2. BIOPHYSICAL ENVIRONMENT

2.1 Description of the coasts and distinctive features

In terms of shoreline changes, marine and coastal erosion affects the coast of Madagascar at several places. Morondava, Manakara and Mahajanga are most affected by coastal erosion. If the cases of Manakara and Mahajanga seem recent, the city of Morondava is for a long time in conflict with the sea. It is the reason of the presence of these enormous breakwaters on the beach of the city, intended to limit the effects of marine erosion.

In addition, sedimentation is also responsible for the modification of shorelines (Bowuen 1967). The most spectacular effects are often observed in estuaries and mouths of major rivers. The Bay of Betsiboka is an example of this phenomenon. The river carries huge quantities of reddish orange silt which are deposited in large quantities at the mouth or bay as the flow slows when the river meets the sea. In the Southwest, the same phenomenon occurs at the mouth of the river Fiherenana, resulting in silting of reef flats and the mangrove forest nearby (Bemiasa 2009).

2.2 General description of the climate

- Floods following heavy rains which often accompany cyclones and hurricanes affect low-lying areas, such as basins and slums of cities. Flood in rivers and coastline have also been observed.
- Tropical Storms and Cyclones
- Drought and famine

The maps below show the annual variability in rainfall around Madagascar and drought indexes that result from it. The data and information on natural disasters, tropical storms and cyclones that struck Madagascar from 1968 to 1999 are summarized in Tables 1, 2 and 3.

Table 1: Tropical storms and cyclones that struck Madagascar from 1968 to 1999 (EM-DAT 2000 *www.md.ucl.ac.be/cred*)

YEAR	NAME	NUMBER OF DÉAD	NUMBER OF INJURED	NUMBER OF HOMELESS	PEOPLE AFFECTÉD	TOTAL AFFECTÉD	DAMAGES (IN US$)
1968	-	29	-	10.000	65.000	75.000	3.100
1969	-	81	40	3.000	40.000	43.040	5.000
1970	-	70	-	-	10.000	10.000	11.400
1972	-	91	56	10.000	2.500.000	2.510.056	12.420
1975	-	7	50	-	10.000	10.050	-
1976	-	16	26	8.850	500.000	508.876	17.000
1977	-	10	-	-	30.000	30.000	350.000
1978	-	70	-	-	18.000	18.000	29.000
1981	-	107	-	50.000	118.000	168.000	250.000
1982	-	100	-	117.000	-	117.000	-
1983	-	42	100	-	13.560	13.660	25.000
1984	-	68	215	-	100.000	100.215	250.000
1986	-	99	424	-	83.885	84.309	150.000
1989	-	46	-	1.050	55.346	56.396	-

YEAR	NAME	NUMBER OF DÉAD	NUMBER OF INJURED	NUMBER OF HOMELESS	PEOPLE AFFECTÉD	TOTAL AFFECTÉD	DAMAGES (IN US$)
1991	Cynthia	36	0	125.000	125.000	250.000	-
1994	Daisy Geralda	200	43	40.000	500.000	540.043	10.000
1994	Nadya	12	8	-	-	8	-
1994	Litanne	-	-	-	-	-	-
1996	Bonita	9	-	-	100.000	100.000	-
1997	Gretelle	140	-	80.000	520.000	600.000	-
1997	Josie	34	-	-	-	-	-
	Total	1.267	962	444.900	4.788.791	5.234.653	1.112.920

Table 2: The 10 most important natural disasters in Madagascar (EM-DAT *www.md.ucl.ac.be/cred*)

DISASTER	DATE	NUMBER OF DEADS	PEOPLE AFFECTED
Tropical storm	February 2, 1994	304	357 217
Famine	March 15, 1992	200	-
Tropical storm	January 13, 1994	200	540 043
Tropical storm	January 24, 1997	140	600 000
Tropical storm	December 20, 1981	107	168 000
Tropical storm	February 14, 1972	91	2 510 056
Drought	1981	-	1 000 000
Tropical storm	May 22, 1992	-	950 000
Drought	January 10, 1976	16	508 876
	December 16, 1990	-	250 000

Table 3: The floods affecting Madagascar from 1968 to 1999

DATES	CONCERNED REGIONS	CAUSED BY / CHARACTERISTICS	EFFECTS
March 12-23, 1975	Antananarivo Manjakandriana	Cyclone Inès ; rise in water level of 370 m^3/s	Low zones, railway, 740 ha of rice fields, cut road
February 12, 1977	Antananarivo	Cyclone Emilie ; rise in water level of 350 m^3/s	
January 1982	Antananarivo	Centennial rise in water level;	102 deaths, 37 injured, 130.705 homeless, 47 missing
March 26, 1986	Antananarivo	Cyclone Honorinina	28.223 affected people, with thousands homeless, hundreds flooded houses, dyke breaking at Ikopa, Andromba and Sisaony
1987	Antananarivo	Torrential rain, continuous	40.220 affected people and 2 deaths
February 4, 1994	Antananarivo and eastern part of the country	Cyclone Geralda	
February	Antananarivo,	River floods	20.000 homeless, damaged roads

DATES	CONCERNED REGIONS	CAUSED BY / CHARACTERISTICS	EFFECTS
1998	Fianarantsoa, Mahajanga and Toliara		and blocks

Sources:

1- Conseil National de Secours (CNS) – Madagascar (March 1998)

2- EM – DAT : The OFDA / CRED International Disaster Database - www.md.ucl.ac.be/cred – Université Catholique de Louvain – Brussels – Belgium / juillet 2000.

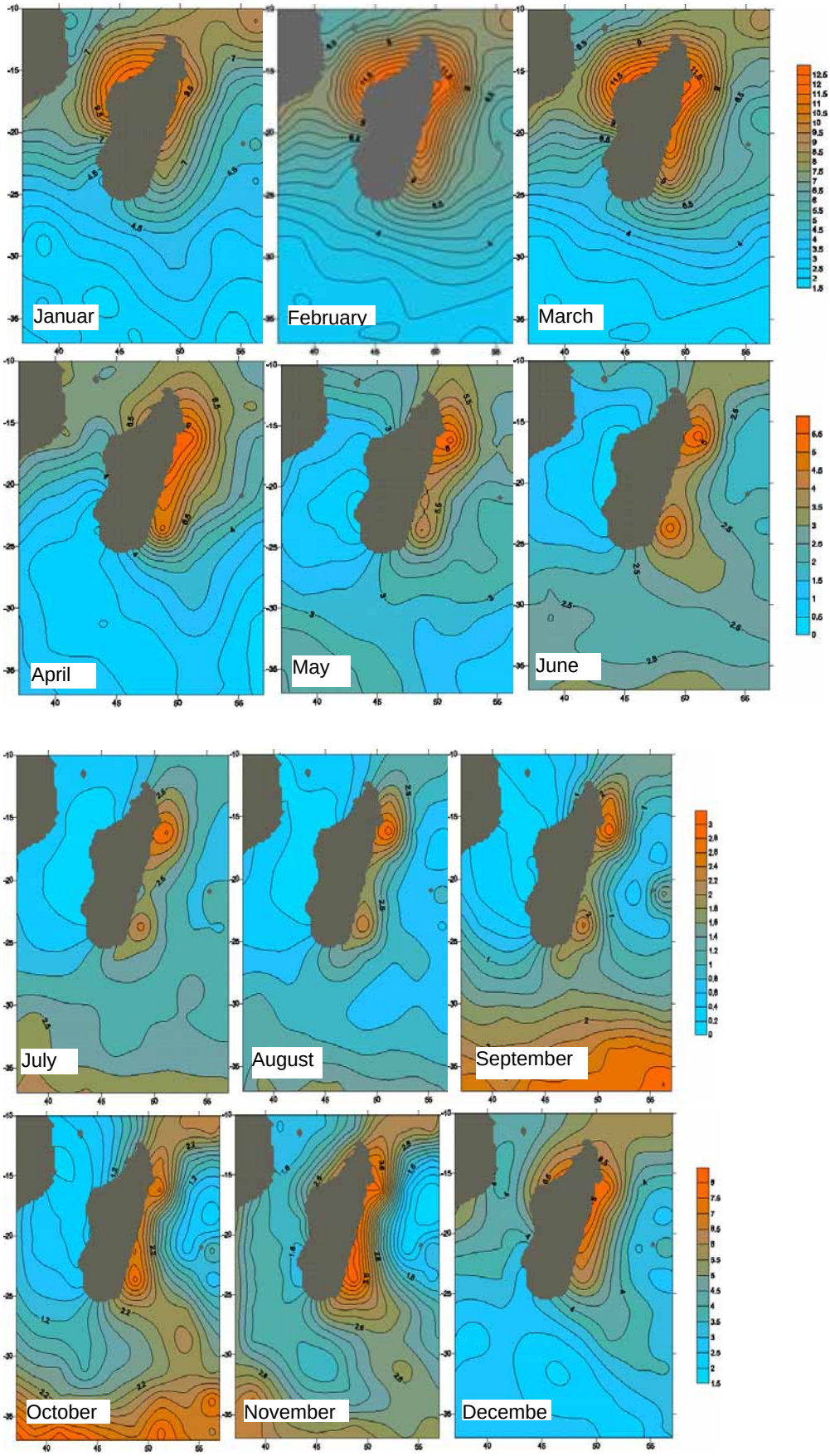

Figure 2. Map of the distribution of rainfall around Madagascar. Climate averages calculated over the period 1957-2004. (Bemiasa 2006). The unit is x100mm.

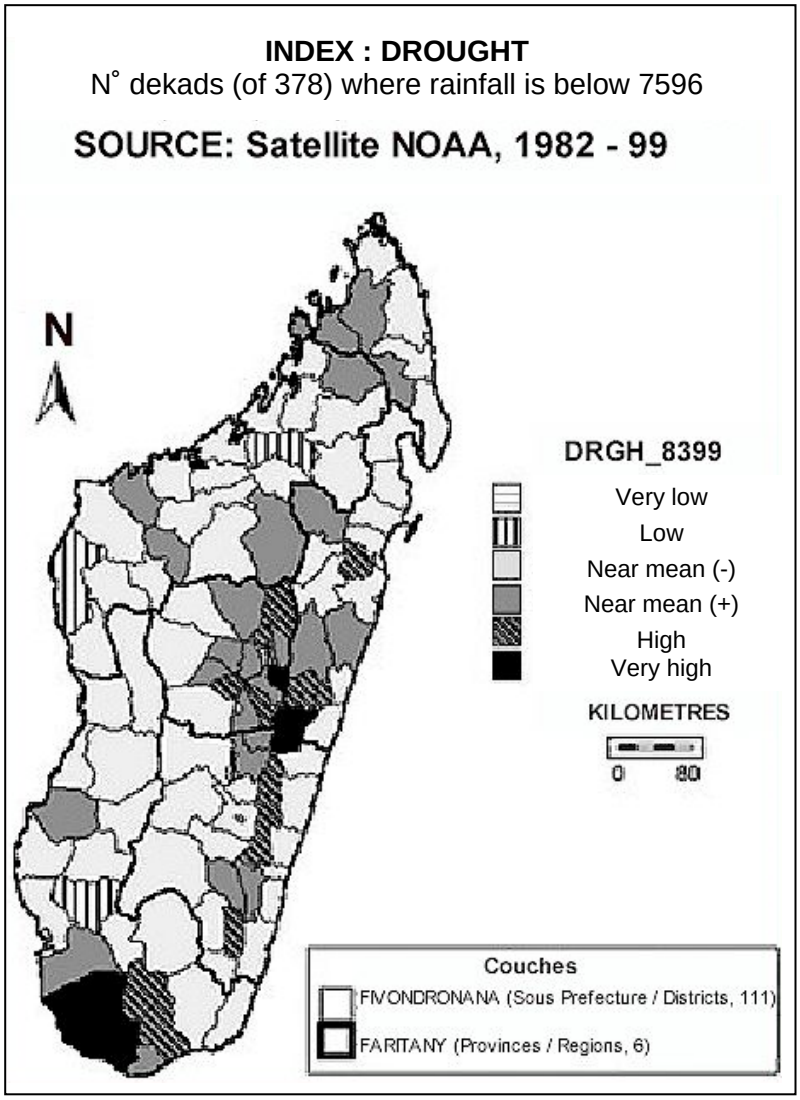

Figure 3. Drought index map of Madagascar. The indexes are calculated over the period 1982-1999. (NOAA, 1982-99).

2.4 Freshwater resources and drainage, including rivers, estuaries, deltas and coastal lakes

Coastal erosion and sedimentation

Coastal erosion, which is amplified along the west coast of Madagascar (regions of Mahajanga, Maintirano, Morondava and Manakara) is the result of changes in coastal hydrodynamic conditions. The most spectacular of these phenomena are located in the northwest coast of Madagascar.

The estuary of Betsiboka (Northwest) is considered as the "mouth" of the largest rivers in Madagascar and one of the most unstable on the coast. The spectacular growth of mangrove swamps in this zone results from sedimentation due to inland coastal erosion. During the rainy season, reddish soils are leached and carried by the rivers to the coast. Seen from above, it has been said that "Madagascar bleeds" (NASA, 2004) into the ocean. The estuary of Betsiboka illustrates this phenomenon which is particularly intensified during the passage of a tropical cyclone (eg Gafilo, March 7, 8, 2004).

Eg. Freshwater input into the coastal environment – impacts of water abstraction or pollution.
Eg availability of fresh water resources
Eg water abstraction and pollution -pollution input (agricultural or industrial)
Eg. Sediment input

2.5 Physical Oceanography

2.5.2 Tidal regime

Tropical cyclones which cause flooding and damage due to storm surges, flooding and extreme waves.

2.5.3 Variation of the sea level

- Heaves
- Floods
- Extreme waves

(These areas was addressed in the previous section 2.5.2)

2.5.4 Sea temperature

The phenomenon of coral bleaching caused by high water temperature, in particular that of 1998, marked the reefs of the south-west coast of Madagascar. Indeed, as the area is one of the most exploited reef areas from intense human activity, the effect of ocean warming has been devastating. There are large areas where the coral colonies are still in place but are dead and covered with algal turf. This indicates that the degradation is not mechanical but due to the change of water temperature (Maharavo, 2010).
Fish kills.
Loss of colour, and hence value in seaweed products.

2.5.6 Ocean-atmosphere interaction

extreme events
ocean acidification.

2.6 Biological and chemical oceanography

2.6.1 Nutrients

eg. influx of nutrients from rivers
algal blooms

2.6.2 Persistent organic/ inorganic pollutants

Heavy metals
In Madagascar, the pollution of the marine and coastal environment is due to industrial, agricultural, port and mining activities whose importance and consequences are not well quantified. Most pollutants are biodegradable but there are also persistent organic pollutants such as highly toxic insecticides such as DDT used in malaria control, and phenols from wood industries which makes up 34% of industries in coastal zones. This pollution is linked both to the intensity of continental sedimentation carried by the Fiherenana River and the increase of urban polluted waste (domestic and industrial) in Toliara, a coastal city with high population growth (Anonymous , 2003).

The main problems encountered are the salinization of soils and the extension of large bare lands which are generally barren. The sedimentation is especially dramatic in rainy season, during which

the river flow can reach 3000 to 4000 m^3/s compared to 40 to 60 m^3/s in the dry season. The pollution problem is caused by the absence of global policy in environmental management (legislation, high technical staff and equipment). In Madagascar, these sources of degradation are either specific or diffuse and are often due to large industrial infrastructures such as refineries, shipyards and mines. The oil refinery at Toamasina, the shipyard at Antsiranana, whose effluents contain naphthenic pollutants, sulfides and thiophenols is one such point source. It is the same case with mining zones (mica, quartz, iron, chromium, graphite) whose pollutants are made up of solid waste and sludge mineral suspensions (anonymous, 2003).
Industries in coastal zones, which accounts for 34% of all industrial companies in Madagascar, are among the sources of pollution load. This sector is dominated by the food industry (38.4%) and wood industry (34.8%).
The semi-intensive shrimp aquaculture in mangrove areas has two operational farms. This breeding is expected to limit the negative impacts of pollution load, especially biodegradable sources, through regular controls in each farm.

2.6.3 Primary production

- dead zones
- harmful algal blooms (HABs)
- ocean acidification

Any data and information are available on these topics.

2.6.4 Secondary production

eg - trophic relationships

2.7 Coastal zone and continental shelf

2.7.1 Description and extent of marine and coastal habitats

Any of the following could be areas of concern:

- Bleaching,
- acidification,
- destructive fishing methods eg. dynamite fishing, IUU fishing, trawling
- coral mining
- sand mining
- seagrass clearing / beach cleaning
- urban expansion
- nutrient loading

2.7.2 Productivity of the coastal zone

- overharvesting
- unsustainable mangrove harvesting
- pollution
- sedimentation
- sea level change
- ecosystem health
- coral bleaching and degradation

2.8 Microfauna and meiofauna

- dead zones
- harmful algal blooms (red tide)

2.9 Macrofauna (state of knowledge)

2.9.1 Invertebrates

Excessive harvesting of invertebrates

Crustaceans

Shrimping

Artisanal and traditional fisheries joined the industrial fishing after a few some years of delay. With fairly stable industrial catches in the early 90s, a first decline in industrial catch was observed in 1999 and a significant drop from 2002, which is a major concern.

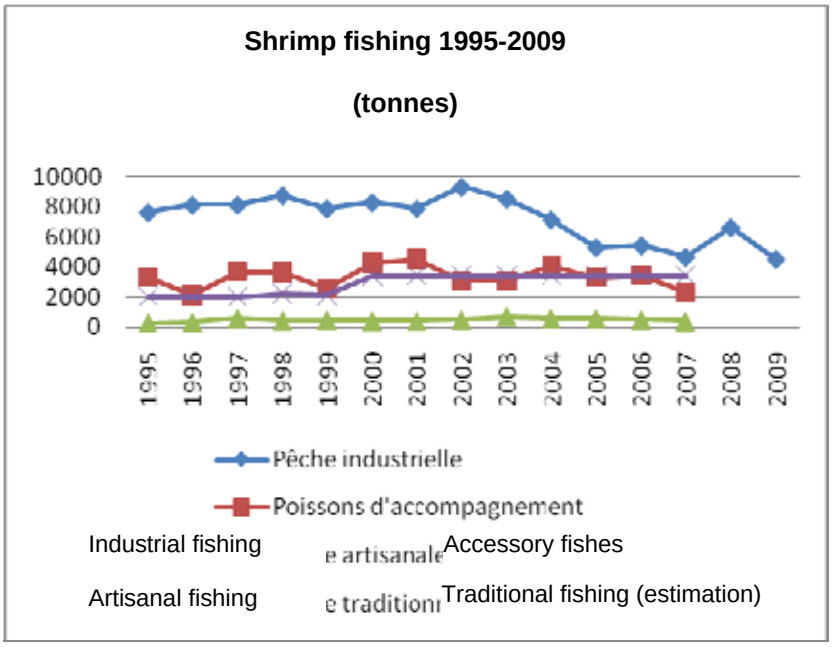

Figure 16. Annual production of shrimps 1995-2009 (Source : MPRH) These are data provided by MPRH personnel from the statistics unit, without reference to a publication.

To meet the supposed impacts on traditional fisheries and to facilitate a better stock recruitment, the members of GAPCM proposed the seasonal closure of breeding shrimp.

Crayfish fishing

The fishing practices are still traditional and include trap fishing, diving and fishing with torches (Mara 1993). Recently, fishermen have started to use nets to trap crayfishes. *Panulirus homarus* and *P. japonicus*, the dominant species in South and Southeast are caught while diving or caught with traps or nets. A bio-statistical monitoring of the fishery is necessary to seriously assess stocks and to allow simulation of changes in fishing effort, in order to determine an effective management system.

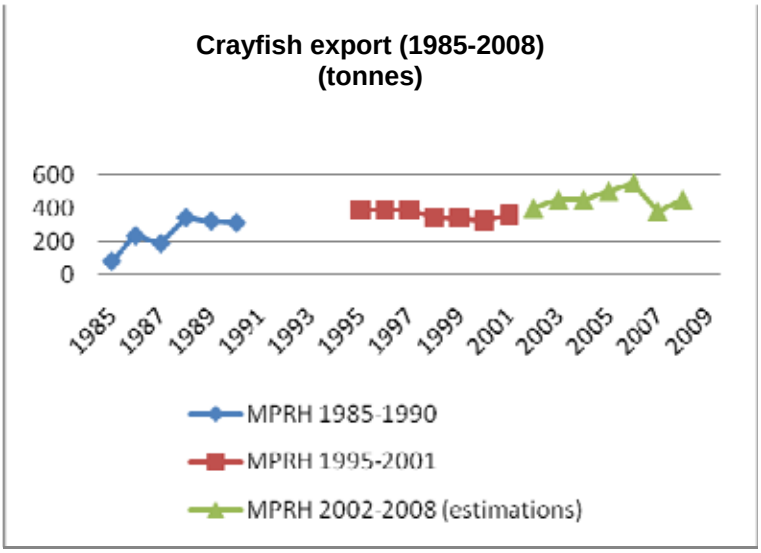

Figure 17. Annual export of crayfishes 1985-2008 (Source : MPRH)

An assessment of crayfish fishing in Taolagnaro, in 2000, based on statistics for the period 1988-1996 (Rabarison 2000) reported that yields remained constant around 250-300 tonnes per year although the average size of animals has decreased. The study concluded that the exploitation of *P. homarus* approaches the maximum sustainable yield (MSY). The main problem was identified as a tendency to catch too many juveniles and pregnant females, which threaten the stock recruitment (Rabarison 2000).

Crab fishing

Fishing is mainly limited to the collection of the mangrove crab *Scylla serrata*. It is mainly practiced between Mahajamba Bay and Cape St Andrew. Bautil *et al.* (1991) studied the fisheries near Mahajanga and estimated the potential sustainable yield at between 1.66 and 1.8 tonnes/km^2 mangrove / year or 5.500 tonnes / year for whole of Madagascar. The production of crabs steadily increased from 500 tonnes in 1985 to 1,500 tonnes in 2007. Mangrove areas near coastal cities are subject to overharvesting, while more remote areas still support fishable stocks. To avoid overfishing for crabs, regulations were introduced in 2006 by Decree N° 16365/2006 on the exploitation mode of the mangrove crab, *Scylla serrata*.

Molluscs

Octopus fishing in Toliara

With only 50 tonnes of production, in 1994, the production in Toliara region reached more than 700 tonnes in 2002. Today, the fishing area for octopus stretches 400 km, between Fanambosy and Morombe reefs, and involves some 60 fishing villages. In 2005, the first decrease of catches was seen, a possible sign of overexploitation. Consequently, the Ministry of Fishery announced a closed season between December 15 and January 31 and imposed a minimum size of 350 g. Meanwhile, an initiative of COPEFFRITO and Blue Ventures Conservation Andavadoaka showed the advantage of longer closure period to maximize the size of octopus, taking advantage of international markets that prefer sizes above 500 g (Humber 2006).

Gastropoda fishing

The main Gastropods targeted are the edible and ornamental species. Mangroves are exploited for mangrove gastropoda *Terebralia* (= *Pyrazus*) *palustris*, whose shells are transformed into lime. In Toliara, at least 138 species of gastropod are exploited for ornamental shell trade (Romaine 1997). Many are considered threatened, including helmets (*Cassis cornuta* and *Cypraecassis rufa*) and

porcelain (Cypraeidae). Turbo (*Turbo maromorata*) and pearl oysters (*Pinctada margaritifera*) are exported for the manufacture of buttons and other pearly objects. Between 1989 and 1991, one Indian exporter from Toliara annually exported 8,000 kg of ornamental shells and 50 tonnes of industrial shellfish (WWF 1993).

Echinodermes

Sea cucumber fishing

Sea cucumber fishing is a very common practise in Madagascar (Laroche and Ramananarivo 1995, Rasolofonirina and Conand 1998, McVean *et al.* 2005) and natural populations are overexploited (Conand 1998, Conand *et al.* 1997). Their operation saw a rapid and significant increase as the market for sea cucumbers grew with the economic growth in China and the Eastern region

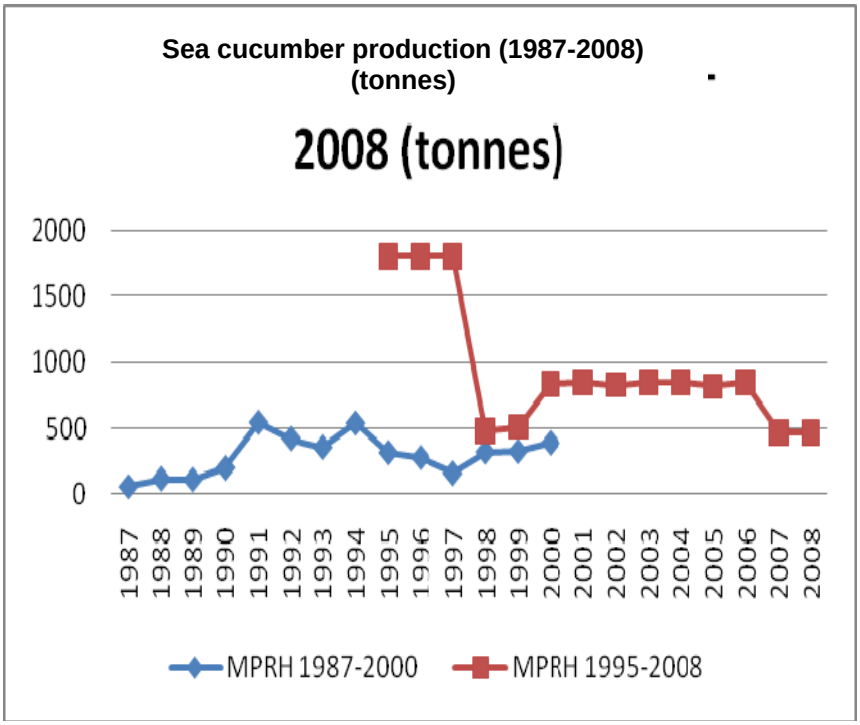

Figure 18. Dried sea cucumber production (tonnes) (trepang) 1987–2008 (MPRH 2009)

In the Northwest, the collecting has become almost industrialised, with 'mother' ships with many teams of divers diving off small boats to collect sea cucumbers at considerable depths (Metcalf *et al*. 2001). In other regions, the collection is traditional but still intensive. To address the problem of sea cucumber overfishing, a project established by IHSM in the1990s aims at developing techniques for breeding, hatcheries and sea cucumber aquaculture. After twenty years of scientific assistance by Belgian University Cooperation for Development, Copefrito and IHSM established, in 2008, the company Madagascar Holothurie SA, the first commercial society centred on aquaculture of sea cucumbers in Madagascar (Eeckhaut *et al.* 2009).

Sea urchin fishing

The sea urchin fishery only targets edible species, *Tripneustes gratilla*, mainly in the region of Toliara.

Exotic/invasive species impacts on invertebrates

Invasive seaweeds

Also present on the Southwest reefs, *Turbinaria* became invasive in coral reefs of Toliara region. This phenomenon is associated with reef degradation due to the combination of overfishing and bleaching events (McClanahan *et al.* 2009). While the effects of this invasion have not been studied yet, the reduction of light might have negative effects on coral growth.

Invasive Cnidaria
Sometimes jellyfish blooms occur. This phenomenon is observed regularly in the region of Toliara during the warm season (P; Vasseur, pers. comm., 1992) and was observed near Anjajavy, in Northwest coast in May 2009. (Pers. obs, A Cooke)

Invasive Echinodermata
In southwest reefs, spiny sea urchin blooms occur (*Diadema* spp.), probably caused by overfishing which removes sea urchins predators and herbivorous fish that are potential competitors for the algae. In the region of Nosy Be, in the late 90s, industrial shrimp fishermen observed the proliferation of sea urchins species, *Salmaciella erythracis*, whose thorns contaminated their catch (Cooke et *al* 2003).

Pollution

Coastal pollution
In terms of impact, pollution by terrigenous sedimentation is probably the most important given that Madagascar is still industrially undeveloped. The urban pollution is locally important, and induces significant health risks for fishing, for local populations and for the development of seaside tourism (Cockcroft and Young, 1998).

Terrigenous sedimentation
In the region of Toliara, the reefs receive large quantities of sediment carried by the Onilahy and Fiherenana rivers. The presence of sediment led to the loss of lagoon water transparency and the rising percentage of terrestrial sediment on lagoon floor (Randriamanantsoa 1997). The reduction of water transparency reduces the level of "irradiance" and, consequently, the growth rate of hermatypic corals and calcareous algae, the main coral reefs developers.

In the Southwest, there is a phenomenon of hypersedimentation with complex origins. A study done by the National Environmental Action Plan (NEAP) showed that hypersedimentation in coastal zones around the Onilahy river mouth in 90s was linked to the bad cultivation techniques of rice growers along the river banks. The proliferation of invasive insects, leading in turn to the reduced variety of insects, following bush fires and deforestation, was the main reason for the high erosion rates (CNRE / CNRIT / IHSM 2000).

Destructive fishing practices affecting invertebrates

The main destructive techniques affecting invertebrates are:

- Sea fish trawling primarily practiced in the Northwest from Mahajanga. The continental shelf floor at medium depths (30 to 50 m) is rich in sponges which are removed by trawls. A preliminary assessment of the impacts of this type of destructive and non-selective fishing is necessary, before allowing the fishery to develop furthur (Reference>).

- Shrimp trawling, mainly practiced on West, Northwest and Northeast coasts, especially in large bays such as Ambaro, Ampasindava, Narindra, Antongil. Shrimp trawling uses trawls which scrape the bottom and can degrade large areas of habitat, including fields of seagrass, a critical habitat for many species of invertebrates (Reference?). Ecological impacts of

trawling have not been studied until recently. Apart from the degradation of seagrass beds (observed by the CSP), fishing companies observed the *Salmaciella erythracis* proliferation whose thorns contaminate the catch (Reference?).

- Use of mosquito seine fishing from traditional shrimp fishery led to the capture of juveniles of many invertebrate species, mainly in the West and Northwest coasts.

- Common use of beach seines often with net, especially in the region of Toliara.

- Use of poison from plant species, *Euphorbia Laro*, practiced in the Southwest.

- Fishing on foot on reef flats, targeting octopus and shellfish in the Southwest.

Non-selective gear by traditional shrimp fishermen
Traditional methods of shrimp fishing are diverse in all regions of Madagascar. Five main types of gear are used which include; *Periky*, a set gillnet; *Kaokaobe* a haul seine off a boat, *Valakira* a dam or fish lock, *Pôtô* a stownet or foreshore rigged trawl and cast nets. It is thought that the low selectivity of traditional gears could have a negative impact on the stock recruitments (reference?).

Impacts of aquaculture on invertebrates

In recent years, the aquaculture activities have developed considerably in some mangrove forests of Madagascar. Except for shrimp aquaculture, already well established with an annual production of 8,000 tonnes, some experimentation has been made with other species such as milkfish, *Chanos chanos*, oysters and *Artemia,* a food species, and penaeid shrimps which have been tested and proven to be successful in salt basins, north of Toliara (reference?).

Effects of aquaculture ponds evacuation
The main impact of fish farms on environment is the periodic draining of wastewater ponds. This water is rich in phosphates, nitrates and organic matters and may also contain pathogens, antibiotics and pesticides. During the last five years, diseases emerged in wild populations of shrimp but the link to aquaculture has not yet been excluded (Z. Kasprzyk, pers. comm.).

Effects of aquaculture on invertebrate habitats
The construction of fish farms in the west coast of Madagascar has benefited from the significant presence of bare soils in mangrove swamps, called tanne soils. Most of the construction of aquaculture ponds is made in these zones, without significant loss of mangroves. The amplification of tides consecutive to development works can also destabilize the channel banks, thereby undermining ecological niches and shelters (pers. obs., author).

The mangroves support a rich invertebrate fauna, including crustaceans and molluscs. Some of these species are commercially important, such as the mangrove crab, *Scylla serrata*, the mangrove gastropod *Terebralia* (= *Pyrazus*) *palustris* and mangrove oysters. Currently, because of the disparition of continental forests from the coast, mangroves are increasingly exploited for its timber and energy resources, especially in suburban areas (case of Nosy Be, Mahajanga and Toliara). The degradation is particularly severe near Toliara, where forest land was largely eliminated. An assessment of mangrove vulnerability, taking account of climate change is currently underway, supported by WWF.

Effects of fishing on foot on reef flats
Fishing on foot is practiced on most exposed coral at low water. Breaking the coral blocks, to expose the octopus and other targeted species, is particularly destructive. On the Great Reef of Toliara, the

density of collectors can exceed 36 persons per km^2 and it was estimated that they can annually raze 22-36% of the flat (Randriamanantsoa 1997). In Masoala, the reef is damaged by the collecting of live coral in order to hide fish traps (McClanahan and Obura 1998).

2.9.2 Fish and fish resources

Stock overexploitation

Chondrichtyans

Approximately 50 species of sharks and rays of neritic and oceanic deep waters (including 2 or 3 species of sawfish) of Madagascar are affected by industrial tuna fishing (longline and seine ocean fisheries), industrial fish fishing, industrial shrimp fishing, artisanal and traditional fishing.

Due to their slow reproductive rates, chondrichthyes are very vulnerable to overexploitation. Sawfishes, in particular, seem to be close to extinction. Official statistics on local production and export of meat and fins show an annual mortality of sharks by various forms of fishing from 200,000 to 600,000 individuals (Cooke *et al*. 2003).

Tunas and big pelagic fishes

Tuna are subject to industrial seine fishing (under two agreements with Anabac and EU) and longline fishing (under three agreements - the EU, Korea, Dae Young, and Japan, Japan Tuna). Official fisheries statistics indicate catches of 10,000 to 11,000 tonnes per year (Source: Unité de Statistique Thonnière d'Antsiranana (USTA), reported in Cooke et al 2003).

Sea fishes

Non-reef sea fishes are targeted by industrial fishing, industrial fishing shrimp, artisanal and traditional fishing. In 2004, experimental fishing under the SEPRH-OFCF (*Overseas Fisheries Cooperation Foundation* of Japan) agreement assessed the relative abundance of sea fishes along the northwest continental slope of Madagascar. The main species belong to Lutjanidae family (Two-spot red snapper, *Lutjanus bohar*, emperor red snapper, *Lutjanus sebae*), Sparidae, Serranidae, Lethrinidae, Carangidae and Thonidae (Source : SEPRH – extracts from the OFCF project report).

The main interest of demersal resources is the very high value of large noble fishes belonging to Lutjanidae and Serranidae families, especially those located along the continental slope at relatively accessable depths (e.g. 50 m and more). However, these large fishes are often progenitors and overharvesting could have rapid negative impact on stock-recruitment. In addition, the techniques of bottom trawling, targeting demersal fish can cause physical damage to bottom habitats and significant by-catch.

Small pelagic fishes

Small pelagic and demersal fishes are targeted by shrimp trawling in all shrimp fishing zones, by artisanal fishing, mainly concentrated in Northwest and by traditional fishing mainly concentrated along west coast, in Antongil Bay and in the Southeast. The most common species belonged to Sciaenidae, Leiognathidae, Trichiuridae, and Mullidae families (PNRC 2006). The reduction of incidental catches and discards remain major environmental and socio-economic concern.

The most affected species by traditional and artisanal fisheries are small Scombridae, often called "small tunas", such as the eastern little tuna, *Euthynnus affinis,* the wahoo, *Acanthocybium solandri*, the narrow-barred Spanish mackerel, *Scomberomorus commerson*, the indian mackerel, *Rastrelliger kanurgata* and *Auxis* spp., Sphyraeindae, Carangidae, sardines (Clupeidae), anchovies (Engraulidae), Hemirhamphidae, Belonidae and others (Anon 1982).

Reef fishes

Fishing for reef fish is mainly done by traditional fishermen from dugout canoes. This is a multispecific fishery, mainly targeting carnivorous fish (Serranidae, Lutjanidae, Lethrinidae,

Carangidae), herbivorous fish (Siganidae, Scaridae, Acanthuridae), scavengers (Mullidae and others) and to lesser degree, planktivores such as Caesionidae. In Toliara, the percentage of Serranidae in catch has been reduced to 2.5% (Gabrié *et al.* 2000). Annual yields of fish from traditional fishing are estimated at around 50,000 tonnes (DPRH, annual reports)

The major concern is the decline of resources due to overfishing and irrational exploitation of resource. Widespread effects on fisheries, arising from coral reefs degradation (including climate change), are also a major concern.

Deep-water fishes
In 2007, a pilot fishing for alfonsino, *Beryx splendens,* was launched by a South African company. Using deep trawling techniques, this fishery has been able to catch 7 tonnes per with a single vessel, over several months. The fishing site consists of seamounts in the south of Madagascar located at approximately 26°S 46°E (Centre de Surveillance des Pêches 2007, unpublished report).

Effect of invasive species on fish

Tropical marine fish species are cosmopolitan and are in constant relation with various kinds of invasive species from high seas and those from coastal areas. Therefore, the risk of invasive species impact on fish is low. However, there is a problem of intoxication from consumption of marine animals (ICAM) due to the proliferation of micro-organisms such as microalgae, bacteria, cyanobacteria or diatoms, mainly in the warm season (e.g. Rabarison 1994).

Pollution affecting fish

Terrigenous pollution, pollution from domestic waste and pollution caused by ship discharges at sea (oil discharge, toxic waste by boat beaching) could have effects on fish and their habitats. However, marine pollution levels are still limited in Madagascar due to lack of industrial development (Rakotoarinjanahary et *al* 1994).

Destructive fishing practices

<u>Destructive industrial practices:</u>

- *Longline industry in ocean*

While these gears do not physically destroy the environment, their impacts on ecosystems and vulnerable species such as turtles, seabirds, sharks and whales may be very important.

- *Deep industrial trawling*

Bottom trawls are able to deflect rocks weighing several tonnes and destroy large areas of underwater habitat, particularly on seamounts or continental slopes and shelves. These gears are already used in Madagascar legally in a pilot fishery for alfonsino (CSP 2007, unpublished report).

- *Shrimp trawling in shallow water*

Shrip trawls used in mud flats leads to the destruction of floor micro-habitat, reducing the number of ecological niches and therefore the diversity of fish communities and other species. The long use of trawls in Madagascar (since 1967) could remove the majority of natural habitats, replacing them with purely muddy habitats, poor in biodiversity. The creation and monitoring of closed areas would assess trawling impacts and protection benefits. Habitat destruction by trawling may be a factor in recent decline of shrimp catches.

<u>Destructive practices of traditional fishing</u>

- *Fishing using poison*

In the Southwest, some fishermen in some villages use the latex of *Euphorbia laro* in catching fish, the method is not selective and could affect other species.

- *Beach seine*

Beach seining is widespread in Madagascar and largely used in Toliara lagoons but also in many other sites. Often with mosquito nets, this gear is somewhat selective and in its usual practice of dredging lagoons, is destructive to floor habitats.

Effects of tourism on fish resources

The effects of tourism on fish is mainly confined sport fishing, mainly targeting large pelagics, but generally (and for over ten years) based on "catch and release". Spear fishing is becoming rarer but often targets vulnerable large fish such as groupers. Some operators keep data on their exploitaions. Local indirect effect of tourism is the high consumption of fish; one study showed that tourists eat five times more by weight of fish than a fisherman villager, increasing local pressure on fish (Tanner 2000).

2.9.3 Marine mammals

Overexploitation of marine mammals

Cetaceans (dolphins, whales) are affected by several different fisheries; industrial tuna fishing, including longlining and seine netting, industrial fishing for fish, industial fishing for shrimp and traditional hunting. Sirenia (Dugongs) are mainly affected by traditional hunting and, at least indirectly, by loss of habitat (seagrass beds) due to industrial shrimp trawling. While evidence shows a massive decline of dugong (Rafomanana and Rasolonjatovo 2004, WWF 2004), evidence for cetacean decline in Madagascar is limited.

Impacts of industrial tuna fishing on cetaceans

The industrial seine fishing recorded some incidental catches of small cetaceans. Apart from catch and direct interactions, the fishing industry can have negative impact by decreasing the availability of prey for cetaceans, but the importance of this effect has not been assessed. The effects of industrial tuna fisheries are a particular concern, but its importance is difficult to determine without more information.

Hunting and incidental catches of cetaceans

The main threats to coastal cetacean populations are intentional fishing and incidental capture by nets. Intentional hunting of dolphins is known from several fishing communities along the western and eastern coasts of Madagascarand quantitative data have shown the importance of this threat in the south west region, particularly Anakao (Andrianarivelo 2001, Andrianarivelo 2004, Razafindrakoto *et al.* 2008). Table 12 summarizes information on the numbers of dolphins caught in three locations in the West Coast, between 1975 and 2009, and in the region of Antongil Bay, in 2006-2009 (Razafindrakoto et al, in prep.).

Table 12: Number of individuals of coastal dolphins caught in 4 regions from 1975 à 2009
(Source - Razafindrakoto et al in prep.)

Years	Andavadaoka	Anakao	Iles Barren	Baie d'Antongil
1975-1980	-	3	-	-
1980-1985	-	6	-	-
1985-2000	2	3789	-	-
2000-2005	138	1441	-	-
2006-2009	-	-	14	4

More in depth studies have been done on direct hunting in the Anakao area. Dolphin species inhabiting shallower coastal areas are most commonly exploited, including the bottlenosed dolphin *Tursiops truncatus*, the Indo-Pacific humpbacked dolphin, *Souza chinensis* and the long-nosed dolphin *Stenella longirostris* (Andrianarivelo 2001, Razafindrakoto *et al.* 2004, 2005 & 2007).. At Anakao, the annual catch was estimated at 150 spinner dolphins, with smaller catches of large dolphin and Risso's dolphin *Grampus griseus* (Razafindrakoto *et al* 2008). According to an earlier report, in 1991, 1992 and 1993, 100 to 150 dolphins were caught annually by fishermen at Anakao (COUT & Cooke 1994).

Accidental catches of marine mammals are made by various fisheries (commercial, artisanal and traditional) in Madagascar but scant data on the scale of the problem are available. Cetaceans are accidentally caught by different gears, mainly *jarifa* (shark nets). Drift nets and longlines take coastal species of dolphins (bottlenosed dolphin, Indo-Pacific humpbacked dolphin, long-nosed dolphin). (Razafindrakoto *et al. in prep*)

Hunting and incidental catches of dugongs

Dugongs are rarely hunted by traditional fishermen around Madagascar. Hunting this species was very important in early 1980s until 1990, off small island coast of Vohémar (Rafomanana and Rasolonjatovo 2004) and also off Cape St. Andre (16°11'S, 44° 27'E) (WCS, unpublished data). Accidental catch by driftnets also poses a threat to dugongs, in traditional fishing sector. Habitat loss (seagrass beds) due to trawling for shrimp, noise pollution associated with trawling is a real concern for dugongs.

Impact of gill nets on all marine mammals

Accidental catches of marine mammals in the artisanal sector is mainly by gill nets, although the total impact of these gears remains unknown. It is recommended that it is necessary to quantify the impact of incidental catches by gill nets on marine mammal populations and implement effective mitigation measures if necessary (CTOI 2008).

Pollution effects on marine mammals

Noise pollution

In Madagascar, where coastal shipping is still limited, noise pollution is localized around major ports (Toamasina, Mahajanga, Toliara and Taolagnaro later) and specific activities producing underwater noise, particularly industrial shrimp trawling and by seismic and sonar studies undertaken by the oil industry. Noise pollution disrupts the orientation, feeding and communication ability of cetaceans, causing interference which may lead to strandings and physical damage to the ear of the animals if they are close to the source noise.

Effects of aquaculture on marine mammals

Up to now, no interaction was found between aquaculture and marine mammals. However, the creation of aquacole farms could change the local hydrological regime that could, in turn, change local conditions for ecosystem development such as seagrass beds (crucial for dugong) and mangroves (where some dolphin species may enter from time to time), but the effects are expected to be small compared to other impacts.

Effects of habitat destruction on marine mammals

Human activities such as fishing in addition to climate change effects can have significant impacts on essential ecosystems for marine mammals, particularly the trophic effects of industrial fishing and episodes of surface water warming. For coastal cetaceans (including humpbacked dolphin) and dugongs, the destruction of their foraging habitats could have major impacts.

Effects of tourism on whales and dolphins

The humpbacked whale is the main attraction for sightseers in Madagascar for the period June to October. Dolphins are observed during diving, fishing and marine tours. In 1998, 12 tour operators attracted 4,000 tourists and this grew to an estimated 15,928 tourists led by 13 operators by 2008. Boats can transport 3 to 35 passengers, with an average of 10 tourists (WCS, unpublished data)

Collisions between ships and cetaceans and harassment, whether intentional or accidental, is an increasing potential problem of conservation in coastal waters, but still largely unknown. The effects can be cumulative. While there are reports of harassment in Ste Marie Island and Antongil Bay, no collisions have been reported in Madagascar to date. A code of whale watching has been adopted for the main site of observation, Ste Marie Island which recommends minimum distances between baots and whales (C. Webster, pers comm.).

2.9.4 Marine reptiles

Sea turtle overexploitation

Traditional hunting

Traditional hunting of turtles is performed with harpoon or spearguns. Catches have been estimated, by Hughes (1971) on 800 km of coastline in Southwest to be as high as 13,248 turtles per year (*Chelonia mydas* 51%, *Eretmochelys imbricata* 15%, *Caretta caretta* 15% and *Lepidochelys olivacea* 18%). Hughes (1973) estimated the national catch of *E. imbricata* at 2,500 individuals and concluded that the species was threatened. Rakotonirina and Cooke (1994) estimated the national annual catch of turtles in traditional fisheries at 11,276 individuals for all species. In 1998, 2.9, 8.5 and 4.9 tonnes of turtle meat were sold on the markets of Toliara, Morombe and Taolagnaro respectively, indicating a catch of at least several hundred individuals (MPRH regional data unpublished). For Maintirano region, the annual catch, in 2006, was more than 350 individuals (Leroux 2007). Traditional hunting continued despite the promulgation of the decree 2006-400 making it illegal to fish for turtles.

The capture of females in spawning condition is relatively easy and as females are naturally numerically dominant in spawning areas, the equivalence or predominance of males in catch is an indicator of overfished population (Hughes 1971). The predominance of males in catches of green turtles, in Toliara region, was already observed in the early 90s (Rakotonirina, pers. com.). The predominance of young turtles in catches is also a sign of overexploitation. In conclusion, at least *C. mydas* and *E. imbricata*, and probably also *L. olivacea* and *C. caretta* are overexploited in Madagascar which constitutes a major concern

Nest Raiding

Turtle nests are systematically looted in sea turtle zones (Petit 1930, Rakotonirina 1989, Rakotonirina and Cooke 1994, Sagar 2001, Metcalf *et al.* 2001). The pillage is practiced even in remote or isolated areas where there is no longer a tradition of turtle exploitation, such as the Masoala peninsula (Rakotonirina 1999).

The decline of sea turtles nesting in Madagascar has been seen all over the country (Rakotonirina 1989, Rakotonirina and Cooke 1994). Recent observations in the Southwest suggest that many ancient nesting beaches identified by Rakotonirina (1989) are no longer in use (A. Harris, pers. com., January 30, 2008).

The effects of pollution and diseases on sea turtles

Sea turtles may be affected by various forms of pollution, such as marine debris, oil pollution, sedimentation, noise pollution and light pollution.

Marine wastes such as plastic bags are a threat to turtles which feed on jellyfish, particularly *D. coriacea* and *C. caretta* (Hirama and Witherington 2006). Abandoned fishing gear such as cast nets

can trap and drown all species of turtles. The pollution impacts of marine wastes on marine turtles are at regional or even global scales and require analysis and action at regional and global levels.

Oil pollution may become a risk as the oil industry grows. Telluric sedimentation could affect the water quality and sand from nesting beaches, near river mouths. No studies on sedimentation impacts on sea turtles have been made in Madagascar.

Sea turtles are sensitive to noise, especially between 50 and 1000 Hz. Turtle reaction to noises includes an increase in swimming speed and diving to attempt to escape from the noise source. In the case of seismic campaigns, turtles fled 1 to 2 km from the source. It is recommended that seismic campaigns are avioded sea turtle nesting sites (LGL 2007).

Female turtles generally spawn at night and can be disturbed by the presence of lights on the beach, inducing them to leave the premises without laying. Electric lights can also affect new hatches, inducing them to approach the light instead of moving toward the horizon to the sea. The importance of these effects is incompletely understood and has never been studied in Madagascar.

The turtle Fibropapillomatosis (fibropapillomonas)
The turtle conservation project in the Maintirano region, coordinated by the Museum of Natural History in Geneva and supported by WWF, found a high incidence of Fibropapillomatosis among sea turtles caught for research purposes around Maroantaly Island, one of Barren Islands. This disease caused by a type of herpes virus, causes tumors in soft parts of the turtle. As they grow, tumors restrict movement of neck and limbs and can ultimately cause death by suffocation or immobilization. The disease affects approximately 25% of captured green turtles and can be a significant cause of mortality among sea turtles. Fibropapillomonas affects green turtles globally. Links to environmental factors such as pollution or global warming are suspected but not proven. (Mortimer 2003)

The effects of destructive fishing practices on sea turtles
Apart from non-destructive fishing practices, sea turtles are affected by offshore industrial fishing (longline and seine), fishing on the continental shelf, industrial shrimp trawling, fishing nets for shark and traditional fishing with poison.

Industrial trawling for shrimp is an important cause of incidental catches of turtles, but has never been scientifically evaluated. In 2000, a trawler captain in Toliara (pers com.) estimated incidental catch at 300 turtles per ship per year. Most of these turtles were alive when landed, but were subsequently killed by shipmates. Although this estimate may be exaggerated, with 50 trawlers around Madagascar, incidental catch of sea turtles could be several thousands per year, and could have decimated turtle populations since the beginning of industrial shrimp fishery in 1967. Before 2003, some operators voluntarily installed TEDs or "turtle exclusion device" (Ratsimbazafy 2003). In the early 2000s, the installation of TEDs became mandatory for shrimp trawlers, which reduced the number of catches. One operator expressed some disappointment in the sense that before, catching turtles, which is rarely fatal, allowed the identification and banding animals, while turtle monitoring is not possible anymore after the installation of TEDs (fishing company agent in the East Coast, pers. com.).

Artisanal and traditional fishermen fishing for sharks use gill nets of more than 100 meters in length, known as *jarifa*. This destructive and non-selective gear can catch several different species, including sea turtles which often drown in the net that is usually left overnight.

Traditional fishing with poison is limited to the southwest of Madagascar; here fishermen use the latex of *Euphorbia laro* called *famata* in protected waters of reefs where they occasionally manage to kill turtles (Rakotonirina and Cooke 1994).

In conclusion, the impact of destructive fishing practice for sea turtles has still not been investigated fully but is a major concern.

Destruction or modification of breeding and spawning sites

Turtles breed in the sea near nesting areas. While the marine environment is not subject to physical destruction, the nesting beaches are affected by urban development, major construction works such as ports, dams, mining and oil installations and constructions for tourism and development.

Little is known about the location and historical importance of turtle nesting sites in Madagascar. Besides rough indications of nesting sites in old works (Petit 1930), the first study of nesting sites was made by Rakotonirina (1989), and again by Rakotonirina and Cooke (1994), followed by several more localized studies (Ramamonjisoa 1997, Andriantahina 1999, Soafiavy 1999, Sondrotra 2000, Metcalf *et al.* 2001, Rafaelarisoa 2001, Sagar 2001, Leroux 2007). The studies confirm that the most important turtle nesting sites are on small islands in the west of Madagascar (particularly the north west of Madagascar), while nesting is less frequent on mainland beaches, and absent in mainland areas near to coastal towns.

There are often sea turtle eggs in the sea. The phenomenon of abandonment of eggs to the sea may be due to nesting site destruction. The nesting female could not get the beach to build their nests because of a new element present at its breeding place, such as light on the beach, or morphological change by new construction (Rakotonirina 1993).

General decline in spawning frequency has been observed (Rakotonirina and Cooke 1994), but the extent of habitat destruction in this decline is not known. The general decline indicates that the main cause is not the localized destruction of habitat, but rather factors a larger scale, such as overfishing or nest raiding.

Effects of climate change on sea turtles

Climate change can have several effects on sea turtles. First, the rising sea levels rising reduce or modify the nesting beaches. Rising temperatures may affect embryo development, causing sex ratio bias toward females. Water warming could have negative impact on foraging areas, particularly turtles depending on coral reefs. Finally, the increased influx of terrestrial sediments, due to preview increase in extreme rainfall events, erosion due to poor land use and upstream deforestation can change the shape and characteristics of the sand beaches. This may discourage females from nesting or inhibit young turtles from digging their way out of the nest. This last effect was observed in Masoala region (Randriamanantsoa, pers. comm, January 29, 2008). None of these effects has been studied in details in Madagascar.

In conclusion, climate change effects are a general concern, but there is still no assessment of their impacts on sea turtles in Madagascar.

Effects of tourism on sea turtles

Tourism may have three main effects on sea turtles:

1) The promotion of turtle hunting by an increased market for hand made turtle shell products (mainlt from *E. imbricata* shells)

2) The modification of nesting beaches, particularly through beach lights overlooking the sea

3) The direct interference with turtles nesting through uncontrolled tourist camps in nesting sites.

The modification of nesting beaches, in particular by electric lights, could be a factor handicapping nesting turtles in some places. Despite this risk, some new beach hotels, in remote areas, persist to install powerful lights that directly overlook the beach. To the contrary, some others are aware of risks and have taken measures to hide the lights from the sea. Generally, tourism operators think they are conservationists, and should be receptive to the systematic requirement of specifications of environmental permits with regards to hiding the lights from the sea.

In the past, there have been many cases of uncontrolled tourist camps on the island of Nosy Iranja and tourists sometimes set fires directly into turtle nest craters. These camps disappeared with the private management of the island. Such tourist camps are not frequent, but may develop with coastal tourism in Madagascar which can touch more and more remote areas, becoming a major concern for turtle conservation (Ratsimbazafy 2003).

2.9.5 Birds

Pollution

Seabirds can be affected by marine debris, particularly oil spills where they can be soaked with oil although fortunately this is still rare in Madagascar where impacts have been minimal so far. Birds can also become be entangled in nets and other discarded fishing gear.

Destruction of breeding and nesting sites

The main impact on endangered seabirds is through egg collecting which takes place on many continental islands of Madagascar, accessible to fishermen. Harvesting eggs is considered to be a major factor in the decline of seabirds in coastal waters (ZICOMA 1999). However, no systematic study on this subject has been conducted in Madagascar.

Fishing

Albatrosses and giant petrels are sometimes accidentally caught by longlines in the fishing industry, when these birds dive after the bait on the fish hooks. No studies have been done on the importance of its catches in Madagascar and the level of these effects is unknown. There is no data on the impacts of fishing on seabirds and coastal wetland birds in Madagascar.

Introduced species

Introduced brown rats, *Rattus rattus,* abound on most islands of Madagascar and are thought to be responsible for declining populations of nesting birds. However, there has been no systematic study of this phenomenon and the extent of the effects is therefor unknown. In 2000, a rat extermination was conducted in Nosy Ve Island, Southwest of Madagascar. No impact was observed on the viability of the *Phaeton rubricauda* nesting colony. The number of nests was the same after extermination (Cooke and Randriamanindry 1996, Frontier 2002).

3. HUMAN ENVIRONMENT

3.1 Coastal and island populations: current status and trends

- (causing) pollution
- accessibility (hospitals, markets)
- lack of infrastructure (cross ref to infrastructure section)
- population pressure

3.2 Sites of religious or cultural significance

- accessibility
- cultural erosion – loss of appreciation of the importance of cultural sites
- physical erosion of culturally important sites
- economic pressures

3.3 Human Health

- malnutrition
- education – literacy levels
- disease
- access to drinking water
- access to health services

3.4 Infrastructure

lack of investment / poor maintenance
- level of education

4. COASTAL LIVELIHOODS

4.1 Small scale fisheries SWOT analysis

<table>
<tr>
<td>Strengths

• Traditional fishing operating mode not involving huge marine expenditures (no fuel or food needed)

• Lucrative activities for those targeting sought after export or local market resources as well as for those situated close to the major consumption centres.</td>
<td>Opportunities

• Relatively easily accessible resources exist that do not interest the industrial fisheries, but that are quite lucrative (rock lobster, crabs, cephalopods)
• High demand from local and export markets
• SME development for exportation / marketing of "PTA" (Traditional and Artisanal Fisheries) produce
• ASCLME approach could :
1. Inform and make Madagascar aware of best practices for the management and development of small coastal fisheries in the other countries concerned by the project;
2. Propose rules / principles for the defence of small coastal fisheries' interests;
3. Help countries to define and implement a policy and blueprint for the development of small coastal fisheries</td>
</tr>
<tr>
<td>Weaknesses

• Lack of information / statistics, current and complete, on small coastal fisheries and related activities
• Complete and to date socio-economic data for small fisheries is non-existent
• Disparate and incomplete data on the fishing areas of small fishermen, except for shrimp fishing
• Fishing associations and cooperatives created solely to receive grants, little or no operational activity
• Fisheries Master Plan not updated
• No policy concerning small coastal fisheries
• Lack of specific socio-economic goals for small fisheries within the fishing policy
• No special protection of the small fisheries from the competition of industrial fishing boats
• Improper storage of products in remote villages (lots of post-harvest losses)
• Fishing activities at sea is risky and unsafe
• Non-involvement of small fishermen in the</td>
<td>Threats

• Over-exploitation of certain areas (trawling zones, lagoons, reefs) and of some resources (sea cucumbers, shellfish)
• Lack of trust from banks and micro-finance towards PTA
• Inflation, leading to increased cost of equipment and fishing material, coupled with a lower demand from local and export markets
• Competition from industrial fishing in the trawling areas for the exploitation of demersal fish
• Increased fuel prices for motorized small coastal fisheries
• Lack of coordination between government departments involved in coastal activities, especially between the Ministries of Fisheries and the Ministry of Environment
• Inadequate training of human resources in the sector</td>
</tr>
</table>

global fishing management scheme • No arrangements to ensure that the information reaches the fishing communities • Lack of specific mechanisms / arrangements to manage small fisheries • Means for fishing surveillance insufficient compared to the length of the country's coastline • Weak institutional capacity incapable of managing the fishery industry as a whole	

4.2 Tourism SWOT analysis

Strengths	**Weaknesses**
• High potential as an exotic destination • Different climatic zones and • diversified landscapes (highlands, primary forest, desert zones, 5,000 km of pristine coastline, islands) • unique biodiversity in flora and fauna with many endemic species, • different ethnic cultures with their associated traditions, • no-jetlag for European and African source markets • Low side-expenses for food and beverages	• Poor international accessibility (few flight connections with renowned airlines) • Rainy season (with very hot and humid climate) during winter in the Northern Hemisphere, • Lack of appropriate hotel and restaurant facilities for international clientele • Insufficient service performance • Low-standard and comparatively high extra cost for domestic transport and infrastructures

Opportunities	Threats
• Establishment of a new destination in the competitive surrounding of the Indian Ocean • General improvement of infrastructure and facilities • Development of high service quality • Diversification of tourism products throughout the country • Revival of traditions and cultural heritage contributing to civil pride and feelings of belonging • Quality control management (labelling)	• Detrimental effect as a result of widespread destruction of rainforest • Negative impacts through environmental pollution in Antananarivo • Risk of cyclones on the East coast from December to March • Tropical diseases caused by climatic conditions • Internal migration adding pressure on often fragile natural resources

4.3 Mariculture SWOT analysis

Strengths	Weaknesses
• High quality seawater • Research support capacity at IHSM / FOFIFA, and research support from European Universities • Historical presence of bilateral donor agreements to support mariculture development • Willingness of the MAEP to develop the sector • Strength of the private sector in the prawn industry – providing trained workers to the rest of the industry • Willingness and eagerness of coastal communities to adopt mariculture • High number of potential candidate species for small (and large) scale mariculture • Large areas of coastline suitable for mariculture • Private sector willing to invest in mariculture (e.g prawn culture, emergent sea cucumber culture)	• Sector plan – existing plan needs to be updated and funded • Extension capacity needs to be enhanced • Funding issues concerning the CDCC
Opportunities	**Threats**

• Dedicated government and / or bilateral support for mariculture development • Potentially, the CDCC could become a major fish hatchery / research centre for the development of new species • Development of sea cucumber ranching – a first in the Western Indian Ocean • Large number of potential culture species for which technologies have been developed or are in the process of being developed	• Unsustainable farming practices • Theft and vandalism • Resource conflicts • Potential biosecurity issues if small scale prawn farms are allowed to develop

4.4 Agriculture and forestry SWOT analysis

Strengths	**Weaknesses**
• Vibrant coastal and forest resources including many unique endemic species offer great potential for natural resource management and economic development • Livestock production well established and suited to part of the island's terrain; crop production also well developed, including export crops, with scope for expansion through change from traditional to more industrial methods of farming • Strong civil society and NGO activities and interest in preserving Madagascar's unique environmental landscapes means resources are likely to be forthcoming for development efforts	• Heavy local dependence on subsistence agriculture, and particularly traditional tavy agriculture has cause massive deforestation and threatens to continue to do so in the face of poverty, rising population growth and limited non-agricultural income-generating opportunities • Limited information on alternative livelihoods and non-forestry or mariculture related projects found in this scoping study, suggesting substantial development needed to identify and promote alternatives to tavy agriculture • Limited information on capacity of local communities to manage their own resources sustainable, particularly if NGO projects end or pull out due to political problems (see under 'threats' below) • Lack of information on government planning and management activities in the natural resources sector raises questions about long term domestic capacity to lead sustainable natural resource management without donor and NGO support

Opportunities	Threats
• Tourism, and especially eco-tourism, offer one line of potential development, as does carbon trading as other countries respond to climate change concerns by offsetting their own emissions against the world's existing forests • Madagascar's romantic image due to its high level of endemic species and unusual flora and fauna creates likelihood of interest from donors and international NGOs continuing into the future	• Difficult political and governmental situation in Madagascar at present hinders efficient implementation of government policies and future political violence and instability cannot be ruled out – this has already led to the withdrawal of the Millennium Challenge Corporation from supporting the island's development, and could lead to similar withdrawals by other donors and NGOs

4.5 Energy SWOT analysis

Strengths	Weaknesses
• The legal framework is nearly comprehensive • Strong environmental regulations • Oil fields are sparsely inhabited • Dutch disease strictly monitored by the Government • Land availability	• The absence of a legal government in Madagascar constrains the implementation and application of development policies of the country. Furthermore, most of international donors have suspended their support and private companies are not willing to invests in an insecure environment • Weak centralized Public Service, with insufficient capacity to apply the legal framework • National framework giving CSR guidelines and minimum does not exist • Insufficient capacity to monitor EIA and environmental experts not available in the sub-regions • The status of the ICZM Program of Madagascar is still on stand by due to the political situation in the country. • SMEs weak compliance to international standards • Poor education of the local population impeding them from getting jobs and offering services to the Oil companies • Land access remains difficult to foreign investors for agribusiness or biofuels projects (but this could be an asset for better monitoring at the national level and assure proper benefits to local populations)

Opportunities	Threats
• Experience of oil and gas companies in other regions • Sector development is the early stages, therefore, giving the government the opportunity to fill in the sector management gaps • Commitment to EITI process • Signatory of the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (The "Nairobi Convention", 1985).	• In-migration of workforce • Unidentified impacts of offshore explorations on Marine ecosystems • Creates very few jobs at local level • Vulnerability of fuel and LPG infrastructure to Climate Change • Application of all the development strategy papers have been placed on hold • Population in the coastal zone is very poor.

4.6 Ports and coastal transport SWOT analysis

Strengths	Weaknesses
• Unexploited mineral reserves. • Gradual increase in manufacturing activity. • Location on major shipping corridor. • Access to large expanse of ocean.	• Political instability. • Some ethnic tensions.
Opportunities	**Threats**
• Development of mining in several areas, with relevant port developments. • Increased general cargo traffic through Port Ehoala. • Potential for 100 million-ton bauxite mine within reach of Port Ehoala.	• Damage from cyclones and tsunamis.

4.7 Mining SWOT analysis

Strengths	Weaknesses
• Strong environmental regulation • Strong mining regulations	• The absence of a legal government in Madagascar restrains the

• PGRM supports foreign investments in the mining sector. • Madagascar is rich in natural resources	implementation and application of development policies of the country. • The status of the ICZM Program of Madagascar is still on stand by due to the political situation in the country. • There is no more funding from international donors.
Opportunities • Development of many mining projects such as WISCO in Soalala, and Toliara Sands. • Greater NGO involvement. • Employment for local workers and SMEs • Signatory of the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (The "Nairobi Convention", 1985).	**Threats** • Political instability in the country • Application of all the development strategy papers in stand by. • Population in the coastal zone very poor.

5. POLICY AND GOVERNANCE

5.2 Administrative/legislative zones of the sea

- administrative boundaries are political, based on land, not water.
- countries haven't necessarily negotiated EEZs.
- baselines may be inadequate.

5.3 Legislation

At national level, many texts of legislation govern sea zones. These texts, classified by domain, are in annex 20.

- implementation/enforcement of legislation
-overlapping legislation

5.4 Continental shelf extent

- deadline for submitting shelf claims
- technical capacity.

5.5 National, provincial and local authorities in coastal/marine affairs

- unclear mandate on some marine issues
- overlapping mandates.

5.6 NGOs and private sector

- non-fulfillment of commitments, lack of monitoring, inadequate accountability
- lack of transparency and accountability
- participatory planning is good, but implementation is poor

5.7 International relations, conventions and committees

- inadequate nationalization of international conventions
- inadequate implementation.

6. PLANNING AND MANAGEMENT

6.1 National disaster management

Lack of coordination between agencies

The response structure for the Risk and Disaster Management in Madagascar is very heavy so that it cannot function normally. This problem is especially observed in the coordination of all agencies that provide assistance during critical periods. The excessive centralization of decision making had strengthened a wait-and-see attitude of decentralized communities which are used to be assisted and still waiting for hypothetical aid from outside.

The law No. 2003-010 on the national policy of risk and disaster management (and its decree application), has established a national system of RDM consisting of some structures that correspond to institutions or coordinating entities at central and local levels, namely: the Conseil National de GRC attended by the CPGU (Cellule de Prévention et de Gestion des Urgences), the Bureau National de GRC, Regional, Communal and Local Councils, NGOs and organs from international cooperation.

The RDM in Madagascar is under the responsibility of the Bureau National de Gestion des Risques et Catastrophes (BNGRC), the central anchor of any intervention in the RDM. It is attached to the Ministry of Interior. It is the organ of management, coordination, monitoring and support of the Conseil National de Gestion des Risques et Catastrophes (CNGRC) which is attached to the Prime Minister's Office. The CNGRC, under the chairmanship of Prime Minister, Head of Government, is the national strategic entity of design and supervision for GRC. It is represented at Regional level by the CRGRC, in Districts by the Comités Locaux de Gestion des Risques et Catastrophes (CLGRC), in Municipalities by the Comités Communaux de Gestion des Risques et Catastrophes (CCGRC) and in Fokontany, the RDM is led by the Local Relief Teams.

The CPGU is a technical organ, with the Prime Minister's Office, responsible for assisting the Prime Minister and the CNGRC in their design, strategy development and evaluation for managing risks and disasters missions. Moreover, the UN system, in 2004, also created a «Thematic Group on Prevention and Disaster Management» which is currently chaired by UNICEF and regularly gets together the Emergencies focal points of different UN agencies. This Thematic Group is transversal and multisectoral. The Office for the Coordination of Humanitarian Affairs (OCHA) is providing support for coordination, preparedness and disaster management at the Resident Coordinator of the UN System and BNGRC offices. The Resident coordonator and the OCHA also ensure the secretariat of the Sectoral Working Groups and GTPGC.

There are also some specialized structures, with different status, acting directly or indirectly in GRC, among others :
- Corps de Protection Civile, attached to the Ministry of Defense,
- Centre National Anti-Acridien (CNA),
- Office National pour l'Environnement (ONE),
- Autorité Nationale De l'Eau et de l'Assainissement (ANDEA), mandatée pour l'exécution de plans d'urgence pour la prévention et la lutte contre les inondations et les sécheresses,
- Office National de Nutrition (ONN),
- Comité national de lutte contre la propagation de la grippe aviaire,
- Organe de Lutte contre les Evénements de Pollution marine (OLEP), attached to the Ministry of Environment.

There are also some units or offices within some sectoral Ministries, particularly :
- Office des Travaux d'Urgence (OTU), newly created into the Ministry of Public Works
- Direction des Urgences et des Catastrophes, into the Ministry of Health
- Direction de la Sécurité Alimentaire and Division des Opérations agricoles de secours, into the Ministry of Agriculture.

Awareness and communication of plans in place

There is no centralized database on disasters and in addition, the key sectoral ministries of agriculture, health, transport and education do not have an up to date database on the impacts of disasters. The information available in these departments is generally incomplete and fragmented. Finally, although efforts have been developed for analyzing risks and vulnerabilities, they remained very rudimentary and the country has no detailed risk maps that can be used for land development program. Overall, it can be argued that the lack of basic information on risk analysis and the mapping and identification of priority areas, especially the practical identification of technical solutions to specific risks, harms the development of a risk prevention plan and the mainstreaming of risk reduction into development processes. The information is the most important tool to guide decision-making process at various levels in RDM.

During a disaster, communication is by radio, television and print media. Disaters mainly occur during cyclonic periods. Communication is the main activity of the Ministry of Interior and BNGRC. In

affected zones, the mobilizations are organized by the responsibles in Regions, but the lack of means (local radio, local television, transport) and the inadequate capacity of decision-making are among the major causes that affect the dissemination of information and the rescue plan. Nevertheless, the UNDP had supported Madagascar, since 1997, in the establishment and implementation of an integrated information system on food security and disaster risk management.

Implementation of the disater management plans

With limited resources, often from international cooperation projects, the BNGRC has promoted and established committees across the country. Unfortunately, the lack of financial and organizational resources (also linked to the framework of "project" in which these interventions were included) inhibited the necessary monitoring and transfer capacity to local collectivities, thus limiting the consolidation of operational network of committees throughout the country. Moreover, NGOs are involved at different levels in the establishment and strengthening of committees at the lowest territorial level. Unfortunately, there is no complete inventory of actions at local level, nor good practices that could supply the local management process. These facts limit action efficiency.

During cyclones, the implementation plans are disrupted because the responsible people in the affected areas are working as volunteers. They have their own activities and are not prepared in advance to deal with hurricanes. On the other hand, during these critical periods, their relatives and their assets (animals, cars, fields, shops ...) are their priority. Such situation makes more fragile the implementation of risk and disaster management plans.

The CPGU, through the implementation of an integration of climate risk and disaster management in the economic development of Madagascar, is developing a series of activities focusing on prevention and reconstruction in order to reduce the risks of disasters. These measurements aim at decreasing the magnitudes of damage and losses caused by natural phenomena. These activities are
1) strengthening the risk assessment,
2) risk mitigation through the adoption of anticyclonic standards,
3) the establishment of a contingency fund and a mechanism risk financing and development of an early warning system and
4) a national plan for risk management.

Contingency plans

In terms of reducing overall risk and vulnerability, progress is limited. Indeed, the actions developed by the CNS and its partners are focused almost exclusively in the field of preparedness and disaster response. Although efforts have been made to take account of the GRC in the Strategic Document for Poverty Reduction and more recently in the Madagascar Action Plan (MAP), this does not happen in the form of mainstreaming and effective integration. There was little or no intervention developed to change the structural conditions of existing risks. Indeed, the institutional framework remains fragmented and is absent from a systemic and comprehensive management of risks. Nevertheless, there are, through policies and strategies, and sectoral programs, major opportunities to influence risk.

Fortunately, the Contingency Plan for Natural Disasters exists for Madagascar. The first contingency plan was prepared in accordance with the commitments / challenges in the Madagascar Action Plan (MAP) 2007-2012 and based on lessons from the 2006-2007 cyclone season, which call for lessons learnt:
1) strengthening coordination and communication and information,
2) developing common assessment methodologies (rapid and detailed) and intervention,
3) optimizing the process of fundraising and
4) strengthening the capabilities of logistics.

This plan, entitled "Contingency Plan of the Permanent Committee and the Government" showed its usefulness as a reference tool during cyclonic season. The preparedness, assessments and responses were coordinated by the BNGRC with the support of the CRIC (Committee of Reflection of Stakeholders in Disaster) and OCHA or the BCR, and were carried through sectoral groups: Water and Sanitation, Nutrition and Food Safety, Health, Agriculture, Education, Logistics and Habitat, operational since early 2008.

This plan does not consider tsunamis however and is annually prepared by the Malagasy State, with the support of the United Nations Systems.

ALERT network for tsunami early warning

The Institut et observatoire géophysique d'Antananarivo (IOGA) noted that Madagascar is well within reach of terrestrial waves from telluric events occurring along the Sumatra fault, but the island is protected by a band of coral reefs. The tsunami of 2004 has caused concern when preparing the population to a such destructive phenomenon. The threats to Madagascar were nevertheless considered since 2005 and in 2008, a project funded by the UNDP and UN-ISDR (United Nations-International Strategy for Disaster Reduction), involved the establishment of a tsunami warning system. This project, led by BNGRC, has regional scale with the consortium of the Indian Ocean over the entire Indian Ocean zone.

6.2 Environmental sensitivity mapping

Madagascar faces many problems of degradation and loss of resources by overexploitation with improper major impact on the resource sustainability. The areas of concern are:

- Erosion
- Extinction of vegetation
- Population growth.

6.3 Coastal management/ development plans

Lack of Coordination Between Agencies and Awareness and communication of plans in place

The various Malagasy institutions involved in sustainable coastal management have certainly taken action more or less appropriate to address the growing problem of coastal zones, but these interventions are conducted on a generally occasional, isolated and mainly sectoral basis.

Rapid coastal population growth

The low level of economic growth compared to the relatively high population growth inhibits the success in consolidating the process of economic transition and has resulted in real increase in poverty in the country (Madagascar. Direction General du Plan year ?). The current high rates of population growth in the country imposes a huge burden on its resources and its social and environmental services. Although the major cities of Madagascar, as poles of attraction, are provided with Town Planning Guides, these guides do not sufficiently consider the population growth due to rural exodus.

6.4 Areas under special management

Poaching activities

Human pressures on Malagasy coastal resources undermine the ecosystem functions crucial to its productivity and the socio-economic development of coastal population. Illegal and destructive fishing and coral collecting as well as overexploitation often damage habitats. The development of insufficiently regulated fishing and tourism may threaten biodiversity and some biotopes. The management of protected areas in Madagascar is governed by Malagasy Code of Protected Areas

Management and its implementing regulations. As such, marine protected areas (MPAs) appear in the literature as "management tools to protect, maintain and restore natural and cultural resources of coastal and marine waters. The MPAs are used nationally and internationally to conserve biodiversity, manage natural resources, protect endangered species, reduce use conflicts, provide opportunities for research and education, and develop commercial and recreational activities " (Salm *et al.* 2000). Three formal MPAs exist in Madagascar as directed by the Madagascar National Park. Current initiatives are framed into the System of Protected Areas of Madagascar (SPAM). Four potential sites for additional MPAs have been identified according to specific criteria by the Committee on Environment and Fishing. They cover an area of one million ha.

Coastal development

The implementation of the « Secure Local Management of the renewable natural resources and of the land (GELOSE) » in coastal zones is governed by law 96-025. Fifty two (52) transfers of management were officially carried out for marine and coastal resources and 4 contracts of Community Management of Forests regarding the management of mangroves have been established. In addition, several projects related to conservation and protection of coastal and marine resources are currently underway:

- Activities of World Wildlife Fund and Madagascar National Parks in the south of Toliara (MPA design, support to fishermen):
- PACP program funded by the African Development Bank, from Morombe to Soalary;
- Activities of Madagascar National Parks in Belo sur Mer;
- Activities of Fanamby, Millenium Challenge Account, local and regional authorities in Menabe
- Activities in Sainte Marie (Ile aux Nattes with Conservation International, on Megaptera whales), Ambaro, Morondava and Bay of Antongil,
- Activities of Wild Conservation Society in the Bay of Antongil (Whales, ICZM).

Conflict between users

The authorities have extended the reserves into areas where local people who are viewed as destructive have been evicted. The misunderstanding of Malagasy people who can no longer survive often leads them to perpetuate the destructive practices of natural resources. The model "protected area" causes many land use conflicts between parks and the resident population. Conventional methods of resource and marine and coastal ecosystems management failed. In most cases, these methods cannot find compromise between the needs of their conservation and those of their exploitation. There are, in particular, the case of land reserves for tourism, and also conflicts of use generated with oil and mining sectors.

Lack of participation in planning process (leading to conflicts)

During the second phase of the Environmental Program, the regions of Toliara and Nosy Be, were chosen by the Belgian Marine and Coastal Environment (ECM) as pilot areas. The design and implementation of development plans, with participatory approach were initiated but, the mechanism was not followed by appropriate measures in its application throughout the country.

Lack of education and awareness of the value of managed areas

The lack of tangible benefits for local communities from conservation activities ultimately affects the long-term success of these activities. Without appropriate models for community integration and sharing of profits, local support for preservation projects is unlikely.

Conflicts over increasing area under protection

The problems related to lack of awareness and poverty make the setting up of marine protected areas difficult. The Administration and the coastal populations could not develop a defensive strategy because they have only few alternatives to pressure. The low level of knowledge and lack of

alternatives offered to these populations accentuate the dependence on their fishing areas. Indeed, to address this experienced poverty, the strategy adopted by the population is either to extend the fishing areas, or intensify fishing effort, or violate any laws with consequences on ecosystem performance. The uncontrollable demography only aggravates the situation.

6.5 Monitoring, Control, Surveillance

Policy issues

With nearly 5600 km of coastline and more than one million km^2 of areas under jurisdiction near strategic shipping lanes, Madagascar undoubtedly arises as a potential regional pillar with development opportunities focused on the sea. The government gave priority to the development of State action at Sea concept, for 2008.

Inadequate enforcement of regulations

The ratification, by Madagascar, of the United Nations Convention on the Law of the Sea in 2000, clearly shows the country's commitment in this area. Ensuring the State's right in sea allows to develop Malagasy wealth in smoothly exploiting the marine environment, in using the waterways, or in preserving law and public peace from troublemakers and traffickers.

Economic issues

Untill now, no study has been undertaken to comprehensively assess the economic values of coastal and marine areas.

Regional cooperation

Launched in October 2007 and expected to last four years, the African Monitoring of Environment for Sustainable Development project (AMESD) aims at improving the operational use of surveillance technology on Earth and ensuring the sustainability of environmental and climatological applications specifically for Africa in order to give African nations the tools they need to more effectively manage their environment. In 1999, the network of IOC Coral was officially recognized as a regional node of the Global Coral Reef Monitoring Network (GCRMN) for the south-western Indian Ocean island region.

Availability of resources (manpower, patrol vessels)

Besides the Naval Forces, Madagascar now has six other jurisdictions that operate in the framework of the State Action at Sea, depending on their specific skills and capabilities: the Gendarmerie Nationale, the Centre for Fishery Monitoring of (CSP), the Autorité Portuaire Maritime et Fluviale (APMF), the Organe de Lutte contre l'Evénement de Pollution marine par hydrocarbures (OLEP), the Administration des Douanes et Sécurité civile. The FN and CSP have buildings capable to operate in high seas The Centre also has a trained and specialized staff to carry out surveillance and control activities. It currently has the material means: two offshore surveillance ships named Atsantsa and Tendromaso; one support ship for fast units (*Telonify*), seven rapid response units, satellite monitoring equipment (Vessels Monitoring System in conjunction with IMARSAT and ARGOS)

Lack of communication with policy makers

The general population may not understand the value of the resource, so government spending on MCS systems is not easy. While dialogue, even exchange, were recently established between these different administrations, their actions are not yet coordinated by a single authority.

Permits are issued for quotas but there is no monitoring of catches :

The Fishery Monitoring Centre of Madagascar was created in April 1999 by Decree No. 4113/99 of 23 April 1999. For rational and sustainable exploitation purposes, this centre has to protect and preserve fishery and aquaculture resources in its monitoring, control and surveillance activities.

Monitoring of fishing effort concerns the traditional, artisanal and industrial sectors. Control of fishing activities is carried on throughout the country; monitoring ensures compliance with laws and regulations by all ships operating in Malagasy national waters and by all economic sectors of fishery and aquaculture.