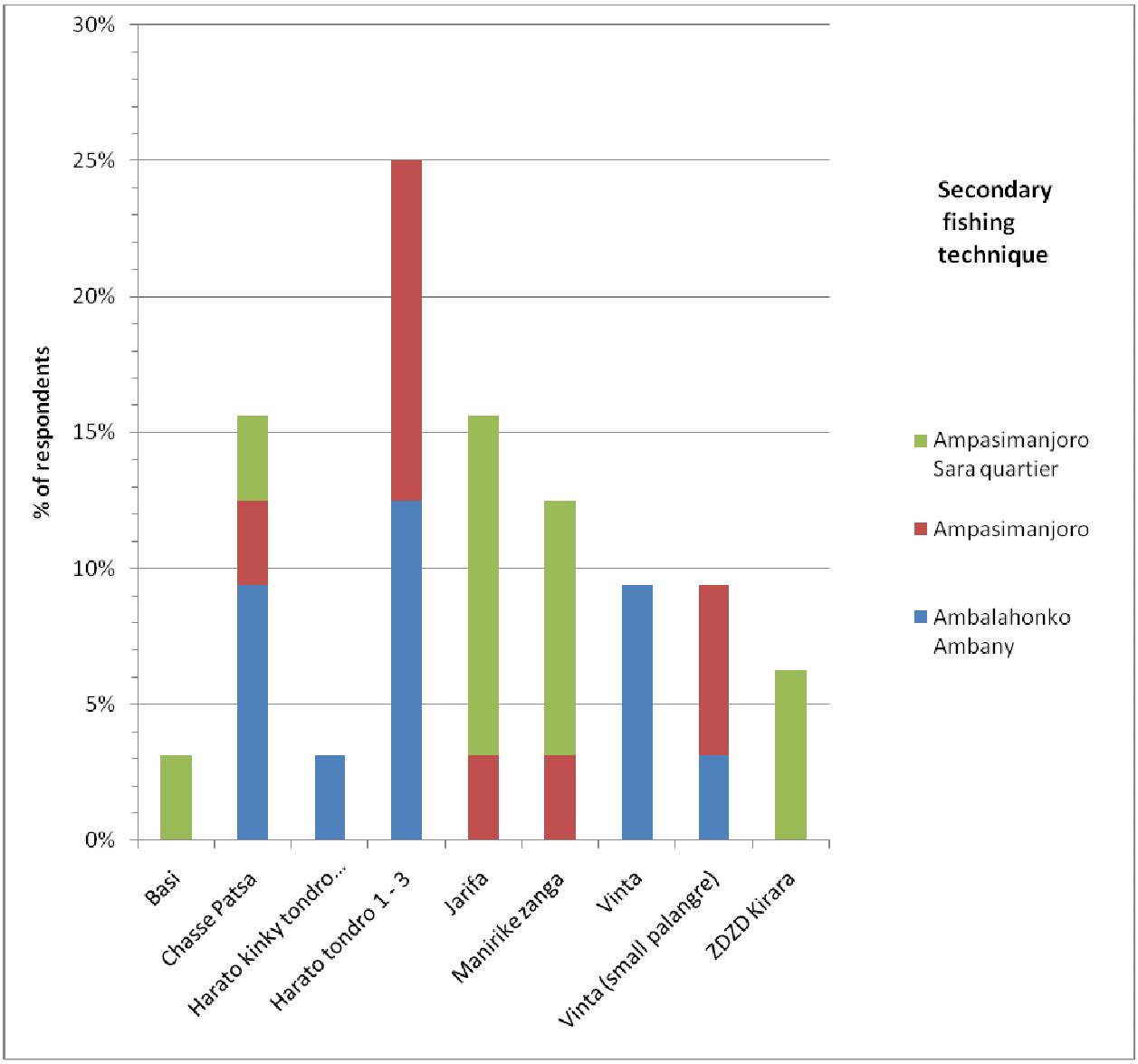


**Figure 28. Secondary fishing techniques used and the percentage of total respondents using these for fishers living within the Maintirano fishing villages**

Table 55 presents the periods of the year when each of the villages uses specific fishing techniques. For the techniques that are of principal importance to the Vezo Sakalava of Maintirano – *harato tondro 1 -3* – it is difficult to discern any global fishing seasons as certain villages use harato throughout the year while others

use them only seasonally. Furthermore fishers will also alternate between the mangroves and sea, depending on both weather and fishing conditions. Broadly speaking, the period between December and March does appear to be favoured for using *Harato tondro 1 – 3* and chasse en moustiquaire in the sea.

*Maminta* is also a technique of importance to the Vezo Sakalava. It is used throughout the year and particularly in the mangroves when bad weather does not permit fishing at sea.

*ZDZD kirara* does have a distinct seasonal use that occurs between March and November/December.

**Table 55. Calendar of fishing technique utilisation for the fishing villages within Maintirano (lighter green shading indicates less frequent use)**

| Technique | Village | Jan. | Feb. | Mar. | Apr. | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Moustiquaire** | Maintirano villages | Opportunistically throughout the year | | | | | | | | | | | |
| | Ambalahonko | Dec. - Mar. in the | | | | | | | | | | | |
| | Ampasimandroro | Jan. - March | | | | | | | | | | | |
| **Harato tondro 1 / Filet de crevette** | Maintirano villages | Dec. - Feb. | | When bad weather use in mangroves | | | | | | | | | |
| | Ambalahonko | | | Mar. - June in the sea | | | | Used in mangroves for bika | | | | | |
| **Harato tondro 2** | Ampasimandroro | Dec. – Mar. | | | | | | | | | | | |
| | Ampasimandroro | Throughout the year (in mangroves when weather bad) | | | | | | | | | | | |
| **Harato tondro 3** | Maintirano villages | Dec. - Feb. | | When bad weather use in mangroves | | | | | | | | | |
| | Ambalahonko | Throughout the year | | | | | | | | | | | |
| | Ampasimandroro | Throughout the year (in mangroves when weather bad) | | | | | | | | | | | |
| **Maminta** | Maintirano villages | Throughout the year (in mangroves when weather bad) | | | | | | | | | | | |
| **Maminta (small palangre)** | Ambalahonko | Throughout the year, no season | | | | | | | | | | | |
| **Mila drakaky** | Maintirano villages | Throughout the year (mangroves) | | | | | | | | | | | |
| **ZDZD kirara** | Maintirano villages | | | March - November (Barren Isles) | | | | | | | | | |
| | | | | March - December (Nosy Vao) | | | | | | | | | |
| | | | | March - December (Marify / Maintirano) | | | | | | | | | |
| | Ambalahonko | | | | | | | | Aug. - Sept. | | | | |
| **ZDZD** | Ambalahonko | | | | | | | | Aug. - Sept. | | | | |
| **Jarifa** | Ambalahonko | Dec. – Mar. | | | | | | | | | | | |
| **Mihake** | Ambalahonko | | | | April - November (Nosy Barren) | | | | | | | | |
| **Manirike zanga** | Ambalahonko | | | | | | | | | Sept. - Nov. (Nosy) | | | |

### 4.2.4 Spatial utilisation of traditional fishers

The location of traditional fishers' key fishing grounds was investigated by carrying out participative mapping exercises in all of the fishing settlements. These individual maps were integrated into one overall map showing the principal fishing activities (see Figure 29). It shows in effect how traditional fishers use the larger Barren Isles ecosystem spatially. A clear understanding of this will enable an estimation of the impact on resource users of different management actions. Combined with knowledge of the location of key conservation priorities, it will provide a foundation for a socially acceptable zoning of the future MPA. For the Barren Isles more than half of fishers are migrants and so fishing areas are likely to change in time and with specific groups of fishers. The map is therefore not a definitive inventory of fishing sites; it does however present a clear picture of where fishers are active.

Figure 29 presents the fishing zones of the Barren Isle ecosystem according to the following principal fishing techniques. (Note: the following are not shown on this map: jarifa and ZDZD kirara fishing areas extending northwards all the way up to Nosy Vao; migrant fishers based in Benjavily fish the offshore reefs opposite this village; the fishing areas of fishers from Soahany are not shown).

***ZDZD kirara*** – this is carried out mainly in the area between the isles and the mainland and normally no more than 5 km from the shore - principally a strip running from Maintirano Maty south to Soahany. Fishers based on Marify also fish the area between the isle and Maintirano. During March and April some fishers based on Maroantaly will fish an area north west of the isle rather than between the isles and the mainland. Fishers fish above a soft, muddy substrate.

***Basy*** – spear-fishing is a technique that migrant Vezo fishers from the South West brought to the area and it is still mainly used by them. Its area of use is limited to reefs in proximity to the isles where these fishers live and where the visibility is good. Migrant fishermen will also spear-fish opportunistically while free-diving on the outer reef areas for sea cucumbers.

***Jarifa*** – this is practised over an extensive area but it must be borne in mind that the nets are anchored in specific locations within this extent. The area over which jarifa nets are set includes the Mozambique Channel immediately west and south west of the submerged barrier reef, areas between the isles and the mainland, and an extensive area north of Nosy Manandra and Marify. Fishermen normally set the nets above a soft substrate in waters of 100 – 250 m deep (though sometimes in shallower water). The nets are often set in the vicinity of features, such as deep reefs, that would congregate fish and sharks.

***ZDZD*** – the areas where ZDZD are used fall within those of jarifa, but are less extensive. This type of net is far more expensive than a jarifa and so less commonly used.

***Zanga*** – mostly migrant fishermen free-dive for sea cucumbers on rocky reefs of that are commonly 16 – 20 m in depth (reefs shallower than this have been overexploited). The most popular reefs for this are those west of the isles towards the Mozambique Channel, particularly those accessible from Nosy Manandra and Nosy Marife.

***Mihaky horita*** – migrant women and children glean for octopus principally on the reef flats of Nosy Manghily, Abohazo and Marify, but also Nosy Lava, Manandra and Maroantaly (Sara). The reef flat of Nosy Ampasy is known as a particularly rich fishing ground for octopus.

***Maminta*** **and** ***Harato tondro 2 -3*** – line and net fishing are carried out both near-shore and in the mangroves. Fishers from the coastal fishing villages (Ampandikoara, Manombo) use these techniques in fishing areas that are limited in extent and close to shore (normally within 3 km). They are also used in the channels of the mangroves that are immediately accessible from the coastal villages. The fishers of the Maintirano fishing villages use them over a narrow strip that stretches from north of Maintirano to Manombo in the South.

***Moustiquaire*** – mosquito nets are used mostly to catch *patsa* in the shallow water of the beaches near the coastal fishing villages.

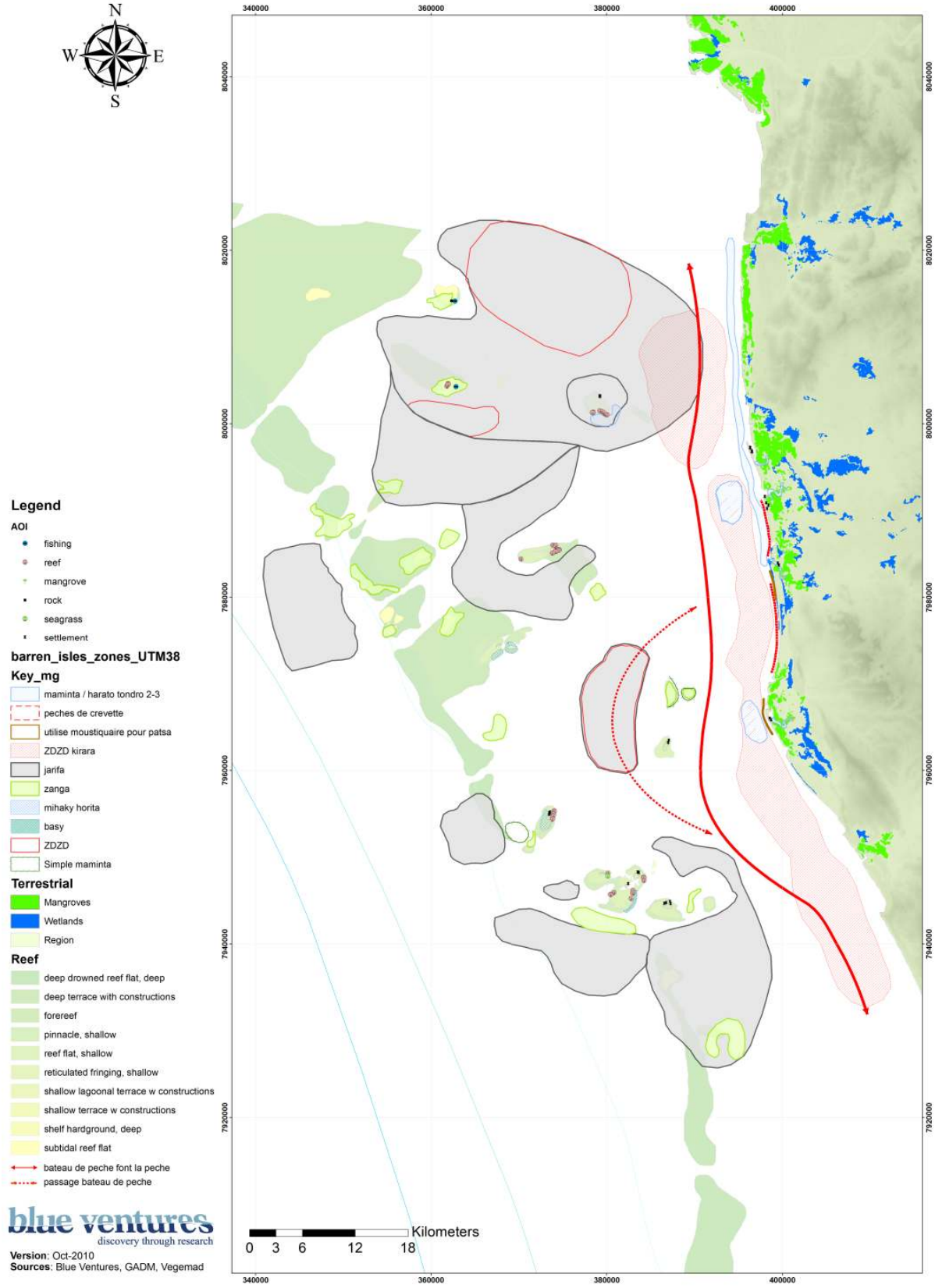


**Figure 29. Map of the fishing areas used by traditional fishers in the Barren Isles and neighbouring coast**

## 4.3 Artisanal fishing

Itinerant artisanal fishermen from Mahajanga and the North East of Madagascar often fish around the Barren Isles. They are equipped with small motorised boats and fishing equipment of much greater capacity than that of the traditional fishers. For example, they use "barrage" – gill nets 2 km long that are weighted so that they sit on the seabed and so target guitar fish.

Teams equipped with Scuba, GPSs, motorised dive boats and backup motorised vessels also dive for sea cucumber around the Barren Isles. These teams belong to 'grand patrons' and come from Morondava, Mahajanga and North East Madagascar (Nosy Be, Antsohihy, Analalava and Ambanja). Using Scuba to collect sea cucumbers is outlawed in Madagascar, but these teams presently operate with impunity. During this study five large motorised vessels, each with 2 – 4 motorised dive boats and scuba divers, were present in the Barren Isles area, pillaging even the shallower reefs where traditional fishermen were trying to collect sea cucumber by free diving. Scuba dive teams were particularly active in the Barren Isles around 2000 – 02; became less conspicuous during the Ravalomanana presidency, and are now again very active with the present political crisis.

Though the activities of itinerant artisanal fishers are clearly degrading the natural resources of the Barren Isles and stripping out the basis of the traditional fishers' livelihoods, there is no law enforcement (and in the case of artisanal shark fishers, no appropriate laws) to govern their activities.

## 4.4 Industrial fishing

During the years prior to 2010 active trawling for shrimp frequently occurred in the area between the Barren Isles and the mainland, particularly early in the season (April – May). The passage of shrimp trawlers is delineated in Figure 29. The bankruptcy of the Maintirano-based commercial shrimp fishing company in 2009 may diminish this problem, though the trawlers passing through this area are also from Mahajanga and Nosy Be. (According to fishers these trawlers are SOMAPECHE as well as unidentifiable trawlers).

Industrial shrimp trawlers frequently operate around the isles (ONE, 2002). Zone violations, closed season violations and gear infringements in coastal industrial and semi-industrial fisheries are the most commonly detected offence in the east African shrimp fishery, including Madagascar (SADC, 2008). Coastal shrimp and demersal reef fisheries are considered to experience the most serious impacts of illegal, unreported and unregulated fishing (IUU). The ecosystem impacts resulting from IUU fishing are significant; affecting both the target resource and the discarded species and bycatch. A government strategy document emphasised that the damaging impact of these activities necessitates a better control and respect of the statuatory 2 nautical mile (approx. 3.7 km) exclusion zone around each isle (ONE, 2002).

Several known IUU vessels, which previously targeted Patagonian toothfish in the southern Ocean, have been reported to have converted to bottom-set gillnet gear, targeting nurse sharks in South and West Madagascar. The target species, probably *Nebrius ferrugineus* and *Pseudoginglymostoma brevicaudatum*, are highly sought after for their valuable liver oil. *N. ferrugineus*, the tawny nurse shark, commonly inhabits shallow inshore environments from 5 to 30m, and is found to at least 70m on coral reefs.

## 4.5 Extractive industries

Figure 30 illustrates the mining, oil and gas permits located within the Barren Isles area. This map is based on information from the BCMM from the 1 October 2008 (and published by Rebioma) as the study did not have the full mandate to obtain up-to-date information on planned extractive industry activities in the area from the respective government agencies. Figure 30 therefore does not necessarily reflect the current reality of prospecting, mining and oil and gas activities planned in the area.

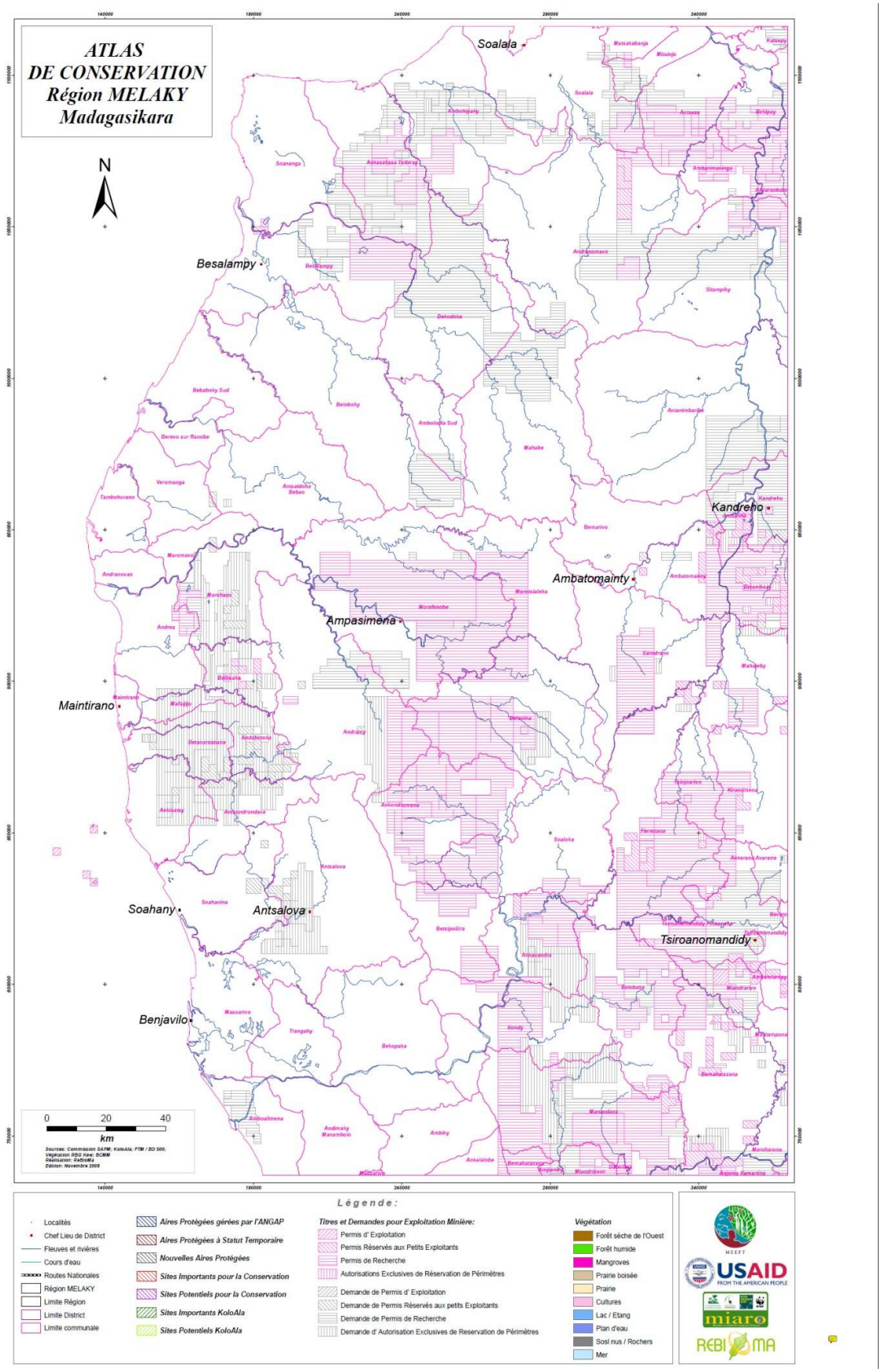


**Figure 30. Map showing mining permits in the Melaky region**

According to the map mining permits exist for four of the Barren Isles exist - Nosy Lava, Nosy Andrano, Maroantaly and Nosy Abohazo (also called Androtra).

There are also applications for mining permits reserved for small holders in two areas inland of Maintirano maty (at Betanantanana and Ankilida). There are large areas under "demande d'autorisation exclusives de reservation de perimeters" inland of the coastline opposite the Barren Isles. These areas are encompassed by the catchment areas of rivers flowing into the Barren Isles ecosystem. Consequently if uncontrolled mining activities were to take place in these areas they could have an effect on the marine and coastal ecosystem.

There are no mining permits reserved for smallholders, mining prospection permits, applications for permits to mine ("demande de permis d'exploitation (mines)") nor applications for mining prospecting permits.

### 4.5.1 Guano (phosphate) mining

The Barren Isles have previously been mined for seabird guano in the 1990s, but until now no environmental impact assessment has been carried out of the impacts of such an activity on the environment and biodiversity of the Isles. Four "permis d'exploitation" for the exploitation of "phosphorite" have been centrally issued and belong to the Societe Malgache D'Engrais Biologiques "SMEB" S.A. The permits are each for an area of 2.5 km² and cover the following isles: Nosy Lava, Nosy Andrano, Maroantaly and Nosy Abohazo (also called Androtra). They give the title holder the right to mine "phosphorite".

Guanomand, an exporter of bat guano based in Antananarivo, is presently mining guano on the isles. In late 2009 they began mining on Nosy Andrano, despite no Environmental Impact Assessment (EIA) having been carried out – normally obligatory by law (MECIE) since small islands are classed as "sensitive zones". At this time Guanomad planned to mine 100 tonnes of phosphate, ostensibly as a sample. Further mining is said to have begun in March 2010. According to a recent newspaper article (see Appendix 7) the reserves are approximately 500,000 tonnes.

SAPM recognises the Barren Isles as an important Potential Conservation Area – an area that plays a very important role for the conservation of biodiversity but does not have a promoter/the financing to bring about its protection. A ONE document – Stratégie des isles – strongly proscribes extractive activities, including quarrying, on Madagascar's isles. It is difficult to see how Guanomad could mine large volumes on a particular isles without causing irreversible damage. Nor how they could do this legally.

On the 10 November 2009 the Association "Melaky Miaro ny Tontolo Andriakany" approached the Chef de Region in Maintirano to express their disaccord with illegal sampling for phosphate beginning on Nosy Andrano. The meeting was fairly short, and resulted in the Chef de Region expressing his dismay, and assuring the association that he would contact the local authorities immediately to make sure that the activities were halted as soon as possible.

"Melaky Miaro ny Tontolo Andriakany" wrote a petition against the mining; in addition letters saying the same were written by the chef de fokontany of the two fishing villages of Maintirano – Ampasimandroro and Ambalahonko.

### 4.5.2 Oil and gas exploration

From the OMNIS map of oil and gas exploration blocks (September 2007), the southern Barren Isles are just beyond the northern limit of the exploration block entitled "Grand Prix". (From the available maps of exploration permits it is difficult to accurately judge the exact geographical limits.) The Canadian company "Compagnie Niko Resources (Overseas VIII) is undertaking the exploration of this block ("Projet d'exploration petroliere offshore dans le bloc Grand Prix").

The area of exploration will run from Soahany (south of Maintirano) southwards to Morondava. They will be exploring in water between the depths of 20 m – 300 m. Other companies possess permits further out to sea, so there may be other operations going on in the area which are not related to Niko. Activities were expected to commence in December 2009, but may have been delayed slightly by logistical problems with getting their equipment and boat to the area on time. This testing is expected to last around four months, but possibly up to six. Bathymetric surveying was expected to commence in December 2009 as well, and the eventual area of exploration is meant to be only 16 $km^2$. Niko currently possesses a permit for exploration, has had an EIE conducted, and possesses a *cahier de charge*.

The use of underwater sonar to detect petroleum deposits poses dangers to cetaceans, which rely on sonar for navigation and communication. Exploration activities would consequently have an impact on the annual migration of humpback whales through the area, as well as the other cetaceans that frequent the Barren Isles. Niko maintains that at 2.6 km from the origin of the sonar, the wave has lost strength to the point where it will no longer affect marine mammals. Additionally, exploration will maintain a 500 m radius "zone of observation"; if any marine mammals are found in this area, activities will be suspended for 30 minutes, and the animals will be driven away.

The mainland area neighbouring the Barren Isles is entirely encompassed in an exploration block that has been granted to Essar Energy. The block begins at the southern limit of Masoarivo, extends northwards to just North of Maintirano and inland to the western boundary of the Tsingy de Bemaraha National Park. It is not clear whether exploration will take place within the vicinity of the Barren Isles.

## 4.6 Tourism

There are no records on the number of tourists who visit the Barren Isles, but it is fair to say that tourism to the isles is minimal despite the great natural beauty of the area. Malagasy tourists, mostly from Maintirano but also from Antananarivo, and visiting dignitaries sometimes visit the isles (particularly Maroantaly). Very few foreign tourists visit the isles; those who do are mostly independent travellers who are guided to the isles by Geraud Leroux. An expatriate living in Maintirano also takes foreign tourists game fishing near the isles, but this is a low key operation. There is no tourism infrastructure on the isles and from what this study could establish, no plans to build any.

## 4.6 Research

The BITCP maintain a small field base / research site on Nosy Lava; members of the research team are the only people, besides traditional fishers, who regularly visit the isles.

## 4.7 Land tenure

The judicial status of the Barren Isles and the neighbouring coastline was established through interviews with both the land registry office and the cadastral services in Maintirano.

A ministerial decree from the government of Ratsiraka of the 25 August 1994 (see Appendix 7) stayed any occupation of the Barren Isles and appears to still be valid. As such there are no valid land claims to the isles nor any long-term leases. The isles remain entirely public government land ("domainiale").

The coastline South of Maintirano town until Soahany is entirely public government land with the exception of one privately-owned parcel of land at the Namakea headland, owned by a Malagasy living in Maintirano. At the time of the study (October 2009) no applications to buy or lease land along this stretch of coastline had been made.

The land tenure situation of the isles and the neighbouring coastline is abnormally conducive to the establishment of a MPA.

# 5 Conservation planning

## 5.1 Summary

This section first summarises the institutional context to establishing a Barren Isles MPA and describes conservation measures already undertaken in the Barren Isles. Secondly it recommends actions to be taken to establish a co-managed MPA through a number of steps: the target species and threats to these are analysed; from these potential strategies to protect them are identified; based on these strategies MPA management and zoning plans are defined.

The Barren Isles ecosystem that is characterised by the reef systems and coastal habitats in the vicinity of the isles encompasses a vast area – approximately 6,200 km². Within both this area and the broader seascape, there are large areas of potentially important habitat that have not been surveyed and little is known about them. For example: the areas to the north of the Barren Isles, such as the system of reefs and sand cays surrounding Nosy Vao and the extensive mangroves between Maintirano and Tambohorano. They are almost certainly of high conservation value, but have not been studied yet. Many of the potentially very important conservation targets in the region are also discrete areas separated by large expanses of sea. Many of the conservation target species are wide ranging and are dependent on a diversity of habitats. All fishers in the area, including resident traditional fishers, are also highly mobile and will quickly cover large distances to seek out fishing grounds. Within this ecological and human environment, the definition of a large new MPA boundary, as well as an MPA zoning, presently has little scientific basis and risks discounting areas of conservation value. Equally it has little management feasibility given the likely resources of conservation actors. The study therefore argues for the step-wise establishment of a biosphere/conservation seascape that will protect vital conservation areas within a larger conservation management area where sustainable economic development is possible. Conservation and development actions should build towards achieving this regional-scale conservation seascape.

The first step in achieving this would be the establishment of a Barren Isles MPA that protects core traditional fishing areas and immediately evident conservation targets. An MPA boundary is therefore defined largely on the basis of what important habitats are immediately under threat and in need of protection. The zoning of the MPA is based on what areas are of evident conservation value, the practicability of implementing this zoning and traditional fishers' utilisation of the isles. Clearly it will be necessary to fully involve stakeholders in the definition of a zoning plan and to evolve this based on new scientific data. The MPA boundaries and plan presented here are entirely indicative.

In addition to a tentative MPA design, future areas of interest that should be further studied and included in a wider management strategy are also defined. These include important coastal habitats (mangrove, wetlands and sand dunes), as well as the vast reef systems to the south and north of the Barren Isles.

## 5.2 Institutional context

### 5.2.1 SAPM and regional conservation planning

The importance of the Barren Isles as a marine and coastal conservation site has long been recognised institutionally in Madagascar. The "Commission d'Environnement et Pêche" identified it as a site for protection in the "Document d'orientation pour la création et la gestion des aires protégées à Madagascar". The Système d'Aires Protégées de Madagascar (SAPM) recognises the Barren Isles as an important Potential Conservation Area – an area that plays a very important role for the conservation of biodiversity but does not have a promoter/the financing to bring about its protection. SAPM planning (see Figure 31) shows that the Barren Isles CMPA complements well several existing and planned terrestrial conservation areas at a landscape level:

- The coastal area immediately east of the Barren Isles going south to the Soahany river mouth is identified as a Potential Site for KoloAla;
- To the south and contiguous to this potential site is the **Bemamba Wetland Complex**, a Potential Conservation Area;
- To the immediate south and contiguous to the Bemamba Wetland Complex is a New Protected Area - the **Complexe Zones Humides-Forêt Dense Sèche Tsimembo**.
- It is bordered to the north and east by the Soahany River, extending south along the coast into the Manombolo delta, and joining the **Manombolomaty Complex** inland;
- The **Menabe Antimena New Protected Area**, which has temporary protection status, borders the Complexe Zones Humides-Forêt Dense Sèche Tsimembo to the immediate south.
- Inland of these coastal conservation areas lies the MNP-managed **Bemaraha Nord and Bemaraha Sud Protected Areas**.

Equally to the north of the Barren Isles there is an existing landscape level conservation plan that the Barren Isles CMPA would link into:

- To the immediate north of Maintirano exists the KoloAla Important Site **Maintirano**;
- To the north this joins a coastal and marine area identified as a Potential Conservation Area **Tambohorano Wetlands and Nosy Vao**;
- The New Protected Area **Mandrozo** is enclosed within the Tambohorano Wetlands and the Maintirano KoloAla Important Site;
- To the north of the Tambohorano Wetlands lies a Potential Site for KoloAla.

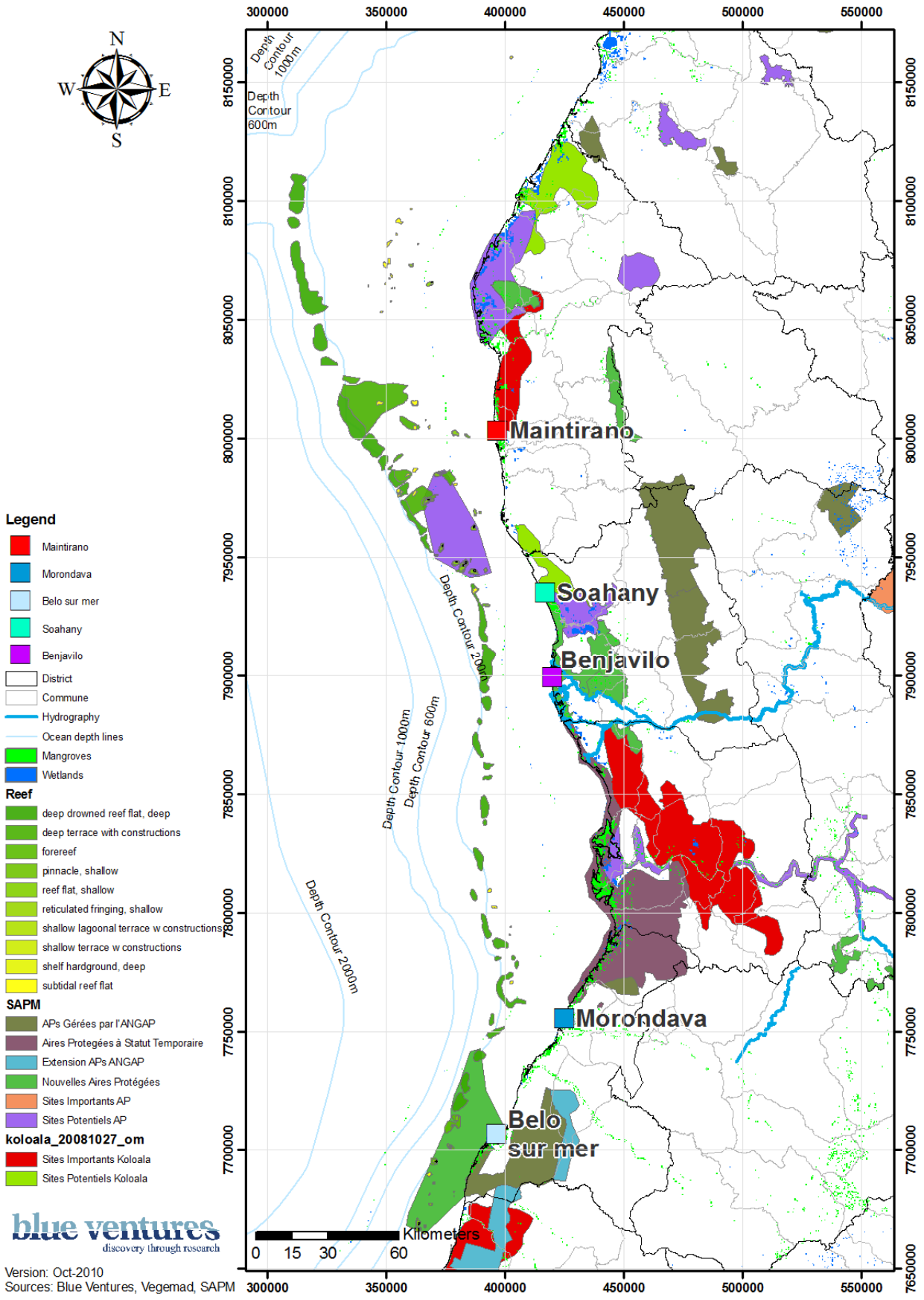


**Figure 31. Landscape conservation planning for the larger region that includes the Barren Isles**

### 5.2.2 Birdlife International Important Bird Area

The Barren Isles are classified by BirdLife International as an Important Bird Area (IBA) - a site considered critical for the conservation of the world's birds (BirdLife International, 2009). The Important Bird Areas is a worldwide initiative aimed at identifying and protecting a network of such sites. To be classified as such a site the Barren Isles have met the following criteria:

- A critical site for the conservation of birds and biodiversity;
- A place of international importance;
- A practical target for conservation action;
- Selected according to internationally recognised criteria;
- Used to reinforce existing protected area networks;
- And used as part of a wider approach to conservation.

### 5.2.3 Government policy on the management of Madagascar's isles

A government strategy document on the management of Madagascar's isles (ONE, 2002) emphasises the biodiversity conservation, socio-cultural and tourism value of Madagascar's isles. It clearly states that they should be managed for this value and prohibits mining and industrial activities over these:

"Given the ecological, tourism and socio-cultural importance of the isles, mining and industrial activities, often unsustainable, should be kept to a strict minimum."

"The general principal should be adopted that the exploitation of a resource or a mineral should be very restricted on the isles… The presence of local villages, of an exceptional biodiversity or of an important tourism potential of an isle should prevent mining, because the benefits of these [former] types of management are more substantial long term."

"The importance of Guano as a fertiliser is acknowledged. However, as it originates from sea birds, it is likely to have a substantial environmental impact on the colonies of sea birds. The activity of mining, as well as the transport of large quantities of Guano by water, risks damaging the marine ecosystem. As such, the use of an isle for mining necessitates firstly an independent environmental impact assessment, which would equally establish an economic and environmental cost benefit analysis in the medium and long term."

### 5.2.4 History of conservation actions

The Barren Isles Turtle Conservation Project (Natural History Museum of Geneva, WWF, IH.SM) and leaders of the local community have formed an association for the protection of local marine and coastal resources - "Melaky Miaro ny Tontolo an-Driakany". They are working together with the local government authorities of Maintirano to protect the biodiversity of the Barren Isles. Their long term vision is to establish a Barren Isles CMPA.

Local management of the isles has already been undertaken by the above grouping. They have enacted regulations to better manage the influx of migrants to the Barren Isles as well as to afford protection to the seabird and turtle nesting populations found there. The creation of the MPA is nascent but a number of actions by the local leaders show a pragmatic approach and strong motivation towards achieving this:

- The Barren Isles Turtle Conservation Project has worked with both local and migrant fishers to raise awareness of turtle conservation since its inception; a number of fishers are employed by the project.
- In Maintirano the mayor, together with UPTM (Union des Pêcheurs Traditionnels de Maintirano), the PSDR and MAEP, the Barren Isles Turtle Conservation Project and "Melaky Miaro ny Tontolo an-Driakany" have established a number of regulations regarding fishing and the question of migrants on the Barren Isles:
    - In addition to having a signed and valid passport, all fishermen must pay a pirogue tax to the authorities in Maintirano, on doing so they will have their pirogue numbered and will be given a fisherman's card with their fishing activities listed on it.
    - The pirogue tax of 15 000 Ar will be used to pay the salaries of two eco-guards who will be responsible for enforcing the regulations.
    - The total number of pirogues allowed to fish in the Barren Isles is limited to 150. (This was not enforced in 2009 with a view to studying the carrying capacity of the isles and setting a reasonable limit.)
    - The presence of fishers on Nosy Abohazo is strictly prohibited during the rainy season (1 November to 1 April). (This the turtle nesting period.)
    - The capture of turtles is strictly prohibited outside of the period of 1 June to the 1 September.
    - The sale of turtle is strictly prohibited the entire year.
    - The harvesting of turtle and bird eggs is strictly prohibited the entire year.
    - Schoolchildren are not allowed on the islands except during the school holidays (a major problem with the migrants is that the children do not attend school).
    - Fishermen cannot throw shark carcasses (the head, skin and skeleton that remains after slaughter) into the water; they must be buried under the sand (previously many fishermen kept the heads next their camps as trophies).
    - These regulations were to be applied by the 15 May 2009; migrants who do not respect them will have to pay a fine of 100 000 Ar / will be sent back
    - The local fishers from Maintirano proposed giving a single island to the migrants (for example Nosy Andrano); the other isles would be open to the residents. This idea has not been acted on.

The mayor of Maintirano also passed a local law in 2007 strictly prohibiting fishermen from landing on Nosy Mboro the year round in order to protect the colony of nesting seabirds as well as turtles nesting on the island. The majority of fishers have respected this regulation.

All of the above regulations, together with awareness-raising on the sustainable management of marine resources, were communicated in early 2009 to the populations of Maintirano and Morombe through local radio broadcasts. Unfortunately Madagascar's political crisis brought with it a wide disregard for law and order. In 2009 the Barren Isles were exploited by 4 – 5 teams of illegal sea cucumber dive teams with scuba. Within this context of lawlessness, traditional fishers themselves no longer respect the local rules and regulations.

At the time of writing (December 2009) the Maintirano branch of SAF/FJKM was preparing a proposal to develop a "Transfert de Gestion" on the Barren Isles.

## 5.3 Conservation opportunity and potential obstacles

The host of high conservation value species that occur in the Barren Isles have already been presented in section 2: Natural habitats and biodiversity. The effective protection and management of the Barren Isles and its associated coastal habitats is justified in the protection it will afford to the more site-specific of these species. The larger ecosystem also supports productive fisheries that form the foundation of the livelihoods of local and migrant traditional fishers.

Protection of the ecosystem presents a feasible conservation opportunity chiefly because of its remoteness and the sparse human population of the region. The coral reef ecosystems of the Barren Isles and the neighbouring far-offshore reefs are well removed from much of the stresses that have caused widespread degradation of coral habitats in Madagascar:

- They are relatively remote from large rivers bringing in high levels of sediment;
- It is only relatively recently that they have been fished; even now the principal fishing activities target shark, large pelagic fish and sea cucumber only. This means that the reef fish populations are still healthy;
- The hydrodynamics that would surround these islands, their exposure to the open ocean, would make them less prone to localised water temperature increases and so bleaching. (The Barren Isles are notorious for the strong currents passing around them.)

The ecological surveying undertaken in this study shows the coral reefs of the Barren Isles to be in good condition. The present healthy state of the surrounding coral reef habitats gives the archipelago high conservation value in its self. Much of the "*riva*" - far-offshore reefs - remain unexplored by scientists; but are likely to be relatively undisturbed and in comparable or better condition to those reefs surveyed due to their remoteness. The extensive estuarine and mangrove habitats east of the archipelago form key components of the larger Barren Isles ecosystem. These habitats are largely intact and exist in areas that are sparsely populated and relatively unexploited, with the exception of those in immediate proximity to Maintirano.

On a regional scale, the Barren Isles exist within an extensive system of reefs and mangroves that are of conservation value themselves. Since the population of the region is sparse, much of these ecosystems remain intact and the opportunity exists for conservation on full seascape scale.

There are presently four economic activities taking place in the Barren Isles that would have to be reconciled with the establishment of a MPA:

1. Traditional fishers: ca. 600 fishers frequent the Barren Isles and are completely reliant on fishing for their livelihoods. A community- or co-managed MPA would help these fishers to manage their fishing stocks sustainably and could empower local communities to protect their fishing rights. If managed properly, the MPA could also be an effective vehicle to achieve other development objectives within the fishing communities.

   Presently traditional fishers target chiefly sea cucumbers, sharks and Spanish mackerel (and other pelagic fish species in this guild) – they are not dependent on reef fisheries. The fishing techniques used are not physically destructive. However, while the Spanish mackerel fishery may very well be sustainable, the sea cucumber and shark fisheries, which are mining keystone species, have declined over the last eight years and will have a negative impact on the coral reef ecosystem. Within the context of the strong Asian demand for these species coupled with the absence of an effective national strategy to manage the fisheries, it will be a major challenge for the MPA to implement local fisheries management measures and so play a meaningful role in their conservation.

2. Artisanal fishers: the groups of itinerant 'artisanal' fishers who frequent the Isles has increased markedly since the beginning of the political crisis in 2009. As for the Vezo fishers, they target sea cucumbers and sharks, but have motorised boats, use scuba to illegally dive for sea cucumbers and have much larger shark nets. Since they frequently work for wealthy and politically connected bosses, controlling their activities within the Barren Isles will present a challenge to the MPA. However, it is foreseeable that the MPA could give local traditional fishers and local government authorities a stronger mandate to control the over-exploitation of resources by artisanal fishers.

3. Industrial fishing: shrimp trawling does periodically take place between the isles and the mainland. Independent assessments have judged shrimp trawling in Madagascar to have a strong negative impact on the benthos and marine life (MRAG, CAPFISH 2008). However, the export of shrimp is an important foreign currency earner for Madagascar. At the same time this particular area of coastline provides habitat for endangered species, such as turtles and potentially sawfish, that are particularly impacted by shrimp trawling, as well as a socio-economically important traditional Spanish mackerel (and other pelagic fish species in this guild) fishery. Further research would be needed to demonstrate the presence of endangered species and any negative impacts of trawling on the traditional Spanish mackerel fishery. This would provide a basis for negotiating a trawling exclusion zone between the isles and the mainland.

   On the other hand the MPA will also bring benefits to the shrimp fishery through protecting mangroves and working with local traditional fishers to minimize their catch of juvenile shrimp.

4. Guano mining: at the time of this study guano mining was taking place on Nosy Andrano, with Gunaomad planning to exploit other isles. If carried out on a major scale (Guanomad state that there are 500,000 tonnes of exploitable guano), this could cause irreversible damage to the isles and surrounding reefs.

## 5.4 Conservation priorities

Miradi software was used throughout to assist the conservation planning shown here. Miradi is adaptive management software for conservation projects that uses Conservation Measures Partnership's (CMP) *Open Standards for the Practice of Conservation* (www.conservationmeausre.org).

### 5.4.1 Conservation targets of the Barren Isles ecosystem

A number of preliminary conservation targets were selected that are representative of the known biodiversity within the Barren Isles ecosystem as well as the dependency of fisher livelihoods on marine resources. The conservation targets selected here consist of key habitats and focal species. Together they capture all of the ecological processes and communities making up the Barren Isles ecosystem. Through focussing conservation strategies on these targets, the MPA management can define practical management actions that should maintain the ecosystem functioning of the Barren Isles and conserve species. Future management actions will need to include a scientific assessment of the presence and status of conservation targets, as well as the definition and rationalisation of conservation targets with key stakeholders so as to achieve socio-economic objectives. Indicative conservation targets are as follows:

> **Habitats:** coral reefs, seagrass, soft bottom near-shore, mangroves and coastal wetlands, island vegetation, coastal sand dunes and littoral forest
>
> **Species:** sharks and rays, sea cucumbers, marine turtles, Spanish mackerel (and other pelagic fish species in this guild), cetaceans and sea birds

The conservation targets selected here include species for which conservation actions would need to be taken on a regional scale, for example, sharks and cetaceans. While some species may show site-fidelity, most would have distributions that range well beyond the Barren Isles. However, conservation measures taken within the Barren Isles would contribute to reducing threats to these species, particularly if they are replicated within other MPAs planned on the West coast of Madagascar. They could also catalyse wider management efforts. Further surveying is needed to establish the presence and status of other species of high conservation value that probably occur in the Barren Isles ecosystem, such as sawfish. The overall MPA management plan and individual management plans would have to be adjusted accordingly.

Figure 32 and Figure 33 present conceptual models of the conservation targets, direct threats to them, factors that contribute to the direct threats, and the relationships between these. A wide diversity of targets, direct threats and underlying drivers of threats exist in the Barren Isles. Consequently two conceptual models are presented: one for habitats, the other for species.

| Conceptual model legend | |
|---|---|
|  | Conservation target |
|  | Direct Threat |
|  | Contributing Factor |

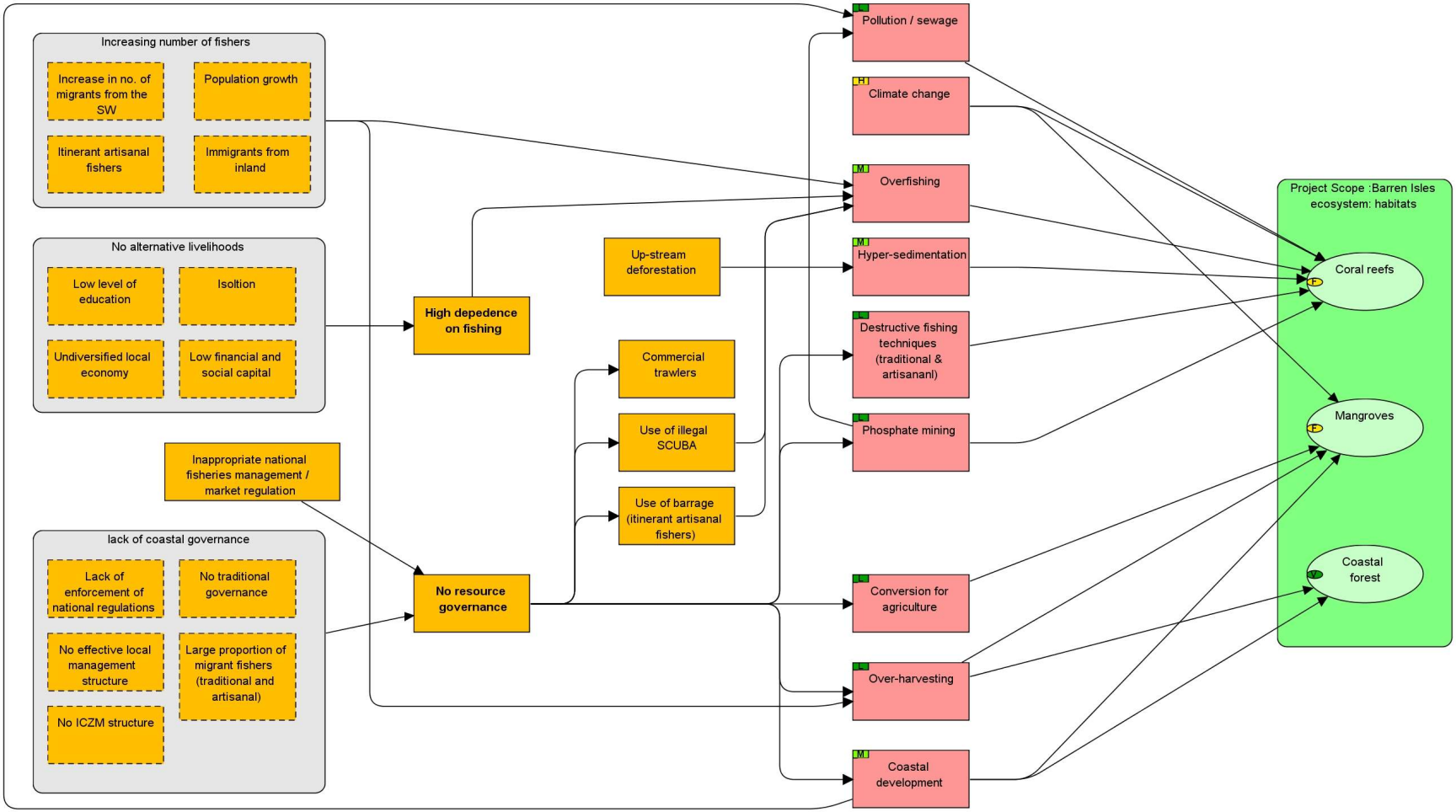


**Figure 32. Barren Isles habitat conceptual model depicting the relationships between conservation targets (habitats), direct threats and factors contributing to these**

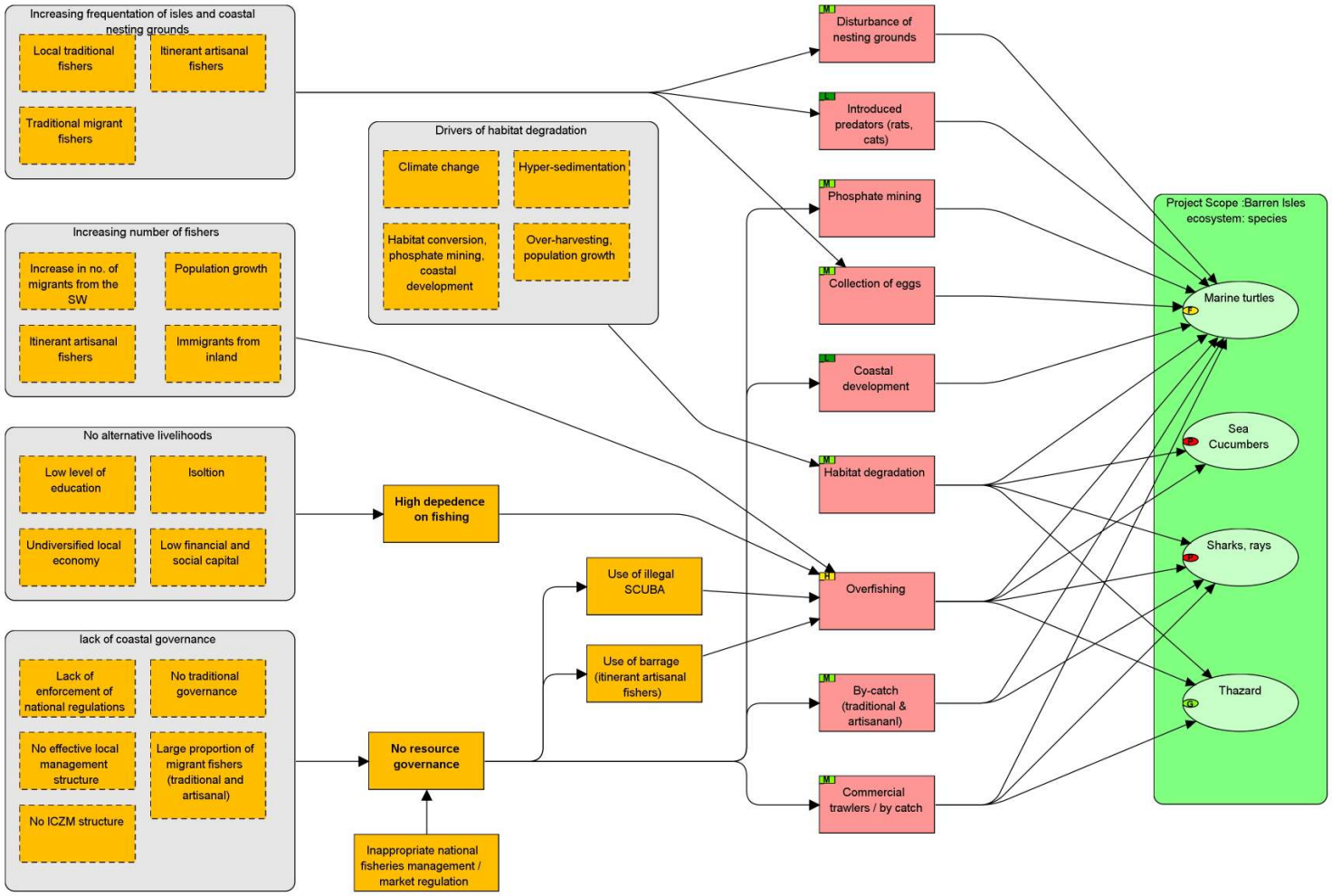


**Figure 33. Barren Isles species conceptual model depicting the relationships between conservation targets (species), direct threats and factors contributing to these**

### 5.4.2 Target viability

A simple viability analysis was carried out for each conservation target to gauge its status and the likelihood of the target maintaining a healthy state over many generations. It shows which targets are most in need of immediate attention; and allows a prioritisation of where conservation resources should be invested. If a target is close to collapse and requires an extraordinary effort to conserve, it may not be a feasible option.

Since little or know quantitative data exists on the status of the conservation targets, a subjective assessment is done here that is based on scant existing data and anecdotal evidence. In the future, the MPA management would need to scientifically establish the baseline state of the targets.

Table 56 presents the viability of each target rated against the following scale Miradi scale[1]

**Very Good** - Ecologically desirable status; requires little intervention for maintenance.

**Good** - Within acceptable range of variation; some intervention required for maintenance.

**Fair** - Outside acceptable range of variation; requires human intervention.

**Poor** - Restoration increasingly difficult; may result in extirpation of target.

Full details of the assessment of the viability of conservation targets are presented in Appendix 3

**Table 56. Estimated viability of conservation targets of the Barren Isles ecosystem**

| Target | Status | Notes |
|---|---|---|
| **1. Habitats** | **Fair** | Overall viability of habitats based on the summation of the viability of individual target species. |
| Littoral forest | Fair | The Western dry forest is comprised of fragments disconnected from other large stands within the region. They have been logged and continue to be so. Slash-and-burn agriculture results in a deflected succession without natural regeneration of original forest. |
| Coral reefs | Good | Coral reefs were generally observed to be healthy; local fisheries do not specifically target reef species; most of the reefs experience low anthropogenic stresses (hyper-sedimentation, pollution, fishing), except the more E and S reefs, where there was evidence of hyper-sedimentation. |
| Mangroves & coastal wetlands | Fair | The mangroves in the vicinity of Maintirano town have been heavily exploited; those between Ampandikoara and Soahany have not been heavily exploited and in parts are largely undisturbed; generally there is no extensive clear-cutting, but selective cutting of trees suitable for poles, building timber etc. so the physical structure of the mangroves is relatively intact; large die-off (due to a sudden change in salinity) at the mouth of Ampandiakoara was noted. |
| **2. Species** | **Fair** | Overall viability of species based on summation of the viability of individual target species. |
| Marine turtles | Fair | The Barren Isles is not thought to constitute an important nesting ground, but more a foraging area; the oceanic isles in the Mozambique Channel are likely to be the principal nesting grounds of the turtles frequenting the Barren Isles. Fibropapillomonas affects the local population (ca. 25 % for Maroantaly) and could be a significant cause of mortality, but there is also evidence that some |

[1] Miradi, Adaptive Management Software for Conservation Projects, Version: 3.2.3 2010-10-13

| Target | Status | Notes |
|---|---|---|
| | | individuals do recover from it. |
| Sea Cucumbers | Poor | Scuba dive teams have exploited populations down to 45 – 50 m; the teams also exploit the far offshore banks, operating off larger boats anchored near the reefs; there is evidence that foreign trawlers have exploited these populations as well. Since 2009 there has been a marked increase in the number of illegal dive teams operating in the isles; it is unlikely that this fishery will be managed effectively at a national level in the foreseeable future. |
| Sharks, rays | Poor | Shark fishers report significant declines in catches since the fishery began in the mid-1990s. In SW Madagascar Vezo fishermen have over-exploited the fishery and now the majority of their catch is juveniles; ; it is unlikely that this fishery will be managed effectively at a national level in the foreseeable future. Many of the species are globally threatened and targeted by industrial trawlers in the Mozambique Channel; rays are a significant by-catch of jarifa and ZDZD shark nets (sometimes 40 - 50 individuals are caught in a single net) |
| Spanish mackerel, and other pelagic fish species in this guild | Good | The fishery targets species that are largely pelagic rather than demersile/coral reef associated; it takes place within a zone of high primary productivity. There is anecdotal evidence that catch levels have not noticeably decreased |

### 5.4.3 Threats to the Barren Isles ecosystem

From the causal analyses presented in the conceptual models, direct threats to habitat and species conservation targets were defined, as well as the underlying drivers of these threats (see Figure 32 and Figure 33). This section presents an analysis of how each threat will impact on respective conservation targets, as well as overall rankings of these threats. The threat ratings take into account three factors:

1. Scope - the proportion of the target that can reasonably be expected to be affected by the threat within ten years given the continuation of current circumstances and trends. (Commonly defined spatially, for habitats measured as the proportion of the target's occurrence; or for species the proportion of the target's population.)

2. Severity - within the scope, the level of damage to the target from the threat that can reasonably be expected. (For example, the degree of destruction or degradation of a target habitat within the scope; or the reduction of the target species population within the scope.)

3. Irreversibility (Permanence) - the degree to which the effects of a threat can be reversed and the target affected by the threat restored.

Within each of these three factors, the threat is rated as: very high, high, medium or low. Based on the combination of the impacts for each factor, an overall threat-target rating is summed. To calculate the overall threat rating for threats and targets, Miradi rolls up threat ratings for each target and threat using another rule-based system for combining ratings for each target-threat combination. Full details of the Miradi threat rating definitions and methodology used to arrive at the overall threats are given in Appendix 3.

Since the threat rating is carried out to devise a locally-focussed management plan for the MPA, we do not consider more global threats or try to address global issues that are beyond the geographical and institutional scope of the MPA[1]. Examples of such threats include:

Upstream deforestation that results in hyper-sedimentation;

Mining in the catchment area of the rivers flowing into the Barren Isles ecosystem;

National laws pertaining to shark and sea cucumber fisheries, and artisanal fishers;

The drivers - or 'push factors' – that are causing migrant fishers to leave their villages of origin;[2]

Climate change.

#### *5.4.3.1 Threats to target habitats*

Threats to the target habitats are presented in Table 57, as well as the overall rating of each threat. The details of the threat ratings can be found in Appendix 3. Table 59 presents the ratings of the threats posed to each individual habitat that they impact on; the underlying causes of these threats are shown in the conceptual model (Figure 32). The overall threat to the habitats comprising the Barren Isles ecosystem is judged as 'medium'. Most of the locally driven threats have a threat summary rating of 'low'. With the exception of overfishing and coastal development, all of the 'medium' to 'high' threats originate from outside of the project zone. Only one individual threat – climate change – has a summary threat rating of 'high'. This threat is strongly likely to have ubiquitous, severe and irreversible impacts on coral reefs, as well as having strong impacts on mangroves and coastal dunes. Threats that are estimated to have 'medium' overall impact on habitat conservation targets include: coastal development, overfishing and hyper-sedimentation (impacting negatively on coral reefs and seagrasses). The threat of phosphate mining is detailed in the section below.

**Table 57. Threats to habitat conservation targets**

| Threats | Notes | Summary Threat Rating |
|---|---|---|
| Commercial trawlers | Shrimp trawlers using nets that impact on the benthos operate between the isles and the mainland, mostly for a period of 3 months around May. | Low |
| Coastal development | The scope of coastal development is expected to be low, but the severity and irreversibility of its impacts will be high. | Medium |
| Conversion for | The vegetation map shows that there is conversion of mangrove and | Low |

[1] One of the major problems with PA management worldwide is that they are site-focused, while many of the processes threatening them operate at different spatial scales. Management should always focus at the appropriate scale. While some of these threats (e.g. climate change) cannot be influenced by site managers, once the MPA has been established actions, such as lobbying for better fisheries laws, better management of upsteam forests or mitigation by mines, could be considered.

[2] Note that the problems caused by the influx of migrants to the isles are accounted for as underlying causes of a number of the direct threats and are addressed in the management plan.

| Threats | Notes | Summary Threat Rating |
|---|---|---|
| agriculture | littoral habitat to cropland. | |
| Climate change | Ocean acidification, increased sea surface temperatures, increased extreme weather events and sea level rise will all have widespread, severe and irreversible impacts on coral, mangrove and coastal sand dune habitats. | High |
| Logging | Littoral forest is particularly vulnerable to deforestation and degradation given that it is currently being logged and takes a very long time to regenerate (if at all); a large part of the mangroves directly south of Maintirano have already been heavily exploited and with population growth the demand for timber and fuelwood will grow. | Low |
| Overfishing | The current fisheries are over-exploiting keystone species (shark and sea cucumber), which will negatively impact on coral reef habitats in particular; currently fishing pressure on the majority of coral reef-associated species (besides particular shark and sea cucumbers) is low. | Medium |
| Destructive fishing techniques (traditional & artisanal) | There is limited use of damaging fishing techniques, such as beach seine nets and 'barrage' nets by artisanal fishers; this includes the illegal use of scuba. | Low |
| Phosphate mining | While the summary threat rating of phosphate mining to the overall viability of the chosen habitat conservation targets is summed as low, mining could take place on four of the six vegetated islands. If done so on a large-scale its impacts would be severe and irreversible on the island habitats. | Low |
| Pollution/sewage | There is limited point-source pollution from fishing settlements (offal and sewage); Maintirano town is a source of pollution, but most of the isles are remote with the exception of Marify (12 km to the W) | Low |
| Hyper-sedimentation | There is evidence of the impacts of hyper-sedimentation on the more southerly and easterly reefs; even the waters to the west of the isles are reported to carry high sediment loads during certain periods. Hyper-sedimentation will have widespread, fairly severe and irreversible impacts on coral reefs and seagrass beds | Medium |
| **Overall threat rating** | | **Medium** |

#### *5.4.3.2 Threats to target species*

The direct threats to the target species are presented in Table 58, as well as the overall rating of each threat. Table 60 presents the ratings of the threats posed to each individual species that they impact on, while the underlying causes of these threats are shown in the conceptual model (Figure 33). The summary threat rating for all species conservation targets is estimated to be 'very high'. This is mainly due to three threats that are rated 'very high' for the impact that they have (or will have) on marine turtles and seabirds, namely: the

disturbance of nesting grounds, phosphate mining and the collection of eggs. Overfishing poses a 'high' threat to sharks, sea cucumbers and marine turtles. A fifth notable threat that impacts on seabirds is the presence of introduced predators, particularly rats.

**Table 58 Threats to species conservation targets**

| Threats | Notes | Summary Threat Rating |
|---|---|---|
| Habitat degradation | The impact of probable habitat degradation is assessed against each target species. Overall threat ratings for particular habitats are taken from the threat ratings to target habitats (see Threats to the target habitats are presented in Table 57, as well as the overall rating of each threat. The details of the threat ratings can be found in Appendix 3. Table 59 presents the ratings of the threats posed to each individual habitat that they impact on; the underlying causes of these threats are shown in the conceptual model (Figure 32). The overall threat to the habitats comprising the Barren Isles ecosystem is judged as 'medium'. Most of the locally driven threats have a threat summary rating of 'low'. With the exception of overfishing and coastal development, all of the 'medium' to 'high' threats originate from outside of the project zone. Only one individual threat – climate change – has a summary threat rating of 'high'. This threat is strongly likely to have ubiquitous, severe and irreversible impacts on coral reefs, as well as having strong impacts on mangroves and coastal dunes. Threats that are estimated to have 'medium' overall impact on habitat conservation targets include: coastal development, overfishing and hyper-sedimentation (impacting negatively on coral reefs and seagrasses). The threat of phosphate mining is detailed in the section below.<br><br>Table 57). As most of the target species are not highly dependent on habitats found within the Barren Isles, and these habitats are generally in good condition, the overall threat rating is low. | Low |
| Overfishing | Overfishing poses a high threat to marine turtles, sharks and sea cucumbers. The life cycles of sharks and turtles make them vulnerable to overfishing. All three of these fisheries are difficult to manage: turtle fishing has a strong traditional and cultural role for the Vezo and turtles are prized as food; the shark and sea cucumber fisheries are driven by Asian demand and there is no effective national management in place. | High |
| Disturbance of nesting grounds | Fishers living on the isles for most months of the year, artisanal fishers using compressors, quarrying for phosphate etc. all disturb turtle and seabird nesting and pose a 'very high' threat to these conservation targets; with increasing numbers of migrant and local fishers frequenting the isles this threat is likely to continue in the future. | Medium |

| Threats | Notes | Summary Threat Rating |
|---|---|---|
| By-catch (traditional & artisanal) | Shark nets consistently catch a variety of ray species, as well as turtles; ZDZD nets also entangle dolphins, though infrequently; the 'barrage' nets of artisanal fishers pose more of a threat because of their length (ca. 1.5 - 2 km); since 2009 more and more artisanal fishers are fishing the area | Medium |
| Commercial trawlers/by-catch | Shrimp trawlers use small-mesh nets, trawl at night and on the seabed; the amount of by-catch is notoriously high. By-catch species include turtles and rays and shrimp trawling is a threat to sawfish. Some trawlers are equipped with turtle exclusion devices, but crew may close these up to meet catch-targets quicker. | Medium |
| Phosphate mining | In addition to contributing to other direct threats (e.g. disturbing nesting grounds, collection of eggs, introduction of rats) phosphate mining could mean the removal of habitat and nesting grounds. | Medium |
| Coastal development | Large buildings would remove turtle and seabird nesting grounds, cause light pollution and drive a number of other direct threats to seabirds, turtles and other conservation targets; no major coastal development is planned and it will be very low in scope; however, its impacts will be severe and irreversible within the scope. | Low |
| Collection of eggs | Fishers collect both sea bird and marine turtle eggs to eat, as well as to sell in Maintirano; however, the Barren Isles are not thought to be a key nesting ground for the turtle species present, but rather a foraging area. | Low |
| Introduced predators (rats, cats) | Human presence means the introduction of rats; on certain isles of the West coast, including Nosy Abohazo, it is taboo for Vezo to kill or even mistreat rats. Nosy Maroantaly has a large feral cat population; these introduced predators pose a particular threat to nesting sea birds, but could be eradicated | Low |
| **Overall threat rating** | | **High** |

**Table 59. Summary of habitat conservation targets and ratings of threats to these**

| Threats \ Targets | Coastal forest | Coral reefs | Mangroves | Summary Threat Rating |
|---|---|---|---|---|
| Coastal development | Medium | Low | Medium | Medium |
| Conversion for agriculture | | | Medium | Low |
| Climate change | | Very High | Medium | High |
| Logging | Medium | | Low | Low |
| Overfishing | | High | | Medium |

| Threats \ Targets | Coastal forest | Coral reefs | Mangroves | Summary Threat Rating |
|---|---|---|---|---|
| Destructive fishing techniques (traditional & artisananl) | | Low | | Low |
| Phosphate mining | | Medium | | Low |
| Pollution / sewage | | Medium | | Low |
| Hyper-sedimentation | | High | | Medium |
| **Summary Target Ratings:** | *Medium* | *High* | *Medium* | **Medium**[1] |

Notes: 1. Overall project threat rating; 2. the scope, severity and irreversibility of each threat to the individual conservation targets are detailed in the Appendices.

**Table 60. Summary of species conservation targets and ratings of threats to these**

| Threats \ Targets | Marine turtles | Sea Cucumbers | Sharks, rays | Spanish mackerel, and other pelagic fish species in this guild | Summary Threat Rating |
|---|---|---|---|---|---|
| Habitat degradation | Medium | Low | Low | Low | Low |
| Overfishing | High | Very High | High | Low | High |
| Disturbance of nesting grounds | High | | | | Medium |
| By-catch (traditional & artisananl) | Medium | | Medium | | Medium |
| Commercial trawlers / by catch | Medium | | Medium | Low | Medium |
| Phosphate mining | High | | | | Medium |
| Coastal development | Medium | | | | Low |
| Collection of eggs | Medium | | | | Low |
| Introduced predators (rats, cats) | Medium | | | | Low |
| **Summary Target Ratings:** | *High* | *High* | *Medium* | *Low* | **High**[1] |

Notes: 1. Overall project threat rating; 2. the scope, severity and irreversibility of each threat to the individual conservation targets are detailed in the Appendices.

#### *5.4.3.3 Phosphate mining*

Since very little information is available on the "phosphorite" mining it is difficult to judge how much damage is or will be done. According to a recent statement by Guanomad (newspaper article, see Appendix 7) the reserves are approximately 500,000 tonnes. If they mined this, it would correspond to a significant volume and the effects on physical structure of the isles would be irreversible. Besides the direct physical damage to the isles caused by quarrying there would be other foreseeable negative impacts on the surrounding island environment, including:

1. Physical damage to sensitive habitats (island vegetation, coral reefs, seagrass beds) caused by the mining effort and transport of the phosphate. For example, there is a f extensive fringing reef that runs the eastern length of Nosy Abohazo, beginning about 15 m off the beach. The other shores of the isle are too shallow to access by boat and this reef will surely be damaged if mining takes place on the isle.

2. Disturbance of seabird and turtle nesting grounds caused by the mining effort and more people living on the isles. Increased hunting of these species. All of the isles have turtle nesting grounds; Birdlife classes the Barren Isles as an Important Bird Area. The Vezo fishers are already doing this, but mining will necessitate workers living on the sites and this will intensify the threats.

3. The risk of the mining and transport of the phosphate causing significant nutrient enrichment that would damage the surrounding reefs by favouring a phase shift to algae / seagrass. (For example: there is a sheltered fringing reef on the eastern side of Maroantaly that was once spectacular but is now mostly overgrown by dense seagrass. The seagrass grew over a living reef. The only corals still doing well are those that are associated with turbid waters and they are present in 5 m + of water. Since the fish life still looked good on this reef, it can be surmised that nutrient enrichment caused a sudden shift. Such a shift could be caused by a significant source of nutrients such as phosphate being dumped, or by the fishing village and the fishermen burying all their fish offal on the eastern beach.)

4. Pollution caused by mining and transport (hydrocarbons, sewage etc.)

While small scale quarrying may potentially not have such a high environmental impact, mining permits exist for the largest four of the six habitable, vegetated isles and there is the commercial potential to mine large volumes. The Barren Isles have long been considered as a strategic source of fertiliser for Madagascar and in the current political context it is unlikely that the activity will be controlled on the isles. Consequently, a 'worst-case' scenario is used in estimating the threat of phosphate mining to the isles. Since its impacts on certain habitats and species will be of high scope, severity of likely impact and high irreversibility, it is rated as a 'very high' threat.

### 5.4.3.4 *Fisher community threats problems*

What resident fishers perceived to be the main threats/problems to their fishing livelihoods was investigated through quantitative household surveys carried out in the fishing villages of Maintirano. In the surveys, household heads were asked to list principal threats and then to prioritise these in order of importance. The results are summarised in Figure 34 and Figure 35.

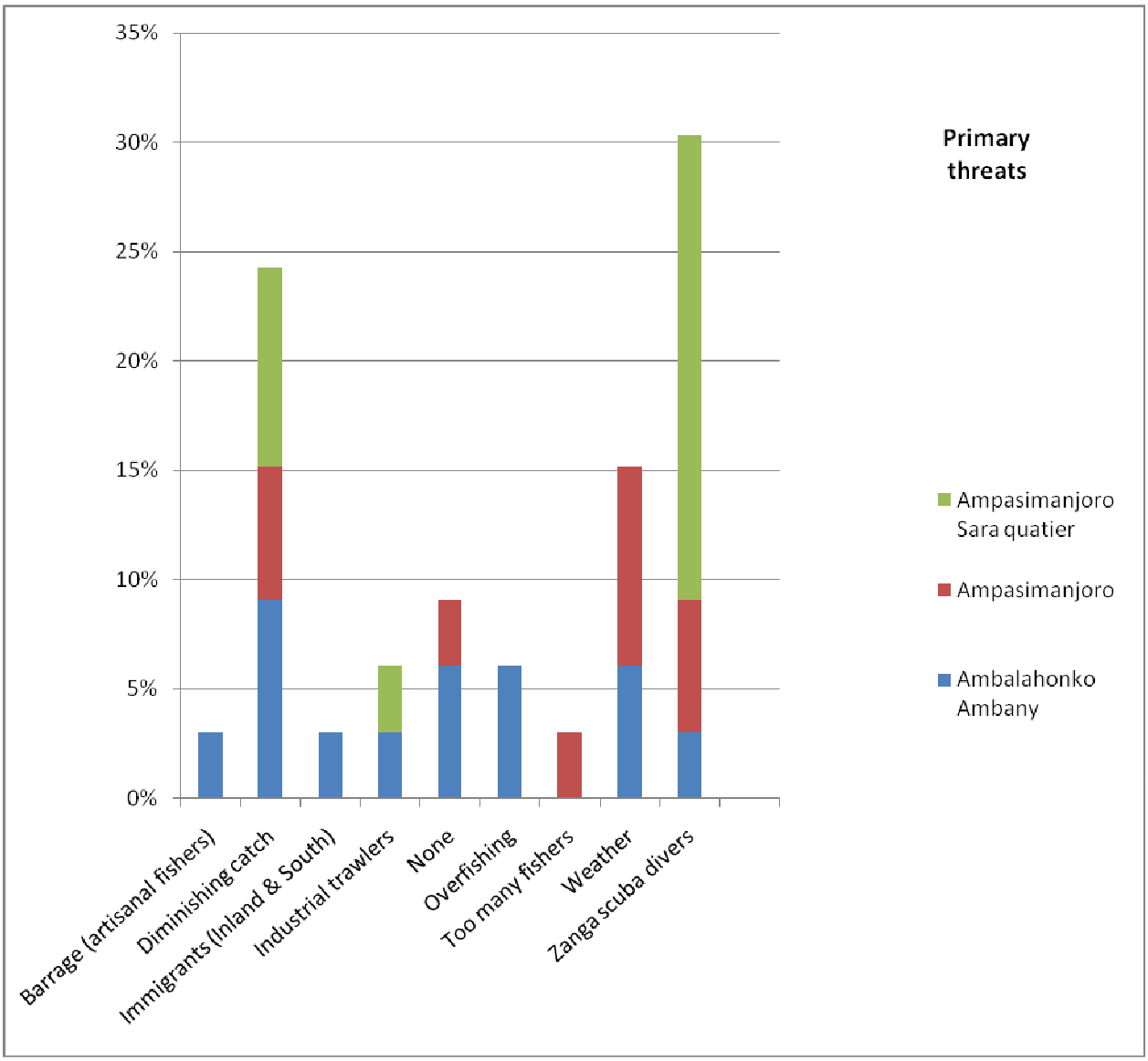


**Figure 34. Percentage of respondents stating primary problems and threats fishers of the Maintirano fishing villages face.**

Nearly a third of respondents identified illegal sea cucumber dive teams as the most important threat to fishing livelihoods; this was followed by diminishing catches (about 25 % of respondents); and bad weather (15 % of respondents). Sea cucumbers must be an important income earner for fishers that they are currently

losing because the scuba dive teams are working even shallow reefs where normally free divers are able to find sea cucumbers. This was a complaint that fishers bitterly voiced to the surveying team while on Nosy Marify and Nosy Manandra.

Less than 3 % of respondents perceived migrants (both from inland and from the South) as a primary threat and seven other threats were more cited than this. Furthermore no respondents identified migrants as a secondary threat. For whatever reasons, the vast majority of fishers interviewed in Maintirano do not perceive migrants to be a problem/threat.

Other primary threats that fishers identified included: industrial trawlers, overfishing, artisanal fishermen who use 'barrage' nets and too many fishers.

A little more than a quarter of respondents did not identify any secondary threats, while about 20 % said that either bad weather or diminishing catches respectively were secondary threats. A number of other threats that were identified as primary threats were also cited as secondary ones. These included: illegal scuba dive teams harvesting sea cucumbers, too many fishers and industrial trawlers. Fishers said that trawlers are a threat because they diminish the catch available to traditional fishers, but also can cause major damage to the traditional fishers' nets. The nets represent a vital asset to fishers and damage to them represents a major loss. This is the same reason the 'boutres at night' are identified as a threat. The 'Surveillance de Pêche' was named as a threat because they 'taxed' or 'controlled' traditional fishers while turning a blind eye to scuba dive teams because of corruption. The 'Surveillance de Pêche' was broadly mistrusted and seen to be corrupt by traditional fishers.

The threats identified by fishers were worked into the conceptual models presented at the beginning of this section. We note that the future management of the MPA would need to undertake a more in-depth consultation with fishers to identify socio-economic targets, and threats to these. These will have to be included in the conceptual models so that the socio-economic objectives of the MPA can be more fully tackled in the management plan.

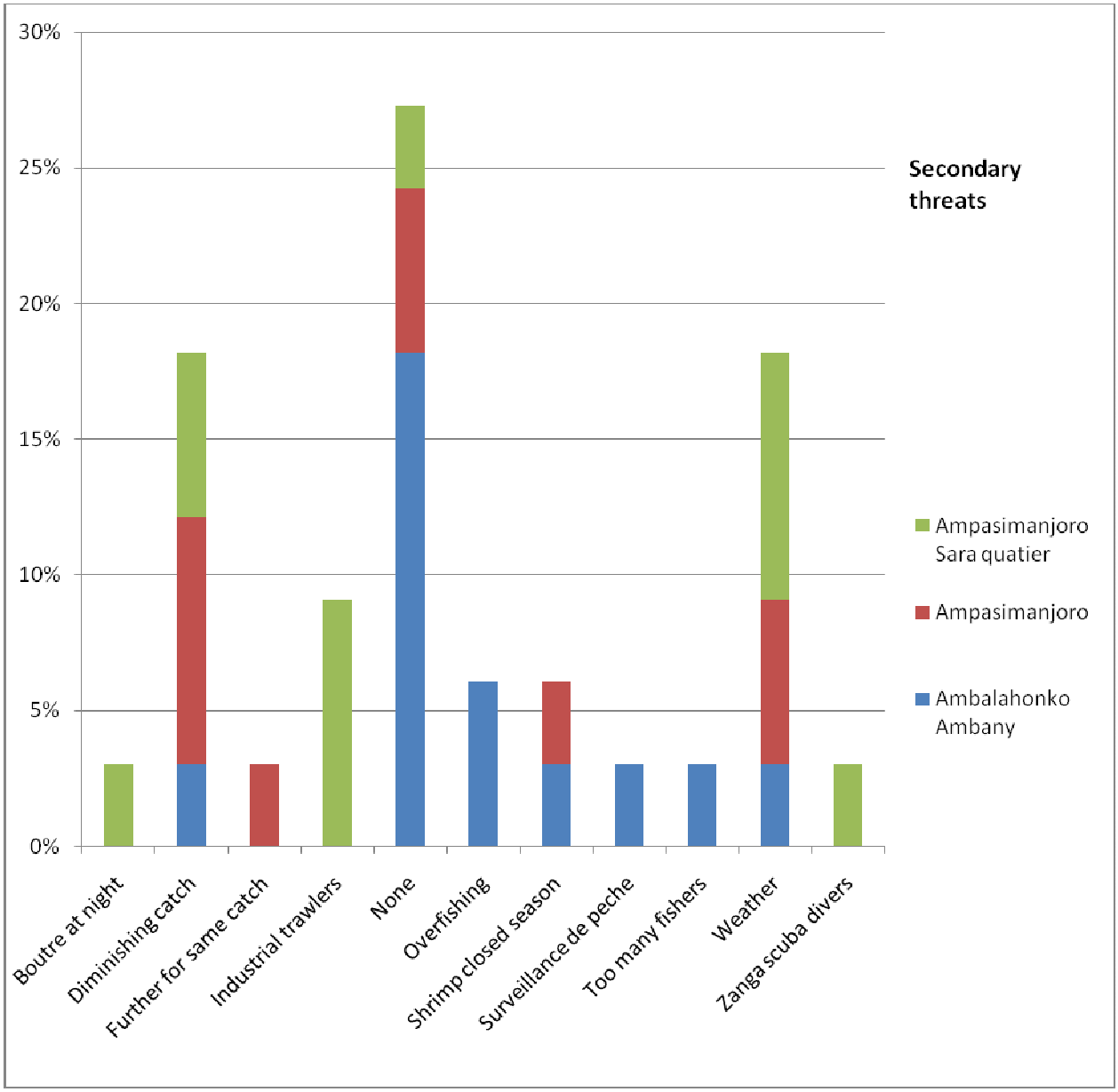


**Figure 35. Percentage of respondents reporting secondary problems and threats fishers of the Maintirano fishing villages face**

## 5.5 Priority conservation and management areas

Table 61 summarises potential conservation areas within the Barren Isles, while selected areas are shown in the figures below. Descriptions of the species and habitats that these areas support have already been presented in the section 2. Natural habitats and biodiversity (section 2), but Table 61 also details some of the particular attributes of the conservation areas. The areas were selected not only for their ecological value, but also for the value that they have to fishers and the practical use they would have in facilitating management measures. The areas were chosen on the basis of the rapid surveying carried out for this study, interviews with people knowledgeable about the area and existing published information. This is an indicative

list and further scientific surveying will be needed to refine conservation targets. Moreover, proper involvement of local people in the identification of conservation areas based on their livelihood needs will be essential.

Figure 36 gives an overview of the potential conservation management areas, while Figs 37 to 40 illustrate some of the individual areas of conservation importance.

**Table 61. Potential conservation management areas within the Barren Isles**

| Potential conservation areas | Attributes | Conservation targets | |
|---|---|---|---|
| | | Habitats | Species[1] |
| Banc de l'Ouest & surrounding waters to the north and east | Offshore rocky bank that has varied topography and prolific *Acropora* growths in the leeward of ridges, large assemblages of adult reef fish, as well as green turtles<br>Popular reef with traditional fishers for sea cucumber free-diving<br>The extensive areas to the north and west of here are popular shark fishing grounds (see Figure 29)<br>A small part of the very extensive submerged reef to the NW of the Banc de l'Ouest was briefly explored during the study; the southerly part briefly explored was mostly smooth rock dominated by standing macro algae, with sparse soft corals and the odd *Acropora*; on both the E and W sides it gradually descended into deeper water<br>Aerial surveying of this zone and further west (by Centre de Recherche sur les Mammifères Marins, Universite de La Rochelle) showed it to be rich in marine life, with notable observations including: leatherback turtles, manta rays, whale sharks, different species of sharks, marlin/sailfish/swordfish, and schools of large pelagic fish | coral reefs | sharks & rays<br>sea cucumbers<br>marine turtles |
| Nosy Marify | Though separated from the other isles, Nosy Marify is very popular with fishers because of the productive sea cucumber, shark and turtle fishing areas accessible from the isle, as well as its proximity to Maintirano. It is therefore an important management area<br>Despite very turbid water, healthy and dense stands of hard coral occur on S and SW parts of the reef | coral reefs | sharks & rays<br>sea cucumbers<br>marine turtles |
| Nosy Manandra and neighbouring reefs | Nosy Manandra is very popular with traditional fishers because of the access it gives to the far offshore reefs to the W, where fishers target shark and sea cucumbers<br>An extensive (ca. 800 m long) and healthy patch reef, which is certainly of conservation value, occurs just W of the sand cay | coral reefs | sharks & rays<br>sea cucumbers<br>marine turtles |
| Nosy Mavony & surrounding reefs (Banc Amarella, | Historically Nosy Mavony supported a nesting colony of Roseate tern (*Sterna dougallii*). To protect this colony the Mayor of Maintirano prohibited human | coral reefs<br>island vegetation | sharks & rays<br>sea cucumbers |

| Potential conservation areas | Attributes | Conservation targets | |
|---|---|---|---|
| | | Habitats | Species[1] |
| Banc du Milieu) | presence on the isle; this law was respected until 2009<br>Before the law prohibiting fishers from living on the isle, it was a popular isle because it gave ready access to the westerly reefs; prohibiting fishers from staying on the isle is an effective way to diminish fishing pressures on these reefs<br>There are a diversity of reef types surrounding the isles that are in excellent condition and mostly undisturbed; though there are two reef flats neighbouring the isle that fishers glean<br>Turtles nest on the isle<br>This isle and the surrounding reefs are likely to be the least affected by high levels of sedimentation | | marine turtles<br>sea birds |
| Nosy Abohazo & neighbouring reefs | One of the most important turtle nesting grounds in the isles<br>The fringing reef that runs almost the length of the eastern side of the isle is comprised of dense stands of hard coral and is in good health<br>The reef to the SW of the isles is notorious for currents and is not often fished<br>The isle is a popular base for fishers | coral reefs<br>island vegetation | sharks & rays<br>sea cucumbers<br>marine turtles<br>sea birds |
| Banc Rontonina & Reef Croissant and surrounding area | This system of reefs is an opportunity for management for a number of reasons: it is an example of a close shore reef. It is not exploited by fishers, and it forms a natural landmark that could be used as a marker for the MPA<br>The reefs do experience high levels of sedimentation | coral reefs<br>soft bottom near-shore | sharks & rays<br>sea cucumbers<br>Spanish mackerel |
| Nosy Andrano | Harbours a high diversity of trees and plants in comparison to the other isles, including a small mangrove area<br>A turtle nesting site<br>The fringing reef to the SE and S of the isle is in reasonable condition but shows the impacts of hyper-sedimentation (particularly on the E)<br>It is one of the largest isles yet has the least fishers living on it for its size | coral reefs<br>island vegetation | marine turtles |
| Nosy Manghily & neighbouring reefs | The fringing and small patch reefs to the S and SW of the isle, as well as the barrier reef (NW) were diverse and in fair condition<br>A turtle nesting site<br>Reported to have a resident population of Madagascar heron *Ardea humbloti* (Endangered)<br>While the isle represents similar habitats to Nosy Lava, it is much smaller in area and has only one migrant | coral reefs<br>island vegetation | marine turtles<br>sharks & rays<br>sea cucumbers |

| Potential conservation areas | Attributes | Conservation targets | |
|---|---|---|---|
| | | Habitats | Species[1] |
| | Vezo family (28 persons) from Andavadoaka living on it | | |
| Nosy Ampasy (Banc Simpson) | The inter-tidal reef flat is a very productive octopus fishing ground<br>There are said to be healthy coral reefs on the western side of the bank and patch reefs between Nosy Ampasy and Nosy Lava, though it was not possible to survey these because of bad visibility | coral reefs | sharks & rays<br>sea cucumbers<br>marine turtles |
| Maintirano – Soahany near shore coastal waters | A band, 3 – 5 km wide, that runs the length of the coastline and is the favoured fishing ground for Spanish mackerel (and other pelagic fish species in this guild)<br>It is also an area that shrimp trawlers fish | soft bottom near-shore | Spanish mackerel[2]<br>sharks & rays<br>sea cucumbers |
| Maintirano - Maintirano maty – Manombe mangrove complex | An extensive, interconnected mangrove complex that would play a key role in the wider ecosystem<br>Areas closer to Maintirano town have been heavily exploited, while most of the extended area has been selectively logged | mangroves and coastal wetlands | Spanish mackerel[2]<br>sharks & rays<br>sea cucumbers |
| Ampandikoara mangroves | In comparison to the mangroves closer to Maintirano, these are less exploited and the S/SE part of the forest is said to be undisturbed | mangroves and coastal wetlands | Spanish mackerel[2]<br>sharks & rays<br>sea cucumbers |
| Tondrolo - Antsorosoro mangroves | These mangroves are in the least populated part of the coastline and should be in good condition; the study did not survey them | mangroves and coastal wetlands | Spanish mackerel[2]<br>sharks & rays<br>sea cucumbers |
| Coastal sand dunes Kimazimazy - Namakia | These extensive coastal sand dunes play a defining role in the formation of the mangroves and their preservation is essential in guaranteeing the overall integrity of the coastal ecosystem | coastal sand dunes | |
| Namakia littoral forest | An area where Western dry forest descends to the water's edge and that is of great natural beauty<br>Though this area of forest is effectively isolated from the larger blocks inland, there is strong argument for protecting or properly managing it given its extraordinary scenic beauty and conservation value | littoral forest | |
| Soahany mangroves and wetlands | According to the REBIOMA maps of conservation planning the Soahany mangroves are already considered for protection under a separate protected area. They are therefore not considered in this conservation planning exercise. | mangroves and coastal wetlands | Spanish mackerel[2]<br>sharks & rays<br>sea cucumbers |

Notes:

1. These areas would support the target species within the limits of: the particular species' level of association with the habitat, the degree to which the species ranges between different habitats and its geographical distribution, and the size of the particular conservation area. The conservation area may also support important parts of the species' life cycle (e.g. nesting grounds). Though certain management areas do not necessarily have an ecological role for target species, they are important in its conservation because they will enable the management of fishing levels and other threats (e.g. Nosy Marify).

2. In that mangroves are an area of high net primary productivity whose output would form the trophic base for these species; mangroves also support stages of the life cycles of certain sea cucumbers and sharks.

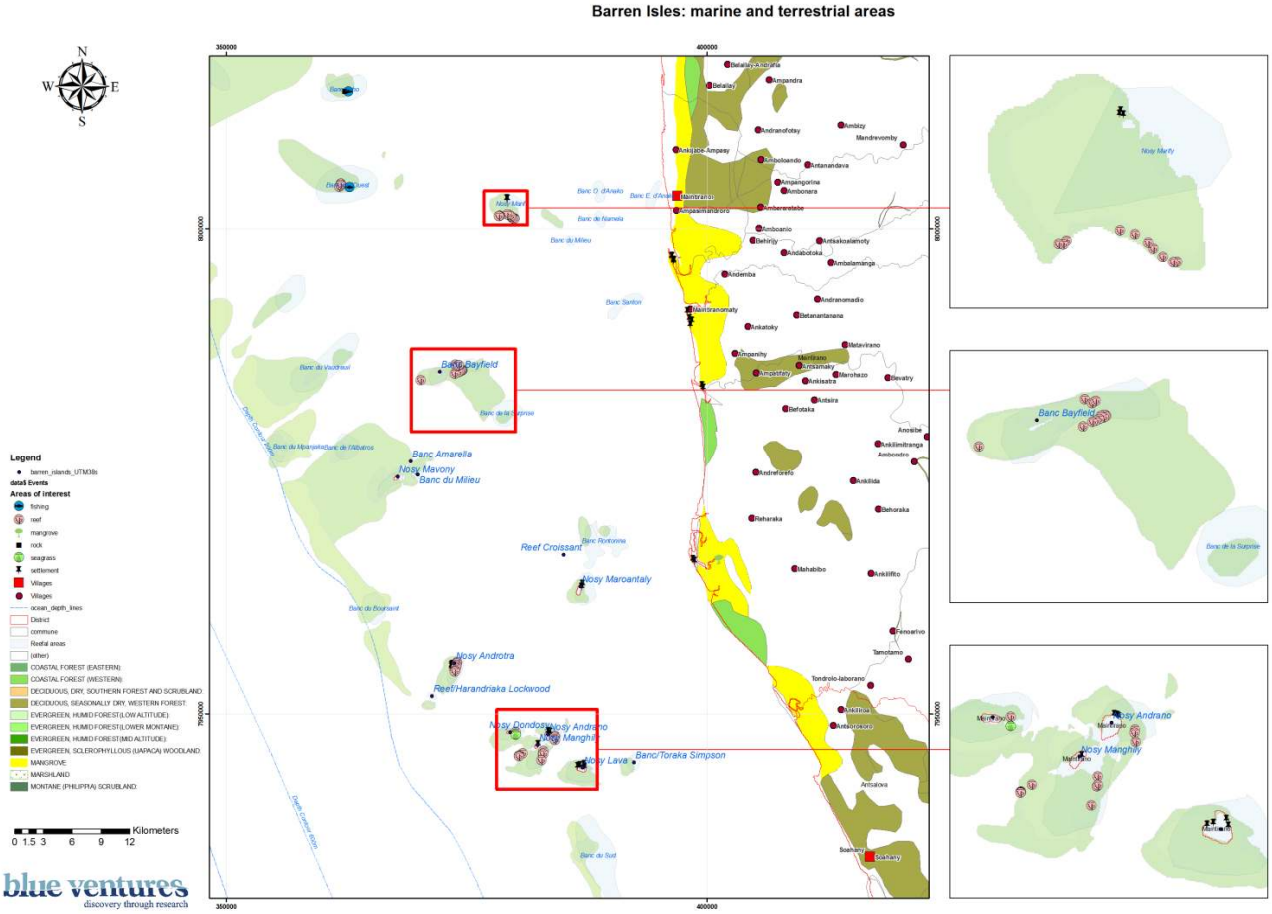


**Figure 36. Map of Barren Isles showing key conservation areas**

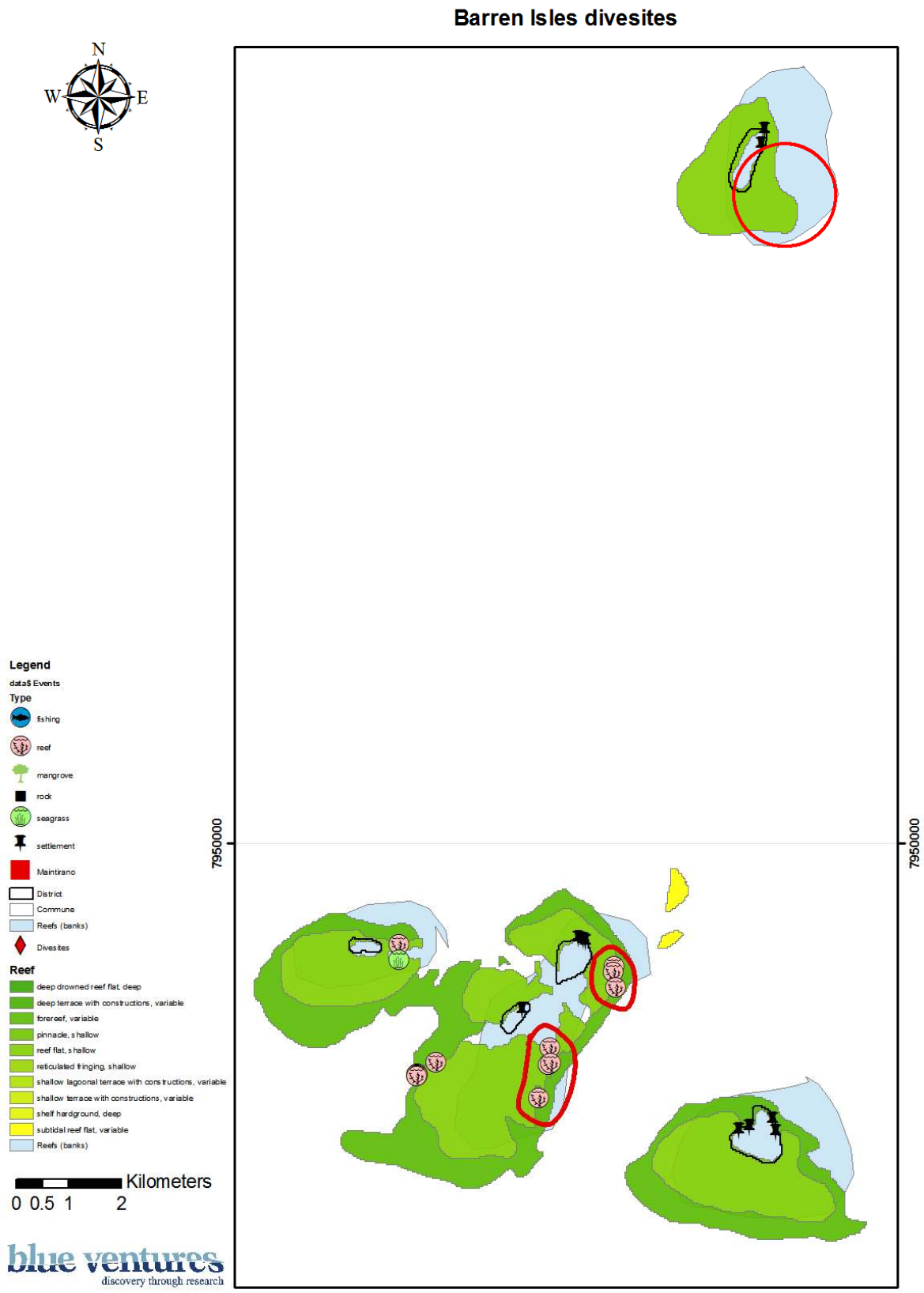


**Figure 37. Areas of conservation interest - Nosy Lava, Manghily, Andrano and Dondosy**

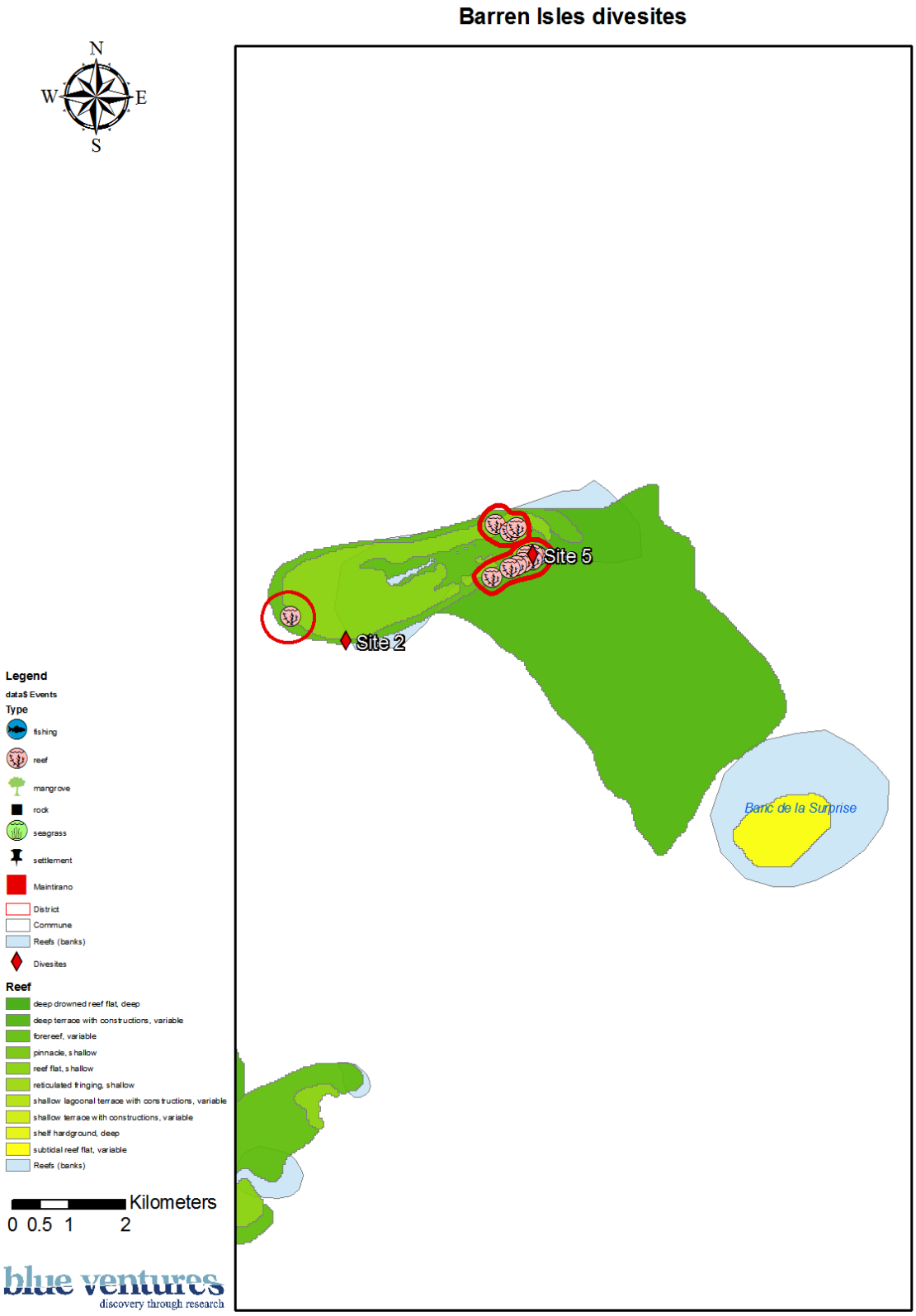


**Figure 38. Area of conservation interest – Nosy Manandra**

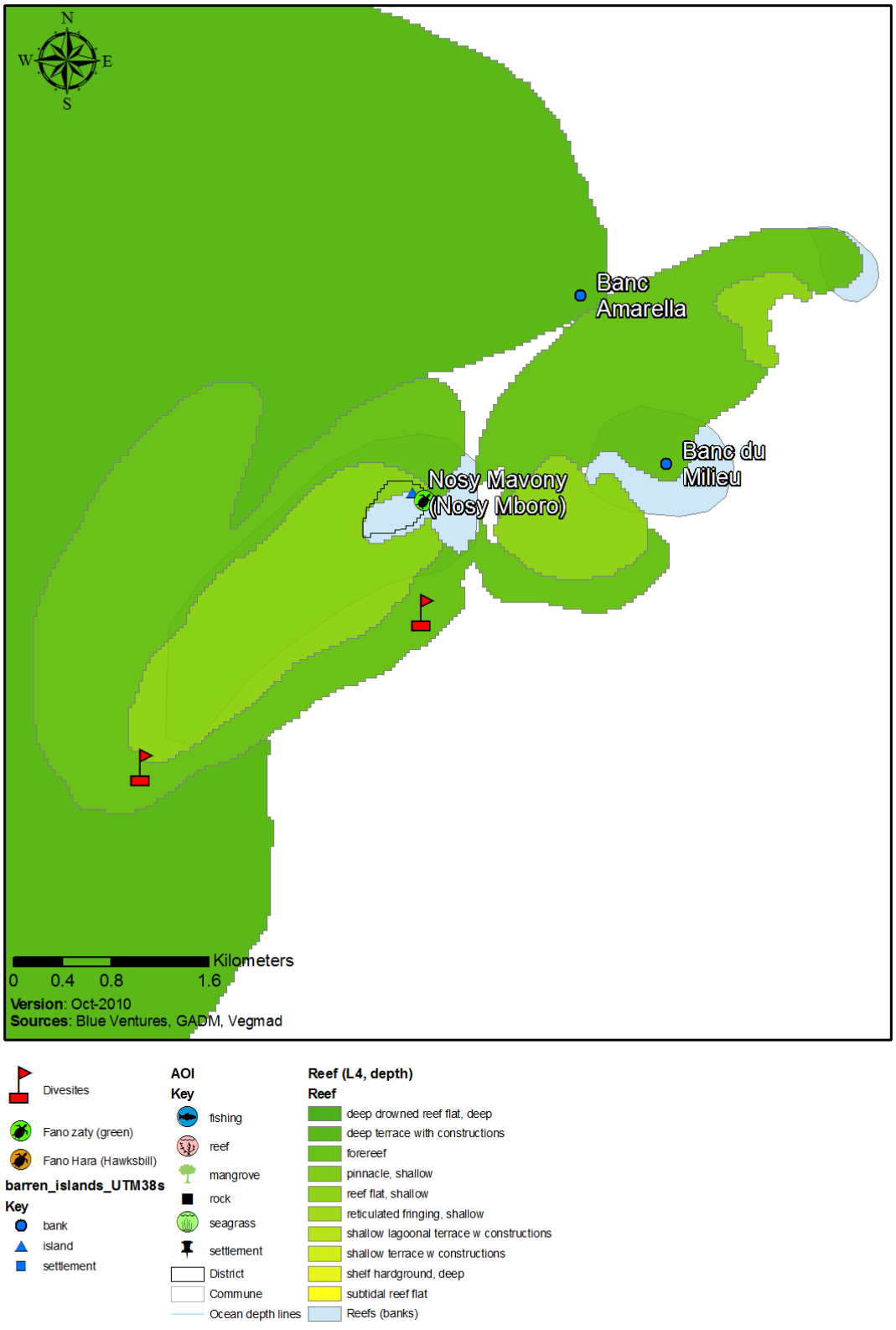


**Figure 39. Area of conservation interest - Nosy Mavony / Banc Amarella**

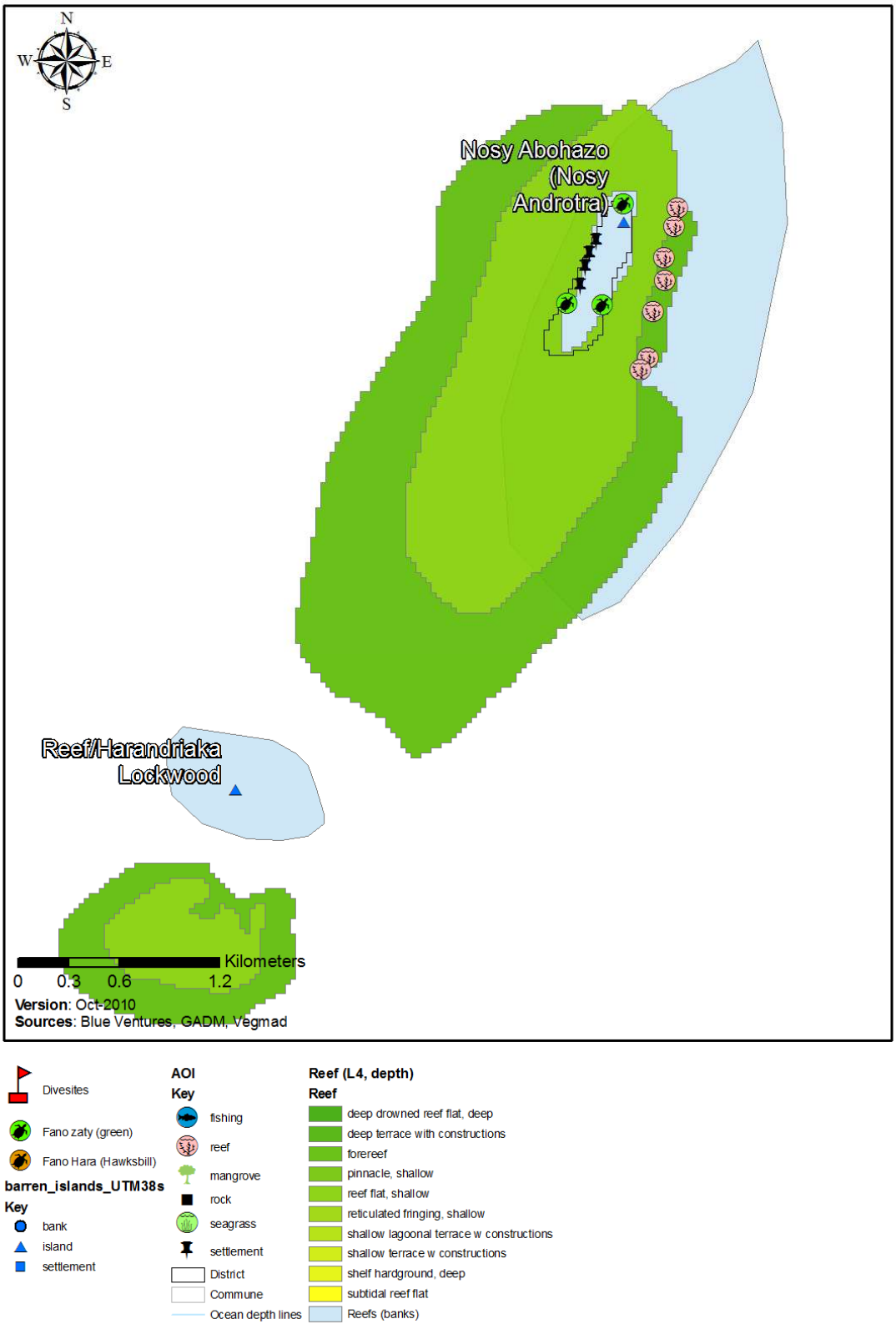


**Figure 40. Area of conservation interest - Nosy Abohazo**

## 5.6 Potential conservation strategies and management plan

The future management of the MPA has a host of potential management actions that they could be undertaken to address the threats to the Barren Isles and the sustainability of local fisheries. Table 62 presents examples of management measures that have been enacted in other tropical marine and coastal management areas.

**Table 62. Examples of management measures from other tropical marine and coastal management areas.**

1. Permanent no-take zones (marine reserves, marine protected areas, etc.)
2. Rotational or temporal no-take zone (giving the reef a resting period)
3. Zoning the management area – delineating different areas for different uses (for example, banning commercial fishing where it competes with subsistence fishing or tourism, etc.)
4. Ban the use of poisons for fishing (both traditional and modern)
5. Ban fishing that destroys habitat (dynamite fishing, smashing corals to chase fish into nets, etc.)
6. Regulate or ban night fishing with underwater lights
7. Regulate or ban spear fishing using SCUBA
8. Control the use of pressurized gas or SCUBA for harvesting bêche-de-mer (sea cucumbers), etc.
9. Ban the harvest of egg-bearing female lobsters or crabs
10. Establish size limits for clams, lobsters, crabs, octopus, and certain fish
11. Control the use (and sale) of small-mesh fish nets (require a minimum mesh size of 3 inches for most types of net fishing)
12. Ban gill netting, or replace gill nets with fish traps that don't kill the fish, so that rare species can be released. Use fish traps and fish fences to replace some types of net fishing (perhaps using more durable modern materials).
13. Protection of spawning aggregations from fishing
14. Seasonal closure of a fishery (during reproductive season)
15. Ban on harvest of very rare species in the larger management area (turtles, bumphead parrotfish, humphead wrasses, triton's trumpet or other shells, etc.)
16. Discouraging destructive practices such as walking on corals, anchoring on corals (make permanent moorings, or buy or make sand anchors), and harvesting corals (replace with sustainable coral farming)
17. Ban the disposal of rubbish into the sea, especially plastics, batteries, and cans

18. Removal of crown of thorns starfish if there are > 5 per hectare
19. Removal of tree trunks that wash up or fall onto the reef, as they roll around during storms, smashing corals
20. Replanting corals to dredged or dynamited reefs that are not recovering
21. Planting corals
22. Restocking or aggregation of surviving rare shellfish within a limited area of a no-take zone, with proper monitoring and a protection program
23. Training and activation of community "Fish Wardens"
24. Limiting the numbers of commercial fishers in a particular area
25. Development of effective enforcement and problem-solving process in the community
26. Re-establishing traditional fishing methods that allow "totem" species (species sacred to a particular clan) to be easily released
27. Reduce nutrient pollution to reefs by improving sewage systems and reducing other sources of nutrients such as run-off from piggeries, fertiliser, etc.

Clearly, the future management of the Barren Isles MPA will have to thoroughly appraise threats to the ecosystem and evolve suitable management measures with the support of stakeholders. Here we present an indicative management plan entailing measures that could be undertaken to address existing threats. It is based on the causal analyses, target viabilities and threat ratings presented in section 5.4. These conservation actions are presented in Table 63, along with the relevant conservation targets and the anticipated impact of each strategy. The strategies were rated according to their potential impact (would the strategy lead to desired changes?) and their feasibility (is it possible to implement the strategy given likely time, financial, staffing, ethical, and other constraints?). Full details of the assessment of the conservation strategies and the criteria used are presented in the Appendices. This preliminary assessment of the potential conservation strategies showed that the following six are most likely to be effective given probable resources, and the socio-economic and political context of the project:

1. Community-based natural resource management – specifically the definition by fishing communities and local authorities of a Dina to govern natural resource use in the Barren Isles
2. Biodiversity conservation actions:
    a. the implementation of marine reserves by the fishing communities who frequent the Barren Isles
    b. the eradication of introduced predators (rats and cats) on the isles
3. Implementation of a social marketing to promote sustainable natural resource use and conservation actions

4. Inclusion of the Barren Isles in the a West coast MPA network to ensure coherent overall management of migrant fishers

5. Alternative livelihoods:

    a. Increasing the value chain of the traditional Spanish mackerel fishery and other fisheries, ensuring that it is sustainable. Although this holds a danger of encouraging overfishing rather than sustainable management.

    b. Introducing village-based seaweed aquaculture, as well as initial treatment and developing access to markets.

6. Implementing an integrated Population Health and Environment programme, particularly addressing family planning, provision of contraceptives and infant and maternal health needs.

The study recommends that the future MPA management should concentrate on implementing these particular strategies within the supporting framework of an overall management plan. The conservation strategies judged to be effective will address some of the key underlying causes of threats to the Barren Isles that can reasonably be tackled by the project.

**Table 63. Summary of conservation strategies for the Barren Isles ecosystem**

| Strategy | Strategy rating | | | Conservation Targets | |
|---|---|---|---|---|---|
| | ***Overall Strategy Effect*** | ***1. Potential Impact*** | ***2. Feasibility*** | ***Habitats*** | ***Species*** |
| **1. CBNRM** | | | | | |
| Community management structure | Less effective | Medium | Very High | Littoral forest<br>Coastal dunes<br>Coral reefs<br>Mangroves & wetlands<br>Island vegetation | Marine turtles<br>Sea Cucumbers<br>Sharks, rays<br>Spanish mackerel<br>Seabirds |
| Dina | Effective | High | High | | |
| Biodiversity conservation actions | | | | | |
| 1. Reserves | Effective | Very High | High | | |
| 2. Closure period for isles | Less effective | High | Medium | | |
| 3. Closure of 3 isles | Less effective | Very High | Medium | | |
| 4. Eradication of introduced predators | Effective | Very High | High | | |
| 5. Turtle conservation measures | Less effective | High | Medium | | |
| Social marketing | Effective | High | High | | |
| MPA network | Effective | High | High | | |
| Monitoring | Less effective | Medium | High | | |
| **2. ICZM** | | | | | |
| Establish ICZM structure (ZAC) | Less effective | Medium | High | Littoral forest<br>Coastal dunes<br>Coral reefs<br>Island vegetation<br>Mangroves & wetlands<br>Seagrass<br>Soft-bottom | Marine turtles<br>Cetaceans<br>Sea Cucumbers<br>Sharks, rays |
| Develop a ICZM plan for Melaky Region | Less effective | Medium | High | | |
| Industrial fishing ban within the MPA | Less effective | Very high | Medium | | |
| **3. Alternative livelihoods** | | | | | |
| Sustainable traditional pelagic fishery | Effective | High | High | Littoral forest<br>Coastal dunes | Marine turtles<br>Spanish mackerel |
| Village-based seaweed aquaculture | Effective | High | High | | |

| Strategy | Strategy rating | | | Conservation Targets | |
|---|---|---|---|---|---|
| | ***Overall Strategy Effect*** | ***1. Potential Impact*** | ***2. Feasibility*** | ***Habitats*** | ***Species*** |
| Mangrove REDD project | Less effective | Very high | Medium | Coral reefs<br>Island vegetation<br>Mangroves<br>Seagrass | Spanish mackerel |
| Ecotourism | Less effective | Medium | Medium | | |
| **3. PHE** | Effective | High | High | Coastal forest | Marine turtles |
| | | | | Coastal dunes<br>Coral reefs<br>Island vegetation<br>Mangroves & wetlands<br>Seagrass | Marine turtles<br>Spanish mackerel |

### 5.6.1 Preliminary management plan

**Table 64. Summary of a preliminary management plan for the Barren Isles MPA**

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| **1. CBNRM** | • Resource-dependent communities empowered to manage resources<br>• CBNRM forms a foundation for the creation and management of the MPA<br>• Management of the MPA and natural resources gain high legitimacy through broad | Effective CBNRM will form the foundation for the establishment of the MPA and will be made up of the following actions:<br>1. Formation of the participatory/multi-stakeholder MPA management structure<br>2. MPA management planning<br>3. Definition and legalisation of an MPA Dina<br>4. Biodiversity conservation actions | |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | stakeholder inclusion<br>• Resource-dependent communities gain a voice in ICZM<br>• CBNRM forms a basis for eventual income generating projects (MPA entrance fees, increased fishery productivity, REDD etc.) | 5. Sustainable fisheries management<br>6. Peer to peer learning and community-led awareness raising<br>7. Integration into a regional MPA network<br>8. Addressing drivers of fisher migration<br>9. Monitoring<br>10. Gazetting of the MPA | |
| 1.1. Formation of the MPA management structure | • The establishment of an effective community management structure that has the capacity and motivation to manage the MPA and to enact effective natural resource management measures<br>• CBO ultimately forms a focal point within the community to tackle broader issues | 1. Formation of initial management group to catalyse and promote CBNRM and the creation of the MPA | Members of the existing CBO, but would also have to include more representation of active fishers |
| | | 2. Full stakeholder consultation: an initial presentation and familiarisation with all communities; building of rapport, support and broad inclusion | This study did not have the full mandate to undertake this |
| | | 3. Exchange visits with Velondriake to build vision and mutual learning | |
| | | 4. Reinforcement and evolution of the existing CBO to guarantee broad stakeholder involvement and so a strong mandate for MPA management | The existing CBO needs stronger involvement of fishers based on the isles and needs to devolve more authority to them. Furthermore it will have to have fair representation of migrant fishers because they constitute the majority of fishers living on the isles |
| | | 5. Establishment of a co-management structure: executive committee comprised of representatives from local government; NGOs; and the MPA management committee; MPA management committee comprised | One possibility for including all stakeholders would be to establish a new management committee that is made up of elected representatives (with sufficient provision for migrant fishers) from all of the isles and fishing villages; the existing CBO |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | entirely of representatives from each of the fishing villages | would form an executive committee overseeing the activities of this management committee. It would be essential to have an outside, NGO to provide technical and financial support as well as impartial leadership. |
| | | 6. Clear definition of all partners' roles and responsibilities, procedures and accounting | Agreement on these is made concrete through written documents |
| 1.2. MPA management planning | • Definition of a clear vision and objectives for the MPA by the community<br>• Development of MPA management measures having wide support and community understanding<br>• The new co-management structure is implementing effective management measures | MPA management planning is comprised of the following 5 actions | Process is carried out through several village meetings and workshops; always beginning with individual fishing communities (villages/isles) |
| | | 1. Community appraisal of their situation | By using participatory appraisal tools (historical resource trends, mapping, problem identification) the community analyses the condition of its marine resources, and identifies problems and issues |
| | | 2. Learning and awareness; period of assimilation | Through consideration of traditional and scientific information, the partners gain an understanding of the issues necessary to planning suitable management measures. This will draw on scientific data and traditional ecological knowledge, and will make use of problem trees, identification of direct and indirect threats, root cause analysis, harvesting calendars |
| | | 3. Development and planning of management measures by the community | Priority issues are selected and actions developed to address these, including timeframe and responsible people/agencies. Tools: ranking and planning matrices |
| | | 4. Definition of a MPA creation and management plan that includes conservation | |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | and development objectives | |
| | | 5. Implementation of management measures | The CBO will work with the communities to implement the management measures |
| 1.3. Definition and legalisation of a MPA Dina | • To develop a set of community-supported set of regulations that provide the foundation for governance of the MPA | 1. Development of the Dina from a village level upwards through a process of consensus | No clear form of traditional governance exists. The definition of a set of regulations using the tradition of local law - Dina - will provide a foundation for this |
| | | 2. Inclusion of key management measures, for example: ban the use of night fishing with torches and condoms, outlawing the use of mosquito nets (with a caveat for the *patsa* season) | The Dina will ultimately define all management measures and regulations (e.g. reserves, closures of isles, annual closure period, control use of destructive techniques, respect for nesting and breeding periods), as well as fines and procedures of enforcement |
| | | 3. Continual communication of the Dina to achieve a wide understanding and knowledge of it | Broad and continued communication of MPA management measures to all stakeholders will be achieved through wide publication of the Dina |
| | | 4. Legalisation of the Dina by the district court | |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| 1.4. Biodiversity conservation actions | • Ensure that ecosystem functioning continues and that fisheries remain productive | Biodiversity conservation actions are comprised of the following 4 potential actions:<br>1. MPA design (reserves, closure periods, permanent protection of certain isles)<br>2. Assessment and management of number of new fishers living on the isles<br>3. Eradicate introduced predators<br>4. Reduction of sources of nutrient enrichment | • These measures will form part of the sustainable management of the fisheries so as to gain community buy-in, but will also achieve biodiversity conservation objectives.<br>• It will be initially difficult to gain full support for management actions 1. - 4. It will be necessary to establish pilot examples, to slowly evolve these options over time and to provide strong incentives to implement them (the provision of alternative livelihoods, through the demonstration of tangible benefits etc.) |
| | | 1. MPA design: develop an MPA zoning plan that includes permanent reserves | |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | • Protect 30 % representation of all key habitats and populations through permanent reserves; ensure that reserves are ecologically linked<br>• Guarantee the long term viability of the populations of the target species<br>• Through the reduction of local anthropogenic stresses (fishing, harvesting, sewage) increase the resilience and adaption capacity of the ecosystem to climate change | 1.1 Reserves<br>1.1.1. Each fishing community will define their zoning plan, these will be synthesised together into one community zoning plan<br>1.1.2. Further scientific surveying and TEK to identify key conservation areas (fish spawning aggregations, turtle nesting grounds etc.), the distribution and state of habitats; definition of a scientific zoning plan<br>1.1.3. Negotiation of zoning between local authorities and the fishing community<br>1.1.4. Negotiation and agreement on MPA boundaries with other stakeholders; broad communication of the zoning plan<br>1.1.5. Implementation of zoning plan by the fishing communities and supporting partners. Physical demarcation with buoys and signs; fulfilment of SAPM procedures<br>1.1.6. Continual evolution of the zoning plan to achieve ecologically meaningful protection | The reserves will provide protection to key habitats (e.g. coral reefs, mangroves) and species (e.g. turtle, cetacean and seabird populations) |
| | • Diminish fishing effort on all key target species<br>• Lessen other local anthropogenic stresses (sewage) associated with the presence of humans<br>• Allow for the annual eradication of introduced predators during the absence of fishers. This is controversial because harming | 1.2. Closure period for isles<br>Close isles (or as many as possible) to human presence / fishing over three month cyclone season (December, January, February) | The cyclone season is the period when this would be most socially acceptable |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | rats is a local taboo | | |
| | • Enable regeneration of island vegetation and fauna<br>• Protection of bird and turtle nesting grounds<br>• Manage access to fishing grounds in the vicinity of these isles<br>• Allow island biodiversity to be re-established by removing human disturbance<br>• Allow for long term eradication of introduced predators and invasive plants | 1.3. Closure of 3 isles<br>Permanent closure of Nosy Mboro, Dondosy and Andrano and the waters surroundíng them to húman presence | Nosy Mboro is already prohibited to fishermen; Nosy Dondosy and Andrano are possible candidates because they are hardly frequented by fishers. The other isles are all seasonally or permanently settled by fishers and so this measure would be difficult to implement. Other candidates include: Nosy Manandra (extensive coral reefs, a point of access that if removed would result in fishing pressure being removed from many other reefs, but it is frequented by a large number of migrant fishers); Nosy Manghily (only has one migrant Vezo family living on it, but who are causing damage); Nosy Abohazo (very good leeward fringing reef, turtle nesting beaches, but large fisher presence) |
| | | 2. Limit the number of fishers living on the isles (particularly Manandra and Marify) through a system of licensing | Particular isles are often over-crowded (particularly Nosy Manandra and Marify, but sometimes Nosy Lava). A system of licensing with numbered pirogues has already been developed by the local authorities; this would need to be reinforced and evolved so that it functions effectively. |
| | Removal of predators to native island biodiversity so that avifauna can re-establish itself | 3. Eradicate introduced predators (rats and cats) from the isles | |
| | Reduction of local sources of nutrient enrichment | 4. Educate the community on the health gains of using latrines; build latrines; find alternative ways of disposing of shark carcasses and fish | The most effective way of achieving this objective will be to limit the number of fishers on the isles: the use of latrines will be culturally unacceptable to |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | offal rather than burying on landing beaches | the Vezo; the present system of burying offal is probably the most practical |
| 1.5. Sustainable fisheries management | Sustainable management of the Spanish mackerel (and other pelagic fish species in this guild) , sea cucumber and shark fisheries to ensure viable populations | The biodiversity conservation actions 1. – 2 described above as well as the following 4 actions: | Four traditional fisheries exist that are key to fisher livelihoods as well as attaining biodiversity conservation objectives: the pelagic fishery targeting species such as Spanish mackerel, and other pelagic fish species in this guild; sea cucumber collection by free-diving; shark fishing and the traditional turtle fishery. Through a participative appraisal the project will enable the local communities to define threats to these fisheries and to develop local solutions to overcoming these. |
| | | 1. Implement turtle conservation measures:<br>1.1 Reinforcement of existing conservation measures<br>1.2. Other potential actions: maximum catch size; banning of hunting for commercial trade; banning of killing laying females and gathering eggs; nesting grounds protected as reserves; social marketing campaign | The RIPB and have already implemented a number of turtle conservation measures. CBNRM would continue reinforcing and building on these efforts |
| | | 2. Enforcement of the ban on scuba | The sustainable management of the sea cucumber and shark fisheries is particularly vulnerable to outside fishers (itinerant, artisanal, scuba divers), and will only be feasible within a strong enforcement environment provided by the relevant regional and national authorities |
| | | 3. Outlawing of destructive artisanal fishing techniques (barrage etc.) within the MPA; | |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | 4. Spanish mackerel (and other pelagic fish species in this guild) fisheries management measures<br>4.1. Increase value of fishery through development of the value chain<br>4.2. Introduce a licence system with limited numbers. (based on monitoring) | The Spanish mackerel (and other pelagic fish species in this guild) fishery is almost entirely undertaken by a cohesive social group - the Sara. This presents a good opportunity to manage this fishery coherently through: monitoring; increasing the value of the fishery; implementing local ownership of the fishery through, for example, the establishment of a licensing system |
| 1.6. Social marketing | • Enhancement of existing traditional beliefs that enhance resource management<br>• Culture of local ownership of marine resources developed<br>• Strong sense of cultural pride in resource stewardship | Implement social marketing campaign targeting turtles/destructive fishing | |
| 1.7. MPA network | • Create ecological and human synergies by inclusion of the Barren Isles in a regional MPA network<br>• Contribute to the protection of an ecologically meaningful proportion of biodiversity on a regional scale<br>• Provide protection to fishing grounds of traditional fishers on a meaningful scale<br>• Enable a cohesive management of the problems created by migrant fishers in both the places of origin and destination | 1. Integration of the Barren Isles management structure into a national MPA network so that know-how, experiences and existing tools/materials can be shared | On a regional level the MPA will form the cornerstone of a network of MPAs extending over the western coast of Madagascar that presently comprises the Velondriake MPA and Kirindy Mitea MPA. In doing this it will make a crucial contribution to the long-term economic viability of indigenous Vezo and Sara communities that reflects their livelihood strategy of migration. |
| | | 2. The establishment of the MPA, and the CBNRM and ICZM measures that it entails, will provide adequate protection to the habitats and species of the Barren Isles so that the MPA forms a building block of the MPA network | The network will help to reinforce a culture of responsible resource management on a regional scale and increase the effectiveness of efforts to build capacity and tackle over-population. Through the repeated protection of a diversity of representative ecosystems the MPA network will |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | | build a mutually replenishing marine and coastal landscape. This will lend it some degree of adaptability and resilience to climate change on a seascape level. The positive synergies that such a network will provide, both at an ecological and a human level, will be invaluable in halting the decline of marine resources regionally and alleviating poverty in resource-dependent fishing communities. |
| 1.8. Address drivers of fisher migration | Through addressing the drivers of migration (both in the place of origin and destination), to diminish the threats caused by migrant fishers | CBNRM and MPA network actions | • All of the actions that comprise CBNRM will explicitly address the threats posed by migrant fishers; the integration of the MPA into a regional MPA network will allow for a coherent management of the migration<br>• An appropriate and enforced national regulation of the shark and sea cucumber markets will have to be put in place if migration is to manageable<br>• The global socio-economic drivers of migration (local poverty, over-population, exhaustion of local natural resources) will have to be addressed if the influx of migrants is to be stopped. This is beyond the remit of this project. |
| 1.9. Monitoring | • Provide the scientific data for the adaptive management of target species and habitats<br>• Through community-based monitoring (CBM), build community understanding and | 1. Baseline scientific surveying of target habitats and species (coral reef, seagrass, mangroves, turtles, sharks, seabirds)<br>2. Establish CBM of key fisheries (Spanish mackerel, shark, turtle, sea cucumber); | • Community-based ecological monitoring: In the first instance this will provide a basic measure of the condition of the habitats and species present in the area. Secondly, it will monitor the evolution in the state of these, particularly those of key fisheries. This |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | support for management measures<br>• Build community capacity to monitor and adaptively manage the MPA | monitoring will be carried out with the assistance of NGOs<br>3. Establish village-based monitoring of key indicators; simple methods that clearly demonstrate trends<br>4. Development of a monitoring plan according to the planning matrix developed in the conservation planning stage<br>5. Monitor and evaluate the implementation of management measures | monitoring, carried out hand-in-hand with the fishers, will enable them to understand the state of their resources and the necessity of managing them. In the long term it will quantify the impacts of conservation actions and inform adaptive management.<br>• CBM will be used as much as a means of informing management decisions as a tool to develop community understanding of issues and to gain their support |
| 1.10. Gazetting of the MPA | To gain full legal recognition of the MPA | Fulfil the SAPM process and formalities in order to gazette the MPA | The procedures and documents that must be produced to legalise the MPA are described in detail in the respective SAPM guidelines |
| **2. ICZM** | | | |
| | • Ensure that an effective ICZM environment that is conducive to CBNRM and the MPA exists in the Melaky region | 1. Management and planning<br>1.1. Review current progress of ICZM activities in the region and identify its potential for application in the region<br>1.2. Implement a Melaky ICZM management structure/ZAC that has a strong mandate for management through stakeholder inclusion<br>1.3 Develop an ICZM vision and management plan for Melaky that is consistent with CBNRM | |
| | • High-level institutional support for the MPA and CBNRM exists in the Melaky region | 2. Develop institutional support for the MPA and effective CBNRM<br>2.1. Include members of the CBO in the ICZM management structure and vice versa<br>2.2. Work with the regional government to ensure | Collaboration and engagement of local and national government authorities and fisheries department to build institutional support for the MPA |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | they are aware of and support the MPA | |
| | | 3. Industrial fishing<br>3.1. Negotiate and monitor an industrial fishing ban within the MPA<br>3.2. Work with the industrial trawling sector and the "Programme National de Recherche Crevettière (PNRC)" to define boundaries for the MPA that accommodate all stakeholders<br>3.3. Develop a system of transparent reporting to facilitate the enforcement of the industrial fishing and illegal sea cucumber diving ban within the MPAs | Intensive, near shore industrial trawling renders any local management efforts ineffective. Illegal, itinerant teams of sea cucumber divers equipped with scuba gear will also undermine management efforts |
| | | 4. Mining on the Barren Isles<br>4.1. Work with ONE and other relevant authorities to examine the legality of mining phosphate on the isles<br>4.2 Lobby to ensure the EIA of the phosphate mining is carried out in accordance with MECIE<br>4.3. Campaign against the continued mining of phosphate on the isles if the EIA demonstrates that this in not compatible with conservation objectives<br>4.4. Engage Guanomad so that if mining continues, the environmental impacts are minimised | |
| | | 5. Oil and gas exploration<br>5.1. Work with mining and oil companies to ensure their awareness of the restrictions applicable to them within the boundaries of the MPAs | |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | 5.2. Engage companies carrying out oil exploration activities so that these do not take place during the humpback whale migration | |
| | | 6. Work with MNP to manage the influx of new migrants pushed out of the Kirindy Mitea Protected Area marine extension | |
| **3. Alternative livelihoods** | • To break the dependence of fishing communities on fishing by developing alternative livelihoods<br>• To provide strong incentives to the local communities to support management measures<br>• To generate additional revenue streams for the financing of the MPA management | Alternative livelihood actions are comprised of the following 5 potential actions | In the long term the MPA will work with local people and private enterprise to create sustainable incomes for the MPA management and jobs for the local people. This approach will have to ensure that conservation actions make economic sense to local users, contribute to poverty alleviation and so guarantee that conservation is sustainable and broadly implemented |
| | | 1. Sustainable traditional pelagic fishery: feasibility study and business plan development; engagement of private partners who will invest in the fishery; eventually undertake a sustainable fishery certification process (MSC). Surely first step is scientific stock assessment etc? | Presently traditional fishers catch high-value pelagic fish but sell them as bulk, salt-dried fish on the local market. An opportunity exists in enhancing the value of this fishery by enabling fishers to sell onto higher-value markets. This would require the development of a viable business plan so that a partnership with a private seafood export company could be developed. |
| | | 2. Village-based sea cucumber/seaweed aquaculture: feasibility study and growing trials; engagement of investors; expansion of the program | The variety of coastal habitats present in the protected area provides suitable conditions for these types of aquaculture projects. These activities have the potential to provide valuable complementary incomes to fishers, particularly women |

| Strategy | Objectives | Actions | Notes |
|---|---|---|---|
| | | 3. Mangrove REDD project: could generate carbon revenues for the local communities. Initial measurements of carbon pools; examine the historical deforestation and degradation of the mangroves; establish opportunities for restoration; preparation of a PIN; and project development | Significant mangrove forests exist within the Barren Isles ecosystem; the establishment of a carbon offsetting project that conserves these habitats could allow for the generation of carbon credits and consequently an income stream for the MPA |
| | | 4. Ecotourism: feasibility study of niche ecotourism development opportunities (scuba diving, fly fishing, whale watching, bird watching, guided sailing trips to the isles); development of investment sources; development of tourism infrastructure (island camp, mangrove boardwalk, training of local guides; development of a website; signposts; publicity); work with tour operators to promote the isles; implementation of a fee payment system | With unspoilt natural beauty, pristine coral reefs, several charismatic marine mammals and high game fishing potential, the Barren Islands has extraordinary eco-tourism potential. These natural assets will be leveraged to develop ecotourism in the Barren Islands as a means of providing sustainable income to the protected area. The inaccessibility of the Barren Isles poses a real barrier to the development of ecotourism and niche clients will have to be targeted. |
| | | 5. Development of a Women's Association to promote their interests, a focal point for creating and selling artisanal goods etc. | |
| **4. PHE** | • Population growth amongst coastal communities is controlled<br>• Fishers educated about family planning and sexual health<br>• Wide provision of contraceptives and family planning service | 1. Establish a PHE practice<br>2. PHE social marketing campaign<br>3. Development of a community service provider program | In addition this project will be developed as a fully integrated Population, Health and Environment programme, to incorporate sexual and reproductive health services within conservation planning, in order to tackle a fundamental driver of poverty and threat to food security amongst fishing communities. And build community buy-in by providing a service that communities need. |

## 5.7 Proposed MPA design

### 5.7.1 Indicative design of the Barren Isles ecosystem MPA

The zoning of a protected area is one of the most crucial steps in its creation, being fundamental to the management success and thus community support. On the one hand, for conservation and fisheries management goals to be achieved, permanent reserves must be of sufficient size and number and protect a diversity of habitats. This initially exacts on the community a heavy loss of resources – fishing sites and mangroves. Yet obtaining and retaining strong community support determines the success of any zoning strategy.

Selecting conservation priorities and defining boundaries for an area as vast and as ecologically interconnected as the Barren Isles presents a significant challenge. Some examples of the challenges in delimiting the area for protection include:

- The Barren Isles ecosystem is composed of a diversity of inter-dependent habitats that extend over a vast area. The establishing of an all-encompassing MPA that affords protection to each of these habitats will be too large to be politically feasible, yet it is essential to protect both coastal habitats (e.g. mangroves, coastal sand dunes) and marine habitats (from inter-tidal reef flats to far offshore reefs).
- Certain key conservation targets that are threatened, such as sharks, range across a diversity of habitats as well as large distances that are unlikely to be adequately protected by a single traditional MPA. Species of socio-economic importance, such as Spanish mackerel, also have a large range. Other target species, such as sea cucumbers, depend on a diversity of habitats at different stages of their life cycle, from mangroves to offshore reefs. Furthermore, the distributions of sawfish - a potentially key conservation target - is unknown, but is likely to be reliant on mangroves extending the length of the coast, not just opposite the Barren Isles.
- While SAPM delimits a boundary only around the more southern isles, this study shows that the waters around the northern isles harbour far more diverse and healthier coral reefs. These include the areas around Nosy Manandra and Nosy Mavony, which are not included in the SAPM prioritisation.
- As these areas form important traditional fishing areas; any management measures must therefore include traditional fishers, both to regulate the negative impacts they have on the environment but also to protect the basis of their livelihoods. Local fishers are reliant on fishing for their livelihoods and the most logical management approach to the MPA will be community-based or co-management by the fishing community and supporting NGO. Consequently the MPA will have a strong fisheries management element. Yet traditional fishers use a very extensive area of sea. An example of this is the use of *jarifa* and *ZDZD Kirara* from Nosy Manandra and Marify extending all the way north to Nosy Vao.

- The majority of fishers on the isles at the time of the study were migrant Vezo from the South West. They are highly mobile and will move long distances in a short period to more productive fishing grounds. The same is true of the resident Sara fishers of Maintirano. The static boundaries of a MPA will have little meaning to these fishers. It is not likely that the future MPA management will have the resources to effectively survey and/or patrol an area the size of the Barren Isles.
- Some of the reef areas of the Barren Isles, such as the vast northern reef area, are rarely fished by traditional fishers and are *de facto* reserves. The justification for including them within the MPA would be to protect them from illegal scuba dive teams, artisanal and industrial fishers. Yet significant means would be required to patrol and enforce this area. With the likely resources for managing the MPA in the near future, the inclusion of these areas within an MPA boundary would be meaningless except on paper.
- Nosy Vao, and the surrounding system of shallow sub-tidal reefs and deep water, experiences less pressure from traditional fishers because there are only two habitable isles in this area. In terms of a purely marine conservation opportunity affording strong protection, this area may present a more practicable option than the Barren Isles as it will exact a smaller social penalty.

It is arguable that the definition of an MPA boundary in this context is of little value.

Figure 41 gives an idea of the scale of the challenge. It presents the Barren Isles within an arbitrary conceptual boundary that encompasses most of the key ecosystem areas as well as the majority of fishing grounds of traditional fishers. It also shows selected areas of potential conservation interest within the 'ecosystem'. Note that the boundary presented here is not a "MPA limit" but rather defines the entire conceptual area of conservation interest.

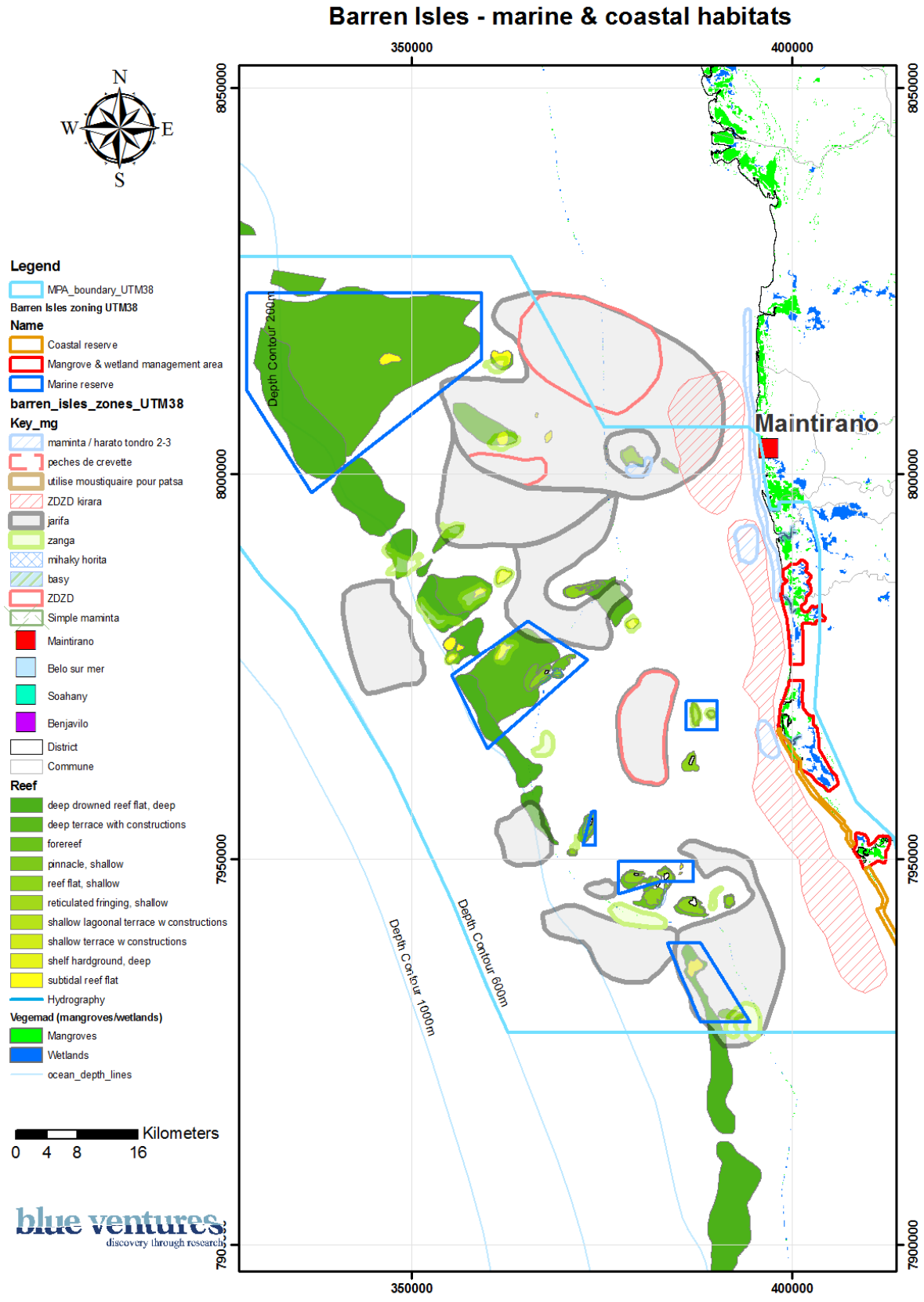


**Figure 41. Conceptual boundary of the Barren Isles ecosystem and selected potential conservation management areas**

Table 65 presents the areas of conservation interest, as well as the total area of the approximate 'Barren Isles ecosystem'. At 6,200 km², it is a vast area. Furthermore, traditional fishers' spatial utilisation stretches over the full extent of this 6,200 km². On the other hand, the key areas of conservation interest are generally only a small percentage of the total area.

**Table 65. Areas of selected areas of conservation interest occurring within the Barren Isles area**

| Zones | Area (km²) | % of the total Barren Isles area |
|---|---|---|
| **Marine and isle areas** | **798.1** | **13.6[1]** |
| 1. North Riva | 547.9 | 9.3 |
| 2. Nosy Mavory | 144.1 | 2.5 |
| 3. Reef Croissant & Banc Rontonina | 14.9 | 0.3 |
| 4. Abohazo | 4.9 | 0.1 |
| 5. Nosy Dondosy & Andrano | 30.1 | 0.5 |
| 6. Banc du Sud | 56.2 | 1.0 |
| **Mangrove & wetland areas** | **101.9** | **33.8[2]** |
| 1. Manombo | 37.6 | 12.5 |
| 2. Ampandikoara | 50.2 | 16.6 |
| 3. Tondrolo | 14.1 | 4.7 |
| **Coastal areas** | **19.6** | **6.5[2]** |
| 1. Ampandikoara-Tondrolo | 9.8 | 3.3 |
| 2. Namakia | 9.8 | 3.3 |
| **General village user zones[4]** | **5,254.2** | **85.1[3]** |
| 1. Marine | 5,073.9 | 86.4 |
| 2. Terrestrial | 180.3 | 59.8 |
| **Barren Isles ecosystem area** | **6,173.7** | **100.0** |

Notes: 1. % of the total marine area; 2. % of the total terrestrial area; 3. % of the total area; 4. total area not including the areas of conservation interest

Within this context, the study recommends a biosphere approach – establishing a broad-scale conservation seascape that is comprised of units of well protected habitat within a larger, 'biodiversity friendly' management area. This would be constituted by a global category V/VI with embedded smaller zones of different management categories, such as a stricter category II. This approach will allow the protection of the diverse, inter-dependent but geographically well-separated ecosystems that make up the diverse seascape,

while allowing for sustainable economic development across the seascape. More extensive surveying is essential to pinpoint conservation targets within the Barren Isles area, as well as the broader seascape, so that conservation efforts can be focussed on key sites. The research required to achieve this is presented in the section 'Recommended future research'.

Given the importance of the isles to fisher livelihoods, the high conservation value of certain of the isles, and the fact that they are the most immediately threatened of the coastal and marine habitats, their protection should be a priority. The Barren Isles would form the foundation for establishing a conservation seascape, with other key habitats (such as mangroves and coastal sand dunes) being protected or properly managed in subsequent practicable steps once management zones are in place. Here we present a design for the Barren Isles and its marine area only, but also give recommendations for the future location and management of future coastal conservation areas.

A preliminary MPA design is therefore defined that includes the core traditional fisher use of the isles, as well as the immediately evident conservation targets. A good understanding of the distribution, diversity and health of habitats is required for the scientific design of a protected area. It must be borne in mind that this design is based on the rapid and exploratory surveying carried out for this study and existing data. Local stakeholders would also have to be more fully involved in the definition of the design. The zoning plan presented here is tentative, and more qualitative than scientific. Nevertheless, it is based on the fundamentals of protected area design:

- risk spreading through representation and replication of habitat types;
- protection of refugia - sites that demonstrate natural resilience and resistance to climate change and other stresses;
- recognition of connectivity between and within ecosystems, spatial configuration of permanent reserves that will ensure mutual replenishment.

The design also reflects fisher usage of the area in an effort to protect conservation targets in a way that is socially acceptable. The preliminary MPA design is presented in Figure 42. The MPA is comprised of a large fisher user zone (2,230 km$^2$, 91 % of the total MPA area) that encompasses four permanent reserves (totalling 189 km$^2$, 8 % of the total area), a temporary marine reserve (6 km$^2$), a tourism development zone (1.1 km$^2$) and an economic development zone (small-scale aquaculture & fisheries) (7 km$^2$). An explanation of these different management areas and their objectives is given in the section Management zones and regulations.

**Table 66. Summary of the proposed MPA management areas**

| Zone | Name | Area (km$^2$) | % of the total MPA area |
|---|---|---|---|
| Permanent marine reserves | Nosy Mavory | 144.1 | 6.2 |
| | Reef Croissant & Banc Rontonina | 17.5 | 0.8 |

| Zone | Name | Area (km²) | % of the total MPA area |
|---|---|---|---|
| | Abohazo | 9.7 | 0.4 |
| | Nosy Manghily | 17.9 | 0.8 |
| | *Total permanent marine reserves* | *189.1* | *8.2* |
| Temporary marine reserve | Nosy Ampasy | 6.3 | 0.3 |
| Tourism development zone | Nosy Lava | 1.1 | 0.0 |
| Economic development zone (small-scale aquaculture & fisheries) | Maroantaly | 7.2 | 0.3 |
| Fisher user zone | | 2,115.7 | 91.2 |
| **Barren Isles MPA** | | **2,319.5** | **100.0** |

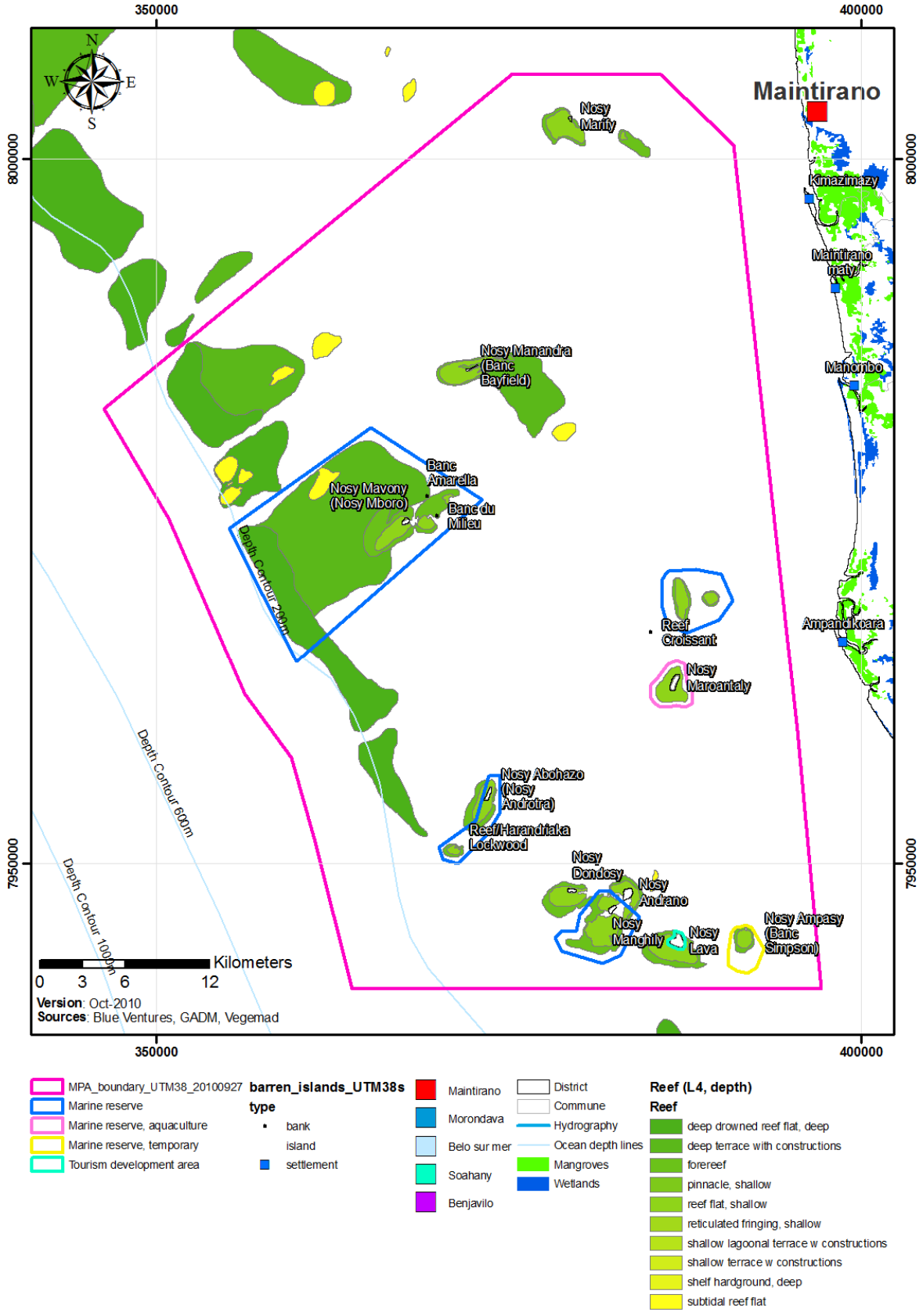


**Figure 42. Indicative boundaries and zoning of the Barren Isles MPA**

**Table 67. Summary of the reef habitat protected in the proposed MPA design**

| | Deep drowned reef flat (km²) | Deep terrace with constructions (km²) | Fore-reef (km²) | Reef flat (km²) | Subtidal reef flat (km²) | Total area (km²) |
|---|---|---|---|---|---|---|
| Nosy Mavory | 19.4 | 73.3 | 9.1 | 3.9 | 2.5 | 108.2 |
| Reef Croissant & Banc Rontonina | | | 1.4 | 2.6 | | 4.0 |
| Abohazo | | | 2.0 | 2.3 | | 4.3 |
| Nosy Manghily | | | 4.5 | 5.6 | | 10.1 |
| Nosy Ampasy | | | 1.0 | 1.2 | | 2.2 |
| ***Total protected*** | ***19.4*** | ***73.3*** | ***18.0*** | ***15.6*** | ***2.5*** | ***128.8*** |
| Fishing areas | 64.4 | 45.6 | 15.0 | 21.4 | 10.0 | 156.3 |
| **Total** | **83.7** | **118.8** | **33.0** | **37.1** | **12.5** | **285.1** |

| | % Deep drowned reef flat | % deep terrace with constructions | % Fore-reef | % reef flat | % Subtidal reef flat | % Total |
|---|---|---|---|---|---|---|
| Nosy Mavory | 23.1 | 61.7 | 27.7 | 10.6 | 20.4 | 38.0 |
| Reef Croissant & Banc Rontonina | | | 4.4 | 7.0 | | 1.4 |
| Abohazo | | | 6.0 | 6.2 | | 1.5 |
| Nosy Manghily | | | 13.5 | 15.2 | | 3.5 |
| Nosy Ampasy | | | 2.9 | 3.2 | | 0.8 |
| ***Total protected*** | ***23.1*** | ***61.7*** | ***54.5*** | ***42.2*** | ***20.4*** | ***45.2*** |
| Fishing areas | 76.9 | 38.3 | 45.5 | 57.8 | 79.6 | 54.8 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

### 5.7.2 Reconciliation of traditional fisher utilisation of the Barren Isles and the MPA zoning

Figure 43 shows the indicative MPA zoning overlain on the map of fisher utilisation of the Barren Isles area. The reserve zones were chosen not only on the basis of their conservation value but also on the likely social acceptability. In general there is little conflict between the proposed reserves and traditional fishing areas. Potential conflicts may, however, arise in a number of instances:

- The reserves of Nosy Mavony, Abohazo and Manghily will conflict with fishers' use of these reefs for gleaning and sea cucumber diving (only in the case of Nosy Mavony).
- Nosy Abohazo and Manghily are lived on by fishers and the closure of these isles as reserves will exact a high social cost on these fishers.

These conflicts reinforce, once again, that this is an indicative MPA design, and the location of reserves must be decided-on together with local fishers.

The proposed boundaries exclude certain traditional fishing grounds, notably:

- The shark and sea cucumber fishing grounds to the north, around the Banc de l'Ouest;
- The Spanish mackerel fishery to the east of the isles;
- The shark and sea cucumber fishery to the south that takes place around the Banc du Sud.

The isles that fishers use to access these fishing grounds are included within the MPA boundaries and will facilitate the management of the fishing grounds. Inclusion of the shark fishing areas within the boundaries would not have much practical meaning. Exclusion of the sea cucumber fishing reefs (Banc de l'Ouest and Banc du Sud), and particularly the nearshore Spanish mackerel fishing area, leave these areas vulnerable to exploitation by artisanal and industrial fishers. However, it is impractical to manage such a large area and it is unlikely that other stakeholders will accept the closure of these areas to their activities, in particular the industrial shrimp fishers. This compromise should make the MPA more politically acceptable, although it conflicts with the goals protecting the wider ecosystem and depedent traditional fisheries.

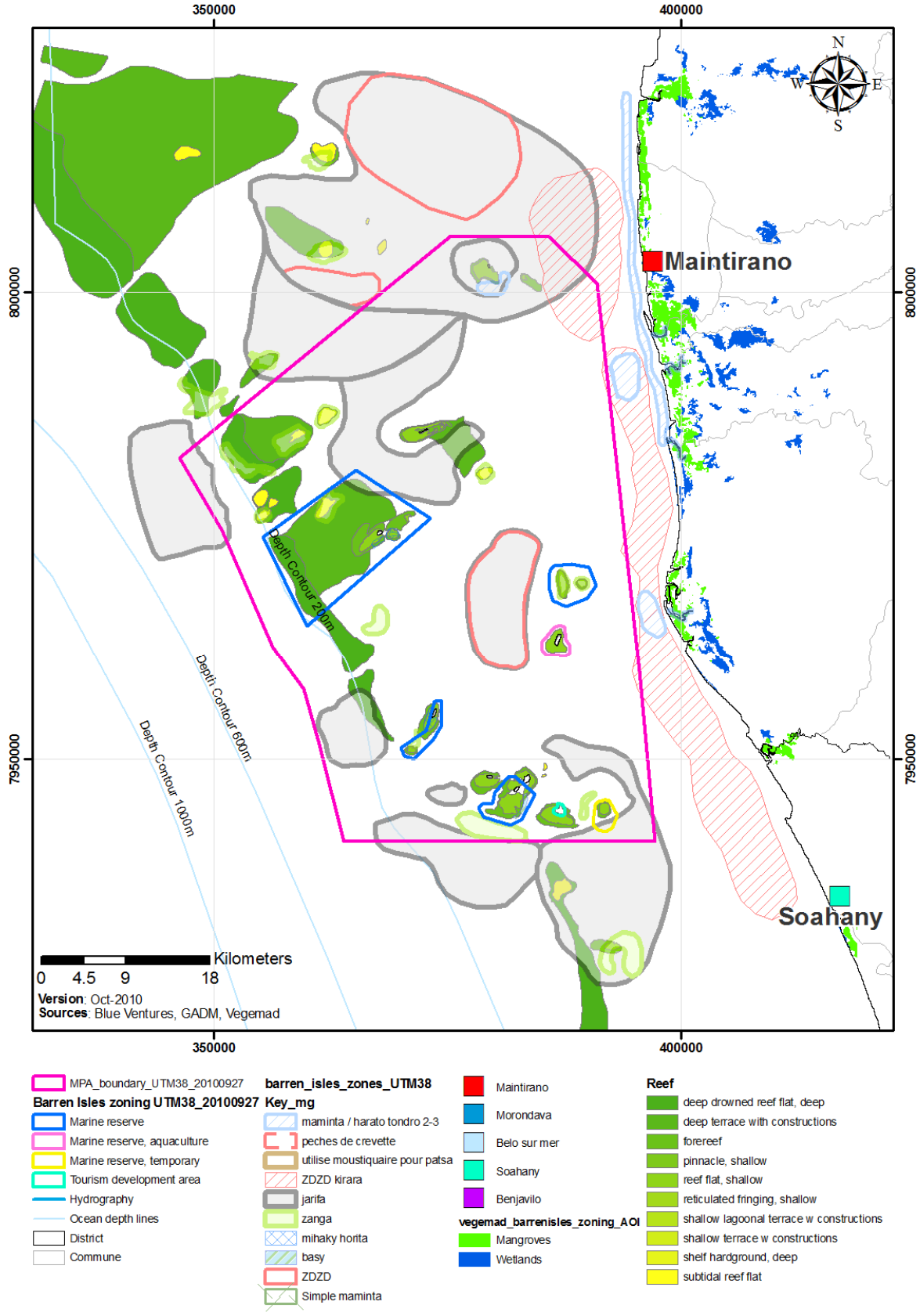


**Figure 43. Comparison of traditional fishing areas with the proposed MPA zoning**

### 5.7.3 Management zones and regulations

This study proposes the following management areas within the multiple-use MPA:

1. Marine village user zone, where traditional fishing is permitted but destructive techniques and industrial fishing are outlawed. Artisanal fishers who are licensed by the MPA management are allowed to fish using non-destructive techniques. Regulated tourism and aquaculture is permitted within this area (Category V or VI).

2. Marine and isle reserves, which are permanently closed to any extractive activity and protect marine and isle habitats. Three different management regimes exist for the marine reserves:

    a. Marine No-Go-Zone - human presence is kept to an absolute minimum, with only very limited scientific research and access for cultural rites being permitted in these reserves; the presence of tourists is prohibited. It is recommended that Nosy Mavony and its surrounding reefs are so protected (Category II).

    b. Marine No-Take-Zone – a reserve where a controlled presence of tourists and researchers is permitted. This reserve type is recommended for Nosy Manghily/Abohazo and the other purely marine reserves (Category V).

3. Temporary fishing reserve – this is meant primarily as a fishery management tool and will involve the temporary closure of a defined fishing ground for a period of months that will then be open to fishing again. Nosy Ampasy and the surrounding reef flat are recommended as a temporary octopus fishing reserve (Category V).

4. Two development zones that will permit economic development to take place. Limiting this to two well defined zones will make sure that it does not cause environmental damage, that management is simplified and that other areas of the isles are left untouched.

    a. Tourism development zone – Nosy Lava is set aside as an area where regulated tourism development can take place that does not detract from the natural beauty of the isles and cause environmental harm. Nosy Lava is the largest of the isles, already has a permanent community living on the isle, gives access to both the marine and coastal attractions of the area (including Soahany), and already has some infrastructure on it, including a reservoir. The French are also said to have once built an airstrip on it (Category V).

    b. Small-scale aquaculture and fisheries development zone – Nosy Maroantaly is set aside as an area where regulated aquaculture and fisheries development can take place. Maroantaly is the base for the largest number of Spanish mackerel fishers and is in close proximity to Nosy Lava, where most other Spanish mackerel fishers are based. Maroantaly has extensive sub-tidal flats that are likely to be suitable for seaweed aquaculture. The isle also has relatively easy access to Maintirano (Category V).

5. Mangrove & wetland management areas, which will consist of two management areas:

a. Villager user area, where local communities are able to continue with a sustainable utilisation of these habitats and destructive activities will not be permitted (Category V).

b. Mangrove and wetland reserves, which will afford permanent protection to these habitats and the biodiversity within them (Category V).

6. Coastal reserves – permanent reserves that will protect historical turtle nesting grounds, as well as beaches and coastal areas of natural beauty/landscape value. Traditional use of these areas by local communities will be permitted within restrictions that will protect biodiversity (Category V).

7. Terrestrial village user zone, where local communities continue with their livelihoods and regulated tourism and private property development is accommodated (Category V).

The division of the MPA into these multiple-use areas should allow it to achieve its management objectives while enabling a continued and productive use of the area by stakeholders. The section below presents the suggested detailed regulations for each of these management areas, firstly for the Barren Isles, and secondly for the future coastal management areas. Table 69 details the fishing activities that would be prohibited within the MPA. These are indicative and the future management committee and community stakeholders would have to define the exact regulations.

### 5.7.4 Regulations of each management zone

#### *5.7.4.1 Barren Isles*

**Table 68. Proposed zones and regulations within the Barren Isles MPA**

| | **Legend** | **Marine village user zone** | **No-go zone (Nosy Mavony** | **NTZ (Nosy Manghily / Abohazo)** | **Marine NTZ** | **Tempoary fishing reserve** | **Villager user area isles** | **Tourism development zone** | **Local economic development zone** |
|---|---|---|---|---|---|---|---|---|---|
| | Activity permitted with no restriction | | | | | | | | |
| | Prohibited activity | | | | | | | | |
| | Activity permitted only to holders of a valid permit | | | | | | | | |
| | Activity regulated by the restriction of techniques | | | | | | | | |
| | Not applicable | | | | | | | | |
| **Access** | | | | | | | | | |
| Local traditional fishers and community | | | | | | | | | |
| Traditional migrant fishers | | | | | | | | | |
| Itinerant artisanal fishers | | | | | | | | | |
| Traditional fisher settlements and habitations | | | | | | | | | |
| Patrols and surveillance by MPA management | | | | | | | | | |
| Researchers | | | | | | | | | |
| Tourists and tourist guides | | | | | | | | | |
| Local cultural rights and traditional ceremonies | | | | | | | | | |
| Supporting partner organizations | | | | | | | | | |

| | Legend | Marine village user zone | No-go zone (Nosy Mavony | NTZ (Nosy Manghily / Abohazo) | Marine NTZ | Tempoary fishing reserve | Villager user area isles | Tourism development zone | Local economic development zone |
|---|---|---|---|---|---|---|---|---|---|
| | Activity permitted with no restriction | | | | | | | | |
| | Prohibited activity | | | | | | | | |
| | Activity permitted only to holders of a valid permit | | | | | | | | |
| | Activity regulated by the restriction of techniques | | | | | | | | |
| | Not applicable | | | | | | | | |
| **Fishing** | | | | | | | | | |
| Traditional fishing | | | | | | | | | |
| Artisanal fishing | | | | | | | | | |
| Industrial fishing | | | | | | | | | |
| Notes: within the restrictions of the MPA regulations detailed in Table 69 | | | | | | | | | |
| **Tourism** | | | | | | | | | |
| Diving and snorkelling[1,2] | | | | | | | | | |
| Line fishing | | | | | | | | | |
| Speargun fishing by tourists | | | | | | | | | |
| Collection of any fauna and flora by tourists | | | | | | | | | |
| Notes: 1. With the clear proviso that damaging corals or capture any marine life is illegal. 2. Anchorage of pirogues/ boats: use of metal anchors is banned unless more than 50m landward from reef edge, over sand substrate or in case of emergency | | | | | | | | | |
| Tourist camping | | | | | | | | | |
| Construction of tourism infrastructure | | | | | | | | | |
| Hotel Development | | | | | | | | | |

| | Legend | Marine village user zone | No-go zone (Nosy Mavony | NTZ (Nosy Manghily / Abohazo) | Marine NTZ | Tempoary fishing reserve | Villager user area isles | Tourism development zone | Local economic development zone |
|---|---|---|---|---|---|---|---|---|---|
| | Activity permitted with no restriction | | | | | | | | |
| | Prohibited activity | | | | | | | | |
| | Activity permitted only to holders of a valid permit | | | | | | | | |
| | Activity regulated by the restriction of techniques | | | | | | | | |
| | Not applicable | | | | | | | | |
| Notes: Hotel development and construction of tourism infrastructure is subject to following requirements: 1. it abides by national and local laws governing construction in protected areas; 2. it respects the ecological carrying capacity of the MPA, does not diminish the natural beauty of the landscape, and contributes to local development; 3. requires authorisation from the MPA management | | | | | | | | | |
| **Extractive** | | | | | | | | | |
| Commercial quarrying of coral, coral rubble, stone and sand | | | | | | | | | |
| Oil, gas, mineral exploration and exploitation | | | | | | | | | |
| Commercial exploitation of mangroves and coastal forest | | | | | | | | | |
| Commercial charcoal production | | | | | | | | | |
| Conversion of habitat for agriculture | | | | | | | | | |
| Collection and sale of birds eggs on the isles | | | | | | | | | |
| Hunting, consumption and sale of endangered or protected species[1] | | | | | | | | | |
| Notes: 1. Endangered species include (but not limited to): turtles, cetaceans, Humphead/Napoleon wrasse, lemurs, Madagascar Fish Eagle, Madagascar Heron | | | | | | | | | |
| **Research and Education** | | | | | | | | | |
| Non-manipulative research | | | | | | | | | |

| | Legend | Marine village user zone | No-go zone (Nosy Mavony | NTZ (Nosy Manghily / Abohazo) | Marine NTZ | Tempoary fishing reserve | Villager user area isles | Tourism development zone | Local economic development zone |
|---|---|---|---|---|---|---|---|---|---|
| | Activity permitted with no restriction | | | | | | | | |
| | Prohibited activity | | | | | | | | |
| | Activity permitted only to holders of a valid permit | | | | | | | | |
| | Activity regulated by the restriction of techniques | | | | | | | | |
| | Not applicable | | | | | | | | |
| Manipulative research (removal of species or samples) | | | | | | | | | |
| Education and awareness raising | | | | | | | | | |
| **Aquaculture** | | | | | | | | | |
| Small-scale aquaculture[1] | | | | | | | | | |
| Industrial aquaculture | | | | | | | | | |
| Notes: 1. requires the authorisation of the MPA management; includes small-scale seaweed, sea cucumber and fish, crab and shrimp aquaculture; does not permit significant conversion of habitats and the construction of large, permanent infrastructure (industrial aquaculture) | | | | | | | | | |
| **Construction, property development** | | | | | | | | | |
| Development of private or public property not in conflict with rules outlined below, purchase and sale of property | | | | | | | | | |
| Large-scale construction | | | | | | | | | |
| Small-scale construction by private landowners and local villagers | | | | | | | | | |
| Notes: Notes: Construction is subject to following requirements: 1. it abides by national and local laws governing construction in protected areas; 2. it respects the ecological carrying capacity of the MPA and does not diminish the natural beauty of the landscape, contributes to local development; 3. requires authorisation from the MPA management. 2. Construction on the isles is prohibited except that of wooden homes by traditional fishers | | | | | | | | | |

**Table 69. Fishing activities prohibited throughout the MPA**

| | |
|---|---|
| Beach seine nets and other net types and netting techniques that damages fragile benthic habitats (corals and seagrass) | |
| Small meshed nets (except for catching patsa and shrimp during a limited period defined by the MPA management) | |
| The use of any fishing gear that kills juvenile fish | |
| Hunting or harvest of protected marine species such as turtles and dolphins | |
| Any fishing or collection using compressed air (SCUBA or hookah). | |
| Bomb or explosive fishing | |
| Poison fishing (including *laro*) | |

Note: Although certain of this activities are not practiced in the region (such as using explosives for fishing), it is possible that they could be used in the future.

### *5.7.4.2 Future coastal management areas*

**Table 70. Proposed zoning and regulations within the future coastal management areas**

| | **Legend** | **Mangrove & wetland management area** | | **Coastal reserves** | **Terrestrial village user zone** |
|---|---|---|---|---|---|
| | Activity permitted without restrictions | | | | |
| | Prohibited activity | | | | |
| | Activity permitted only to holders of a valid permit | **Villager user area** | **Reserves** | | |
| | Activity regulated by the restriction of techniques | | | | |
| | Not applicable | | | | |
| **Access** | | | | | |
| Local traditional fishers and community | | | | | |
| Traditional migrant fishers | | | | | |
| Itinerant artisanal fishers | | | | | |
| Traditional fisher settlements and habitations | | | | | |
| Patrols and surveillance by MPA management | | | | | |
| Researchers | | | | | |
| Tourists and tourist guides | | | | | |

| | Legend | Mangrove & wetland management area | | Coastal reserves | Terrestrial village user zone |
|---|---|---|---|---|---|
| | Activity permitted without restrictions | | | | |
| | Prohibited activity | | | | |
| | Activity permitted only to holders of a valid permit | | | | |
| | Activity regulated by the restriction of techniques | | | | |
| | Not applicable | | | | |
| | | Villager user area | Reserves | | |
| Local cultural rights and traditional ceremonies | | | | | |
| Supporting partner organizations | | | | | |
| **Fishing** | | | | | |
| Traditional fishing | | | | | |
| Artisanal fishing | | | | | |
| Industrial fishing | | | | | |
| Notes: within the restrictions of the MPA regulations detailed in Table 69 | | | | | |
| **Tourism** | | | | | |
| Diving and snorkelling[1,2] | | | | | |
| Line fishing | | | | | |
| Speargun fishing by tourists | | | | | |
| Collection of any fauna and flora by tourists | | | | | |
| Notes: 1. With the clear proviso that damaging flora or capture any marine life is illegal. | | | | | |
| Tourist camping | | | | | |
| Construction of tourism infrastructure | | | | | |
| Hotel Development | | | | | |
| Notes: Hotel development and construction of tourism infrastructure is subject to following requirements: 1. it abides by national and local laws governing construction in protected areas; 2. it respects the ecological carrying capacity of the MPA, does not diminish the natural beauty of the landscape, and contributes to local development; 3. requires authorisation from the MPA management | | | | | |
| **Extractive** | | | | | |
| Commercial quarrying of coral rubble, stone and sand | | | | | |
| Oil, gas, mineral exploration and exploitation | | | | | |
| Commercial exploitation of mangroves and coastal forest | | | | | |
| Commercial charcoal production | | | | | |
| Conversion of habitat for agriculture | | | | | |

| | Legend | Mangrove & wetland management area | | Coastal reserves | Terrestrial village user zone |
|---|---|---|---|---|---|
| | Activity permitted without restrictions | | | | |
| | Prohibited activity | | | | |
| | Activity permitted only to holders of a valid permit | | | | |
| | Activity regulated by the restriction of techniques | Villager user area | Reserves | | |
| | Not applicable | | | | |
| Collection and sale of birds eggs on the isles | | | | | |
| Hunting, consumption and sale of endangered species[1] | | | | | |
| Notes: 1. Endangered species include (but not limited to): turtles, lemurs, Madagascar Fish Eagle, Madagascar Heron | | | | | |
| **Research** | | | | | |
| Non-manipulative research | | | | | |
| Manipulative research (removal of species or samples) | | | | | |
| Education and awareness raising | | | | | |
| **Aquaculture** | | | | | |
| Small-scale aquaculture[1] | | | | | |
| Industrial aquaculture | | | | | |
| Notes: 1. requires the authorisation of the MPA management; includes small-scale seaweed, sea cucumber, fish and shrimp aquaculture; does not permit significant conversion of habitats and the construction of large, permanent infrastructure | | | | | |
| **Construction, property development** | | | | | |
| Development of private or public property not in conflict with rules outlined below, purchase and sale of property | | | | | |
| Large-scale construction | | | | | |
| Small-scale construction by private landowners and local villagers | | | | | |
| Notes: Notes: Construction is subject to following requirements: 1. it abides by national and local laws governing construction in protected areas; 2. it respects the ecological carrying capacity of the MPA and does not diminish the natural beauty of the landscape, contributes to local development; 3. requires authorisation from the MPA management. 2. Construction on the isles is prohibited except that of wooden homes by traditional fishers | | | | | |

## 5.8 Recommended future research

The reefs and mangroves of the region are vast. It is also a sparsely populated region. The opportunity therefore exists to determine conservation priorities based on ecological needs rather than mainly according to stakeholder needs. The challenge is to identify which key areas need to be protected and what are the

threats to target species in the broader region. From this conservation promoters can work with local people to establish a mosaic of small but effective conservation areas that protect critical habitats within a broader landscape where common threats are mitigated. Research would involve:

- Remote sensing of shallow water marine and coastal habitats – broad-scale habitat mapping of the region would allow the efficient selection of priority sites for ecological surveying and conservation.
- Ecological surveying of selected coral reef, seagrass and mangrove sites that is guided by the broad-scale habitat mapping so that conservation areas can be selected for area specific, 'static' protection.
- Identification of habitat areas that provide key support to far-ranging species (e.g. key foraging areas for marine turtles) or key stages of life cycles (e.g. fish spawning aggregations or shark pupping grounds) so that critical sites are guaranteed protection and an efficient use of conservation resources is attained. Surveying to establish the presence of sawfish, the status of any populations and the location of important habitat areas supporting this species. The region has extensive, intact habitat that may support these endangered species.
- Marxan modelling that draws on the outputs of the above research to further support the location of key sites for conservation.
- Identification of activities that threaten conservation targets in the broader landscape in order to enact measures (beyond the defined protected areas) to mitigate these threats.

In addition, future research will have to help local people rationally manage their fisheries community and develop the local economy:

- Participative monitoring of the sea cucumber, shark, turtle and Spanish mackerel fisheries to provide the data needed for the sustainable management of these fisheries.
- Research and develop viable aquaculture techniques for local people.
- Establish the feasibility of mangrove REDD financing.

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# 8. Appendices

## Appendix 1. Survey methods

### Ecological surveying of coral reefs

The methodologies employed during this study were adapted from Manual and Field Guide for Monitoring Coral Reef Ecosystems, Fisheries, and Stakeholders - Wildlife Conservation Society (McClanahan 2008). The main adaptations to these standard reef survey methodologies were to allow for logistical and time constraints within the study period.

**Benthic Community Structure**

Corals are particularly sensitive to relatively small changes in environmental conditions such as water temperature, pH levels, and sedimentation. Stress often results in bleaching and associated mortality is commonly a major factor influencing changes to the benthic community structure of reefs (Brown *et al.* 2000; McClanahan 2000a; Ostrander *et al.* 2000; Obura 2001a; Goldberg and Wilkinson 2004). Studies have shown that coral species vary in their susceptibility to bleaching, due to the dynamic relationship between the coral and its symbiotic algae, as well as the ability of corals to exhibit acclimatisation and genetic adaptation to high levels of temperature or irradiance (Brown *et al.* 2000; Fitt *et al.* 2001; Obura 2001b).

Examination of the benthic community structure of a coral reef can provide insight into the ecological processes and pressures within the ecosystem. Healthy reef communities are often dominated by hard corals while declining reef health is commonly characterised by an ecological 'phase-shift' with increasing dominance of macro-algae. A number of studies have shown that anthropogenic factors such as fishing pressure and pollution greatly affect the ability of a reef to recover from natural disturbances and may even help to push a mid-equilibrium reef into decline (Levitan 1992; Roberts 1995; McClanahan *et al.* 1999; Grimsditch and Salm 2005; Mumby *et al.* 2007)

Benthic community surveys are therefore paramount to reef health assessments as they not only inform us of the diversity and structure of the reefs themselves but also act as a key indicator to the health of the reef ecosystem in general.

**Line Intercept transects**

The Line Intercept Transect (LIT) is a widely used method that allows researchers to measure accurate, quantitative percentage cover data for all benthic categories (English *et al.* 1997; McClanahan *et al.* 1999).

General procedure:

- One observer is responsible for reading the measurements for the entire transect and recording the data on a pre-prepared slate.
- At the survey depth, a 10 m measuring tape is secured at one end, under or around a rock or other suitable anchor, and then rolled out, loosely following the depth contour, leaving the second end free.

- The benthic or substrate groups lying directly under the transect line are recorded by noting the point along the tape at which the benthos or substrate changes.
- Readings start at one end, at the first marking.
- No measurements under 3 cm are taken and all measurements are taken to the nearest centimetre, along the contour, as close to the substratum as possible, even if the transect line does not directly follow the contour.
- Each coral colony is recorded separately but other categories can be summed as convenient.
- Once the observer reaches the end of the transect, marked by the last 'meter mark', they go back along it leaving the anchored end secured, pressing the transect line down close to the substratum, following the contour. When the surveyor reaches the end again, the point on the substratum where the end of the transect line reached is marked and the line is pulled taut. The difference in the lengths between the marked point and the extended taught lines is then recorded. Subtracting this value from 1000 (cm) gives the value for the contour, as a comparable value for rugosity.
- The transect is now complete and the observer rolls in the line to repeat the transect at another area.
- The transect is repeated six times for each survey site at haphazardly-chosen non-overlapping points. Care must be taken to avoid bias between transects by avoiding carrying transects out in one area or laying survey lines through large areas of non-reef habitat, for example seagrass beds or lagoonal floor.
- Results are recorded in centimetres under the following categories: coral (genus level); algae (genus level); soft coral; sponge; sand; algal turf; contour

**Reef fish community structure**

In addition to being the major coral reef resource used by local communities, coral reef fish play an important ecological role in coral reef ecosystems. The role of herbivores is particularly well documented in being a key factor influencing the health of coral reefs (Hixon and Brostoff 1996; Carreiro-Silva and McClanahan 2001; Mumby *et al.* 2007). Reef fish communities are vulnerable to natural disturbances and anthropogenic activities, particularly those that impact on the physical structure of the reef (Graham *et al.* 2007).

Coral reef fish are commercially important, particularly in resource-poor coastal regions with low agricultural productivity such as southwest Madagascar, where local artisanal fisheries are the primary income-generating activity (Watson and Ormond 1994; Laroche and Ramananarivo 1995; Walters and Samways 2001; Woods-Ballard *et al.* 2003).

With changes in fish community structure acting as indicators of reef health it is vitally important to assess fish diversity and abundance as well as determining stock biomass of commercially important species, so that appropriate conservation and management strategies can be implemented and their effects monitored over time.

**Fish Underwater Visual Census (UVC)**

Underwater Visual Census (UVC) is a widely used surveying technique for the assessment of reef fish communities. This study employs two UVC methods:

**Discrete Group Sampling**

General Procedure:

- A 50 m line is laid out along the coral reef benthos at the appropriate depth 5 minutes prior to sampling.
- One observer then swims along the line, at a constant distance of 2.5 m, carrying a slate with length markings. The observer swims at a steady pace, counting and recording fish seen 2.5 m either side of the line, covering an area of 250 m2.
- The transect is passed 4 times, with fish identified to species level with 1-3 fish families sampled with each pass of the line transect. There were two fish transects completed at each site.
- The observer adjusts the swimming rate slightly (10-30 min per transect), to account for the varying fish densities in different sites; sites with high fish densities are sampled more slowly than those with low densities.
- Other observers ensure they remain well out of the way to avoid scaring fish.
- The fish counts are preferably conducted during neap high tides as the lower movement of the water means it is less likely for the fish to hide. This was not always possible during this study due to time constraints.
- While reef fish diversity is adequately assessed using this method, it does not provide a full biodiversity assessment of the reef, as the observations are limited to only those fish species that are observed during the transects.

**Abundance and Biomass Assessment**

General Procedure:

- A 50 m line is laid out along the coral reef benthos at the appropriate depth 5 minutes prior to sampling.
- One observer then swims along at a steady pace, perpendicular to and at a constant distance of 2.5 m from this line, carrying a slate with length markings, counting and recording fish seen 2.5 m either side of the transect line covering an area of 250 m2.
- Fish are placed in size categories: 3-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80 and >80 cm, and into their families. Fish smaller than 3 cm are omitted to standardize density comparisons.
- The observer adjusts the swimming rate slightly (10-30 min per transect), to account for the varying fish densities in different sites; sites with high fish densities are sampled more slowly than those with low densities.
- The buddy pairs ensure that they remain well out of the way to avoid scaring the fish.

**Data Analysis**

Mean percentage cover of broad benthic categories was calculated as standard, with between sample variability measured as a standard error (SE) value. The percentage contribution of each coral and alga genus were also calculated in order to allow increased knowledge of community composition and floral and faunal diversity.

Diversity for all categories (fish, benthos and macro-invertebrates) was calculated using Simpson's Diversity Index (SDI).

Simpson's Diversity Index $(1- \lambda) = 1- (\Sigma pi^2)$

Where pi = the proportion of the total count arising from the $i^{th}$ species (Magurran 1988).

This index down-weights the relative importance of abundant categories, expressing diversity not only as a measure of species richness but also how evenly individuals are distributed among the different species.

Simpson's index is often referred to as an equitability index such that an increasing SDI value corresponds with increasing diversity, while inequitability through dominance of a few or a single species lowers the SDI value.

Species richness was calculated as the total number of species observed on each site.

Reef fish biomass ($kgha^{-1}$) was calculated using representative length-weight conversions, used by McClanahan and Kaunda-Arara (1996) to convert size-frequency data into biomass data, using the mid point of each size class to calculate biomass. The mean biomass for each site was calculated with the standard error representative of the variability between samples.

Biomass data were analysed at the family level to assess contributions ($kgha^{-1}$) by each family group. Fish families were also assigned into 8 trophic categories; herbivores, omnivores, corallivores (Chaetodontidae), diurnal carnivores, nocturnal carnivores, piscivores, diurnal planktivores and nocturnal planktivores (Harmelin-Vivien 1979; Gillibrand and Harris 2007). Groups were subsequently reassigned with all groups other than herbivores, omnivores and corallivores, being regrouped as carnivores (Chabanet and Durville 2005), and the mean wet weight calculated for each trophic guild.

**Table 71. Summary of surveys performed**

| Method | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| 20 minute fish diversity | x | x | | x | x |
| 100m coral genera | x | x | x | x | x |
| Fish biomass | x | x | x | x | x |
| Line Intercept Transects | x | x | x | | x |

### Overall reef condition

A rapid assessment of the overall reef condition was made using an approach adopted from McKenna (2003).

The reef surveying team made qualitative assessments of the stresses that have been documented to cause reef degradation in Madagascar and recorded any visible signs of damage, threats, or disturbance at each reef site. Evidence of disturbance, damage, or threat was rated according to the relative amount or level of impact/frequency (none, light, moderate, and excessive). The divers looked for evidence of damage from:

- Fishing (nets, anchor damage),
- Storms or cyclones.

- Coral predators *Acanthaster plancii* and the coral eating mollusc *Drupella cornus,* detected by the presence and number of individuals seen or by feeding scars on the coral.
- Bleaching, indicated by the degree of discoloration of coral tissue colour:
    - Light (or early stages of) bleaching is indicated by a slight discoloration of the coral tissue.
    - Moderate or extreme bleaching is usually indicated by the coral tissue being transparent, opaque, or clear in colour with the coral skeleton visible. The number of colonies showing signs of bleaching and the level of tissue discoloration indicates the extent of the bleaching on the reef.
- Coral pathogens or diseases on the reef were noted. Diseases are identifiable by a distinctive banding or pattern of discoloration on the surface of hard and soft coral. For example, black band disease on hard corals is evident by an obvious black band across the coral head — behind the band the coral skeleton is visible and the coral tissue is dead and gone. On the other side of the band the coral surface looks normal.

Other forms of threat or pressure on the reef cannot be diagnosed equivocally without testing, monitoring, or experimentation. Such types of threat or pressure include pollution/eutrophication, fishing pressure, siltation, and freshwater runoff. In some cases the source of the damage (e.g., sewage outfall pipe, deforested area along the shoreline, coastal development, and river outfall) can be seen from the reef site, thereby providing qualitative evidence. An abundance of algae with low coral cover can be an anecdotal indicator of pollution/eutrophication on reefs. However, the population of herbivores and type of algae need to be considered. The presence of fishers actively fishing or a low abundance of target biota (e.g., sea cucumbers or groupers) on the reef site may indicate fishing pressure, but the frequency and extent of marine resource use and abundance of stocks need to be further investigated and monitored to obtain quantitative data to provide empirical evidence. High percentage cover of mud or silt on the reef benthos indicates siltation stress. These types of threats or disturbance are better characterized by direct measurements of specific parameters (e.g., nutrients in the water column, stock abundance and fisher activity, sediments, and percentage cover of biota/substrata) over a long sampling period of at least one year or more. The nature of the rapid assessment only allows for observation of what may under further investigation prove to be eutrophication/pollution, fishing pressure, siltation, or runoff on the reef site and provides an important first step in determining reef health and the need for follow up.

**Survey sites**

All surveys were carried between the 11th to the 14th November 2009.

Site selection – sites with potential for significant coral growth were selected from an examination of reef geomorphology and from the participative mapping exercises carried out with fishermen. A variety of reef types were surveyed in an effort to gain a representation of the different reef types present. Ten days before the surveying a WCS team had dived a number of reefs around the southern isles – we chose different sites more to the north so as to compliment this effort rather than repeat it.

**Table 72. Summary of the site surveyed**

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| GPS Location (dd.dddd) | S18.30006 E43.62964 | S18.22961 E43.78211 | S18.32463 E43.75006 | S18.33601 E43.72815 | S18.21623 E43.81341 |
| Reef type | Outer barrier | Patch | Fringing | Outer fringing | Fringing |
| Depth at top (m) | 9 | 8 | 6 | 2.5 | 7 |
| Depth at base (m) | 18 | 20 | 21 | 8 | 18 |
| Direction of slope | West | South West | South West | West | South |
| Sea Temperature (˚C) | 27 | 27 | 27 | 27 | 27 |
| Site Description | Outer Barrier reef site characterised by large ridges with boulder channels filled with sand. Little coral diversity and few large colonies. However the topographic complexity gives suitable niches for larger fish to seek shelter. Some current running east to west. | Patch reef site north of Nosy Manandra, diverse coral with the top of the reef dominated by patches of *Lobophyllia* and *Galaxea* while the outer slope of the reef is more diverse. Coral colonies range in size but there appears to be little damage to the reef at present. Fish populations are also diverse with some larger bodied carnivorous species, although it appears that acanthurids and scarids are probably dominant. | Fringing reef south of Nosimboro. The coral here is sparse on the very top of the reef; however, at about 8 - 9 m the cover increases dramatically with large colonies of different species on the slope down to sand at 20m. There appears to be a large diversity of fish although again herbivores such as acanthurids and scarids appear to be dominant. | Outer fringing reef west of Nosimboro. This site is characterised by shallow sand channels between larger stretches of flat reef possibly 10 to 15m across each stretch. These reef tops are dominated by turf algae, crustose coralline algae and small colonies of branching corals such as *Acropora*, *Pocillopora* and *Stylophora*. Fish populations are dominated here by herbivores such as acanthurids, pomacentrids and scarids, while in the channels where topographic complexity allows, there are larger bodied carnivorous species such as serranids and lutjanids. | Fringing reef site south east of Nosy Manandra. The reef top at 7 m is dominated by large sections of red *Galaxea* and others of *Lobophyllia*. This dominance is interrupted by more diverse coral cover as the reef slopes away at around 10 m. There is little sign of physical damage or bleaching. Fish populations are again diverse although dominated by herbivorous species such as acanthurids and scarids. Larger bodied carnivorous species are found on the outer slope of the reef where coral cover and topography is more varied. |

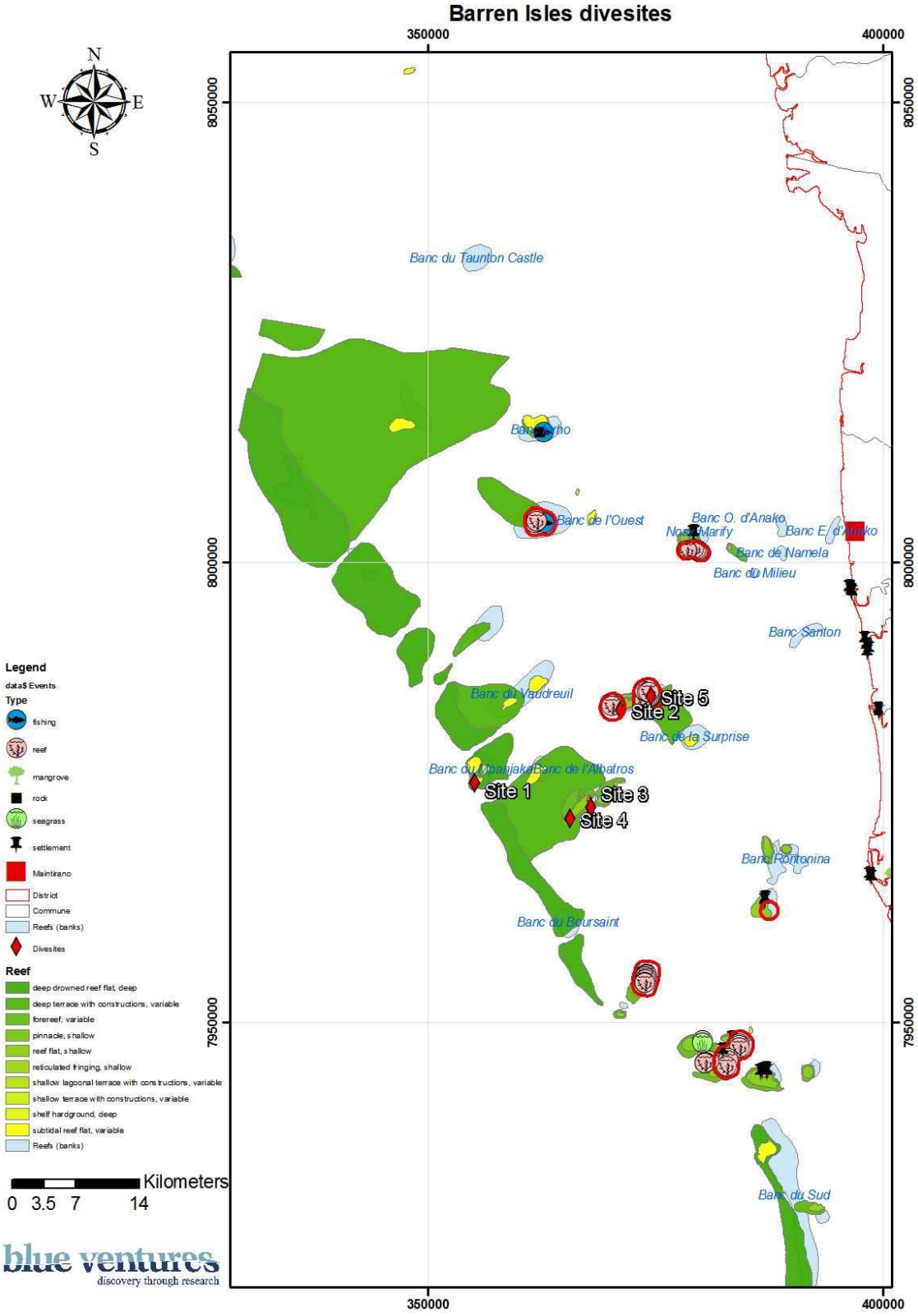


**Figure 44. Coral reef sites surveyed**

## Appendix 2. Ecological surveying data

**Scleractinian coral genera recorded at five sites in the Barren Isles**

Site recordings of scleractinian coral genera recorded during one 100 m transect at each of five sites in the Barren Isles (listed alphabetically first by family, then by genus).

| Family | Genus | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|---|
| Acroporidae | *Acropora* | x | x | x | x | x |
| Agariciidae | *Gardineroseris* | | x | x | | x |
| | *Leptoseris* | | x | | | |
| | *Pachyseris* | | | x | | |
| | *Pavona* | x | x | x | x | x |
| Astrocoeniidae | *Astreopora* | | | | | x |
| | *Montipora* | x | x | x | x | x |
| Dendrophylliidae | *Tubastrea* | | | | | |
| | *Turbinaria* | | | | | x |
| Euphilliidae | *Physogyra* | | | | | |
| | *Plerogyra* | | | x | | |
| Faviidae | *Diploastrea* | | | x | | x |
| | *Favia* | x | x | x | x | x |
| | *Favites* | x | x | | x | x |
| | *Goniastrea* | | x | x | x | x |
| | *Hydnophora* | | x | x | | x |
| | *Leptoria* | | | x | | x |
| | *Oulophyllia* | | x | x | | x |
| | *Platygyra* | x | x | x | x | x |
| Fungiidae | *Cycoloseris* | | | | | |
| | *Fungia* | | x | x | | x |
| | *Herpolitha* | | x | x | | x |
| Merulinidae | *Merulina* | | | | | x |
| Montastreinae | *Cyphastrea* | | x | x | | x |
| | *Echinpora* | x | x | x | x | x |
| | *Leptastrea* | x | x | x | | x |
| | *Montastrea* | x | | x | | x |
| | *Plesiastrea* | x | x | x | | x |
| Mussidae | *Aacanthastrea* | | x | x | | |
| | *Blastomussa* | | | x | | |
| | *Lobophyllia* | | x | x | | x |
| Oculinidae | *Galaxea Green* | x | x | x | x | x |
| Pectiniidae | *Echinophyllia* | | x | x | | x |
| | *Mycedium* | | | x | | |
| | *Oxypora* | | x | x | | |
| Pocilloporidae | *Pocillopora* | x | x | x | x | x |
| | *Seriatopora* | | | | | |
| | *Stylophora* | x | x | x | x | x |
| Poritidae | *Alveopora* | | | | | |
| | *Goniopora* | | | | | x |
| | *Porites branching* | | x | x | | x |
| | *Porites massive* | x | x | x | x | x |
| Psammocoridae | *Psammocora* | x | | x | | x |
| Siderastreidae | *Coscinarea* | | x | x | x | x |
| ***16*** | ***38*** | ***15*** | ***26*** | ***32*** | ***13*** | ***31*** |

**Fish species recorded at five sites in the Barren Isles**

List of fish species recorded at five sites in the Barren Isles during one, 20 minute dive at each site (with the exception of Site 3, where the fish listed here are those observed during 2 fish biomass measurement transects; no 20 minute dive was done). (Species are listed alphabetically first by family, then by genus.)

| Family | Scientific name | Common name | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|---|---|
| Acanthuridae | *Naso vlamingi* | Bignose unicornfish | x | x | x | | |
| Acanthuridae | *Acanthurus nigricauda* | Blackstreak surgeonfish | | | x | | |
| Acanthuridae | *Naso unicornis* | Bluespine unicornfish | x | | x | | |
| Acanthuridae | *Zebrazoma scopas* | Brushtail tang | x | x | x | | x |
| Acanthuridae | *Acanthurus triostegus* | Convict surgeonfish | | | | x | x |
| Acanthuridae | *Zebrazoma desjardinii* | Desjardin's sailfin tang | x | | | | |
| Acanthuridae | *Acanthurus nigrofuscus* | Dusky surgeonfish | x | | x | x | |
| Acanthuridae | *Acanthurus mata* | Elongate surgeonfish | | x | | | |
| Acanthuridae | *Acanthurus dussumieri* | Eyestripe surgeonfish | x | x | x | x | x |
| Acanthuridae | *Ctenochaetus strigosus* | Goldring bristletooth | x | | | | |
| Acanthuridae | *Naso brachycentron* | Humpback unicornfish | | | | x | |
| Acanthuridae | *Acanthurus tennenti* | Lieutenant surgeonfish | x | | x | | |
| Acanthuridae | *Naso lituratus* | Orangespine unicornfish | x | | | x | |
| Acanthuridae | *Acanthurus leucosternon* | Powder-blue surgeonfish | x | | | x | |
| Acanthuridae | *Naso brevirostris* | Spotted unicornfish | | x | | x | |
| Acanthuridae | *Ctenochaetus striatus* | Striped bristletooth | x | x | x | x | x |
| Acanthuridae | *Acanthurus lineatus* | Striped surgeonfish | x | | | x | |
| Acanthuridae | *Acanthurus thompsoni* | Thompson's surgeonfish | x | x | | | |
| Acanthuridae | *Ctenochaetus binotatus* | Twospot bristletooth | x | x | | | |
| Acanthuridae | *Naso annulatus* | Whitemaergin unicornfish | | x | | x | |
| Balistidae | *Balistoides conspicillum* | Clown triggerfish | x | | | x | |
| Balistidae | *Sufflamen chrysopterus* | Halfmoon triggerfish | x | | x | | |
| Balistidae | *Balistoides viridescens* | Moustache triggerfish | x | | | x | |
| Balistidae | *Balistapus undulatus* | Orangestriped trigerfish | x | x | x | | x |
| Balistidae | *Odonus niger* | Redtooth triggerfish | x | | | | |
| Balistidae | *Rhinecanthus rectangulus* | Wedge Picassofish | | | | x | |
| Blennidae | *Plagiotremus tapeinosoma* | Scale eating piano blenny | | | | | x |
| Caesionidae | *Pterocaesio tile* | Bluestreak fusilier | x | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Caesionidae | *Pterocaesio chrysozona* | Goldband fusilier | | | x | | |
| Caesionidae | *Caesio lunaris* | Lunar fusilier | | x | x | | x |
| Caesionidae | *Caesio caerulaurea* | Scissor-tailed fusilier | | x | x | | x |
| Eleotridae | *Pterocaesio capricornis* | Southern Fusilier | | | | | x |
| Caesionidae | *Caesio xanthonota* | Yellowtop fusilier | x | x | x | | x |
| Carangidae | *Caranx melampygus* | Bluefin travelly | x | x | | | x |
| Syngnathidae | *Triaenodon obesus* | Reef whitelip shark | x | | | | |
| Chaetodontidae | *Chaetodon trifascialis* | Chevronned butterflyfish | | | x | x | |
| Chaetodontidae | *Chaetodon kleinii* | Klein's butterflyfish | x | x | x | | x |
| Chaetodontidae | *Heniochus acuminatus* | Long-finned bannerfish | x | x | | | x |
| Chaetodontidae | *Forcipiger flavissimus* | Longnosed butterflyfish | | | x | | |
| Chaetodontidae | *Heniochus monoceros* | Masked bannerfish | x | | | | |
| Chaetodontidae | *Chaetodon meyeri* | Meyer's butterflyfish | | | | x | |
| Chaetodontidae | *Chaetodon lunula* | Racoon butterfly fish | | x | x | x | |
| Chaetodontidae | *Chaetodon trifasciatus* | Redfin butterflyfish | | | x | x | x |
| Chaetodontidae | *Chaetodon guttatissimus* | Spotted butterflyfish | x | x | x | | x |
| Chaetodontidae | *Chaetodon unimaculatus* | Teardrop butterflyfish | | | | x | |
| Chaetodontidae | *Chaetodon auriga* | Threadfin butterflyfish | x | x | x | x | x |
| Chaetodontidae | *Chaetodon xanthocephalus* | Yellowhead butterflyfish | x | | | | |
| Cirrhitidae | *Paracirrhites forsteri* | Freckled hawkfish | x | | | x | |
| Scorpaenidae | *Taeniura lymna* | Blue spotted ribbontail | | | x | | |
| Eleotridae | *Ptereleotris pavides* | Blackfin dartfish | x | | x | | |
| Fistularidae | *Fistularia commersoni* | Cornetfish | x | | | | |
| Haemulidae | *Plectorhinchus schotaf* | Somber sweetlips | | | x | | |
| Haemulidae | *Plectorhinchus flavomaculatus* | Gold-spotted sweetlips | | | x | | |
| Haemulidae | *Plectorhinchus orientalis* | Oriental sweetlips | x | x | | | |
| Clupeidae | *Sargocentro spiniferum* | Long-jawed squirrelfish | | | | | x |
| Holocentridae | *Myripristis kuntee* | Pearly soldier fish | x | | | | |
| Holocentridae | *Myripristis murdjan* | Red soldierfish | x | | | | |
| Holocentridae | *Sargocentron caudimaculatum* | Talispot squirelfish | x | | | x | x |
| Kyphosidae | *Kyphosus vaigiensis* | Lowfin rudderfish | x | | | | x |
| Labridae | *Bodianus axillaris* | Axilspot hogfish | x | x | x | | x |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Labridae | *Oxycheilinus digrammus* | Bandcheek wrasse | x | | x | | x |
| Tripterygiidae | *Hemigymnus fasciatum* | Barred thicklip wrasse | x | x | x | x | x |
| Labridae | *Labroides bicolor* | Bicolor cleaner wrasse | | | | | x |
| Labridae | *Gomphosus varius* | Bird wrasse | x | x | x | x | x |
| Labridae | *Hemigymnus melapterus* | Blackedge thicklip wrasse | x | | | | |
| Labridae | *Anampses caeruleopunctatus* | Blue spotted wrasse | | | x | | |
| Labridae | *Labroides dimidiatus* | Bluestreak cleaner wrasse | x | x | x | x | |
| Labridae | *Halichoeres hortulanus* | Checkerboard wrasse | x | x | x | x | x |
| Labridae | *Coris aygula* | Clown coris | | x | x | x | x |
| Labridae | *Thalassoma lunare* | Crescent wrasse | | x | x | | x |
| Labridae | *Bodianus diana* | Diana's hogfish | x | x | | | |
| Labridae | *Thalassoma hebraicum* | Goldbar wrasse | x | | x | x | |
| Labridae | *Cheilinus undulatus* | Napoleon fish | x | | | | |
| Labridae | *Cheilinus fasciatus* | Red-banded wrasse | | x | | | |
| Labridae | *Stethojulis bandanensis* | Red-shoulder wrasse | | | | x | |
| Labridae | *Thalassoma hardwicke* | Sixbar wrasse | | x | x | x | x |
| Labridae | *Epibulus insidiator* | Slingjaw wrasse | | | | | x |
| Labridae | *Thalassoma purpureum* | Surge wrasse | | | | x | |
| Labridae | *Cheilinus trilobatus* | Tripletail wrasse | | x | x | x | |
| Labridae | *Labrichthys unilineatus* | Tube-lip wrasse | | | | | x |
| Labridae | *Anampses meleagrides* | Yellow tail wrasse | x | | | | |
| Labridae | *Anampses twistii* | Yellowbreasted wrasse | x | x | x | | x |
| Lethrinidae | *Monotaxis grandoculis* | Big-eye emperor | | | | | x |
| Lutjanidae | *Lutjanus lutjanus* | Bigeye snapper | | x | | | |
| Lutjanidae | *Macolor niger* | Black snapper | | x | x | x | |
| Lutjanidae | *Lutjanus kasmira* | Blue-lined snapper | | x | | | |
| Lutjanidae | *Aprion virescens* | Green jobfish | x | | | | |
| Lutjanidae | *Lutjanus monostigma* | Onespot snapper | x | x | | x | x |
| Lutjanidae | *Lutjanus gibbus* | Paddletail snapper | | | x | | |
| Lutjanidae | *Lutjanus fulviflamma* | Quakerfish | | x | x | | x |
| Lutjanidae | *Lutjanus maxweberi* | Pygmy Snapper | x | | | | |
| Lutjanidae | *Lutjanus bohar* | Twinspot snapper | x | x | x | x | x |
| Monacanthidae | *Amanses scopas* | Broomfilefish | x | | | | |
| Monacanthidae | *Cantherines pardalis* | Wire-net filefish | | | x | x | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mullidae | *Parupeneus barberinus* | Dash-dot goatfish | x | x | x | | x |
| Mullidae | *Parupeneus indicus* | Indian goatfish | | x | | | x |
| Mullidae | *Parupeneus rubescens* | Rosy goatfish | x | | x | x | |
| Mullidae | *Parupeneus bifasciatus* | Two-barred goatfish | x | | | x | |
| Mullidae | *Parupeneus cyclostomus* | Yellowsaddle goatfish | x | | | | |
| Ostraciidae | *Ostracion meleagris* | Spotted trunkfish | x | | | | |
| Ostraciidae | *Ostracion cubicus* | Yellow boxfish | x | | | | |
| Pempheridae | *Pempheris oualensis* | Copper sweeper | | | | | x |
| Pomacanthidae | *Pomacanthus imperator* | Emperor angelfish | x | | x | | x |
| Pomacanthidae | *Centropyge multispinis* | Manyspined angelfish | x | x | x | | x |
| Pomacanthidae | *Pygoplites diacanthus* | Regal angelfish | x | x | x | | x |
| Pomacanthidae | *Pomacanthus semicirculatus* | Semicircular angelfish | x | x | x | x | x |
| Pomacanthidae | *Apolemichthys trimaculatus* | Three-spot angelfish | x | | | | |
| Pomacentridae | *Pomacentrus baenschi* | Baensch's damsel | x | x | x | x | x |
| Pomacentridae | *Neoglyphidodon melas* | Black damsel | | x | x | x | x |
| Pomacentridae | *Plectroglyphidodon dickii* | Dick's damsel | x | | | x | x |
| Pomacentridae | *Abudefduf sparoides* | False-eye sergeant | x | x | x | | x |
| Pomacentridae | *Dascyllus aruanus* | Humbug dascyllus | | x | | | |
| Pomacentridae | *Dascyallus carneus* | Indian dascyllus | | x | | | x |
| Pomacentridae | *Abudefduf saxalitis* | Indo-Pacific sergeant | | | | x | |
| Pomacentridae | *Plectroglyphidodon lacrymatus* | Jewel damsel | | x | x | x | x |
| Pomacentridae | *Amphiprion latifasciatus* | Madagascar anemonefish | | | | | x |
| Pomacentridae | *Stegastes fasciolatus* | Pacific gregory | | | | x | |
| Pomacentridae | *Plectroglyphidodon phoenixensis* | Phoenix Damsel | | | | x | |
| Pomacentridae | *Amphiprion akallopisos* | Skunk anemonefish | | | | | x |
| Pomacentridae | *Pomacentrus sulfureus* | Sulphur damsel | | | | | x |
| Pomacentridae | *Chromis ternatensis* | Ternate chromis | x | x | x | | x |
| Pomacentridae | *Dascyllus trimaculatus* | Three-spot dascyllus | | | | | x |
| Pomacentridae | *Chromis dimidiata* | Two-tone chromis | x | x | | x | x |
| Pomacentridae | *Chromis weberi* | Weber's chromis | x | x | x | x | x |
| Pomacentridae | *Neopomacentrus azysron* | Yellowtail demoiselle | x | x | | x | x |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pomacentridae | *Ambloyglyphidodon indicus* | Pale Damsel | | x | | | x |
| Pomacentridae | *Pomacentrus auriventris* | Goldbelly Damsel | | x | x | x | |
| Pomacentridae | *Priacanthus hamrur* | Goggle-eye | x | x | | | |
| Scaridae | *Cetoscarus bicolor* | Bicolor parrotfish | x | | | | x |
| Scaridae | *Scarus atrilunula* | Black crescent parrotfish | | | | x | |
| Scaridae | *Scarus sordidus* | Bullethead parrotfish | x | x | x | x | x |
| Scaridae | *Scarus rubroviolaceus* | Redlip parrotfish | x | x | | x | |
| Scaridae | *Scarus strongylocephalus* | Indian Ocean steephead parrotfish | x | | | x | |
| Scaridae | *Scarus niger* | Swarthy parrotfish | | | x | x | |
| Scombridae | *Gymnosarda unicolor* | Dogtooth tuna | | x | | | |
| Serranidae | *Epinephelus melanostigma* | Blackspot grouper | x | | | | |
| Serranidae | *Variola louti* | Lyretail grouper | x | | | | |
| Serranidae | *Plectropomus punctatus* | Marbled coralgrouper | | | x | | |
| Serranidae | *Epinephelus polyphekadion* | Marbled grouper | | | x | | |
| Serranidae | *Cephalopholis argus* | Peacock grouper | x | x | | x | x |
| Serranidae | *Aethaloperca rogaa* | Redmouth grouper | | | x | | |
| Serranidae | *Plectropomus laevis* | Saddleback grouper | x | | | | |
| Serranidae | *Anyperodon leucogrammicus* | Slender grouper | | x | | | |
| Serranidae | *Variola albimarginata* | White-edged lyretail | x | | | | |
| Serranidae | *Epinephelus flavocaeruleus* | Blue and Yellow Grouper | x | | | | x |
| Siganidae | *Siganus argenteus* | Forktail rabbitfish | | x | | x | x |
| Tetraodontidae | *Canthigaster valentini* | Black-saddled toby | x | x | x | | x |
| Tetraodontidae | *Canthigaster solandri* | Spotted toby | | | x | | x |
| Zanclidae | *Zanclus cornutus* | Moorish idol | x | | x | x | |
| Serranidae | *Pseudanthias sp* | Anthias | x | x | | | |
| **33** | ***150*** | | **86** | **64** | **64** | **57** | **64** |

**Reef fish biomass by family**

| | **Site 1** | | **Site 2** | | **Site 3** | |
|---|---|---|---|---|---|---|
| Family | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| Acanthuridae | 315.40 | 47.87 | 167.34 | 48.67 | 99.24 | 11.57 |
| Aulostomidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Balistidae | 23.91 | 21.55 | 0.75 | 0.21 | 1.43 | 0.48 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Carangidae | 0.00 | 0.00 | 29.75 | 29.75 | 0.00 | 0.00 |
| Chaetodontidae | 1.10 | 0.94 | 1.06 | 0.59 | 0.52 | 0.04 |
| Diodontidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fistularidae | 0.61 | 0.61 | 0.00 | 0.00 | 0.00 | 0.00 |
| Haemulidae | 0.00 | 0.00 | 12.46 | 12.46 | 0.00 | 0.00 |
| Holocentridae | 5.25 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| Labridae | 6.11 | 0.29 | 26.26 | 3.96 | 36.74 | 2.16 |
| Lethrinidae | 0.00 | 0.00 | 0.00 | 0.00 | 35.86 | 23.34 |
| Lutjanidae | 113.15 | 101.29 | 63.60 | 42.61 | 76.71 | 6.83 |
| Mullidae | 0.32 | 0.23 | 2.40 | 1.30 | 1.30 | 1.30 |
| Muraenidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pempheridae | 0.00 | 0.00 | 0.08 | 0.08 | 0.00 | 0.00 |
| Penguipedidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pomacanthidae | 1.59 | 0.00 | 2.89 | 1.30 | 0.00 | 0.00 |
| Pomacentridae | 2.59 | 1.34 | 8.14 | 0.86 | 2.06 | 0.24 |
| Scaridae | 21.23 | 2.04 | 102.95 | 6.27 | 60.80 | 40.82 |
| Scorpaenidae | 60.69 | 60.69 | 0.00 | 0.00 | 0.00 | 0.00 |
| Serranidae | 15.58 | 15.58 | 26.06 | 16.05 | 21.15 | 0.00 |
| Siganidae | 0.00 | 0.00 | 8.10 | 8.10 | 14.17 | 10.12 |
| Sphyraenidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Others | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | **Site 4** | | **Site 5** | | **Average for all sites** | |
|---|---|---|---|---|---|---|
| Family | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error | Biomass (kg/ha) | Std. error |
| Acanthuridae | 121.54 | 37.23 | 118.32 | 2.55 | 164.37 | 39.38 |
| Aulostomidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Balistidae | 1.09 | 0.91 | 0.18 | 0.00 | 5.47 | 4.61 |
| Carangidae | 2.12 | 2.12 | 0.00 | 0.00 | 6.37 | 5.86 |
| Chaetodontidae | 1.18 | 0.55 | 0.44 | 0.28 | 0.86 | 0.16 |
| Diodontidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fistularidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.12 |
| Haemulidae | 0.00 | 0.00 | 0.00 | 0.00 | 2.49 | 2.49 |
| Holocentridae | 0.00 | 0.00 | 4.17 | 0.00 | 1.88 | 1.17 |
| Labridae | 32.53 | 0.00 | 9.06 | 3.02 | 22.14 | 6.19 |
| Lethrinidae | 0.00 | 0.00 | 51.05 | 0.00 | 17.38 | 10.91 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lutjanidae | 0.00 | 0.00 | 67.56 | 40.38 | 64.20 | 18.28 |
| Mullidae | 0.55 | 0.00 | 0.00 | 0.00 | 0.91 | 0.43 |
| Muraenidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pempheridae | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 |
| Penguipedidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pomacanthidae | 0.79 | 0.79 | 0.87 | 0.87 | 1.23 | 0.49 |
| Pomacentridae | 4.79 | 0.29 | 4.36 | 1.48 | 4.39 | 1.07 |
| Scaridae | 132.19 | 75.49 | 58.58 | 39.20 | 75.15 | 19.25 |
| Scorpaenidae | 0.00 | 0.00 | 0.00 | 0.00 | 12.14 | 12.14 |
| Serranidae | 32.00 | 32.00 | 17.82 | 7.81 | 22.52 | 2.95 |
| Siganidae | 14.17 | 14.17 | 0.00 | 0.00 | 7.29 | 3.18 |
| Sphyraenidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Others | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## Appendix 3. Details of conservation planning

The definitions presented here come from the Miradi software *(*www.miradi.org).

**Direct threat** - A proximate agent or factor that directly degrades one or more conservation targets.

**Contributing factor** (Indirect threats and Opportunities) - A human-induced action or event that underlies or leads to one or more direct threats.

**Explanation of threat ratings**

**Scope (Threat Ratings)** - A threat rating criterion that is most commonly defined spatially as the proportion of the target that can reasonably be expected to be affected by the threat within ten years given the continuation of current circumstances and trends. For ecosystems and ecological communities, scope is measured as the proportion of the target's area of distribution. For species, it is measured as the proportion of the target's population.

> **Very High:** The threat is likely to be pervasive in its scope, affecting the target across all or most (71-100%) of its occurrence/population.
>
> **High:** The threat is likely to be widespread in its scope, affecting the target across much (31-70%) of its occurrence/population.
>
> **Medium:** The threat is likely to be restricted in its scope, affecting the target across some (11-30%) of its occurrence/population.
>
> **Low:** The threat is likely to be very narrow in its scope, affecting the target across a small proportion (1-10%) of its occurrence/population.

Explanation of Key Terms: The target refers to the focal conservation target at the scale being assessed - in technical terms, the target occurrence within the defined project area (e.g., small site, landscape, or even global scale). Affected means subject to one or more stresses from the threat. The ten-year time frame can be extended for some longer-term threats like global warming that need to be addressed today. Current circumstances and trends include both existing as well as potential new threats. Occurrence for ecosystems is typically by area. Species includes both single species targets as well as multiple species guilds. If a species is evenly distributed, then the proportion of the target's population is the same as the proportion of the area occupied, but if it is patchily distributed, then it is not. In these cases, it is important to specify the unit of assessment for the target (e.g., breeding pairs vs. nests vs. individuals).

For both ecosystems and species, the proportion is estimated as the percentage of the target's occurrence at the scale being assessed (e.g. a water pollution threat affecting an aquatic ecosystem target is measured as the percentage of that aquatic ecosystem target affected, not the percentage of the area of the entire site).

**Severity** - Within the scope, the level of damage to the target from the threat that can reasonably be expected given the continuation of current circumstances and trends. For ecosystems and ecological communities, it is

typically measured as the degree of destruction or degradation of the target within the scope. For species, it is usually measured as the degree of reduction of the target population within the scope.

> **Very High:** Within the scope, the threat is likely to destroy or eliminate the target, or reduce its population by 71-100% within ten years or three generations.
>
> **High:** Within the scope, the threat is likely to seriously degrade/reduce the target or reduce its population by 31-70% within ten years or three generations.
>
> **Medium:** Within the scope, the threat is likely to moderately degrade/reduce the target or reduce its population by 11-30% within ten years or three generations.
>
> **Low:** Within the scope, the threat is likely to only slightly degrade/reduce the target or reduce its population by 1-10% within ten years or three generations.

Explanation of Key Terms: Within the scope refers to both the spatial and temporal scope defined above. It is important to note that the severity rating is not made for the entire assessment area, but only within the scope the threat affects. Thus, if the scope of a hunting threat only affects a sub-population of the overall species target, the severity assessment is only made in relation to that sub-population. For ecosystem targets, destruction or degradation is defined in reference to one or more key attributes of the target. Likewise, damage to species targets is most often defined in terms of the degree of reduction of the key attribute "population size." In some cases it may be appropriate to consider other key attributes for species targets, such as reduction of breeding pairs or reduction of juveniles.

**Irreversibility (Permanence)** - The degree to which the impact of a threat can be reversed and the target affected by the threat restored.

> **Very High:** The effects of the threat cannot be reversed and it is very unlikely the target can be restored, and/or it would take more than 100 years to achieve this (e.g., wetlands converted to a shopping centre).
>
> **High:** The effects of the threat can technically be reversed and the target restored, but it is not practically affordable and/or it would take 21-100 years to achieve this (e.g., wetland converted to agriculture).
>
> **Medium:** The effects of the threat can be reversed and the target restored with a reasonable commitment of resources and/or within 6-20 years (e.g., ditching and draining of wetland).
>
> **Low:** The effects of the threat are easily reversible and the target can be easily restored at a relatively low cost and/or within 0-5 years.

Explanation of Key Terms: Permanence applies to the effects of the threat on the target, not the threat itself. In other words, it is not a measure of how difficult it is to stop the threat, but rather to undo the stress caused by the threat on the target. It is important to note that the use of the permanence rating as specified is largely with respect to prioritizing potential threats. If a threat is looming that will cause irreversible damage, then it makes sense to try to address that threat. However, if the threat has already occurred and the irreversible damage has already taken place, then it may not make sense to prioritize that threat for action.

**Habitats: Threat Rating Details**

*Coastal forest*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Logging | High | Medium | High | Medium |
| Coastal development | Low | Low | Very High | Medium |

*Coastal marshes*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Conversion for agriculture / aquaculture | Medium | Very High | High | Medium |
| Coastal development | Low | Very High | Very High | Medium |

*Coral reefs*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Overfishing | Very High | High | Medium | High |
| Climate change | Very High | High | Very High | Very High |
| Pollution / sewage | Medium | Medium | Medium | Medium |
| Destructive fishing techniques (traditional & artisananl) | Medium | Medium | Low | Low |
| Phosphate mining | Medium | High | Medium | Medium |
| Coastal development | Low | Medium | Medium | Low |
| Hyper-sedimentation | High | High | High | High |

*Island vegetation*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Phosphate mining | High | Very High | Very High | Very High |
| Coastal development | Low | Very High | Very High | Medium |

*Mangroves*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Climate change | Very High | Medium | High | Medium |
| Logging | Medium | High | Low | Low |
| Conversion for agriculture | Medium | Medium | High | Medium |
| Coastal development | Low | Low | Very High | Medium |

*Seagrass*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Phosphate mining | Low | Very High | High | High |
| Hyper-sedimentation | High | High | Medium | High |

*Soft-bottom, near shore*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Commercial trawlers | Medium | Medium | High | Medium |

**Species: Threat Rating Details**

*Cetaceans*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Commercial trawlers/by-catch | Medium | High | Medium | Medium |
| By-catch (traditional & artisanal) | Low | High | Medium | Low |
| Oil exploration | High | Low | Low | Low |

*Marine turtles*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Overfishing | High | Very High | Medium | High |
| Introduced predators (rats, cats) | High | Medium | Medium | Medium |
| Commercial trawlers / by catch | High | Medium | Medium | Medium |

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Collection of eggs | High | Medium | Medium | Medium |
| Habitat degradation | Medium | Medium | Medium | Medium |
| Disturbance of nesting grounds | High | Very High | Medium | High |
| Phosphate mining | High | High | High | High |
| By-catch (traditional & artisananl) | Very High | Medium | Medium | Medium |
| Coastal development | Low | Low | Very High | Medium |

*Sea Cucumbers*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Overfishing | Very High | Very High | Medium | Very High |
| Habitat degradation | Medium | Low | Low | Low |

*Seabirds*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Introduced predators (rats, cats) | High | Very High | Medium | High |
| Collection of eggs | High | High | Medium | High |
| Phosphate mining | High | High | Medium | High |
| Disturbance of nesting grounds | High | High | Very High | Very High |
| Coastal development | Low | Very High | Very High | Medium |

*Sharks, rays*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Overfishing | Very High | High | High | High |
| Commercial trawlers / by catch | High | Medium | Medium | Medium |
| Habitat degradation | Low | High | High | Low |
| By-catch (traditional & artisananl) | Very High | High | Low | Medium |

*Spanish mackerel*

| Threat | Scope | Severity | Irreversibility | Summary Threat Rating |
|---|---|---|---|---|
| Overfishing | High | Medium | Low | Low |
| Commercial trawlers / by catch | High | Medium | Low | Low |
| Habitat degradation | Medium | Low | Low | Low |

**Rating of strategies**

Strategies were rated on the following criteria:

**Potential Impact** - If implemented, will the strategy lead to desired changes in the situation at your project site?

**Very High** - The strategy is very likely to completely mitigate a threat or restore a target.

**High** - The strategy is likely to help mitigate a threat or restore a target.

**Medium** - The strategy could possibly help mitigate a threat or restore a target.

**Low** - The strategy will probably not contribute to meaningful threat mitigation or target restoration.

Note that there are at least two dimensions being rolled up into this rating: probability of positive impact and magnitude of change. The users will have to integrate these into their rating.

**Feasibility** - Would your project team be able to implement the strategy within likely time, financial, staffing, ethical, and other constraints?

**Very High** - The strategy is ethically, technically, AND financially feasible.

**High** - The strategy is ethically and technically feasible, but may require some additional financial resources.

**Medium** - The strategy is ethically feasible, but either technically OR financially difficult without substantial additional resources.

**Low** -The strategy is not ethically, technically, OR financially feasible.

These ratings are then rolled-up to give an overall summary rating for the strategy (Table 63).

Note that if a strategy is assigned any "red" coloured rating, then the summary rating will also be "red."

## Appendix 4. Official documents relating to existing local management measures

**Nosy Barren Dina**

“MELAKY MIARO NY TONTOLO AN-DRIAKANY”

FITSIPIKA FIFAMPIFEHEZANA

HO FIAROVANA SY FITANTANANA IREO NOSY BARREN

Noho ny fahitana sy fahatsapana fa mihasimba ny tontolo iainana eny amin’ny Nosy Barren ary miena miandalana ny vokatra an-dranomasina azo avy eny, ny Komity Melaky miaro ny tontolo an-driakany sy ny Kaominina Andrenivohitr’i Maintirano dia mamoaka izao fitsipika fifampifehezana izao mba ho fiarovana sy fitantanana ireo Nosy ireo sy hampateza ny fitrandrahana ireo vokatra azo avy ao aminy.

TOKO I - Fepetra sy fandraràna

And.1 - Ho famerenana sy ho fitandrovana ny fahadiovana eny amin’ny Nosy dia :

1.1 - Tsy maintsy alevina avokoa ny loto vokatry ny asa jono (haran’akio, tsinaim-pia, sns.) sy vokatry ny fiainana andavan’andro (sisan-ketrika, taratasy, oditry ny zava-pihinana, poti-kazo, boatin-dronono sy sardine ary voatabia, sns). Ireo fako sasany mety may (toy ny tavoahangy plastika sy sachet plastika, sns.) dia dorana aloha vao alevina.

1.2 - Samy manao lavaka fanariam-pako mariny ny toerana ilasiny ny ekipa tsirairay avy. Ary samy tompon’andraikitra amin’ny fikajiana ny fahadiovana eo amin’ny manodidina azy avy.

1.3 - Diovina matetika ireo bassins famorian-drano eny Nosy Lava sy Nosy Andrano, ka ny mpanara-maso notendren’ny Komity no mitarika ny olona hanao ny fanadiovana amin’ny fotoana ahitany fa tokony atao izany.

1.4 - Tsy maintsy eny an-driaka ihany no manao kibo. (mangery)

And.2 - Ho fanajana ny fomban-drazana sy ho fitandrovana ny fiaraha-monina dia :

2.1 - Voarara ny fivarotana sy fitondrana eny amin’ny Nosy zava-mahadomelina toy ny toaka sy rongony

2.3 - Tsy azo atao ny mampiasa fitaovana mpamokatra herin’aratra (groupe électrogène), afa-tsy ho an’ireo izay nahazo alalana tamin’ny komity sy ny kaominina ihany, toy ny mpamokatra sarimihetsika (tournage de film) sy asa fanadihadihana (reportage) samihafa.

2.4 - Raràna ny fandefasana video sy ny fanaovana fety na lanonana miteraka tabataba: dihy, hira, mozika, sy rehefa karazana ady rehetra (fifamaliana, totohondry).

2.5 - Ireo tsy mana-karatra, na lahy na vavy, dia tsy mahazo miasa eny amin'ny Nosy. Ho an'ny vahiny dia miampy passe-port ahitana fanamarinan-toetra (mention sur la légalité vis à vis de la loi et mention sur le comportement) avy amin'ny Chef fokontany nihaviany

2.6 - Tsy azo atao ny manao masy (asan'ny ombiasy) eny amin'ny Nosy.

And.3 - Mba hisian'ny filaminana sy tsy hisian'ny fifanambakana eo amin'ny asa varotra dia :

3.1 - Ny entana azo avarotra eny amin'ny Nosy dia ireo PPN ihany: sira, siramamy, menaka, mofo, paraky, sigara, vary, labozy, petroly, savony.

3.2 - Ferana ho roa (2) isaky ny Nosy ny isan'ny mpivarotra. Ny kaominin'i Maintirano ihany no manome fahazon-dalana hivarotra eny amin'ny Nosy. Ary tsy maintsy ara-dalàna eo amin'ny contribution ireo rehetra te hivarotra eny

And.4 - Ho fitsinjovana ny reny sy ny zaza dia :

4.1 - Tsy azo entina eny amin'ny Nosy ny zaza latsaky ny 15 taona, raha tsy amin'ny fialan-tsasatra lehibe ihany (grandes vacances), ary tsy tokony ampiasaina fa entina mba hijery sy amantatra ny zava-boahary an-dranomasina ary hianatra ny asa jono.

4.2 - Ny vehivavy bevohoka sy mitaiza dia tsy mahazo mankeny amin'ny Nosy na amin'ny fotoana inona na amin'ny fotoana inona.

And.5 - Ho fikajina ireo Nosy sy hampateza ny fitrandrahana ireo vokatra eny dia :

5.1 - Ferana ho 500 kilao hatramin'ny 1000 kilao (na 25 ka hatramin'ny 50 fehezana fia miisa 10 isaky ny fehezana) fara fahabetsany, ny vokatra fia azo tehirizina eny amin'ny Nosy. Tsy maintsy entina aty Maintirano vao azo ahondrana any ivelan'ny Faritra izany vokatra izany mba hisin'ny fanaraha-maso.

5.2 - Ferana ho 150 isan-taona ny isan'ny lakana mahazo miasa eny amin'ny Nosy. Ka ireo lakana 150 voalohany voasoratra sy nahaloavana saram-piasana 15'000 Ariary teo amin'ny kaominina ihany no mahazo alalana iasa eny.

5.3 - Ny fanoratana ny lakana sy ny anaran'ny tompony ary ny fandoavana ny saram-piasana ho an'ny taona manaraka, dia misokatra ny 1er desambra ary mifarana ny 30 desambra ny taona itsahana. Tsy ekena ny fanoratana mialoha na ao aorian'ny fe-potoana voatondro, eny fa na dia tsy feno aza ny isa 150 voalaza etsy ambony.

5.4 - Tsy maintsy manana nomerao ny lakana rehetra miasa eny amin'ny Nosy mba hanamorana ny fanaraha-maso. Ny kaominina sy ny mpanara-maso ny asa jono no hany afaka manome izany nomerao izany.

And.6 – Fiarovana ny zava-boahary:

6.1 - Ny karazam-pano dimy hita eto amin' ny faritra dia efa eo an-dala-paharinganana ary voarara ny fihazana azy maneran-tany. Noho ny maha biby manan-danja manokana ny fano eto amin'ny faritra amin'ny

lafiny ara-pomba nentipaharazana sy lafiny ara-tsosialy, mba ho fiarovana azy ireo sy hampaharitra ny fitrandrahana netimpaharazana, dia natao ny fampirindrana ireo lalàna fiarovana ny fano amin'ny fomba eto an-toerana (Jereo Fitsipika fifampifehezana iarovana ny fano sy ny toeram-ponenany).

6.2 - Ireo biby voaharon' ny lalàna iraisam-pirenena toy ny fesoky, trozombe, oiseau mpifindra monina sy ny atodiny, dia tsy azo atao mihitsy ny mihaza azy

6.3 - Ny fitrandrahana ireo vokatra toy akio, zanga izay misy fitsipika iraisam-pirenena ny fakana azy, dia azo alaina ihany fa amin'ny fomba nenti-paharazana ihany

And.7 - Fepetra manokana :

7.1 - Tsy azo atao ny mampiditra zava-maniry na biby eny amin'ny Nosy raha tsy nandalo teo anatrehan'ny manam-pahaizana tandrify izany ary nankatoavin'ny komity ny fampidirana.

7.2 - Voarara ny fanapahana hazo mbola velona eny amin'ny Nosy.

7.3 - Tsy azo atao ny mipetraka eny Nosimborona na miasa eny akaikiny na amin'ny fotoana inona na amin'ny fotoana inona.

7.4 - Voarara ny fipetrahana eny amin'ny Nosy Abohazo manomboka ny 1er novambra ny taona itsahana ka hatramin'ny 1er aprily ny taona manaraka.

7.5 - Ny halatra sy fandratrana na famonoan'olona dia entina miakatra avy hatrany eo amin'ny fitsarana (Procédures pénales).

TOKO II - Fanasaziana sy famaizana :

1 - Ho fanajana ny fahadiovana eny amin'ny Nosy (Andininy 1).

1.1 - Ny tsy fanajana ny fahadiovana dia ahazoana fampitandremana sy fanerena anao lava-pako amin'ny voalohany. Afaka 24 ora aty aorian'ny fampitandremana dia mandoa sazy 5000 Ariary raha toa ka tsy mbola manatanteraka ny asa fanadiovana tokony hatao.

1.2 - Ny fandavana ankitsirano tsy handoa ny sazy sy tsy hanatanteraka ny fepetram-pahadiovana takina dia mitarika fandroahana sy tsy fahazoana miasa eny amin'ny Nosy intsony.

2 - Ho fanatanterahana ireo Andininy faha 2, faha 3 sy faha 4 ary faha 5.

2.1 - Ny tsy fanajana ireo andininy ireo dia ahazoana fampitandremana sy fanerena hampitsahatra ny asa fandikan-dalàna amin'ny voalohany. Afaka 24 aty aorian'ny fampitandremana dia mandoa sazy 20000 Ariary

raha toa ka tsy mbola manatanteraka ny fepetra takina (Famerenana ny vehivavy bevoka sy ny zaza tsy ampy taona aty Maintirano, fampitsaharana ny tabataba, sns.).

2.2 - Ny fandavana ankitsirano tsy handoa ny sazy sy tsy hanatanteraka ny fepetra takina dia mitarika fandroahana sy tsy fahazoana miasa eny amin'ny Nosy intsony.

3 - Ho fampiharana ny Andininy faha 6 sy 7.

3.1 - Ireo karazam-biby voarara na voafetra ny fakana azy (And.6) ,ny fanapahana hazo, ny fipetrahana sy fiasana eny amin'ireo Nosy voarara, ny fanondranana antsokosoka ireo vokatra, ny fanaovana masy, ny fampidirana zava-manan'aina tsy nahazoana alalana dia mahavoasazy 100 000 Ariary amin'ny voalohany. Ny famerenana fanindroany ny hadisoana dia mahavoasazy 100 000 ariary miampy tsy fahazoana miasa eny amin'ny Nosy mandritra ny roa volana.

3.2 - Ny fandikana in-telo ireo andinim-pifehezana voalaza ireo dia mitarika ny fampiakarana ny raharaha eo amin'ny fitsarana miampy fandroahana sy tsy fahazoana miasa eny ami'ny Nosy intsony.

TOKO III - Fanendrena mpanara-maso na "écogarde".

Ho fanatanteraha ireo rehetra ireo dia manendry mpanara-maso ny komity sy ny kaominina.

☐ - Mpanara-maso roa (deux écogardes) no tendrena, ka ny Filohan'ny komity sy ny Ben'ny Tanan'i Maintirano no manendry azy ireo, arahan'ny fankatoavan'ny biraon'ny komity

☐ - Rehefa manao fisafoana eny amin'ny nosy ny mpanara-maso dia arahana miaramila na zandary na polisy.

☐ - Ireto avy no andraikitra ho sahanin'ny mpanara-maso:

- Manara-maso ny fanajana ny fepetra hitandrovana ny fahadiovana eny amin'ny Nosy (fisian'ny lava-pako, ny fanaovana maloto, mitarika ny olona hanadio ny fanangonan-drano eny Nosy Lava sy Nosy Andrano, amin'ny fotoana tokony anaovana izany)

- Misava sy manamarina ny taratasy fahazoana mivarotra eny amin'ny Nosy, sy manamarina ny entam-barotra. (PPN)

- Misava ny karapanondro, ny pasipaoro misy fanamariana avy amin'ny Chef Fokontany nihaviana.

- Mandrara ny fanaovana tabataba (ady, vidéo, dihy, sns.) sy misakana ny fandefasana milina mpamokatra herin'aratra.

- Mandrara ny fikapana hazo, fisamborana vorona, fihazana fano miteraka sy fangalana ny atodiny, fihazana fesoky.

- Manara-maso ny habetsaky ny vokatra voatrandraky ny ekipa tsirairay avy, ary milaza ny tokony andefasana izany aty Maintirano rehefa tratra ny fetra azo itazomana izany eny amin'ny Nosy.

- Manao tatitra isan-kerinandro eo amin'ny Ben'ny tananan 'i Maintirano na ny Filohan'ny komity. (Araka ny tatitra voarain'izy ireo no hiantsony haingana ny fivoriam-ben'ny Komity, raha hitany fa tsy tapak'izy ireo samirery ny vahaolana amin'ny raharaha mitranga)

☐ - Ny valim-pakasitrahana omena ireo mpanara-maso dia 50 000 Ariary isam-bolana izay sintonina avy ao amin'ny saram-piasana alohan'ny tompo-dakana isan-taona, izany dia ampiana ampaham-bola azo avy amin'ny fanasazina, izay ferana ho 10%, mba ho famporisihina azy ireo.

☐ - Rehefa tsy mahafapo ny asan'ny mpanara-maso dia azo soloina avy hatrany izy ireo.

☐ - Ny mpanara-maso nandika ny iray amin'ity fitsipika fifampifehezana ity dia entina avy hatrany eo amin'ny manampahefana mahefa (Polisy, Zandary, Tribonaly)

TOKO IV - Fampiharana

Mihatra avy hatrany ity fitsipika fifampifehezana ity raha vao vita fampahafantarana sy sy fanitsiana ary fankatoavana teo amin'ireo ambaratongam-pahefana rehetra misy eto Maintirano (Faritra, Distrika, Solombavambahoaka, ZP, Police, Miaramila, Tribonaly, Solon-tenan'ireo Ministera samihafa, Fokontany) amin'ny alalan'ny fihaonana na fivoriana, ary nampahafantarina ny vahoaka amin'ny alalan'ny fivoriana na amin'ny alalan'ny haino aman-jery.

**Turtle conservation Dina**

"MELAKY MIARO NY TONTOLO AN-DRIAKANY"

FITSIPIKA FIFAMPIFEHEZANA

HO FIAROVANA NY FANO

Noho ny faharesen-dahatra fa biby eo an-dala-paharinganana ny fano eran'izao tontolo izao, ary tsapa fa miha vitsy izy ireo aty amin'ny faritr'i Melaky, ny kaominina an-drenivohitr'i Maintirano izay miara-miasa amin'ny komity miaro sy mikajy ny tontolo an-driaka sy ny zava-boahary ao aminy dia mamoaka izao fitsipika ifampifehezana izao.

A - FANDRARANA

1 - Ferana ny fotoana ahazoana mihaza fano ka:

- Mandritra ny sivy volana, manomboka ny voalohan'ny septambra ka hatramin'ny faran'ny volana mey ny taona manaraka dia voarara ny fihazana ny fano.
- Manomboka ny voalohan'ny volana jona ka hatramin'ny faran'ny volana aogositra, dia azo atao ny mihaza sy mihinana fano. Tokony ampitomboina ny fotoana ahazoana mihinana sy mihaza ny fano

2 - Mandritra ny fotoana ahazoana mihaza ny fano dia:

- Mihaza ihany no azo atao (mampiasa harato izany) fa voarara kosa ny mitoraka (fampiasana samondra na teza) na mitifitra (fampiasana basy) ny fano. Fampiasana ny teza na samondra no mety, amin'izay afaka mikendry ny fano lehibe fa ny haza tsy mifidy fa tonga dia mandroaka. – Atao ahoana ny fano azo tsy fidiny amin'ny jarifa sy kirara?
- Ny fano madinika latsaky ny zehy roa sy tondro dimy dia tsy azo alaina
- Tsy azo atao ny manao kitoza henam-pano
- Tsy azo atao ny mivarotra fano sy ireo vokatra azo trandrahina avy aminy toy ny hena, ny atody, ny harany ary ny kirany. Tokony ho azo hamidy fa tsy ho lany ny fano be vata, sady tsy hizara izany mihitsy izahay fa ny nahazo azy no vizana ka nahoana ny hafa no hinam-potsiny

3 - Mandritra ny fotoana rehetra dia voarara ny mangala atodim-pano sy mamadika ny fano miranga.

B - FANASAZIANA SY FAMAIZANA

(Tsy tokony ho "repression" avy hatrany no atao fa fampianarana aloha )

Ny fandikana ny iray amin'ireo fandrarana sy fifampifehezana ireo dia mahavoasazy toy izao:

- Mandoha sazy iray hetsy ariary (100 000 Ar.) eo amin'ny kaominina na fitanana (tsy ampody intsony) fitaovam-panjonoana mira-vidy amin'io.
- Tsy fahazoana miasa eny anosy mandritra ny iray volana
- Fisintonana ny karatra mahampanjono mandritra ny iray volana
- Fanaovana "fourrière"ny lakana, izany hoe, mipetraka eo amin'ny tompony ihany saingy tsy mahazo mandeha an-driaka

- Ny fandikana lalàna in-telo dia mitarika ny fampiakarana ny raharaha eo amin'ny fitsarana

D - FEPETRA MANOKANA

- Ny kaominin'i Maintirano miaraka amin'ny komity no mamolavola ny mety ampiasana ny vola azo amin'ny fanasaziana sy famaizana
- Ny fano azo amin'ny tsy ara-dalàna dia averina any an-driaka raha toa ka mbola velona, raha efa maty kosa dia omena ekipa hafa ny fihinanana ny henany Raha maty ny fano dia alevina fa tsy omena ekipa hafa noho ny vorika
- Ny lakana rehetra miasa eto amin'ny faritr'i Melaky sy ny manodidina dia asiana nomerao avokoa ka ny kaominin'i Maintirano miaraka amin'ny surveillance de pêche sy ny komity no miandraikitra ny fanaovana izany.
- Eny anosy, raha toa ka tsy misy manoro ny olona nanao hadisoana, dia iharan'ny sazy avokoa ireo tompo-dakana mipetraka amin'ny nosy

PLAN LOCAL DE GESTION ET DE CONSERVATION DES TORTUES MARINES A MAINTIRANO ET AUX ILES BARREN

(Région du Melaky – Sud-Ouest de l'océan Indien)

| **OBJECTIF I: Collecter des données pour la compréhension de la biologie et de l'écologie des tortues marines par des recherches et des échanges d'information** | | | |
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| **PROGRAMMES** | **ACTIVITES** | **INTERVENANTS** | **AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION** |
| 1. Effectuer des études et des recherches sur les tortues marines et leurs habitats | 1.1-Collecter les informations de base sur les zones de ponte et les aires d'alimentation | Projet, Comité<br>Pêcheurs | Continu |
| | 1.2-Préciser l'identité génétique de la population de tortues marines de la région par analyse d'ADN | Projet<br>Partenaire | Soutenance d'une thèse en 2008 |
| | 1.3-Promouvoir l'intégration des connaissances biologiques et écologiques traditionnelles dans les études et les recherches | Projet, Comité<br>Pêcheurs, Ombiasy<br>Service de pêche | 2009 - 2010 |
| | 1.4-Faire un état de lieu des connaissances scientifiques sur les tortues marines de la région | Projet<br>Service de pêche | Identification de 5 espèces/<br>2009 |
| | 1.5-Mener des recherches sur la pathologie (fibropapillomas) des tortues marines | Projet, Pêcheurs<br>Partenaires | En cours<br>2012 |

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| | 1.6-Organiser périodiquement (ou participer) des rencontres scientifiques afin d'évaluer les activités de recherche effectuées | Projet<br>Autorités locales<br>DREFT<br>Service de pêche | A partir de 2010 |
| | 1.7-Continuer la surveillance à long terme de la population de tortue marine afin d'évaluer leur état de conservation | Projet, Comité<br>Autorités locales<br>DREFT, Pêcheurs<br>Service de pêche | Continu |

(Projet = IHSM, WWF, MHNG)

| PROGRAMMES | ACTIVITES | INTERVENANTS | AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION |
|---|---|---|---|
| | 1.8-Etendre les recherches sur d'autres écosystèmes marins et biodiversités associées | -Projet<br>-Partenaires<br>-DREFT<br>-Service Pêche<br>-Comité | -DEA sur la mangrove et le récif 2008- 2009-02-18<br>-Thèse sur les oiseaux marins (en cours)<br>-Etudes sur les requins et les holothuries (à partir de 2009) |
| 2. Echanger des informations | 2.1-Déterminer les méthodes les plus appropriées à la diffusion des informations | Projet, Comité<br>DREFT<br>Service de pêche | 2009 |
| | 2.2-Appuyer les participations au symposium annuel international et aux divers ateliers | Projet, Autorités<br>Partenaires | Continu |

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| | 2.3-Produire et distribuer des rapports annuels sur les recherches et la gestion des tortues marines | Projet, Comité<br>DREFT, PMM<br>Service de pêche | Continu |
| | 2.4-Créer un site WEB pour le projet | MHNG | Amélioration en 2009 |
| 3. Analyser les données pour contribuer à atténuer les menaces, à évaluer et à améliorer la stratégie locale de conservation | 3.1-Identifier les tendances de la population de tortues marines de la région | Projet, Partenaires<br>Service de Pêche | 2009 - 2010 |
| | 3.2-Utiliser les résultats des recherches pour améliorer la gestion, atténuer les menaces et évaluer l'efficacité des activités de conservation | Projet, Comité<br>Pêcheur, DREFT<br>Service de pêche | En cours |

| OBJECTIF II: Réduire les causes directes ou indirectes de mortalité des tortues marines dans la région du Melaky | | | |
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| **PROGRAMMES** | **ACTIVITES** | **INTERVENANTS** | **AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION** |
| 1. Identifier et documenter les menaces envers les tortues marines et leurs habitats | 1.1-Etablir des programmes de collecte de données et des programmes de surveillance afin de rassembler les informations sur la nature et l'ampleur des menaces | Projet<br>Comité<br>Service de pêche | 2006 - 2009 |

| **PROGRAMMES** | **ACTIVITES** | **INTERVENANTS** | **AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION** |
|---|---|---|---|
| | 1.2-Rassembler et organiser les données existantes sur les menaces pesant sur les tortues marines | Projet, Comité<br>DREFT<br>Service de pêche | 2006 - 2009 |

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| | 1.3-Déterminer les espèces affectées par l'exploitation traditionnelle directe, les prises accidentelles et autres sources de mortalité | Projet, Comité<br>DREFT, PMM<br>Service de pêche | 2008 - 2009 |
| 2. Mettre en œuvre des programmes en vue de corriger les incitations économiques négatives menaçant les tortues marines | 2.1-Effectuer des études socio-économiques et éthno-biologiques concernant les communautés en interaction avec les tortues marines et leurs habitats | Projet<br>Partenaires | -Trois rapports d'étude socio-économique (2007/2008)<br>-2007 - 2009 |
| | 2.2-Identifier des alternatives nécessaires permettant de répondre aux incitations culturelles et économiques négatives afin de réduire les menaces et les mortalités des tortues marines | Projet, Comité<br>Pêcheurs, DREFT<br>Autorités<br>Service de pêche | -Amélioration des techniques de conservation et de transformation des produits de la pêche (en cours)<br>-DCP, Fumoir amélioré, 2009-2010 |
| | 2.3-Développer des programmes relatifs à ces alternatives et identifier les sources de financement pour ces programmes | Projet, Comité<br>Autorités<br>Partenaires | À partir de 2009 |
| 3. Déterminer et appliquer les approches fondées sur les meilleures pratiques afin de minimiser les menaces envers les tortues marines et leurs habitats | 3.1-Adapter par des actions concrètes, les meilleures pratiques de conservation et de gestion des tortues marines dans la région | Projet, Comité, BCM<br>Service de pêche<br>DREFT, Police | En cours |
| | 3.2-Promouvoir et appuyer les meilleures pratiques de gestion et de conservation des tortues marines et de leurs habitats | Projet, DREFT<br>Autorités, BCM<br>Partenaires | Continu |
| | 3.3-Etablir des réserves pour tortues marines ou des APM dans leurs habitats prioritaires | Projet, Comité<br>Autorités, DREFT<br>Partenaires, BCM | En cours |
| | 3.4-Développer une collaboration multisectorielle | Projet, Comité | Continu |

| PROGRAMMES | ACTIVITES | INTERVENANTS | AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION |
|---|---|---|---|
| 4. Réduire les prises accidentelles et la mortalité des tortues marines au cours des activités de pêche | 4.1-Collaborer avec les industries de pêche et les organisations de gestion halieutique en vue de développer et mettre en œuvre des mécanismes pour réduire au minimum les captures accidentelles de tortues marines ;<br>- Organiser des formations pour la construction et le déploiement du DET avec les pêcheries<br>- Travailler avec les chalutiers crevettiers pour l'installation du DET et disséminer les résultats obtenus<br>- Etablir des zones de protection pour les aires de nourrissage et les corridors de migration | Projet<br>Service de pêche<br>PMM<br>Autorités<br>DREFT<br>Comité | -Des collaborations ont déjà eu lieu avec le PMM pour le marquage et les mensurations de tortues marines piégées dans les filets des chalutiers.<br>-Continu |
| | 4.2-Développer et mettre en œuvre des systèmes de récupération et de recyclage des filets pour réduire au minimum les accidents mortels de tortue marine dus à ces engins jetés en mer | Projet, Comité<br>Service de pêche<br>DREFT<br>Pêcheurs | 2009 - 2010 |
| | 4.3-Réglementer les engins de pêche traditionnels susceptibles de provoquer la mortalité des tortues marines | Projet, Comité<br>Service de pêche<br>DREFT, Autorités | 2009 - 2010 |
| 5. Réglementer les prises directes et interdire toute forme de commerce des tortues marines et des produits qui en sont issus (viande, œufs, écailles, carapace, spécimen naturalisés) | 5.1-Adopter les dispositions légales et réglementaires en vue de réduire les prises directes et interdire le commerce | Autorités, DREFT<br>Service de pêche<br>Justice, Comité<br>Force de l'ordre | 2009 - 2010 |
| | 5.2-Collecter les informations sur le commerce et l'utilisation locale des tortues marines | Projet, Comité<br>Service de pêche | 2007 - 2009 |

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| | 5.3-Evaluer l'ampleur et l'incidence des prises traditionnelles de tortues marines et de leurs oeufs | Projet, Comité<br>Service de pêche | ( ?) |
| | 5.4-Appuyer les projets communautaires protégeant les femelles nidifiant et les oeufs | Projet, Autorités<br>Partenaires | Continu |

| PROGRAMMES | ACTIVITES | INTERVENANTS | AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION |
|---|---|---|---|
| | 5.5-Etablir des saisons de capture de tortue marine | Projet, Comité<br>Autorités | 2009 |
| | 5.6-Déterminer les valeurs culturelles et traditionnelles ainsi que l'exploitation économique des tortues marines | Projet, Comité<br>Autorités<br>Pêcheurs | 2009 |

| **<u>OBJECTIF III</u>: Protéger, conserver et réhabiliter les habitats des tortues marines aux îles Barren et dans la région du Melaky** | | | |
|---|---|---|---|
| 1. Etablir les mesures nécessaires pour protéger et conserver les habitats des tortues marines | 1.1-Identifier les aires renfermant les habitats critiques tels que plages de ponte, lieux d'alimentation et de repos | Projet, Comité<br>Service de Pêche<br>Pêcheurs | 2009 - 2010 |
| | 1.2-Gérer et réglementer l'utilisation des plages et des îles:<br>- Délimiter les emplacements pour la conception des cases de campement et le parcage des pirogues<br>- Identifier un lieu de décharge des carcasses de requin et autres déchets de la pêche<br>- Identifier et réglementer un endroit pour faire ses besoins | Projet<br>Comité<br>CUM<br>DREFT<br>Service de pêche | Février- Mars 2009 |

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| | 1.3-Limiter le nombre de pirogue pouvant séjourner sur chaque île | Projet, Comité<br>Autorités, Police | Février- Mars 2009 |
| | 1.4-Identifier et délimiter des zones d'ancrage des pirogues et autres embarcations sur les platiers récifaux | Projet, Comité<br>Autorités, Police<br>Service de pêche | Février- Mars 2009 |
| | 1.5-Interdire l'emploi de produits chimiques toxiques et d'explosifs dans l'exploitation des ressources marines | Projet, Comité<br>Autorités, Police<br>Service de pêche | 2009 |

| PROGRAMMES | ACTIVITES | INTERVENANTS | AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION |
|---|---|---|---|
| 2. Réhabiliter les habitats dégradés de tortue marine | 2.1-Enlever les déchets faisant obstacle à la nidification des femelles et au déplacement vers la mer des nouveau-nés après émergence | Projet, Comité<br>Pêcheurs, CUM | -Février-Mars 2009<br>-Tous les mois d'octobre les années suivantes |
| | 2.2-Encourager et renforcer la réhabilitation des mangroves et des zones des herbiers | Projet, Pêcheurs, DREFT<br>Partenaires, Comité | Continu |
| 3. Développer des programmes de gestion des plages de ponte afin d'améliorer le recrutement de nouveau-nés | 3.1-Minimiser la mortalité des œufs et des nouveau-nés, causée par les animaux | Projet, Comité<br>Pêcheurs | Continu |
| | 3.2-Développer des programmes de protection des œufs et des nouveau-nés en vue de porter au maximum le recrutement et la survie des nouveau-nés à l'aide de technique de conservation mettant l'accent sur les processus naturels (telle que les écloserie) | Projet<br>Comité<br>Pêcheurs<br>Service de Pêche | 2009 - 2010 |

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| | 3.3-Inciter l'engagement des pêcheurs dans la politique de conservation des tortues marines par l'utilisation de pratiques traditionnelles permettant de protéger les oeufs | Projet<br>Comité<br>Pêcheurs<br>Service de Pêche | 2009 - 2010 |

| **<u>OBJECTIF IV</u>: Sensibiliser le public aux menaces pesant sur les tortues marines et leurs habitats dans la région du Melaky et encourager la participation du public dans les activités de conservation** | | | |
|---|---|---|---|
| **PROGRAMMES** | **ACTIVITES** | **INTERVENANTS** | **AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION** |
| 1. Etablir des programmes d'enseignement public, de sensibilisation et d'information | 1.1-Créer et développer des modules de formation démontrant les valeurs écologiques, économiques et culturelles des tortues marines | Projet, Comité<br>Partenaires<br>DREFT, DREN | 2009 - 2011 |
| | 1.2-Collecter, développer et diffuser des matériels éducatifs se rapportant aux tortues marines (Par exemple création de bande dessinée) | Projet, Comité<br>Partenaires<br>DREFT, DREN | 2009 - 2011 |

| **PROGRAMMES** | **ACTIVITES** | **INTERVENANTS** | **AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION** |
|---|---|---|---|
| | 1.3-Créer et mettre en œuvre un centre d'interprétation pour tout public | Projet, Comité<br>Partenaires | 2008 - 2010 |

| | | | |
|---|---|---|---|
| | 1.4-Développer et mettre en œuvre des programmes d'information médiatiques rigoureux (Festivité, événement sportif, émission radio-phonique) | Projet<br>Comité, CUM<br>Partenaire, DREN<br>DREFT<br>Service de Pêche<br>Service Information | -Tous les ans<br>-Course de pirogue (2 éditions/2007 et 2008)<br>-Emission radio-phonique (en cours)<br>-Grande festivité voyant la participation d'un artiste très reconnu au niveau national (en cours) |
| | 1.5-Développer et réaliser des programmes d'éducation et de sensibilisation s'adressant à des groupes cibles (Elèves, communauté de pêcheurs, autorités, force de l'ordre, services techniques, ONGs, etc.) | Projet, DREFT<br>Comité, DREN<br>Servie de Pêche | -Tous les ans<br>-Atelier de formation pour toutes les forces vives de Maintirano (2008)<br>-Cours pour les élèves de niveau collège et lycée (2008 – 2009) |
| | 1.6-Développer et disséminer des matériels de sensibilisation et d'information | Projet, Comité<br>Partenaires | Tee-shirt (2008)<br>Panneaux de sensibilisation (2009)<br>Poster (2008)<br>Continu |
| | 1.7-Organiser des évènements spéciaux portant sur la biologie et la conservation des tortues marines (Exemple journée ou semaine ou année tortue) | Projet, Partenaires<br>Autorités<br>Comité | 2010 |
| | 1.8-Organiser des ateliers de formation pour les éducateurs | Projet, Partenaires<br>Comité, DREN | 2009 - 2010 |
| | 1.9-Développer un réseau pour faciliter le développement et les échanges des matériels d'éducation sur la conservation des tortues marines | Projet, DREN<br>Comité<br>Partenaires | 2009 - 2011 |

| | | | |
|---|---|---|---|
| | 1.10-Sensibiliser les autorités compétentes sur les obligations résultant de l'adhésion de l'Etat aux conventions internationales concernant les tortues marines | Projet<br>Partenaires<br>DREFT<br>Service de Pêche | 2009 |

| PROGRAMMES | ACTIVITES | INTERVENANTS | AVANCEMENT DES ACTIVITES / PERIODES DE REALISATION |
|---|---|---|---|
| 2. Développer des perspectives économiques alternatives pour les communautés de pêcheurs en vue d'encourager leur participation active dans les efforts de conservation | 2.1-Identifier et faciliter l'accès à des ressources alternatives et à d'autres activités susceptibles de produire des revenus, mais non nuisibles aux tortues marines et à leurs habitats, en consultation avec les communautés locales et les autres parties intéressées | Projet<br>Comité<br>Partenaire<br>Service de Pêche | -A partir de 2009<br>-Continu |
| | 2.2-Promouvoir les activités écotouristiques relatives aux tortues marines et garantir un partage équitable des revenus et des autres bénéfices avec les communautés locales | Projet, ORT<br>Comité<br>DREFT<br>Autorités | A partir de 2009 |
| 3. Promouvoir la participation du public | 3.1-Mettre en œuvre, le cas échéant, des régimes d'incitation en vue d'encourager la participation du public.<br>- Tee-shirt pour les retours de bagues<br>- Certificat pour les concours<br>- Prime de récompense pour le gardiennage des nids | Projet<br>Comité<br>Autorités<br>Partenaires<br>Service de Pêche<br>DREFT | Continu |

| | | | |
|---|---|---|---|
| | 3.2-Encourager la participation des administrations publiques, des ONGs, du secteur privé et de la communauté dans son ensemble (étudiants, volontaires, pêcheurs) dans les recherches et les efforts de conservation | Projet<br>Comité<br>Autorités<br>DREFT<br>Service de Pêche | Continu |
| | 3.3-Faire participer les communautés locales dans la planification et la mise en œuvre des mesures de gestion et de conservation des tortues marines telles que l'élaboration de réglementation locale, de loi communautaire, … | Projet, Comité<br>Service de pêche<br>Force de l'ordre<br>Autorités | 2009 - 2010 |

## Appendix 5. Vegetation Classification

From CEPF Madagascar Vegetation Mapping Project (www.vegmad.org)

| Type | Description |
|---|---|
| 1. Forest | A continuous stand of trees at least 10 m tall, their crowns interlocking |
| 2. Woodland | An open stand of trees at least 8 m tall with a canopy cover of 40 % or more. The field layer is usually dominated by grasses. |
| 3a. Bushland | An open stand of bushes usually between 3 and 7 m tall with a canopy cover of 40% or more |
| 3b. Thicket | A closed stand of bushes and climbers usually between 3 and 7 m |
| 4. Shrubland | An open or closed stand of shrubs up to 2 m tall |
| 5. Grassland | Land covered with grasses and other herbs, either without woody plants or the latter not covering more than 10 % of the ground |
| 6. Wooded grassland. | Land covered with grasses and other herbs, with woody plants covering between 10 and 40 % of the ground |
| 7. Mangrove | Open or closed stands of trees or bushes occurring on shores between high and low water mark. |
| 8. Freshwater aquatic | Herbaceous freshwater swamp and aquatic vegetation |
| 9. Halophytic | Saline and brackish swamp vegetation |
| 10. Distinct, restricted | Formation of distinct physiognomy but restricted distribution, e.g. bamboo, inselbergs etc. |
| 11. Anthropic | Man-made landscapes, e.g. agricultural, urban etc. |
| 12. Other | |

## Appendix 6. Coordinates of villages and fisher settlements

**Table 73.** GPS coordinates of the villages and fisher settlements within the Barren Isles region

| Settlement | Position | Description |
|---|---|---|
| Nosy Lava | 38 K 386597 7944603 | Vezo migrant makeshift houses, start |
| Nosy Lava | 38 K 386803 7944664 | Vezo migrant makeshift houses, end |
| Nosy Lava | 38 K 387236 7944794 | Sara houses, start |
| Nosy Lava | 38 K 387295 7944564 | Sara houses, end |
| Nosy Andrano | 38 K 383553 7948199 | Makeshift hut |
| Nosy Andrano | 38 K 383643 7948177 | Makeshift hut |
| Nosy Andrano | 38 K 383688 7948133 | Makeshift hut |
| Nosy Manghily | 38 K 382473 7946851 | Vezo migrant family |
| Nosy Abohazo | 38 K 373559 7955104 | Makeshift huts, start |
| Nosy Abohazo | 38 K 373522 7955028 | Makeshift huts, end |
| Nosy Abohazo | 38 K 373496 7954948 | Makeshift huts, start |
| Nosy Abohazo | 38 K 373464 7954836 | Makeshift huts, end |
| Nosy Maroantaly | 38 K 387020 7963097 | Sara houses, start |
| Nosy Maroantaly | 38 K 387082 7963363 | Sara houses, end |
| Nosy Marify | 38 K 379281 8003087 | Makeshift tents between all of these pts |
| Nosy Marify | 38 K 379244 8003144 | Makeshift tents between all of these pts |
| Nosy Marify | 38 K 379223 8003101 | Makeshift tents between all of these pts |
| Ampandikoara | 38 K 398740 7965715 | Village houses |
| Ampandikoara | 38 K 398592 7965907 | Make shift houses of seasonal migrants from Maintirano |
| Manombo | 38 K 399643 7983630 | Houses of Manombo village, start |
| Manombo | 38 K 399534 7983876 | Houses of Manombo village, end |
| Maintirano Maty | 38 K 398448 7990525 | Pts of single houses, some just makeshift, no village as such, but dispersed homes |
| Maintirano Maty | 38 K 398283 7990144 | Pts of single houses, some just makeshift, no village as such, but dispersed homes |
| Maintirano Maty | 38 K 398206 7990803 | Pts of single houses, some just makeshift, no village as such, but dispersed homes |
| Maintirano Maty | 38 K 398024 7991533 | Pts of single houses, some just makeshift, no village as such, but dispersed homes |
| Kimazimazy | 38 K 396581 7996675 | Pts of single houses / groups of houses, dispersed homes |
| Kimazimazy | 38 K 396556 7996784 | Pts of single houses / groups of houses, dispersed |

| | | |
|---|---|---|
| | | homes |
| Kimazimazy | 38 K 396373 7997126 | Pts of single houses / groups of houses, dispersed homes |
| Kimazimazy | 38 K 396363 7997192 | Pts of single houses / groups of houses, dispersed homes |

## Appendix 7. Documents regarding external threats to the Barren Isles

**Letter from the « Reseau interdisciplinaire pour une gestion durable de la biodiversité marine »**

***"Réseau interdisciplinaire pour une gestion durable de la biodiversité marine"***

***Région Melaky, Madagascar***

Maintirano, le 04.03.10

A l'attention de :

**- Monsieur le Chef de la Région Melaky,**

**- Monsieur le Directeur du Développement Régional**

**- Monsieur le Chef District de Maintirano,**

**- Monsieur le Maire de la CU de Maintirano,**

**- Monsieur le Directeur Régional du Développement Rural,**

**- Madame la Représentante Régionale du DREEF,**

**- Monsieur le Représentant Régional du Ministère de la pêche et des ressources halieutiques,**

**- Monsieur le président du comité '*Melaky miaro ny tontolo an-driakany*',**

**- Messieurs les Présidents de Fokontany d'Ampasimandroro et d'Ambalahonko**

**- Monsieur le Président du Tribunal,**

**- Monsieur le Procureur de la République,**

**- Monsieur le Colonel da la Gendarmerie,**

**- Monsieur le Commissaire de Police,**

**- Messieurs les représentants des médias régionaux,**

Chers tous,

Je me permets, par la présente, de vous rendre compte de la situation actuelle très inquiétante concernant en particulier la survie des populations de tortues marines dans les îles Barren.

En premier lieu je tiens à noter que les efforts de sensibilisation entrepris par notre projet depuis début 2006 en vue notamment de la mise en place de stratégies de conservation de l'environnement marin dans la région du Melaky, semblaient porter leurs fruits jusqu'à il y a quelques mois. Nous avions ainsi constaté plusieurs évolutions positives dans les comportements des pêcheurs face à la préservation de leur milieu.

Or, comme vous le savez, ces derniers mois un brusque renversement de situation a eu lieu, notamment concernant les tortues marines. Ce changement de comportement récent de la part des pêcheurs mais malheureusement aussi de la part des consommateurs, est peut-être à mettre en rapport avec la situation actuelle d'instabilité politique, ou encore peut-être avec le retour massif des plongeurs (en scaphandre) de concombres de mer dans la région, ou encore avec l'arrivée de plus en plus nombreuse de pêcheurs venues d'autres régions à la recherche de lieu de pêche plus productifs, ou encore peut-être aussi avec certaines lacunes dans nos stratégies de conservation. Probablement qu'il s'agit d'un mélange de tous ces facteurs.

Le fait est que depuis plusieurs mois, la pêche, la consommation et la vente des tortues marines ont fortement repris et récemment il n'est malheureusement plus rare de trouver des vendeurs de tortues dans plusieurs quartiers de Maintirano.

De plus, après recensement des nids de cette saison des pontes 2009-2010 (l'essentiel de la saison des pontes dure environs de mi-novembre à début mars), le constat est alarmant : **Sur 26 nids dénombrés dans 5 îles de l'archipel des îles Barren, a priori aucun nid n'a été épargné par les pêcheurs et tous les œufs (et probablement également toutes les femelles venues pondre) ont été braconnés !!!**

Le fait que le mois de janvier n'ai vu aucune tortue pondre est également très inquiétant et démontre que probablement toutes les femelles venues pondre cette année ont été braconnées avec les œufs !!! (Rappelons qu'une femelle vient pondre en une saison 2 à 3 fois sur la même plage)

Au regard du fait qu'une femelle ayant atteint la maturité sexuelle (à l'âge de 20 à 40 ans !) vient pondre sur la même plage où elle est née, la situation actuelle où tous les nids sont consommés ne laisse guère de chance pour le maintient de la population des tortues marines des îles Barren !

Aussi, je suis navré de constater que dans de tels cas par exemple l'argument de certains, défendant la vente pour des causes de nécessités financières, n'est aucunement valable. Il n'existe en effet aucune famille Vezo qui dépend des bénéfices de quelques œufs de tortues pour faire vivre leurs familles. De plus, au regard de la tradition Vezo qui voulait que les tortues marines ne soient pas vendues mais partagées dans le cadre familial, cela est aussi valable pour les individus adultes.

Je tiens aussi à vous rappeler que ce n'est pas notre projet et encore moins une initiative personnelle qui a crée des lois à Madagascar pour la conservation des tortues marines, qui je le rappelle, sont menacées d'extinction et protégées au niveau mondial. Elles sont protégées par des lois malgaches depuis 1923, et la dernière en date, décret présidentiel 88-243, les protège intégralement.

De plus, Madagascar a ratifié plusieurs conventions internationales liées à la protection d'espèces sensibles ou menacées d'extinction, dont les tortues marines.

A travers le comité *Melaky miaro ny tontolo an-driakany* nous voulions justement créer une exception locale en accord avec la tradition régionale de consommation de tortues marines en tolérant une pêche réglementée de ces dernières durant les mois de juin, juillet et août. Bien que ces règlements ont été discutés et validés par le comité, dont la moitié des membres sont des pêcheurs Vezo, certains membres sont revenus sur leur parole et se permettent de diffamer publiquement les propositions de lois qu'ils avaient acceptées quelques mois auparavant.

Les propositions de lois émises par le comité n'ayant pas encore été validées par les autorités compétentes, je me permets de rappeler que les lois actuellement en vigueur concernant les tortues marines au niveau national sont donc celles du décret présidentiel 88-243.

Je vous assure qu'il n'est aucunement dans mon intérêt, ni dans celui de notre projet, d'encourager des actes répressifs vis-à-vis des pêcheurs. Pour ceux qui ne l'ont pas constaté je rappelle aussi que je suis tout à fait conscient des nécessités et des besoins des populations locales et que je donnerais toujours la priorité aux hommes et non aux animaux. Mes études universitaires ont par ailleurs concernées la population Vezo et non pas les tortues marines.

C'est dans cette optique que je vous demande de juger et d'apprécier à leur juste valeur les potentiels socioéconomiques immenses que représente la richesse de la biodiversité marine locale pour la région du Melaky, et le fait qu'il y a une grande nécessité de la protéger.

Un des objectifs ultimes de notre projet est par ailleurs la création d'une Aire Marine Protégée dans les îles Barren (l'étude de faisabilité est actuellement en cours de finalisation). Cette Aire Marine Protégée permettrait de gérer et de contrôler plus facilement : l'accès aux ressources (pêcheurs traditionnels, industriels, etc.) ; les droits des pêcheurs traditionnels ; le respect des règlementations en vigueur ; la protection de certaines espèces : les flux migratoires ; les flux touristiques ; etc.

J'ajouterais aussi que mise à part les projets pétroliers ainsi que le tourisme à l'intérieur des terres (Tsingy du Bemarah), les ressources marines font parti des atouts les plus prometteurs à moyen terme pour un développement de la région. Qu'il s'agisse du domaine de la pêche ou encore des activités liées au tourisme balnéaire et/ou écotouristiques. La création d'une Aire Marine Protégée sera donc un formidable moyen pour gérer ces activités prometteuses et pour servir de levier à leur développement et, par la même, au développement de la région.

Pour finir je me permets de souligner que partout dans le monde il a été largement démontré que certaines espèces prioritaires (souvent rares) ont beaucoup plus de valeurs économiques vivantes, dans leur milieu naturel, que ce que peut rapporter la valeur de leur prix de vente. Là où les populations concernées ont

pris conscience de ce phénomène, ils en deviennent les premiers bénéficiers. C'est le cas à Madagascar notamment avec les baleines à Ste' Marie, ou encore avec plusieurs espèces terrestres (lémuriens, certains reptiles, etc.) dans les différents parcs naturels.

Concernant le cas des tortues, à vrai dire nous sommes parmi les dernières régions dans le monde à ne pas respecter l'interdiction de leur pêche. La plupart des populations côtières dans le monde ont ainsi pris conscience que les tortues vivantes permettent notamment d'attirer les flux touristiques et ont largement plus de valeur économique que les bénéfices de leur chair. Pour ne citer que les îles du sud-ouest de l'Océan Indien nous entourant, la plupart ont déjà franchi cette étape et les retombées économiques (principalement touristiques) sont souvent importantes (Seychelles, Maurice, Mayotte, Réunion, etc.).

Je serais donc extrêmement ravis d'obtenir votre collaboration et, par la même, vos suggestions afin de tenter de freiner cette situation anarchique actuelle qui peut s'avérer irréversible si rien n'est entrepris.

Je vous remercie tous pour l'attention que vous portez à ce dossier et me tiens à votre entière disposition pour tout renseignement supplémentaire.

Géraud Leroux

*Responsable de projet*

*Andranovoribe*

*Maintirano 413*

*Tél. : 032 44 369 35*

*E.mail : geraud.leroux@sunrise.ch*

**Phosphate mining on the Barren Isles**

**l'Express de Madagascar (30.03.2010)**

***ENGRAIS***
***Guanomad exporte vers la France***

*Madagascar importe encore la totalité des engrais chimiques utilisés dans le domaine de l'agriculture. Mais à partir de cette année, par le biais de la société Guanomad, la Grande-île va intégrer la liste des pays exportateurs. Néanmoins, les exportations concerneront principalement l'engrais biologique.*
*La France sera la première destination du produit. « Dès le début du second trimestre, nous prévoyons l'expédition d'engrais sur la France », confirme Eric Rajaonary, directeur général de la société Guanomad. Dans le cadre de ce projet, un nouveau produit sera lancé au mois de mai. Il s'agit du Guano-barren, du mélange de fientes de chauve-souris et de mouettes. La deuxième composante sera extraite d'un site sur l'île Barren, dans le sud-ouest du pays.*
*La Guanomad a déjà obtenu et conclu un contrat de concession. Près de 500 000 tonnes de réserves sont identifiées sur ce site.*
*Un projet de textes relatifs à ce dossier est en gestation, en partenariat avec le ministère de l'élevage et celui des Eaux et forêts.*

*Lantoniaina Razafindramiadana*

*Date : 30-03-2010*

## Appendix 8. IUCN Red List for Barren Isles species

| Order | Scientific name | Common name | Malagasy name | IUCN Redlist status | Observed / likely distribution | Notes |
|---|---|---|---|---|---|---|
| Carcharhinidae | *Carcharhinus melanopterus* | Blacktip Reef Shark | Akio mainty lambosy | NT | Fishermen reported catch | Blacktip Reef Shark is a common tropical Indo-West Pacific and Central Pacific species. The Blacktip Reef Shark is commonly found in shallow waters on and near coral reefs (Randall and Helfman 1973, Compagno 1984, Last and Stevens 1994). This species is often seen in water only a few metres deep.<br><br>The Blacktip Reef Shark (*Carcharhinus melanopterus*) is a common and wide-ranging species, regularly caught by inshore fisheries. Globally, populations are not considered to be in immediate danger of significant depletion. However, this species is currently fished, and due to small litter sizes and long gestation periods, is vulnerable to depletion. |
| Carcharhiniformes | *Sphyrna lewini* | Scalloped Hammerhead | Akio viko | EN | Fishermen reported catch | The Scalloped Hammerhead has a circumglobal distribution in coastal warm temperate and tropical seas (Compagno in prep).<br><br>In the **Indian Ocean it is** recorded from South Africa (Western Cape to kwaZulu-Natal), Maldives, and Red Sea to Pakistan, India, Myanmar (Compagno in prep).<br>Hammerhead shark fins are more highly valued than other species because of their high fin ray count, leading to increased targeting of this species in some areas. Wide ranging, there is genetic evidence for multiple subpopulations. Population segregation and the species' aggregating habit make large schools highly vulnerable to fisheries and means that high CPUEs can be recorded, even when stocks are severely depleted. |
| Carcharhiniformes | *Galeocerdo cuvier* | Tiger Shark | Akio kary | NT | Fishermen reported catch | The Tiger Shark has a worldwide distribution in tropical and warm temperate seas. It occurs throughout the Indo-Pacific region from the northern Red Sea to South Africa and east through the islands of Oceania and northern New Zealand (though not yet reported from Easter Island.<br>Little is known of the Tiger Shark's depth range. Clark and Kristof (1990) illustrate a female Tiger Shark of about 250 cm total length (TL) from a photograph taken from a submersible in 350 m of water off Grand Cayman. The species is also encountered in very shallow water. |

| | | | | | | |
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| | | | | | | They consume carrion and readily take baited hooks. Tiger Sharks also have a propensity to consume garbage of human origin, including plastics, metal, sacks, kitchen scraps and almost any other item discarded in the sea . The fins, skin and liver oil from Tiger Sharks are all considered to be of high quality and can fetch good prices. The high value of products has increased commercial fishing pressure on this and similar species worldwide, especially since demand for high quality shark fins has increased. |
| Orectolobiformes | *Stegostoma fasciatum* | Leopard Shark, Zebra Shark | | VU | Fishermen reported catch | This species' range are the inshore waters of the continental and insular shelves. Occurs in tropical, shallow inshore and offshore waters near the bottom; often found on and around coral reefs and on sandy plateaus near coral, at depths down to at least 62 m (Compagno and Niem 1998).<br><br>A broadly distributed continental and insular shelf species of the Indian, west and central Pacific Oceans. Usually found within a narrow band of shallow coral reef habitat and soft bottom (to 62 m), that is heavily fished throughout all its range except Australia. Taken in inshore fisheries (demersal trawls, floating and fixed bottom gillnets and baited hooks) and seen in fish markets in Indonesia, Thailand, Malaysia, Philippines, Pakistan, India, Taiwan, and elsewhere. There are limited data on population declines in these areas, with the exception of the Gulf of Thailand, but the species is susceptible to local inshore fisheries and coral reef habitat loss and damage because of its habitat preferences and limited dispersion. |
| Carcharhiniformes | *Carcharhinus limbatus* | Blacktip Shark | | NT | Fishermen reported catch | The Blacktip Shark is widespread in warm temperate, subtropical and tropical waters. Primarily it is a continental species, although it is found around some oceanic islands. It is widespread in the Indian Ocean from South Africa to western Australia, including the Red Sea and Persian Gulf; and in the Pacific Ocean it is recorded from throughout the Indo-Australian Archipelago, at oceanic islands such as Hawaii, Tahiti and the Marquesas, and in the eastern Pacific from California, USA, to Peru (Garrick 1982, Compagno 1984b, Last and Stevens 1994). |
| Lamniformes | *Odontaspis noronhai* | Bigeye Sand Tiger | Akio ragnaragna | DD | Fishermen reported catch | This shark is very rarely recorded, but apparently with a wide but disjunct distribution in the Atlantic (centre of distribution possibly in Brazilian waters) and Pacific Oceans. A jaw of *O. noronhai* has been collected from the Indian Ocean or South China Sea (Sadowsky *et al.* 1984) and some teeth were also collected from bottom deposits in the central North Pacific, although not clearly identified as *O. noronhai* (Belyaev and Glikman 1970). Presence uncertain: Indian Ocean – |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | western.<br><br>It is so infrequently recorded that its biology and population status is unknown. Its life cycle and biology is likely to be similar to that of *C. taurus*, which has been found to be particularly vulnerable to fisheries, although *Odontaspis noronhai* matures at an even larger size. |
| Carcharhiniformes | *Carcharhinus leucas* | Bull Shark | Boriloha | NT | Fishermen reported catch | The Bull Shark has a worldwide distribution in tropical and warm temperate areas, with seasonal appearances in cool, temperate waters (Garrick 1982, Compagno 1984, Last and Stevens 1994). This has resulted in multiple descriptions and numerous common names for the species (including Zambezi Shark, Swan River Shark and Lake Nicaragua Shark) from throughout its range (see Compagno (1984) for a full list of synonyms).<br><br>Primarily the Bull Shark is an inhabitant of continental shelf waters to a depth of about 150 m (but mostly less than 30 m), but it commonly moves into estuarine and fresh waters. It has been documented as travelling large distances up rivers (Thorson 1972), including the Amazon, Gambia, Ganges, Mississippi, San Juan (and Lake Nicaragua), Tigris and Zambezi. It also has been observed to tolerate hypersaline conditions up to 53 parts per thousand (ppt) (sea water is approximately 35 ppt). Although mostly a continental species, there are insular records from the Philippines and the South Pacific islands of New Caledonia, Fiji and Rangiroa (Compagno *et al.* 1989). |
| Carcharhiniformes | *Triaenodon obesus* | Whitetip Reef Shark | Kivirovola | NT | Fishermen reported catch | The Whitetip Reef Shark is wide ranging in the Indo-Pacific. It occurs along the east coast of Africa from South Africa to Red Sea, Indian Ocean islands, northern Indian Ocean, including India, Sri Lanka, Myanmar, Vietnam, the Philippines, Australia, New Guinea and Polynesia, Melanesia, Micronesia to the Hawaiian Islands and Pitcairn group. The species is also found in the eastern Pacific, Cocos Islands, Galapagos and Panama to Costa Rica (Compagno 1984b). It is found in shallow tropical waters from about 1 m down to 330 m depth, but mainly between 10?40 m (Randall 1977).<br><br>Formally it was abundant over coral reefs, these sharks' numbers are at lower levels than those found prior to widespread expansion of fishing in the past 20 years. The species' restricted habitat, depth range, small litter size and moderately late age at maturity (attain sexual maturity at eight to nine years and live to about 16 years (Randall 1977) suggest that with increasing fishing pressure this species may become threatened. Although its life history pattern suggests a moderate capacity for rebound (Smith *et al.* 1998), heavy fishing pressure inshore |

| | | | | | | |
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| | | | | | | and lack of management plan in most places suggest that this species may be under threat in heavily fished areas, including remote tropical reefs (Anderson *et al.*1998). Its distribution in clear waters over coral reefs makes this species ideal for non-consumptive use in the form of tourism diving, as has been shown in a preliminary analysis by Anderson and Ahmed (1993). |
| Rajiformes | *Pristis microdon* | Largetooth Sawfish, Freshwater Sawfish, Leichhardt's Sawfish, Smalltooth Sawfish | | CE | Likely | A euryhaline species (except in Australia where it has only been recorded in freshwater) of the Indo-Pacific region. It has been recorded from southern Africa to Southeast Asia and the Indo-Australian Archipelago including Australia and the Philippines (Fowler 1941, Wallace 1967, Misra 1969, Paxton *et al.* 1989, Compagno *et al.* 1989, Last and Stevens 1994, Compagno and Cook 1995a).<br><br>It is characterised by extreme and continued vulnerability to fisheries (evidenced by serious declines in virtually all known populations), compounded by habitat loss and degradation over most of its range. Remaining populations are now small, fragmented and Critically Endangered globally. |
| Rajiformes | *Pristis zijsron* | Narrowsnout Sawfish | | CE | Likely | This Indo-Pacific species has been recorded from South Africa to the Persian/Arabian Gulf, Indian subcontinent, Southeast Asia and the Indo-Australian Archipelago (Fowler 1941, Blegvad and Løppenthin 1944, Smith 1945, Bigelow and Schroeder 1953, Stead 1963, Misra 1969, Grant 1972, Paxton *et al.* 1989, Compagno *et al.* in press b, Last and Stevens 1994). Freshwater records have been made from Thailand, possibly in the Tachin River and Songkhla Lake (where the species has not been recorded for many years, Cook and Compagno 1994), Malaysia, Indonesia (Kalimantan at Bandjermassing, Java and Ternate Islands) and in Australia from Queensland in Lake Macquarie, and New South Wales in the Clarence River (Fowler 1941, Smith 1945, Stead 1963, Grant 1972, Paxton *et al.* 1989, Last and Stevens 1994, Compagno *et al.* in press b).<br><br>Like all sawfishes, it is extremely vulnerable to capture by target and bycatch fishing throughout its range, which has contracted significantly as a result. All populations are now very seriously depleted, with records having become extremely infrequent over the last 30 to 40 years. |
| Rajiformes | *Anoxypristis cuspidata* | Knifetooth Sawfish | | CE | Likely | The knifetooth sawfish was historically a relatively common euryhaline or marginal large-bodied sawfish of the Indo-Pacific Region. It has been reported in inshore and estuarine environments from the mouth of the Suez Canal, Egypt, throughout the Red Sea, the Persian |

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| | | | | | | (Arabian) Gulf, the northern Indian Ocean, the Indo-Australian Archipelago from Australia north to Borneo, but not reported from the Philippines (Last and Stevens 1994). In Southeast Asia it was reported from the Gulf of Thailand, Kampuchea (Cambodia) and Vietnam. In eastern Asia it was reported from China to Korea and out to the southern portion of Japan (Honshu), as well as the north west corner of Taiwan (Annandale 1909, Fowler 1941, Blegvad and Loppenthin 1944, Stead 1963, Misra 1969, Chen and Chung 1971, Gloerfelt-Tarp and Kailola 1984, Sainsbury *et al.* 1985, Paxton *et al.* 1989, Last and Stevens 1994, Compagno and Cook 1995a).<br><br>This large sawfish was formerly distributed through much of the Indo-West Pacific region in shallow inshore coastal waters and estuaries. Its morphology, like that of all other sawfishes, makes it disproportionately subject to continued capture in the net gear widely employed throughout its range. It is also vulnerable to habitat loss and damage as a result of human activities. Extensive fishing and this species? K-selected life history have caused substantial reductions in abundance, the fragmentation of remaining populations and the virtual disappearance of this species from commercial catches in regions where it was once considered fairly common. |
| Orectolobiformes | *Rhincodon typus* | Whleshark | | VU | Observed | Whale Sharks are found in all tropical and warm temperate seas except the Mediterranean (Compagno 1984a, Wolfson 1986, Last and Stevens 1994). Although the range of this species typically lies between latitudes 30°N and 35°S, it has occasionally been sighted at latitudes as high as 41°N and 36.5°S (Wolfson 1986). Whale Sharks are known to inhabit both deep and shallow coastal waters and the lagoons of coral atolls and reefs (Demetrios 1979, Wolfson 1983). Iwasaki (1970) reported that they are found in surface seawater temperatures between 18?30°C, but most frequently occur in surface sea-water between 21?25°C. Archival tags have recorded dives to over 700 m and a water temperature of 7.8°C off the coast of Belize (Graham and Roberts in prep.)<br><br>It is the world's largest living chondrichthyan. Its life history is poorly understood, but it is known to be highly fecund and to migrate extremely large distances. Populations appear to have been depleted by harpoon fisheries in Southeast Asia and perhaps incidental capture in other fisheries. High value in international trade, a K-selected life history, highly migratory nature and normally low abundance make this species vulnerable to commercial fishing. Dive tourism involving this species has recently developed in a number of locations around the |

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| | | | | | | world, demonstrating that it is far more valuable alive than fished. |
| Rajiformes | *Dipturus crosnieri* | Madagascar skate | | VU | Observed | A relatively small (to at least 61 cm TL), poorly known, rare deepwater skate with a limited distribution in the Western Indian Ocean off the west coast of Madagascar. Benthic on the continental slope at depths of 300 to 850 m. Virtually nothing is known of the biology of the species. Although its depth range precludes it from capture in most of the industrial trawl fleet targeting shrimp off the west coast of Madagascar, there are presently two boats targeting deepwater shrimp (*Heterocarpus* spp.) operating out of Nosy Be in NW Madagascar. Although bycatch data are not available, this fishery is likely capturing this species. With no market value this small skate is likely discarded with survivorship from capture at such depths being extremely low. Deepsea demersal resources off Madagascar are considered under-utilised at present and as such there is a high likelihood that deepwater fisheries will develop and expand in the Mozambique Channel, following the global trend in expanding deepwater fisheries, particularly as inshore resources are depleted. |
| Rajiformes | *Rostroraja alba* | Bottlenose skate, Spearnose Skate, White Skate, Deep-water skate | | EN | | The overall geographical range of Rostroraja alba covers the Eastern Atlantic coasts from the southern British Isles south to South Africa, including the Mediterranean Sea, and extending into the southwestern parts of Indian Ocean.<br><br>This species is listed as occurring in the Northwestern European seas, however no valid records exist in northern areas of the Northeast Atlantic.<br><br>The size of this large benthic skate renders it particularly susceptible to capture by fishing gears, which in combination with its life history parameters and population demography allow little capacity for it to withstand exploitation by fisheries. This species is likely to be caught as bycatch to multispecies trawl fisheries which operate on much of the continental shelf and slope, coinciding with this species habitat. |
| Coelacanthiformes | *Latimeria chalumnae* | Coelacanth, Gombessa | Coelacanth, Gombessa | CE | Observed | Known as the "living fossil", this species occurs in the Indo-West Pacific in the vicinity of the Grand Comoro and Anjouan islands, the coast of South Africa, Madagascar, and Mozambique. It is listed on CITES Appendix I |
| Testudines | *Dermochelys coriacea* | Leatherback turtle | fano ronto, valo zoro | CE | Observed | The Leatherback turtle has a worldwide distribution. It is found from tropical to sub-polar oceans; nests on tropical (rarely subtropical) beaches. Very little is known about the distribution of post-hatchlings and juveniles. Leatherbacks smaller than 100 cm curved carapace |

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| | | | | | | length seem limited to regions warmer than 26°C. Sightings of turtles less than 145 cm show that some juveniles remain near to the coast in St. Lucia, E. Trop. Pacific, Mexico, Barbados, USA (east and west coast-Georgia, S. Carolina, Texas, Rhode Island, California) Puerto Rico, Amer. Samoa, Bonaire, Chile, Spain, Venezuela, Scotland, and England (Eckert 1999).<br><br>The main procedure for evaluating the status of sea turtles is through surveys of reproduction activity at nesting beaches. Decline in nesting has been documented to be much greater than 80% in most of the populations of the Pacific, which has been considered the species' major stronghold. In other areas of its range, the observed declines are not as severe, with some populations showing trends towards increasing or stable nesting activity. Analysis of published estimates of global population sizes (Pritchard 1982, Spotila *et al.* 1996), suggest a reduction of over 70% for the global population of adult females in less than one generation. The populations in the Pacific Ocean, the species' stronghold until recently, have declined drastically in the last decade, with current annual nesting female mortalities estimated at around 30% (Sarti *et. al.* 1996, Spotila *et al.* 2000). In some areas, formerly abundant rookeries have almost disappeared. For the Atlantic Ocean, the available information demonstrates that the largest population is in the French Guyana but the trends there are unclear. Some of the Caribbean nesting populations appear to be increasing but their sizes are very small when compared to those that nested in the Pacific coasts less than 10 years ago. |
| Testudines | *Caretta caretta* | Loggerhead turtle | fano apombo | E | Observed | Wide ranging species **Native to** Albania; Algeria; Australia; Bahamas; Bahrain; Bangladesh; Belize; Brazil; Cayman Islands; China; Colombia; Costa Rica; Cuba; Cyprus; Dominican Republic; Egypt; Eritrea; France; Greece; Grenada; Guadeloupe; Guatemala; Haiti; Honduras; Indonesia; Israel; Italy; Jamaica; Japan; Libyan Arab Jamahiriya; Madagascar; Mexico; Montserrat; Morocco; Mozambique; Namibia; New Caledonia; Nicaragua; Oman; Panama; Philippines; Puerto Rico; Saint Lucia; Senegal; South Africa; Spain (Canary Is.); Sri Lanka; Tunisia; Turkey; Turks and Caicos Islands; United States; Uruguay; Venezuela; Virgin Islands, British<br><br>**Presence uncertain:**<br>Angola; Cape Verde; India; Myanmar; Papua New Guinea<br><br>Documentation about the rationale for listing, habitats, threats, etc. is not yet available. |

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| Testudines | *Eretmochelys imbricata bissa* | Hawksbill turtle | fano hara | CE | Observed | The Hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic Ocean, Indian Ocean, and Pacific Ocean. Hawksbills are migratory and individuals undertake complex movements through geographically disparate habitats during their lifetimes. Hawksbill nesting occurs in at least 70 countries, although much of it now only at low densities. Their movements within the marine environment are less understood, but Hawksbills are believed to inhabit coastal waters in more than 108 countries (Groombridge and Luxmoore 1989, Baillie and Groombridge 1996).<br><br>Analysis of historic and recent published and unpublished accounts indicate extensive subpopulation declines in all major ocean basins over the last three Hawksbill generations as a result of over-exploitation of adult females and eggs at nesting beaches, degradation of nesting habitats, take of juveniles and adults in foraging areas, incidental mortality relating to marine fisheries, and degradation of marine habitats. Analyses of subpopulation changes at 25 Index Sites distributed globally (see W-Figure 1 in attached PDF) show an 84 to 87% decline in number of mature females nesting annually over the last 3 Hawksbill generations. Numerous populations, especially some of the larger ones, have continued to decline since the last assessment of the species (Meylan and Donnelly 1999). Today, some protected populations are stable or increasing, but the overall decline of the species, when considered within the context of three generations, has been in excess of 80%. |
| Testudines | *Chelonia mydas* | Green turtle | fano zaty, fano omby | E | Observed | The Green Turtle has a circumglobal distribution, occurring throughout tropical and, to a lesser extent, subtropical waters (Atlantic Ocean – eastern central, northeast, northwest, southeast, southwest, western central; Indian Ocean – eastern, western; Mediterranean Sea; Pacific Ocean – eastern central, northwest, southwest, western central). Green turtles are highly migratory and they undertake complex movements and migrations through geographically disparate habitats. Nesting occurs in more than 80 countries worldwide (Hirth 1997). Their movements within the marine environment are less understood but it is believed that green turtles inhabit coastal waters of over 140 countries (Groombridge and Luxmoore 1989).<br><br>Analysis of historic and recent published accounts indicate extensive subpopulation declines in all major ocean basins over the last three generations as a result of overexploitation of eggs and adult females at nesting beaches, juveniles and adults in foraging areas, and, to a lesser |

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| | | | | | | extent, incidental mortality relating to marine fisheries and degradation of marine and nesting habitats. Analyses of subpopulation changes at 32 Index Sites distributed globally (Figure 1, Table 1; see link to additional information below) show a 48% to 67% decline in the number of mature females nesting annually over the last 3–generations. |
| Testudines | *Lepidochelys olivacea* | Olive Ridley turtle | fano tsakoi | VU | Observed | The Olive Ridley sea turtle has a circumtropical distribution, with nesting occurring throughout tropical waters (except the Gulf of Mexico) and migratory circuits in tropical and some subtropical areas (Atlantic Ocean – eastern central, northeast, northwest, southeast, southwest, western central; Indian Ocean – eastern, western; Pacific Ocean – eastern central, northwest, southwest, western central) (Pritchard 1969). Nesting occurs in nearly 60 countries worldwide. Migratory movements are less well studied than other marine turtle species but are known to involve coastal waters of over 80 countries (see Table 1 in the attached PDF, see link below). With very few exceptions they are not known to move between ocean basins or to cross from one ocean border to the other. Within a region, Olive Ridleys may move between the oceanic and neritic zones (Plotkin *et al.*1995, Shanker *et al.* 2003) or just occupy neritic waters (Pritchard 1976, Reichart 1993).<br><br>Like other long-lived species, Olive Ridleys are prone to population declines because of slow intrinsic growth rate in combination with anthropogenic impacts. These can accumulate over a protracted development through various life stages, multiple habitats (nesting beaches, migratory routes and pelagic foraging zones) and vast geographic expanses.<br><br>Olive Ridleys and their eggs have been harvested, mostly unsustainably, worldwide. However, the current impact is difficult to evaluate because of other simultaneous factors such as incidental take in commercial fisheries. Nonetheless, there is documentation of recent egg use causing declines (Cornelius *et al.* 2007). . Human use of turtle eggs for consumption and domestic animal consumption historically was widespread in the Indian Ocean and continues today largely wherever Ridleys nest (Cornelius *et al.* 2007). Olive Redley's also face threats from direct take of adults, bycatch in fisheries, habitat impacts, and disease and predation. |
| Cetartiodactyla | *Megaptera novaeangliae* | Humpback whales | | LC | Observed | Humpbacks are abundant throughout the Antarctic in summer south to the ice edge, but not within the pack ice zone. In the winter, Southern |

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| | | | | | | Hemisphere whales aggregate into specific nearshore breeding areas in the Atlantic, Indian Ocean and Pacific, two of which extend north of the equator, i.e. off Colombia in the eastern Pacific and in the Bight of Benin in the Atlantic. Some wintering grounds are fairly localized, e.g. around island groups, and some are more diffuse, e.g. along the western coast of southern Africa and the southern coast of West Africa.<br><br>Although no final assessment of the current global population relative to its 1940 level is available, it seems, based on the recent rates of increase, unlikely that it is below the threshold (50% of the 1940 level) that would qualify the species for inclusion in the Vulnerable category under criterion A, The available population estimates total more than 60,000 animals, well above the C and D criteria thresholds for the Vulnerable category. The range of the humpback whale is not restricted, and therefore the species does not qualify for inclusion under Criterion B. The species is therefore listed as Least Concern. Completion of the ongoing Comprehensive Assessment by the IWC Scientific Committee will enable a more accurate determination of the level of recovery of the species.<br><br>The reasons for the change to Least Concern from the previous classification of Vulnerable (VU A1abd) are threefold:<br>(i) in the areas for which data are available, the population has continued to increase in the 10 years since the previous assessment;<br>(ii) abundance and trend data are available for more areas than were available for the previous assessment;<br>(iii) the criteria for Vulnerable have been changed: the threshold reduction for the A1 criterion has been changed from 20% to 50%.<br><br>Despite the encouraging global status, concern remains about apparently discrete and small subpopulations of humpback whales for which information about status is lacking. These include the Arabian Sea (isolated from the southern Indian Ocean), the western North Pacific, the west coast of Africa, and the South Pacific subpopulations in portions of Oceania (breeding stocks E and F) that likely feed in Antarctic Areas V and VI. |
| Cetartiodactyla | *Physeter macrocephalus* | Sperm whale | | VU | Observed | The sperm whale has a large geographic range (Rice 1989). It can be seen in nearly all marine regions, from the equator to high latitudes, but is generally found in continental slope or deeper water. The distribution extends to many enclosed or partially-enclosed seas, such as the Mediterranean Sea, Sea of Okhotsk, Gulf of California, and Gulf |

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| | | | | | | of Mexico.<br><br>A peer-reviewed publication (Whitehead 2002) provides a model-based estimate of global trend that can be used to evaluate the population under the A1 criterion. The results from that study gave a 6% probability for Endangered, a 54% probability of meeting the Vulnerable category, and a 40% probability of falling into the Near Threatened category. The results suggest little chance that the population would meet the criteria for Endangered or for Least Concern. There is credible and realistic evidence for either the Vulnerable or Near Threatened category. Given that the results give greater probability for at least the Vulnerable category (60%), and that this is the more precautionary category, the species is classified as Vulnerable. |
| Cetartiodactyla | *Tursiops truncatus* | Bottlenose dolphin | | LC | Observed | Common bottlenose dolphins are distributed worldwide through tropical and temperate inshore, coastal, shelf, and oceanic waters (Leatherwood and Reeves 1990; Wells and Scott 1999; Reynolds *et al.* 2000). Bottlenose dolphins generally do not range pole-ward of 45°except in northern Europe (as far as the Faroe Islands 62°N 7°W - Bloch and Mikkelsen 2000) and to southern New Zealand. The species is rare in the Baltic Sea (it may best be considered extralimital there) and is vagrant to Newfoundland and Norway (Wells and Scott 1999).<br><br>Although there are many threats operating on local populations, the species is widespread and abundant, and none of these threats is believed to be resulting in a major global population decline. |
| Cetartiodactyla | *Stenella longirostris* | Spinner Dolphin, Long-beaked Dolphin, Long-snouted Dolphin | | DD | Observed | The spinner dolphin ranges through tropical and subtropical zones in both hemispheres. Limits are near 40°N and 40°S. *S. l. longirostris* occurs mainly around oceanic islands in the tropical Atlantic, Indian, and western and central Pacific east to about 145°W (Rice 1998).<br><br>Throughout their range, spinner dolphins are taken as bycatch in purse-seine, gillnet, and trawl fisheries (Perrin *et al.* 1994; Donahue and Edwards 1996), often in high numbers. Spinner dolphins are the most abundant dolphin in the Indian Ocean (Balance and Pitman 1998) and are taken throughout the region. In the Indian Ocean, annual takes of hundreds of spinner dolphins have been reported bycaught in the few fisheries that have been examined in India (Lal Mohan 1994), and annual takes in the thousands have been reported in Sri Lanka (Leatherwood and Reeves 1991; Lal Mohan 1994). Takes in other areas are unknown, but may be substantial. |

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| Cetartiodactyla | *Stenella attenuata* | Pantropical Spotted Dolphin | | LC | Observed | *S. a. attenuata* is pantropical, found in all oceans between about 40°N and 40°S, although it is much more abundant in the lower-latitude portions of its range. The range extends to some enclosed seas, such as the Red Sea and Persian Gulf, but does not include the Mediterranean Sea (Perrin 2001, 2002).<br><br>The abundance estimates available total more than 2.5 million, and additional likely large populations in the Atlantic, Indian and Pacific Oceans have not been assessed. The northeastern population in the ETP declined 76% within the last three generations (69 years), but that decline has ceased and was not large enough to constitute a global decline of 30%. Large impacts of direct catch and bycatch in other regions have not been identified, and it is unlikely that the global population has been reduced by as much as 30%. Therefore, the species is assesed as Least Concern. |
| Cetartiodactyla | *Stenella coeruleoalba* | Striped Dolphin | | LC | Observed | This is a widely-distributed species, found in tropical and warm-temperate waters of the Atlantic, Pacific, and Indian oceans, as well as many adjacent seas, including the Mediterranean. Northern and southern range limits are about 50°N and 40°S, although there are extralimital records from the Kamchatka Peninsula, southern Greenland, Iceland, the Faroe Islands, and the Prince Edward Islands. Given the estimated population of over 2 million individuals worldwide, despite mortality due to direct and incidental takes in many parts of the world, there is no evidence of a major global decline that would warrant listing in a category of threat. |
| Cetartiodactyla | *Tursiops aduncus* | Indo-pacific Bottlenose Dolphin | | DD | Observed | The Indo-Pacific Bottlenose Dolphin has a discontinuous distribution in the warm temperate to tropical Indo-Pacific, from South Africa in the west, along the rim of the Indian Ocean (including the Red Sea, Persian Gulf and Indo-Malay Archipelago as far east as the Solomon Islands and possibly New Caledonia) to the southern half of Japan and southeast Australia in the east (Wells and Scott 2002; Möller and Beheregaray 2001). It is also found around oceanic islands distant from major land masses within this range.<br><br>Although the species is widespread in Indo-pacific coastal waters and its aggregate abundance is probably in the tens of thousands in multiple local populations, habitat destruction and incidental takes (of unknown but possibly large magnitude) may have a significant impact on this species. However, the lack of available information precludes an assessment of this impact. |

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| Cetartiodactyla | *Sousa chinensis* | Indo-Pacific humpback dolphin | | NT | Observed | Currently, all Indo-Pacific Humpback Dolphins are considered to be part of a single widespread and highly variable species, *Sousa chinensis*. Some biologists consider Humpback Dolphins in the Indo-Pacific to consist of two species: *S. plumbea* in the western Indian Ocean, from South Africa to at least the east coast of India, and *S. chinensis*, from the east coast of India to China and Australia.<br><br>The *plumbea*-type is found in a narrow strip of coastal waters from southwestern tip of South Africa eastward around the rim of the Indian Ocean to the southeastern coast of India (Jefferson and Karczmarski 2001; Ross 2002; IWC 2003). It occurs off Madagascar, Mayotte and the Comoro Islands and around the Arabian Peninsula from the Red Sea into the Arabian (Persian) Gulf and east to Pakistan. There is an extralimital record from Israel in the Mediterranean Sea (apparently a stray that moved through the Suez Canal from the Red Sea – Kerem *et al.* 2001). In the region between northeastern India and Myanmar (Burma) *plumbea*-type and *chinensis*-type dolphins are partially sympatric.<br><br>*Plumbea*-type<br>All available abundance estimates for *plumbea*-type humpback dolphins are low (fewer than 500 individuals), and the total number across their range is unlikely to exceed 10,000 individuals. The distribution is discontinuous across most of the range, with probably discrete local subpopulations. Ongoing environmental degradation and loss of key habitats is likely further fragmenting the aggregate population. Exposure to serious environmental stressors throughout their range makes *plumbea*-type dolphins highly vulnerable, and there are indications of considerable declines in at least some locations. Conservation actions currently are either meager or non-existent throughout the range. It is possible that the decline of *plumbea*-type animals has been large and pervasive enough throughout their range to cause a net reduction of at least 30% over a period of 3 generations (about 60 years; see Taylor *et al.* 2007) including the past and future. The *plumbea*-type geographic form would qualify for Vulnerable (C2a(i) and possibly also A4cd) if it were assessed separately. |
| Cetartiodactyla | *Grampus griseus* | Risso's Dolphin | | LC | Observed | This is a widely-distributed species, inhabiting primarily deep waters of the continental slope and outer shelf (especially with steep bottom topography), from the tropics through the temperate regions in both hemispheres (Kruse *et al.* 1999). It also occurs in some oceanic areas, beyond the continental slope, such as in the eastern tropical Pacific. It is found from Newfoundland, Norway, the Kamchatka Peninsula, and |

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| | | | | | | Gulf of Alaska in the north to the tips of South America and South Africa, southern Australia, and southern New Zealand in the south. Its range includes many semi-enclosed bodies of water, such as the Gulf of Mexico, Gulf of California, Red Sea, Persian Gulf, Sea of Japan, and Mediterranean Sea.<br><br>As with similar species, threats that could cause widespread declines include high levels of anthropogenic sound, especially military sonar and seismic surveys, and bycatch. Threats that could cause declines include entanglement in fisheries and competition with squid fisheries. The combination of the large global range and high abundance with possible declines driven by these more localized threats is believed sufficient to rule out a 30% global reduction over three generations (60 years; Taylor *et al.* 2007) (criterion A). |
| Cetartiodactyla | *Ziphius cavirostris* | Cuvier's Beaked Whale | | LC | Observed | Cuvier's beaked whales may have the most extensive range of any beaked whale species (Heyning 1989, 2002). They are widely distributed in offshore waters of all oceans, from the tropics to the polar regions in both hemispheres. Their range covers most marine waters of the world, with the exception of shallow water areas, and very high-latitude polar regions. They are found in many enclosed seas, such as the Gulf of California, Gulf of Mexico, Caribbean Sea, Sea of Japan, and the Sea of Okhotsk (but not in the Baltic or Black Seas). This is the only species of beaked whale regularly found in the Mediterranean Sea (Podesta *et al.* 2006).<br><br>Global trend or abundance data for this species are unavailable but abundance is at least 100,000. This species also has a very large range. As with other beaked whales, threats that could cause widespread declines include high levels of anthropogenic sound, especially military sonar and seismic surveys, and bycatch. The combination of the large global range and relatively high abundance with possible declines driven by more localized threats is believed sufficient to rule out a 30% global reduction over three generations (criterion A). |
| Cetartiodactyla | *Balaenoptera physalus* | Fin whale | | EN | Observed | Fin whales occur worldwide, mainly, but not exclusively, in offshore waters. They are rare in the tropics, except in certain cool-water areas, such as off Peru.<br><br>The cause of the population reduction in this species (commercial whaling) is reversible, understood, and is not currently in operation. For this reason, the species is assessed under criterion A1, not under A2, A3 or A4. The analysis in this assessment estimates that the global population has declined by more than 70% over the last three |

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| | | | | | | generations (1929-2007), although in the absence of current substantial catches it is probably increasing. Most of the global decline over the last three generations is attributable to the major decline in the Southern Hemisphere. The North Atlantic subpopulation may have increased, while the trend in the North Pacific subpopulation is uncertain. |
| Cetartiodactyla | *Balaenoptera edeni* | Bryde's whale | | DD | Observed | The taxonomy (number and identity of species) is not yet resolved. If there is more than one species, the less abundant species may be threatened. If it is all one species, then it should be classified as Least Concern.<br><br>Because the number of species or subspecies is still unresolved, and because the different forms are not readily distinguishable at sea, considerable uncertainty remains with regard to the geographic range of each form.<br><br>*Ordinary Bryde's whales*<br>"Ordinary" large-type Bryde's whales occur in the Pacific, Indian and Atlantic oceans between about 40°N and 40°S or in waters warmer than 16.3°C (Kato 2002). Migration to equatorial waters in winter is documented for the southeast Atlantic population (Best 1996) and for the northwest Pacific population (Kishiro 1996). Migration patterns of other populations are poorly known<br><br>They are relatively common in the western North Pacific, mainly north of 20°N in summer and south of 20°N in winter. In the eastern North Pacific, they do not venture north of southern California (US), but there appears to be a resident population in the northern Gulf of California (Urbán and Flores 1996), and they occur throughout the eastern tropical Pacific (Wade and Gerrodette 1993). They occur throughout the tropical Pacific, and across the South Pacific down to about 35°S, but with shifts in distributions between seasons (Miyashita *et al.* 1995). They occur off the coasts of Peru and Ecuador but not during July to September (Valdivia *et al.* 1981), and off Chile in an upwelling area between 35°-37°S (Gallardo *et al.* 1983). In the southwestern Pacific, their distribution extends as far south as the North Island of New Zealand (Thompson *et al.* 2002).<br><br>Bryde's whales occur throughout the Indian Ocean north of about 35°S. Those in the southern Indian Ocean appear to be large-type animals (Ohsumi 1980b), as are the Bryde's whales of the northwest Indian Ocean, which were taken illegally by Soviet whaling fleets in the 1960s |

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| | | | | | | (Mikhalev 1997), and those around the Maldives (Anderson 2005).<br><br>The Bryde's whale was the incidental beneficiary of IWC area restrictions on factory ship whaling that were originally designed to protect the low-latitude winter breeding grounds of other baleen whale species, at a time when the Bryde's whale was not yet recognised as a distinct species by the whaling industry (Tønnessen and Johnsen 1982). The Bryde's whale is included in Appendix I of CITES although Japan has held a reservation against this listing since 1983. The species (as *B. edeni*) is listed in Appendix II of CMS. |
| Cetartiodactyla | *Balaenoptera borealis* | Sei whale | | EN | Likely | The sei whale is a cosmopolitan species, with a mainly offshore distribution, occurring in the North Atlantic, North Pacific and Southern Hemisphere, but probably not in the Northern Indian Ocean (Rice 1998); it is an occasional visitor to the Mediterranean (Reeves and Notarbartolo di Sciara 2006). Sei whales migrate between tropical and subtropical latitudes in winter and temperate and subpolar latitudes in summer, staying mainly in water temperatures of 8-–18°C, and tend not to penetrate to such high latitudes as other rorquals. Their winter distribution seems to be widely dispersed and is not fully mapped (Horwood 1987, 2002).<br><br>The summer (Jan–Feb) distribution in the southern hemisphere is mainly in the zone 40–50°S in the South Atlantic and southern Indian oceans, and 45–60°S in the South Pacific (Miyashita *et al.* 1995). Known wintering grounds include a number of former low–latitude whaling grounds, including northeastern Brazil at 7°S (da Rocha 1983), Peru at 6°S (Valdivia *et al.* 1982), and in earlier years off Angola and the Congo (IWC 2006). Catches off western South Africa (Donkergat) and eastern South Africa (Durban) showed peaks in spring and autumn, suggestive of populations on migration routes (Horwood 1987). |
| Cetartiodactyla | *Peponocephala electra* | Melon-headed Whale | | LC | Likely | Melon-headed whales have a pantropical distribution (Perryman 2002). The distribution coincides almost exactly with that of the pygmy killer whale in tropical/subtropical oceanic waters between about 40°N and 35°S (Jefferson and Barros 1997). A few high-latitude strandings are thought to be extralimital records, and are generally associated with incursions of warm water. These include specimens from Cornwall in England, Cape Province in South Africa, and Maryland, USA (Perryman *et al.* 1994; Rice 1998).<br><br>Global trend or abundance data for this species are unavailable, however, abundance is at least 50,000. Threats that could cause |

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| | | | | | | widespread declines include high levels of anthropogenic sound, especially military sonar and seismic surveys, and localized competition with fisheries. The combination of the high global abundance and a large pan-tropical range with possible declines driven by more localized threats is believed sufficient to rule out a 30% global reduction over three generations (criterion A). |
| Cetartiodactyla | *Feresa attenuate* | Pygmy killer whale | | DD | Likely | This is a tropical/subtropical species that inhabits oceanic waters around the globe generally between 40°N and 35°S. It does not generally approach close to shore, except in some areas where deep, clear waters are very close to the coast (such as around oceanic archipelagos like Hawaii).<br><br>This species is naturally uncommon. The combination of potential declines driven by impacts from high intensity anthropogenic sounds and bycatch in fisheries is believed sufficient that a 30% global reduction over three generations cannot be ruled out. |
| Cetartiodactyla | *Globicephala macrorhynchus* | Short-finned Pilot Whale, Pacific Pilot Whale | | DD | Likely | Short-finned pilot whales are found in warm temperate to tropical waters of the world, generally in deep offshore areas (Reilly and Shane 1986; Olson and Reilly 2002). They do not usually range north of 50°N or south of 40°S. There is some distributional overlap with their long-finned relatives (G. melas is the only other species currently recognized), which appear to prefer cold temperate waters of the North Atlantic, Southern Hemisphere, and previously the western North Pacific.<br><br>The short-finned pilot whales are treated as one species even though there is evidence that it may be a complex of two or more species. If it is so designated, the classification may change. If taxonomic designations change, then it is suspected that some new species may warrant listing under higher categories of risk. Because additional data should resolve this taxonomic uncertainty, the current species is listed as DD. Primary threats that could cause widespread declines include entanglement in fisheries and noise. Hunting is localized and has not had a high impact on the status of the species globally. However, if this does represent a species complex, then these as yet unnamed taxonomic units could be at risk levels warranting threatened category listing. The combination of possible declines driven by these factors is believed sufficient that a 30% global reduction over three generations (71 years; Taylor *et al.* 2007) cannot be ruled out. |
| Cetartiodactyla | *Pseudorca* | False killer | | DD | Likely (primarily near fringing reefs | False killer whales are found in tropical to warm temperate zones, generally in relatively deep, offshore waters of all three major oceans. |

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| | *crassidens* | whale | | | and in bays along the West coast of Madagascar and could occur in the Barren Isles) | They do not generally range into latitudes higher than 50° in either hemisphere. However, some animals occasionally move into higher latitude waters. They are found in many semi-enclosed seas and bays (including the Sea of Japan, Bohai/Yellow Sea, Red Sea, and Persian Gulf), but they only occasionally occur in the Mediterranean Sea (Leatherwood *et al.* 1989). There are a few records for the Baltic Sea, which are considered extralimital. There are also records of false killer whales being found far into large rivers in China.<br><br>Global trend or abundance data for this species are unavailable. Threats that could cause widespread declines include high levels of anthropogenic sound, especially military sonar and seismic surveys, and bycatch. Bycatch is particularly worrisome because of known unsustainable levels where fisheries are monitored in Hawaii and the presence of similar fisheries throughout the range of the species. The relative rarity of this species implied from the existing records makes it potentially vulnerable to low-level threats. The combination of possible declines driven by vulnerability to high-level anthropogenic sound sources and bycatch is believed sufficient that a 30% global reduction over three generations cannot be ruled out (criterion A). |
| Cetartiodactyla | *Eubalaena australis* | Southern Right Whale | | LC | Likely (have been recorded in Malagasy waters and the Mozambique Channel and could potentially occur in the coastal waters off of the Barren Isles) | Southern right whales have a circumpolar distribution in the Southern Hemisphere. The distribution in winter, at least of the breeding component of the population, is concentrated near coastlines in the northern part of the range. Major current breeding areas are nearshore off southern Australia, New Zealand (particularly Auckland Islands and Campbell Islands), Atlantic coast of South America (Argentina and Brazil), and southern Africa (mainly South Africa). Small numbers are also seen off central Chile, Peru, Tristan da Cunha (British Overseas Territory), and the east coast of Madagascar (IWC 2001, Rosenbaum *et al.* 2001). In summer right whales are found mainly in latitudes 40-50°S (Ohsumi and Kasamatsu 1986) but have been seen, especially in recent years, in the Antarctic as far south as 65°S (IWC 2007, Bannister *et al.* 1999) and around South Georgia (Rowntree *et al.* 2001).<br><br>Given the recent estimated population size (1,600 mature females in 1997, and approximately twice that number in 2007) and the strong observed rate of increase in some well-studied parts of the range, the species, although still scarce relative to its historic abundance, is not considered under threat at the hemispheric level. The population is estimated to be higher now than it was three generations (87 years, assuming a generation time of 29 years; Taylor *et al.* 2007) ago. Some breeding populations, in particular that off Chile/Peru (see separate |

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| | | | | | | listing), are still very small and may need special protection to become re-established. |
| Cetartiodactyla | *Balaenoptera acutorostrata* | Common minke whale | | LC | Likely (Unconfirmed reports, historical accounts and suspected ranges) | The common minke whale is a cosmopolitan species found in all oceans and in virtually all latitudes, from 65°S to 80°N. In parts of its range it is very abundant, in other parts much less so. Its migration patterns are poorly known. It occurs in the North Atlantic, the North Pacific, and the Southern Hemisphere, but is not known from the northern Indian Ocean.<br><br>Much of the data on the occurrence of minke whales in the Southern Hemisphere is ambiguous with respect to identification as *B. acutorostrata* or *B. bonaerensis*, because the two species are partially sympatric. Japanese scouting vessel data indicated high abundance of minke whales in November between 10°-30°S in the central South Pacific and in much of the eastern and southern Indian Ocean down to 50°S (Miyashita *et al.* 1995), but their species identity is unclear.<br><br>There is no estimate of total global population size, but estimates from parts of the range in the Northern Hemisphere (totaling in excess of 100,000 individuals) show that it is well above the thresholds for a threatened category. While declines have been detected or inferred in some areas, there is no indication that the global population has declined to an extent that would qualify for a threatened category. |
| Cetartiodactyla | *Feresa attenuata* | Pygmy killer whale | | DD | Likely (unconfirmed reports) | This is a tropical/subtropical species that inhabits oceanic waters around the globe generally between 40°N and 35°S. It does not generally approach close to shore, except in some areas where deep, clear waters are very close to the coast (such as around oceanic archipelagos like Hawaii). A few high-latitude strandings and sightings are thought to be extralimital records, and are generally associated with incursions of warm water (Ross and Leatherwood 1994; Donohue and Perryman 2002; Williams *et al.* 2002).<br><br>This species is naturally uncommon. The combination of potential declines driven by impacts from high intensity anthropogenic sounds and bycatch in fisheries is believed sufficient that a 30% global reduction over three generations cannot be ruled out. |
| Cetartiodactyla | *Orcinus orca* | Killer whale | | DD | Likely (unconfirmed reports, historical accounts and suspected ranges) | The killer whale is the most cosmopolitan of all cetaceans and may be the second-most widely-ranging mammal species on the planet, after humans (Rice 1998). Killer whales can be seen in virtually any marine region, from the equator to polar waters. Although they are generally more common in nearshore areas and in higher-productivity areas and/or higher latitudes, there appear to be no hard and fast restrictions |

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| | | | | | | of water temperature or depth on their range.<br><br>This taxonomic unit is treated as one species even though there is evidence that it may be a complex of two or more species. If it is so designated, the category of this taxon may change. If taxonomic designations change, then it is suspected that some new species may warrant listing under higher categories of risk. Because additional data should resolve this taxonomic uncertainty, the current species is listed as DD. The combination of potential declines driven by depletion of prey resources and the effects of pollutants is believed sufficient that a 30% global reduction over three generations (77 years; Taylor *et al.* 2007) cannot be ruled out for some "groups" that may be designated as species. |
| Ciconiiformes | *Ardea humbloti* | Madagascar Heron, Humblot's Heron | | EN | Observed | *Ardea humbloti* breeds only in **Madagascar** but is recorded also on the **Comoro Islands** (where it possibly breeds) and **Mayotte (to France)**. In 1973, it was reported to have declined alarmingly and to be facing extinction unless completely protected. More recently it has been found to be fairly common (though patchily distributed) in parts of north and west Madagascar, and uncommon in the south[1]. It is also seen regularly at Lake Alaotra[5]. Total numbers are now believed to number 1,000-3,000[6].<br><br>This species is listed as Endangered because it has a very small population which is undergoing continuing declines owing to overexploitation and loss and degradation of its wetland habitats. |
| Charadriiformes | *Sterna dougallii* | Roseate Tern | | LC | Observed | This species breeds in widely but sparsely distributed colonies along the east coast and offshore islands of Canada, USA, from Honduras to Venezuela, possibly to Brazil, the Caribbean (including the Bahamas, Greater and Lesser Antilles and the West Indies), UK, France, Ireland, Portugal (Azores, Salvages and perhaps Madeira), Spain (Canary Islands), South Africa, Kenya, Somalia, Madagascar, Oman, Seychelles, St Brandon and the Mascarene Islands (Mauritius), Maldives, Chagos (British Indian Ocean Territory), Andaman and Nicobar Islands (India), Sri Lanka, Ryukyu Islands (Japan), Indonesia, Fiji, Solomon Islands, New Guinea (Papua New Guinea), New Caledonia (to France) and Australia (del Hoyo *et al.* 1996, Snow and Perrins 1998).<br><br>This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). The population trend is |

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| | | | | | | not known, but the population is not believed to be decreasing sufficiently rapidly to approach the thresholds under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern. |
| Charadriiformes | *Sterna anaethetus* | Bridled Tern | | LC | Observed | This species has a very large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). The population trend is not known, but the population is not believed to be decreasing sufficiently rapidly to approach the thresholds under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern. |
| Charadriiformes | *Anous stolidus* | Brown Noddy, Common Noddy | | LC | Observed | This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). The population trend appears to be stable, and hence the species does not approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern. |
| Charadriiformes | *Sterna fuscata* | Sooty tern | | LC | Observed | This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). The population trend is not known, but the population is not believed to be decreasing |

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| | | | | | | sufficiently rapidly to approach the thresholds under the population trend criterion (>30% decline over ten years or three generations). The population size is extremely large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern.<br><br>This species has been observed nesting in the Barren Isles |
| Pelecaniformes | *Fregata minor* | Greater Frigatebird, Great Frigatebird | | LC | Winter migrants have been observed passing through the Barren Isles | Native:<br><br>American Samoa; Australia; Brazil; British Indian Ocean Territory; Brunei Darussalam; Chile; China; Christmas Island; Cocos (Keeling) Islands; Colombia; Comoros; Costa Rica; Ecuador; Fiji; French Polynesia; Guam; India; Indonesia; Japan; Kenya; Madagascar; Malaysia; Maldives; Marshall Islands; Mayotte; Mexico; Micronesia, Federated States of; Mozambique; Nauru; New Caledonia; Northern Mariana Islands; Palau; Philippines; Réunion; Russian Federation; Seychelles; Solomon Islands; Somalia; South Africa; Sri Lanka; Taiwan, Province of China; Tanzania, United Republic of; Thailand; Timor-Leste; United States; United States Minor Outlying Islands; Vanuatu; Wallis and Futuna<br><br>Although this species may have a restricted range, it is not believed to approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern. |
| Pelecaniformes | *Fregata ariel* | Lesser frigatebird | | LC | Observed (winter migrants that have been recorded passing through the isles) | **Native:**<br>Australia; Brazil; British Indian Ocean Territory; Brunei Darussalam; China; Christmas Island; Cocos (Keeling) Islands; Comoros; Fiji; French Polynesia; India; Indonesia; Japan; Kiribati; Korea, Republic of; Madagascar; Malaysia; Maldives; Marshall Islands; Mauritius; |

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| | | | | | | Mayotte; Micronesia, Federated States of; Nauru; New Caledonia; Northern Mariana Islands; Palau; Philippines; Réunion; Seychelles; Singapore; Solomon Islands; Sri Lanka; Taiwan, Province of China; Tanzania, United Republic of; Thailand; Timor-Leste; Tonga; United States; United States Minor Outlying Islands; Vanuatu; Viet Nam; Wallis and Futuna<br><br>**Vagrant:**<br>Djibouti; Eritrea; Israel; Jordan; Kenya; Mozambique; New Zealand; Oman; Somalia<br><br>This species has a very large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern. |
| Charadriiformes | *Anous tenuirostris* | Lesser Noddy, Sooty Noddy | | LC | Observed (aerial survey) | This species breeds in the Seychelles, Mascarene Islands and Agalega Islands (Mauritius), Maldives, the Chagos Archipelago (British Indian Ocean Territory), and Houtman Albrolhos Islands and possibly Ashmore Reef (Australia) (Feare 1984, Higgins and Davies 1996). The Australian subspecies melanops may be resident. The nominate race is a winter visitor to Madagascar and the eastern African coast between southern Somalia and Kenya (Higgins and Davies 1996).<br><br>Although this species may have a small range, it is not believed to approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). The population trend appears to be stable, and hence the species does not approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size is extremely large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature |

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| | | | | | | individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern. |
| Charadriiformes | *Sterna fuscata* | Sooty Tern | | LC | Observed | This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). |
| Falconiformes | *Haliaeetus vociferoides* | Madagascar Fish-eagle, Madagascar Fish Eagle | | CE | Observed | This species survives in low numbers along the west coast of **Madagascar**. Surveys during 1991-1995 recorded at least 222 adults and 99 breeding pairs from 105 sites, apparently concentrated into three main regions: the Antsalova region west of Bemaraha Reserve, along the Tsiribihina River, and the coast from Mahajamba Bay to the island of Nosy Hara. Although this estimate is twice of an estimate from the period 1980-1985 it is probably due to more comprehensive surveying, and a decline in some areas was still recorded. Recent surveys suggest that the Antsalova district is the main stronghold, with 12 pairs in the Manambolomaty complex and a further 15 pairs elsewhere in the district in 2008, and the population is currently thought to comprise c.120 breeding pairs. Immature birds wander widely, making the non-breeding population difficult to assess. |