Payments for Marine protected area ecosystem services in the Caribbean (CARIPES)

Report 2.3 – Quantification of Ecosystem Services and Users

Jean-Philippe Maréchal, Ewan Trégarot

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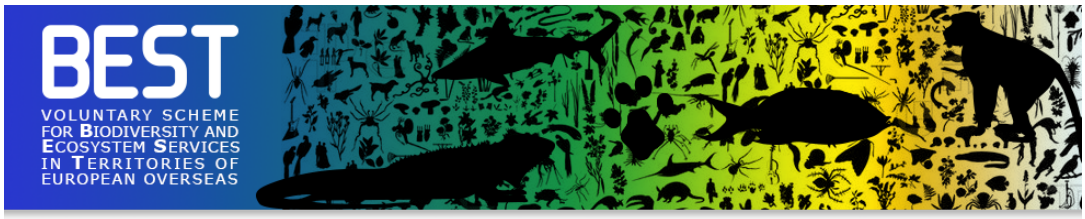


Preparatory Action 'BEST' (Voluntary scheme for Biodiversity and Ecosystem Services in Territories of the EU Outermost Regions and Overseas Countries and Territories).

Table of contents

1. Introduction

Ecosystem services of the Prêcheur MPA ecosystems were evaluated according to methodology developed in RM2.1 report. An overview of the user categories is also presented. These data were collected for WP 4 on socioeconomic valutation of ecosystem services in MPAs.

2. Marine Ecosystem Services diagnostic – Martinique "Le Prêcheur – Albert Falco" MPA.

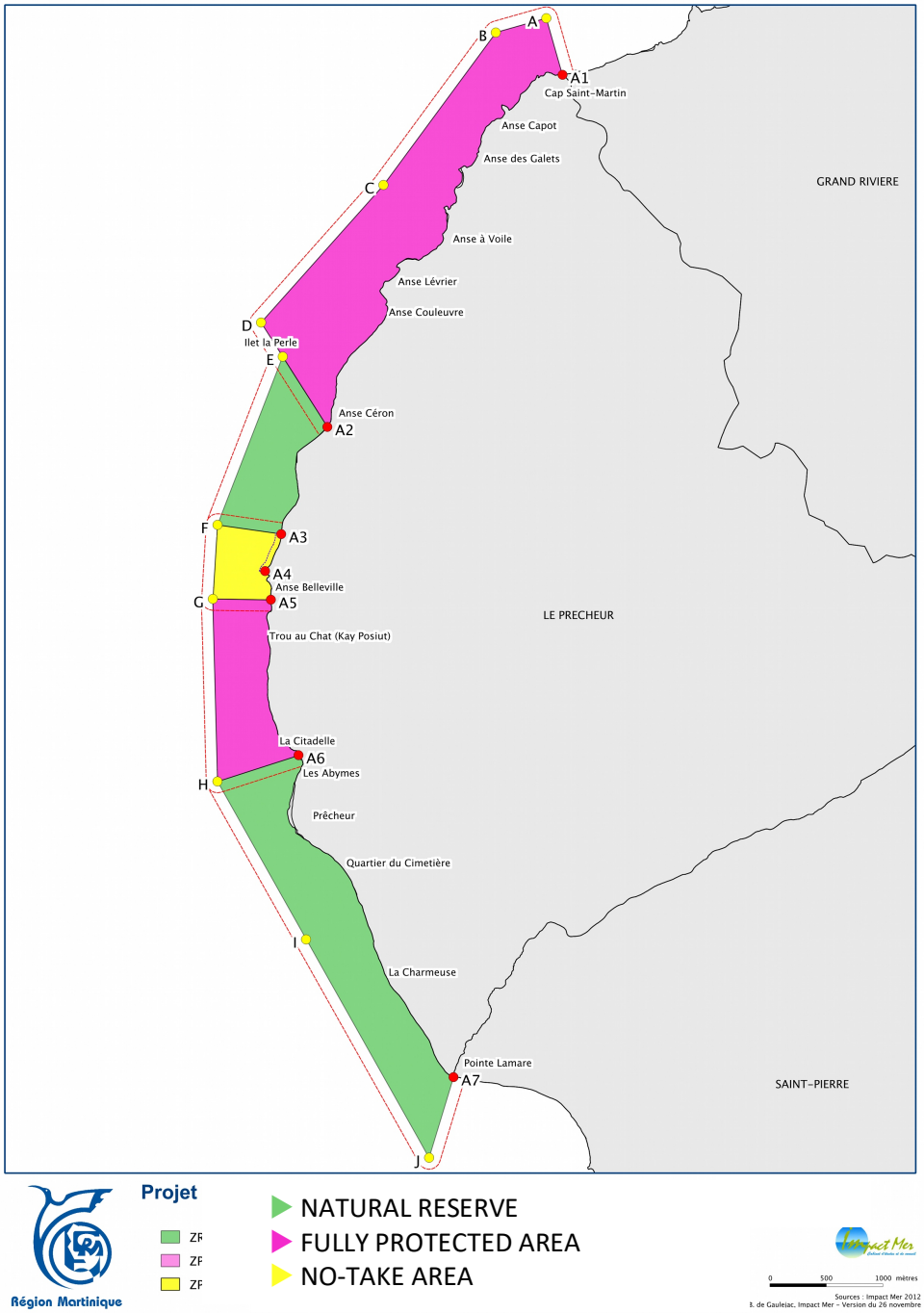
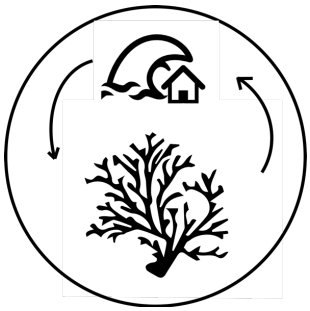


Figure 1. The Prêcheur – Albert Falco Marine Protected Area zoning.

2.1. Coastal protection



Coastal erosion is a very important phenomenon along the coast of the Prêcheur MPA area. The shoreline has decreased from 25 to 35 m in 40 years, or 0.6 to 0.9 meters per year on average (Saffache and Desse, 1999). In some places, erosion has reached 40 m (Pointe Lamarre) or even 70 m (Anse Belleville) (ibid). This erosion is caused by the combined effect of a steep coastline, strong swell, coastal materials facilitating erosion, hurricanes and tropical storms (Edith in 1963, Dorothy in 1970, David in 1979, Allen in 1980, Hugo in 1989 and Klaus in 1990) and finally the collection of sand at the mouth of the rivers. In view of this very significant erosion, artificial constructions were built, particularly in the Babody Canyons area where the coastline is now composed of concrete blocks.
The Prêcheur MPA area does not have bio-constructed reefs, but coral communities on bedrock. These communities have no protection effects on the strong west or south swells, as was seen during the Leny tropical wave-type climatic events in 1998, or more recently with Omar in 2008. Seagrasses are generally found at important depths along the coast, which reduces the contribution of this habitat to the lessening of coastal erosion or the mitigation of the devastating effects of natural disasters. As a result, the protection value of the marine ecosystems against coastal erosion is zero.

2.2. Biodiversity, ecosystem poductivity and catchable biomass

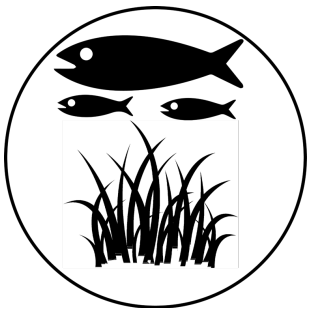
In Martinique, coral reefs shelter more than 200 species of fish, while 65 for seagrass beds and 87 for mangroves (Blanchet et al., 2002). Each of these three ecosystems produces exploitable fish biomass. Only the so-called "catchable" species, that can

be found in the catches of small-scale fisheries (traps, nets, seine), are taken into account. Thus, for each species of fish, which can be captured with 38 mm mesh traps, there is a potential for catchable biomass, whether for commercial purposes or not. This represents the biomass of the marine ecosystems that is sought to be estimated.

2.2.1. Coral communities

For coral communities found on bedrock in this area, the average catchable biomass is 11,454 g / 200 m², or about 57.5 t / km². This ecosystem extends in the 0-50 m zone for 0.46 km^2, what gives a catchable biomass of 26.5 t.

2.2.2. Seagrasses



Seagrass beds are located mostly in the north of the Prêcheur MPA. They represent nurseries and habitats for juvenile fish, conch and sea urchins. They support a much lower catchable biomass than the two categories of reef: they harbor 2.9 t / km² per year of catchable biomass (adapted from Martin and Cooper, 1981). The seagrass beds cover within the Prêcheur MPA is 107.3 hectares, ie 1.07 km², giving a catchable biomass of 3.1 t / year.

2.2.3. Sand bottoms

Sand bottoms are not involved in the production of catchable biomass. They are not critical habitat at any stage in fish lifecycle. Catches in these areas, including beach senne, are related to the displacement of fish from one habitat to another. They are therefore not taken into account in the assessment of this service.

2.2.4. Biomass synthesis

By comparing the values obtained above with the surface of each ecosystem, we obtain the value of the Total catchable biomass. In order not to count the biomasses twice, we extract the biomass captured by professional and recreational fishermen and the biomass of catches that are self-consumed, from the catchable biomass, to have the value of the catchable biomass that is not caught (Table 1).

Table 1. Catchable biomass (not caught)

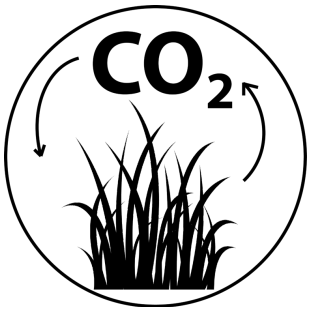
	Coral communities on rock substrate	Seagrass
Total catchable biomass (t/km²)	57.5	2.9
Surface (km²)	0.46	1.07
Biomass captured by fisheries (t)	20	2.2
Biomass captured by non professionnel (t)	2.16	0.24
Catchable biomass (t)	26.45	3.103
Biomass not captured (t)	4.29	0.663

NB : seagrass beds and coral communities cover used here are from the habitat mapping published by OMMM in 2010. It has been shown in the ecological assesment that seagrass cover had largely extended since, essentially because of Halophila stipulacea invasion, while coral communities did not change. Habitat mapping was not planed in the CARIPES program.

2.3. Carbon sequestration

In the current political context, growing attention is being paid to climate change. Carbon dioxide (CO_2) is at the center of all discussions. As a greenhouse gas, produced in large quantities by human activities, it is often pointed out as responsible for global warming. The current will is to reduce the amounts emitted in the atmosphere. For this, man turned to nature and his ability to absorb and trap this gas, with a recurring question: What natural ecosystems could participate in CO_2 sequestration? The ocean is often cited because of its high CO_2 absorption capacity. Over the past two centuries, the oceans have accumulated about 500 Gt of CO_2 from the 1,300 Gt discharged from anthropogenic activities, accounting for nearly 40% of the releases (Metz et al., 2005).

2.3.1. Seagrass



Seagrass are important carbon sinks. From the litterature, carbon sequestration by seagrass beds is estimated to average 129 tC / km² / year (Champenoy 2008, Laffoley 2009, Chauvaud et Bouchon 1997, Agostini *et al.*, 2003). Seagrass beds in the Prêcheur MPA cover 1.07 km². They theoretically can absorb 138 t of carbon per year, or 505 t of CO_2 per year.

2.3.2. Carbon sequestration synthesis

For all marine ecosystems of the MPA, the amount of CO_2 absorbed is close to 583 t per year (Table 2). Carbon sequestration is mostly due to seagrass in the area.
CO_2 emissions have a price following the entry into force of the Kyoto Protocol in February 2005. Countries that have ratified the Protocol are committed to reducing their greenhouse gas (GHG) emissions, in particular CO_2. The target was a 5.2% reduction in emissions for 2012 based on the emissions assessed in 1990. In fact, each country has put in place various practices to reduce GHG emissions, the most widely used being the carbon exchange which determines emission quotas set by the country, each excess of quotas generating an additional cost for the issuer.

Table 2. Carbon sequestration in marine ecosystems – Prêcheur MPA.

	tC/km²/year	Surface Km²	Carbon (t)	CO_2 (t)
Coral communitites on rocks	180	0.12	21.6	78
Seagrass	129	1.07	138	505
Total		1.19	159.6	583

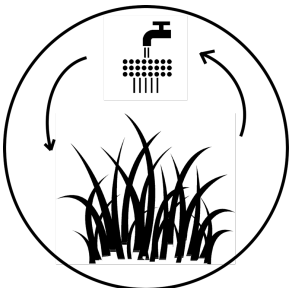
NB : seagrass beds and coral communities cover used here are from the habitat mapping published by OMMM in 2010. It has been shown in the ecological assesment that seagrass cover had largely extended since, essentially because of Halophila stipulacea invasion, while coral communities did not change. Habitat mapping was not planed in the CARIPES program.

2.4. Water purification and nutrients

In the Precheur area, many rills flow directly into the riverbeds and into the sea. This contributes to increasing the turbidity of the water and the concentration of suspended matter. These sediments resulting from runoff and erosion are a major

threat for the health status of marine ecosytems. Plumes disharges with suspended matter have an ecological impact on seagrass and reef areas. Coral and seagrass communities require clear and slightly turbid waters: most of the growth of the organisms constituting these ecosystems is based on photosynthesis and consequently the availability of light. Seagrass and algae essentially contribute to water purification by using certain suspended solids and filtering fluids.

2.4.1. Seagrass



Seagrass beds trap some of the suspended matter in their roots. In addition to this function of substratum stabilisation, phanerogam plants use minerals for growth and participate to water purification. The presence of seagrass beds in the vicinity of reef areas promotes coral growth by maintaining low nutrients concentration in the surrounding water.

The presence of algae probably changes the quality of the water by absorbing a large part of the nutrients. However, the proliferation of algae is to the detriment of coral reefs, and especially the development of corals. In the absence of references on the capacity treatment of the algae, the likely treatment capacity of seagrass beds is used for estimating that of the algal communities. The seaweed coverage in the MPA is 19.1 ha, ie 0.19 km^2.

2.4.2. Coral communities

Coral comunities have little effect on water treatment. The symbiosis with zooxanthellae, using CO_2, nitrogen and phosphorus from the water column to produce organic matter, purifies the water from some of these nutrients. However, this function is negligible compared to that of seagrass and algae. Only 0,46 km^2 of coral communities have been mapped.

2.4.3. Water purification synthesis

Seagrass contribute 99% of this service in the MPA. Coral communities have a minimal effect (1%).

Table 3. Water purification by marine ecosystems – Prêcheur MPA.	
	Surface (Km^2)
Coral communities on rocks	0.46
Seagrass and algae	1.26
Total	1.68

NB : seagrass beds and coral communities cover used here are from the habitat mapping published by OMMM in 2010. It has been shown in the ecological assesment that seagrass cover had largely extended since, essentially because of Halophila stipulacea invasion, while coral communities did not change. Habitat mapping was not planed in the CARIPES program.

3. Users and pressures diganostic

3.1. Geographical context: the Mount Pelée watersheds

The geomorphological structures of watersheds of the Prêcheur were shaped by successive volcanic events. The relief of the northwest flank of the Mount Pelée is the Conil peaks, which culminate at 897 m, and strong depressions on the steep slopes caused by three sectoral collapses of the volcano on the southwest flank. This rather atypical morphology of the western flanks of Mount Pelee led to the formation of a vast hydrographic network, with a significant morpho-dynamic heterogeneity between the different rivers.

Five rivers are found on the slope of Mount Pelée in the Prêcheur area: Anse Galets river, Anse Couleuvre river, Anse Céron river, Prêcheur river, Pointe Lamare river.

The major risks related to the relief and the hydrographic network of the Prêcheur area are phenomena of landslides and flooding of the coastal plain caused by exceptional hydro-climatic events:

- Rainfall runoff in urban and peri-urban areas,
- Remarkable high floods, causing torrential flows with transport of large quantity of materials and MES

Cyclones amplify the processes of torrential dynamics (precipitation, wind, swell...) and prolong the risk of flooding over time. Changes in the surface water network by anthropogenic quarrying and earth-moving activities (for agriculture and town planning) accentuate the phenomenon of surface water diversion.

Transportation of sediment in coastal waters leads to hypersedimentation impact on marine ecosystems (coral communities, seagrass). Nutrients transported by the water can also cause eutrophication in coastal waters.

3.2. Land based pressures

3.2.1. Pollution from domestic sources

The MPA is located north of Saint-Pierre in a minor urbanized area. The vilage is by the sea and is the only small city of the zone. Cosntructions are concentrated on either side of the coastal road. Important sources of organic and bacterial pollution come from discharge from domestic wastewater in coastal waters.

3.2.1.1. Sewage treatment plants

Four sewage treatment plants are located in the MPA area. Treated wastewater get directly to the sea.

Table 4. Sewage treatment plants in the Prêcheur MPA.

Sewage plants	Administrator	Process	Capacity (EI)
Charmeuse	SCCCNO	Activated sludge	300
Cité Coquette	SCCCNO	Activated sludge	200
Ecole Maternelle	SCCCNO	Activated sludge	80
Lotissement Charmeuse	SCCCNO	Bacterial treatment	300

3.2.1.2. Risk

Sewage treatment plants have environmental risks and can affect the environment through:

- Unconformity of the output disharge *Charmeuse* and *Ecole Maternelle* du Prêcheur.
- Carbon and Particulate Pollution
- Nitrogen and phosphorus
- Hydraulic overload
- Organic Overload
- A low dilution capacity of the marine environment

On the other hand, the discharges from the Saint-Pierre wastewater treatment plant can affect the marine environment in the MPA area. The Audit of the treatment plants of Martinique in 2010 concludes to the non-conformity of the discharges, hydraulic overload in dry season and organic overload which requires improvement of the plant in order to expand its processing capacity.

3.2.2. Pollution of agricultural origin

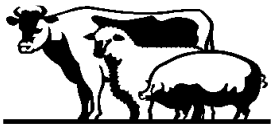
Agriculture is an important activity for the Prêcheur area.

3.2.2.1. Crop growing/Cultivation

The slopes of the Mount Pelée are fertile and are cultivated on small plots in an artisanal way. Vegetable growing dominates and accounts for 71.2% of plantations. The number of plantations is 125 entities for 599 ha exploited (AGRESTE, 2011).
Nevertheless, the Agricultural Area Used (UAA) is low (155 ha). The variety of food crops, the frequent rotation between crop types and the short-lived criteria of these small plantations make the use of fertilizers and pesticides very difficult to monitor. No statistics can be used to assess the pollutant loadings of these crops on the environment (Legrand, 2010).

In Saint-Pierre, 72 plantations use 772 ha, of which 274 ha are allocated for banana culture, 114 ha for fresh vegetables and a part for cattle breeding with about 140 cows (Source: AGRESTE, 2000). Sugar cane represents 30 to 50% of the plantations around Saint-Pierre (source AGRESTE Primeur - n ° 256, February 2011). Sugar cane is grown exclusively on the "Plantation la Montagne" by the Distillerie Depaz.
Pollution comes from fertilizers and pesticides drained from runoff to the marine environment, resulting in nutrient enrichment and toxic molecules in coastal waters.

3.2.2.2. Farming



Breeding activity is mostly sheeps and goats farms, which tripled between 1989 and 2000. Cattle breeding are extensive.

3.2.2.3. Risks and Pressures

3.2.3. Phytosanitary products

The banana and sugar cane crops grown around Saint-Pierre are the main vectors of environmental contamination by 3 types of phytosanitary products found in coastal waters of Martinique (DIREN-ODE, 2010):

Pesticides, including Chlordecone

Herbicides used for the weeding of non-agricultural areas (OMMM, 2004)

Fungicides, a large part of which is used in post-harvest treatment of bananas for export

The spraying above the crops causes aerial dispersion and contaminates surrounding environments and soils. The chemical coumponds are transported to small rivers and underground aquifers, ending up in coastal waters.

3.2.3.1. Fertilizers

Sugar cane and banana crops deplete the soils and cause farmers to use high quantities of fertilizers. At present, no data on the quantity arriving at sea is available.

3.2.4. Pollution of industrial origin

3.2.4.1. Mining and quarrying

The mining companies are located in Saint-Pierre. They are specialized in the extraction and processing of Pouzzolane (Legrand, 2010).

Quarry Gouyer: production 435 000 t/year

Quarry Sablim: 150 000 m^3/year

Quarry les Sablières at Fond Canonville: 540 000 t/year

3.2.4.2. Risks and Pressures

Suspended matter

O released during mining and processing

O Suspended by wind: erosion of the open pit quarry and access road

Draining of the hydraulic system of the material processing plant (direct discharges into the sea of suspended matter)

Loading of barges with materials for export: possible debris and suspended matter discharged directly into the water (accidental).

Suspended matter has an impact on the environment, producing high turbidity in coastal waters and excessive sedimentation (Legrand, 2010).

3.2.4.3. Food processing industry

The Depaz distillery represents the main agri-food activity in the area. It pumps 1080000 m^3 / year (source: IREP). Its production is 11 000 l/day. The treatment of its effluents is carried out by methanisation in order to reduce polluting emissions by at least 95% (OMMM, 2004).

3.2.4.4. Risks and Pressures

The impact comes from the effluents with high pollutant loads: acidic pH (3.3), high temperatures (from 85 to 90°C), high content of organic matter, high concentration of nitrogen and phosphorus. The methanization process limits the releases, but it remains a source of pollution. The distilleries are seasonally operated (sugar cane harvesting period) and discharges occur only from March to July. These effluents have a major impact on the environment (Legrand, 2010).
The Neisson distillery located at Le Carbet presents similar risks of pollution from potential transfers to the marine environment.

3.2.5. Professionnal fisheries

Small-scale fisheries are the second activity after agriculture. However, this activity decreases (slight decrease in the number of registered fishermen).
The marine reserve is mainly visited by fishermen from the Prêcheur but also, by professionals from Saint Pierre, Carbet and Bellefontaine.

3.2.5.1. Fishermen

The number of fishermen registered for the Prêcheur area is 75 (Table 4):

Table 5. Number of registered fishermen and boats in north Martinique.

Village	Registered fishermen		Boats	
	DRAM (02/11)	DRAM (2008)	DRAM (02/11)	IFREMER SIH (2011)
Bellefontaine	14	14	25	16
Carbet	17	20	27	23
Saint Pierre	23	23	41	28
Prêcheur	21	31	32	33

The number of vessels (all fishing activities) is 125. This number exceeds the number of registered fishermen due to the fact that many of them have several fishing boats adapted to their activities and also that many boats registered are not used anymore.

Table 6. Number of fishermen registered in Le Prêcheur and Saint-Pierre between 2007 and 2011.

Village	2007	2008	2009	2011
Prêcheur	36	31	27	21
Saint Pierre	26	23	30	23
Total	**62**	**54**	**57**	**44**

Professionnal fishermen are united through the association *"Ti Tak Pou Yo"*. This association includes 26 members, all from the Prêcheur village. The purpose of the association is to inform fishermen and help them with their investments.

Six fishermen of the Prêcheur diversified their activity, bringing tourists to visit the MPA. For five of them, this activity remains occasional.

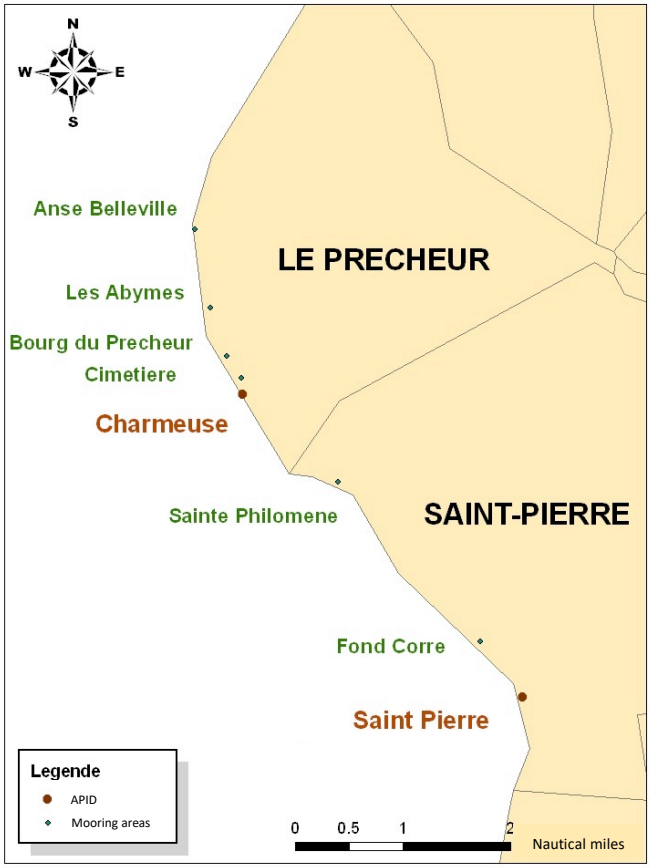
3.2.5.2. Fishing activities

Sixteen boats are used for fish trap fishing, but only two of which are exclusive fish traps users. The others also practice offshore fishing.
Thirteen vessels strictly practice a coastal fishery, 15 also fish offshore. Six boats exclusively fish offshore.

Table 7. Number of boats / type of fisheries (IFREMER 2011).	
Strictly coastal	
Senne	8
Hook & lines	1
Fish trap	2
Hook & lines + fish traps	1
Hook & lines + nets	1
Mixt coastal + offshore	
Fads + multi fisheries	12
Fads + fish nets	2
Fads + fish traps	1
Stricly offshore	
Hook & lines fads	6
Nonactive	10
Total	**44**

3.2.5.3. Fish market coastal areas

A specific area called “APID” (Aménagement pour la Pêche d’Intérêt Départemental) is located at La Charmeuse. There are also four mooring areas inside the MPA: Cimetière, Bourg du Prêcheur, Les Abymes and Anse Belleville (source IFREMER), along with local fish market locations.

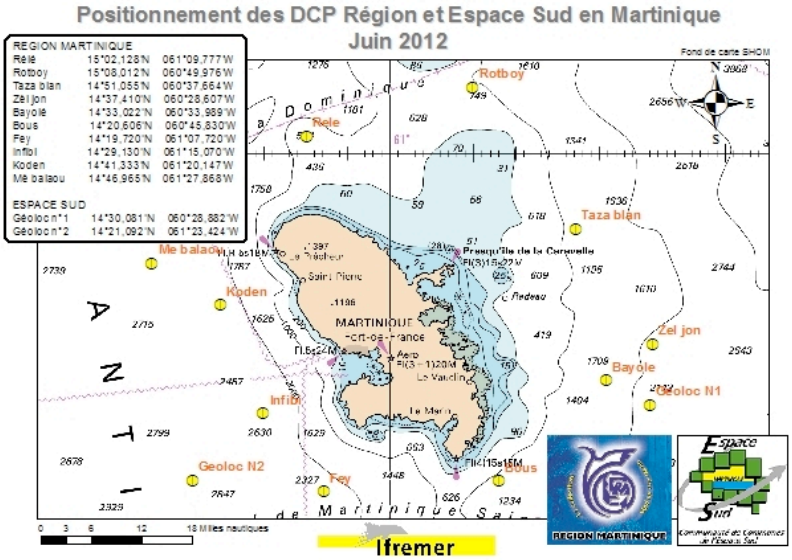


APID : Aménagements pour la Pêche d'Intérêt Départemental

Figure 2. Fish port & market (red) and mooring areas (green) within the Prêcheur MPA.

3.2.5.4. Offshore fisheries

Coastal and offshore fishing is practiced in the area, from Cap Saint Martin in the north to Pointe Lamare in the south, with marked seasonal activity and significant environmental constraints. Fishers are all currently obliged to diversify their fishing activity by combining different techniques that they will use depending on the seasons or the availability of the resource.



Fishing aggregating devices (FADs)

FAD fishing is a major asset, providing year-round resources, which are essential in the event of reduced productivity of other fishing techniques or during the off-season. Twelve fishermen from le Prêcheur practice exclusively this activity. Two methods are used on FADs:

- Lines and hooks: mainly used to catch bait (bonite and small tunas (black, yellow and mottled)
- Bouy fishing: 30 to 150 m long lines attached to a buoy, to which the live bait is hung. This technique allows fishing of large predators, mainly yellowfin and marlins. Occasionally, sharks, big mahi-mahi or mackerel are also caught with this technique.

The use of these two modes simultaneously allows fishermen, in the case of an unsuccessful buoy fishery, to resell the bait fish. However, fishermen are faced with the constraints linked to the increasing distance of FADs from the coast, and hence the higher fuel costs, without ensuring good fishing.

Currently two FADs are accessible off the Prêcheur, 15 and 20 km from the coast. They are relatively difficult to exploit from April to June because of the strong currents that immerse the FAD buoys. From June to March, the fishermen can go there every day.

3.2.5.5. Coastal fishery, saisonnality, fishing effort and fishing grounds

The coastal fishery, once practiced from August to November, has now become uninterrupted.

3.2.5.5.1. Fish traps

Trap fishing is practiced throughout the year, with a peak activity between May and December, with the most favorable season being from May to July. The catches differ during the year depending on the period and depth of the traps.
16 vessels of the Prêcheur use traps, but only two of them are exclusive fish traps users.
The overall fishing effort on the area is not estimated. However it seems high given the number of gear used by fishermen in the area.

There are iron or wooden trap bodies, with metal or plastic mesh. Wood and iron mesh are favored by a large number of fishermen because they quickly disintegrate in the case of a lost trap, preventing it from continuing unnecessary fishing and polluting the seabed, destroying part of the resource and ecosystems. Some fishermen

The lobster represents up to 5 to 6 kg of the catches per weekly shift of traps. In recent years the catch of lobsters in the traps has become more regular according to fishermen, who notice an improvement in the frequency of catches. The bait used for shallow trap fishing is mainly bread and fruit (coconut, breadfruit…).

Buoys, cans or empty bottles on the surface generally locate the traps. Each fisherman uses between 30 and 50 traps (for those who regularly practice this type of coastal fishing). Numerous traps are used without surface marks.

The fishing grounds are located along the coast, near the coral areas. The southern sector of the marine reserve is more exploited, between Pointe Lamare and Anse Belleville, due to more favorable hydrodynamic and weather conditions.

The traps are placed underwater for one week (during the period mid March to

December) or two weeks (January to March) depending on the availability of the resource. Traps are usually picked up on Friday to supply the Saturday market.

At greater depth, the species of fish caught are snappers and jacks: the traps are baited with small bait fish. Trps are used down to 150 m are up to 3 m wide and 1.50 m height. The use of these trap models is less from March to June due to strong currents.
Deep trap fishing is practiced at Abymes site and around ilet la Perle and Cap Saint Martin.

Some professional fishermen, who also are scuba divers, choose the location of their traps during diving. They can place the traps strategically close to overhangs or caves, and attach them to rocks. They can then exploit this sector despite the strong currents. Traps are recovered by scuba diving after one week. This method optimizes the chances of capture, but affects environments previously inaccessible to traditional technique.

Trap fishery Impact
The impact of trap fishing on marine resource is confirmed. The trap mesh allowed in Martinique is of 31 mm (against 38 mm in Guadeloupe). Traps significantly catch juvenile fish. Fishermen noted a decrease in trap catches (except for lobsters) because the number of traps increased and this technique is now practiced continuously throughout the year, whereas it was seasonal in the past.
The use of plastic traps can have an impact on the resource in case of loss of traps. Traps placed over benthic organisms (corals, sponges, gorgonians) destroy communities by physical action.

3.2.5.5.2. Senne fishing

It is a specialized fishery because of the equipment it requires, the heavy logistics and the favourable weather conditions. 11 senne fishermen are listed, including 5 “masters”. The species sought are schools of small pelagic fishes such as “coulirous”, “makros” and “kia-kia”.
Senne fishing depends on:

Weather at sea: must be very calm,
The season: June to August - high season,
The location: preferably sand areas,
The Moon phase.

It requires specific equipments:

Small senne net: 20 to 35 feet high, and 200 to 400 m long - Large seene: 400 m to 1 km long,
Between 10 and 30 person to pull the net, for large sennes, and 2 or 3 boats
1 to 3 divers, to locate the schools of fish, manage the net and to prevent it from getting trapped in obstacles

All the bays in the MPA area are fished, accounting for 27 sites between Pointe Lamarre in the south and Cap Saint Martin in the north.
A management system for this fishery persists and avoids conflicts. Fishermen wishing to fish with senne have to register on the senne book held by an elder. The senne book grants two consecutive fishing days to each master senne fisherman. The number of annual senne fishing is estimated at 241 in the MPA.

Senne fishery impact

Senne fishery impacts the biodiversity of marine coastal species in fishing areas:

Mesh size and net length: senne nets are non-selective and capture almost all species and all sizes of fish, thus impacting the composition and age classes of the coastal populations. Large fish quantities can be caught in a single pass, and the regular practice of senne fishing on the same area leads to a structural and genetic impoverishment of the coastal populations (the capture of a whole school may lead to the complete disappearance of one gene pool) .
Fishing grounds: senne fishing is usually done over sand areas mainly, where seagrass develop. Seagrass beds represent remarkable environments for the reproduction, feeding and growth of juvenile fishes, and are therefore strongly impacted by the passage of the senne net. Senne nets are very close to the bottom. There is a strong risk of damage to the fixed fauna in coral communities or seagrass beds. Divers can help moving the net over sensitive areas.

3.2.5.5.3. Lobster fishery

Trammel nets are used around coral reef communities. Only one fisherman uses this fishing method in the MPA and the estimated fishing trips is below 50 each year (source: IFREMER 2009).

Lobster fishery impact

The impact on the fish resources is low because trammel nets height is low. However, trammel nets are composed of three nets of different mesh and get trapped very easily in structurally complex coral communities. The drift of the trammel nets causes physical damages to the ecosystem. Marine turtles bycatch is also a major issue through the use of trammel nets.

3.2.5.5.4. Balaou fishery

The balaou fishery is practiced with a drifting net from the surface, close to the coast, depending on currents. The fishermen throw cane leaves into the water to aggregate the balaou fish attracted by them, before encircling them with a gill net.
This is a seasonal fishery from December to March, when individuals are large. This fishery is practiced throughout the area, from Macouba to Bellefontaine, depending on the currents. There is no preferred site for this type of fishing.
Prêcheur and Bellefontaine areas are renowned for the abundance of this species along the coastal area. Outside fishermen come fishing in the sea-net on the prechotan coast, they are accepted by the fishermen of the Preacher. The first one on the site has priority.

Balaous fishery impact

This fishing practice, at the sruface of the water, has no impact on benthic ecosystems.

3.2.5.5.5. Gill net fishery

One large and tall net is set at the bottom of the sea, in coastal areas, but is very little practiced in the MPA zone (strong currents). Gill nets are usually used over night for a few hours.

Gill net fishery impacts

Gill net can be trapped in coral communites ecosystems and damage attached fauna and flora.

3.2.5.5.6. Longline fishing

Three boats from Le Carbet regularly frequent the marine reserve area for deep-sea fishing (150-250m). Two fishing boats target sharks and snappers.
One of these vessels also fish at night along the coast throughout the MPA area at 10-20m depth, during 3 days surrounding the full moon. The target species are jacks.

Impact of longline fishing

This practice has limited effect on benthic communities.

3.2.5.5.7. Hook and lines fishery “at the pool”

Fishers from all villages come to fish “at the pool” in the MPA. This fishery generally gather 3 person on the boat, early in the morning, or at the end of the afternoon. Fishermen target all types of fish depending on the depth, size of hooks and bait used.

Impact of hook and line fishing

There is no impact on the ecosystem. However, this fishing practice has an impact on the fish resources, as noted by regular fishermen from the area over the past 10 years.

3.2.5.5.8. Fishing “à la douce”

This is a coastal fishing technique, consisting of a drifting longline suspended from a float (plastic bottle or piece of painted polystyrene). The target species are snappers and jacks. This technique is used in the ilet la Perle sector.

Impact of “à la douce” fishing

There is no impact on the ecosystem. However, this fishing practice has an impact on the fish resources, as noted by regular fishermen from the area over the past 10 years.

3.2.6. Recreational fishing

3.2.6.1. Angling

From the coast

Angling is largelly practiced along the coast, from the beaches (Prêcheur, Céron, Anse Couleuvre), artificial rip-rap (Citadelle, Babody), and pontoons (Prêcheur, Abymes). Angling is practiced all day, by adults and children, with a peak of activity at the end of the day, at weekends and during the holidays. Catches are composed of small size tuna, and various species of coastal predators according to the season. Fishing effort is not quantified.

From boats

Fishing from boats is also practiced by non-professional coming from sectors as far as the bay of Fort de France. Almost every day, small fishing boats come to fish in the same areas as those used by professionals. These recreational fishermen use similar fishing equipments than professionals. Recreational fishing is considered important by many professionals, unfair competition, and expanding.
Its impact on marine resources is significant

3.2.7. Scubadiving

Thirteen dive centers dive in the reserve area. Only 4 are based in Saint Pierre. The other centers come from Carbet, Schoelcher, Fort-de-France, Lamentin, Trois-Ilets and Sainte Luce. The most economically profitable sites for dive centers based in Saint Pierre are the wrecks of Saint Pierre or the sites located south of Point Lamare. Nevertheless the northern dives (Pointe Lamare to La Perle) are exceptional natural environment. The Canyons of Babody are a reference for diving sites in northern Martinique.
Some of the dive sites are accessible from the shore. Their visit frequency is not precisely estimated but remains marginal.

Table 8. Total number of dives/year in the Prêcheur MPA.		
Dive sites	**Number of dives/year**	**%**
Canyons de Babody	325	24.4
Pointe Lamare	285	21.4
La Perle	160	12.0
Le Sous-marin / Les Basses	158	11.9
Caye Maréchal / le Vron-vron	100	7.5
La Citadelle	96	7.2
Le Mat	74	5.6
La Charmeuse	64	4.8
Les Jardins du Prêcheur	43	3.2
Caye Posiut	19	1.4
Les Abymes	9	0.7
Total	**1333**	**100**

Martinique accounts 93 dive sites (OMMM, 2004), of which 11 are located in the MPA (Pointe Lamare, Babody canyons, Jardins du Prêcheur, Le mat, Caye Maréchal, Vron vron, Charmeuse, Abymes, Citadelle, Caye Posiut, Le Sous-marin, Les Basses, La Perle). The number of dive trips is estimated around 1333 per year in the MPA area.

The most visited sites are Canyons de Babody and Pointe Lamare, which are the southernmost dive sites of the marine reserve. They represent 46% of the dive trips for all dive centers.

La Perle, Le Sous-marin and Les Basses represent 23% of the trips. Despite their remoteness, they are visited by many dive centers as a demand of their clients. These sites are renowned and are referenced in diving guides for divers.
The other diving sites individually represent less than 10% of trips. Visit frequency varies according to the dive centers.
The total estimated number of dives in the MPA is estimated about 18,000 every year.

The total numbers of dives for each site are below the acceptable visit thresholds, estimated in the Caribbean between 5 and 6000 dives per year (Schleyer and Tomalin, 2000). Only the Babody canyons reach more than 4,000 annual dives. The changes in the diving professionnal activity since 2008 are not similar according to the dive centers. Some report a significant decline in their activity the past years, while others note a recovery in their activity, particularly in 2011.

Scubadiving impact
Two studies have considered scubadiving activities in Martinique in 2004 (OMMM 2004) and in 2007 (OMMM, 2007). Three risks have been highlighted:

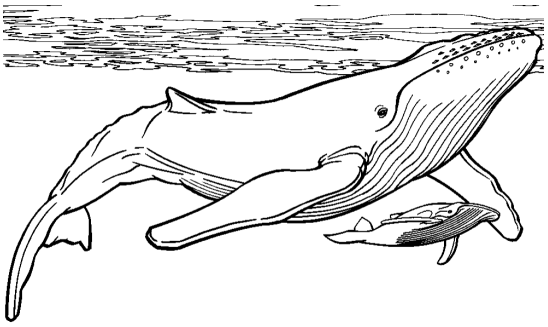
- Disturbance of species: acceptable in the absence of feeding behavior
- Direct impact of divers: dependant on their practice level

- Breakage by anchors and moorings: can be very important

Scuba diving is a recreational activity that can have a direct impact on coral communities if it is not well supervised. The direct physical degradation of diving activities has been the subject of numerous studies. Physical damage potentially caused to reefs is the breakage of fragile colonies and major lesions on massive corals.

Anchoring
All dive centers anchor at all sites, except La Perle where wind, current and depth conditions require constant watch. The impact of anchors on the environment can be very important. The degradations are proportional to the size of the vessels and the nature of sea bottom. The recovery of coral ecosystems after damages caused by anchor is a very slow process.
All dive centers agree on the need for permanent, ecological and environmentally friendly moorings to preserve the quality of the ecosystems.

3.2.8. Daytrip at sea



The Caribbean coast of northern Martinique is spectacular, wild and hardly accessible by land. The daytrip at sea activity is developing rapidly along with a diversification of activities.
Only one company is based in le Prêcheur. It has existed for almost 10 years and offers sea trip in the reserve area in traditional fishing boats bringing people to remote beaches (anse des galets, anse la Selle, anse Anastasie, bourg du Prêcheur). This activity takes place all year long with 60% tourists and 40% local residents.
Another company located in Saint Pierre offers the same activity but only 50% of their activity is in the MPA area.
Other small companies also visit the MPA area, but not on a regular basis and quite rarely.
The usual activities are marine mammals watching, for the day or half-day period.

Impacts
However, marine mammals watching can be detrimental to species and appropriate observation behavior must be charted: observation distance, boat journey, limited presence on site. Frequent passages and/or too close to cliffs or ilets can disturb bird colonies. Camping on remote beaches can quickly lead to pollution. The repeated

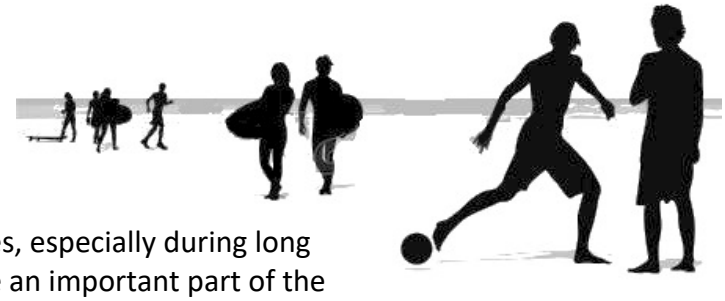
presence of people on normally inaccessible beaches may perturbate spawning activity and nesting of marine turtles. Snorkeling activity may also impact the environment by resuspension of sediments or physical damage to attached animals and plants. However this risk is minimal because of exposed sites in this part of the MPA, but can be significant in the area north of anse Céron where *A. Palmata* vulnerable population are present.

3.2.9. Boating and sailing

Sailing and motor boats are fraquent in the MPA, especially during week-ends, bank hollidays and school hollidays.
While many professionals bypass the ilet La Perle by the west to avoid areas with turtle coastal population, they underline that non-professionnal are passing at high speed between the ilet and the coast.

Impacts
The most important damage related to boating and sailing is anchorage. Permanent moorings are not yet instaled in the MPA area. Anchors and chains can damage coral colonies and seagrass. Motorboats are also source of pollution by gas and oil. Wastewater and organic pollution also impact the area and might contribute to the degradation of coastal marine ecosystems in the area.
Beach activities from people conveyed by those boats also contribute to pollution, especially plastic glass and plates used for lunches that are increasingly found underwater.
These activites can also pertubate the sea bird colonies.

3.2.10. Beach activities



Beach activities, especially during long weekends, are an important part of the social life of Martinique. The tradition leads families and friends to gather on the beaches of the island to share the day. They are well equiped with tent, table, chair, barbecue, sound system ....
The beaches located in the south of the MPA are close to the houses, along the road and are frequented mainly by residents of local villages.
The north beaches are wild and isolated. Anse Céron and anse Couleuvre are regularly visited while the other remote beaches are more difficult to reach.

3.2.11. Surfing

Surfing can be practiced on the beaches at Anse Céron or Anse Couleuvre. These are famous spots when the swell comes from the North.

Impacts
The impact on the environment is low, surfers frequenting the sector master the technique.

3.2.12. Kayak activity

When good weather conditions, people use kayak to discover the remote coastline. There is no direct impact on the environment (no anchoring or engine).

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