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The impacts of marine protected areas on fishing activity: A case study of Le Prêcheur, Martinique

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Abstract

The aim of the paper is to present the expected impacts of the creation of the marine reserve of “Le Prêcheur” in Martinique in 2014. Despite its official establishment, the reserve is still not operational in 2020. The method used refers to a feasibility study done in 2010 for its formulation and to a stakeholder engagement study done in 2012-2013. The main results are that the marine reserve will not fundamentally change the fish catches as mainly old fishermen were using the grounds for fishing, while young fishermen predominantly carry out fishing practices offshore or fish on fishing aggregating devices. The key recommendations are that the management of fishing activity in the marine reserve of Le Prêcheur should first aim to limit the activities that are most destructive to the marine environment, and second to ensure that exploitation levels of sustainable activities are compatible with resource capacity. Further, management of the marine reserve should extend beyond the established boundary in order to maximise the benefits created. To establish the legitimacy of such a management plan, and to monitor its implementation, the key stakeholders e.g. fishermen, scientists, etc. should collaborate to develop a working protocol for the management plan. Engaging key stakeholders in this way should ensure that the management plan is supported by data and actions that are trusted by policy makers, scientists and the fishermen themselves.

Keywords: Le Prêcheur, Martinique, fishery management; marine protected area

1. Introduction

Marine protected areas (MPAs) have been identified as effective tools for biodiversity protection, providing a base for the sustainable management of fisheries resources [1]. However, while the benefits of MPAs are well documented in the literature [2, 3, 4], these benefits remain controversial when considering wider fisheries management [5]. Indeed, as MPA implementation is designed to limit fishing activity, there is bound to be conflict between conservation objectives and wider fisheries objectives – particularly those of fishermen who rely on access to the resource for their livelihood. Therefore, the implementation of an MPA introduces the need for fishermen to adapt.

The MPA of “Le Prêcheur” in Martinique was designated in 2014 as a regional marine reserve. Despite its official establishment that year, it is still not implemented in 2020. The main topics of discussion around its implementation were the effects of the MPA implementation on local fishermen’s activities. In that regard, a specific study was set-up in 2010-2011 to look at the potential impacts that the restriction of access to fishing grounds could have on fishing activities and more broadly on the economics of the town of Le Prêcheur that relies on the fishery sector for job creation and fish supply. The study, undertaken prior to the establishment of the marine reserve in Le Prêcheur, presented three scenarios for the management of the MPA. The analysis of these scenarios shows that the most feasible option is the establishment of a managed area in which activity is monitored and leads to the phasing out of the most destructive practices gradually over time. This outcome leads to the highest economic value of marine and coastal ecosystems of the area of Le Prêcheur in the medium-term. This is because it allows fishermen to benefit from the increase in biomass export due to the well-functioning of the reserve, while experiencing short-term fishing opportunities. It also authorises the pursuit of recreational and tourism activities (such as diving, boat trips and swimming) and promotes the emergence of new activities such as whale and sea turtle watching, resulting in a more sustainable use of resources, while ensuring the profitability of economic operators.

The 2010-2011 study was complemented by a stakeholder engagement review done in 2012-2013 to assess the perceptions of fishermen regarding the MPA access rights.

This article aims to introduce the potential consequences on the fishing sector resulting from the creation of an MPA in Le Prêcheur. The impacts of MPA creation on fishery management are well developed in the scientific literature [6, 7, 8] but they are predominantly investigated after the set-up of the MPA. The added value of this article is to analyse the consequences before implementation and from a number of perspectives to establish an a priori basis for input into the creation of the MPA. This article builds on the socio-economic analysis already undertaken on the preliminary valuation of the establishment of the reserve of Le Prêcheur. The evaluation of the consequences caused by this scenario is essentially qualitative in nature as it is too early to offer quantified elements for the impact on fishing activity.

In the first part, this article reviews the state of play for fisheries in the area of the determined marine protected area, as well as estimating the added value for these fisheries. In the

second part, an assessment of the impacts of fishing on the marine environment in the area of Le Prêcheur is presented. In the third part, management recommendations are given based on both the state of play of fisheries and a review on the expected impact of the reserve on variation in biomass of marine species. In the fourth part, the implementation strategy of the reserve is discussed. Finally, the article provides a short conclusion.

2. State of play and added value of fisheries

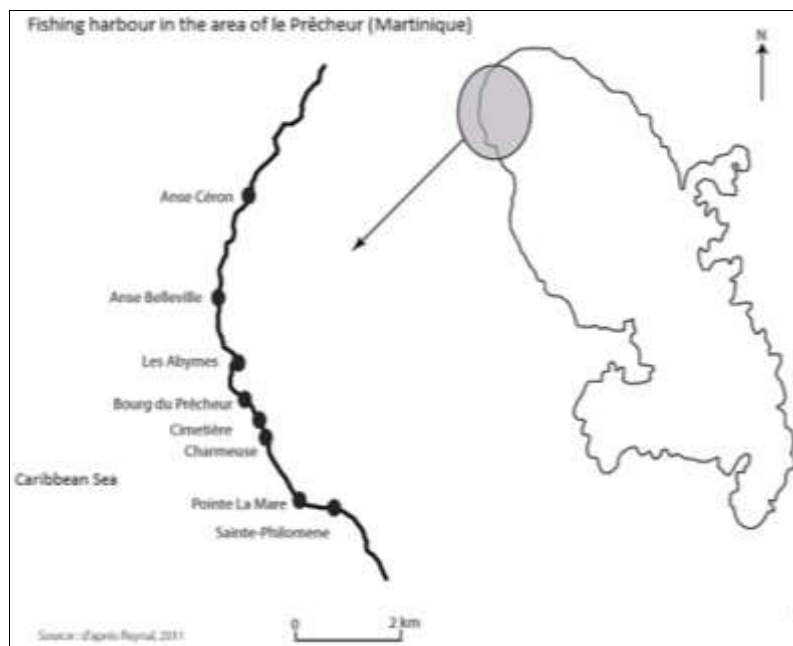
The Prêcheur's Marine Regional Nature Reserve, known as the Albert Falco Marine Reserve, stretches over a 500-metre-wide stretch of coastline along the commune of Prêcheur (northwest of Martinique), from the mouth of the Three Arms River in the north, to Pointe Lamare in the south. It encompasses two exceptional sites, the Pearl and Citadel isles (see figure 1). The reserve is divided into 5 sectors: 2 nature reserve areas (ZNR1 and ZNR2), 2 enhanced protection zones (ZPR1 and ZPR2), 1 exclusive fishing area (ZPE).



Fig 1: Le Prêcheur Marine Reserve and its sectors (Source: Observatoire de l'eau)

In Le Prêcheur, three types of fishermen operate: local professional fishermen (around 30), local recreational and “subsistence” fishermen (about 25), and recreational fishermen from other harbours of Martinique. Before the designation of the MPA, the area of Le Prêcheur (Belleville’s cove, village of Le Prêcheur, Charmeuse, Cimetière, Les

Abymes and St. Philomena) consisted of 44 commercial fishing boats [9]. Some fishermen, from neighbouring municipalities, also utilise the marine ecosystems of Le Prêcheur. Visitation of these ecosystems by these neighbouring fishermen has been estimated by field trips conducted during the diagnostic study carried out in the area.



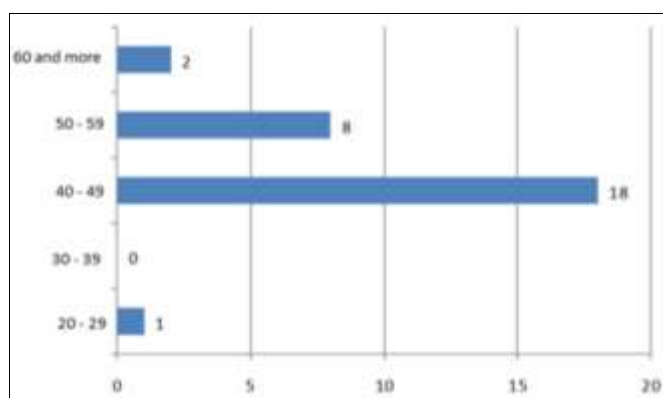
Source: Reynal, 2011

Fig 2: Landing sites in the area of le Prêcheur (Martinique)

Recreational fishermen originate from Saint-Pierre, Cabaret and Fort-de-France. They are often former professional fishermen who are retired and are now engage in recreational fishing. However, this fishery has a significant impact on the resource.

2.1 Professional fishing

Over the fifty years preceding 2010, the population of professional fishermen in Le Prêcheur changed from 63 fishermen in 1961 to 57 in 1980 and 29 in 1998. Since then, the number stabilised at 29 captains and 2 crew members listed in the record of maritime affairs. Most of the fishermen are aged between 40 and 49 and almost no young fishermen are active in the fishery (see figure 3). If all boat owners of Le Prêcheur fulfil the professional registration scheme, it is not the same for the crew members, since of an estimated population of 50, only 2 are on the crew registration list. For most occasional fishermen, crew members only go to sea during the "Miquelon" fishing season (pelagic fishing off the coast performed in November and July) or around the use of fish aggregating devices (FADs). The rest of the year, they engage in activities of family farming, including market gardening, as well as jobs in building construction and others.



Source: IFREMER (2010)

Fig 3: Age structure of professional fishermen in Le Prêcheur in 2012

Despite a population reduced by some 1,000 people in the last half century, fishermen in the working population of Le Prêcheur has remained significant (see table below). Professional fishermen now account for 5% of the working population of le Prêcheur in 2007 (and 7% of the working population in employment) against 7% 50 years prior (and 9% of the working population in employment). Taking into account the population of crew members (by applying a coefficient of equivalence in full-time work), the proportion rises to around 10% in 2007 against 15% in 1961. The proportion was even higher in 1980 when Le Prêcheur was one of the main harbours of the Caribbean coast with the coves of Arlets and Fort-de-France.

The number of skippers' jobs in more recent years is equivalent to nearly half of the number of self-employed male jobs in the municipality (29 of 79). In a socio-economic context, where the unemployment rate is as high as 36% in Le Prêcheur, it is clear that fishing remains an important activity both economically and socially.

Table 1: Working population and fishermen population between 1961 and 2007

	1961	1980	2007
Population	2700	2010	1700
Working population	861	550	619
Employed working population	690	450	394
Listed fishermen	63	57	29
Full-time fishermen	105	120	40
% fishermen/working population	7%	10%	5%
% fishermen/employed working population	9%	13%	7%
% full-time fishermen/working population	12%	22%	6%
% full-time fishermen/ employed working population	15%	27%	10%

Source: INSEE (2010); IFREMER (2010), Régnier-Bohler (1997) and Clément (1980). Note: Estimation of full-time fishermen and own reconstruction of data for 1961

The skippers are owners of 44 boats that berth along the villages of Abymes and Cimetière, (see table 2) the residential areas of the fishermen. These boats are equipped only for small and coastal fishing. All vessels below 7 meters are gum tree canoes and wooden skiffs, while those between 7 and 12

meters are skiffs of the fiberglass type. Designed for proximity fishing, gum tree canoes and wooden skiffs are powered by 15 to 40-horsepower engines and are usually

towed after each fishing trip. Essentially made for Miquelon fishing, fiberglass skiffs are equipped with outboard engines from 115 to 200 horsepower.

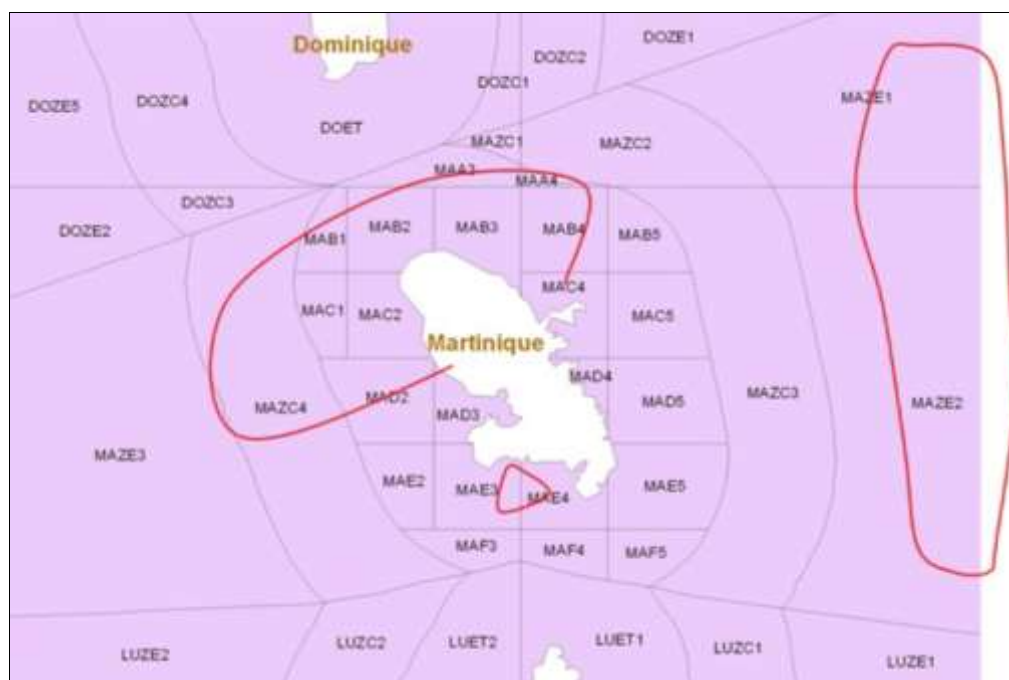
Table 2: Anchorage spot and number of vessels categorized by size in 2010

Anchorage spot	Total number of ships	Ships above 7 meters	Ships between 7 and 12 meters
PR-Belleville's cove	1	1	
PR-Cimetière	12	5	7
PR-Les Abymes	18	7	11
PR-Le Prêcheur village	11	7	4
SP-St Philomène	1	1	
PR-Charmeuse	1	1	
Total	44	22	22

Source: IFREMER, 2010

The gum tree canoes and wooden skiffs are aged, but well maintained. These boats continue to be rigged for specific activities: beach seining for gum tree canoes and surface and bottom nets as well as FADs for wooden skiffs. The number of these boats had more than halved, from 54 to 22 during the 1980s ^[10] because of the unprecedented enthusiasm for Miquelon fishing in the late 1980s and early 1990s (underpinned by subsidised loans granted to fishermen for the purchase of fiberglass skiffs). The younger fishermen, specialized in FAD or Miquelon fishing, only have one modern skiff while the older, versatile fishermen, tend to have a wooden skiff and / or one or two gum tree canoes even if some of them have acquired a modern skiff ^[11]. More manoeuvrable and economical than new skiffs for dropping and bottom tackles, wooden boats persist because they are

well suited to activities that do not require high speed of movement and navigation in rough seas. Increasing motorization in the 1980s has significantly increased exploration areas, which was previously confined to coastal areas ^[12]. Fishermen are now able to move further offshore away from traditional fishing areas, and venture into Atlantic waters and fish the banks of America, Mono (opposite of Caravelle) and those further north of Dien-Bien-Phu or Siberia (in the Dominica EEZ). The fishermen of Le Prêcheur now operate in three fishing areas (Figure 4). The first, located opposite of Le Prêcheur, concerns all coastal, FAD and Miquelon (MAC1, MAC2, MAB2, MAB3) fishing trips. The second, in front of the Arlets coves is related to the practice of longline fishing (MAE3) and third is predominantly Miquelon fishing (MAZE1 and MAZE2).

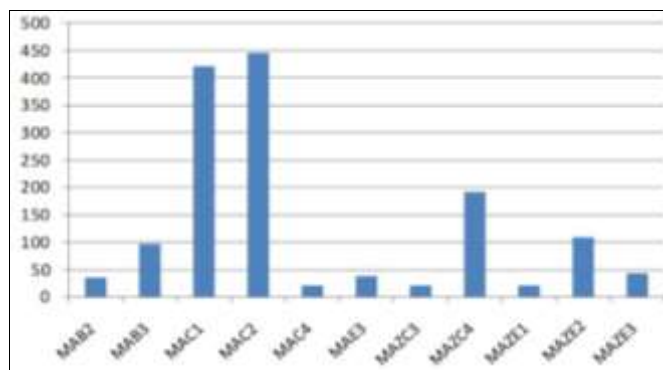


Source: IFREMER

Fig 4: Fishing areas in Martinique

In 2010, fishing trips in the areas in front of Le Prêcheur channel represented 75% of fishing trips (MAC1, MAC2, MAZC4 and MAZE3) and nearly 60% of all fishing trips occurred within the two areas of MAC1 and MAC2 (Figure 5). In the MAC2 area, activities consist of beach seine,

freediving, fish traps and nets. The MAC1 area accounted for almost 45% of trips, where two FADs were located, and the area bordered MAZC4 and MAZE3, where fish concentrating wrecks were implemented by the Regional Council.



Source: IFREMER

Fig 5: Fishing areas by number of trips

Le Prêcheur is situated in the MAC2 area. Beach seine and

saury surface nets are deployed from Anse Céron to the tip of Lamare. Bottom-set nets, trammel nets and others are set off Abymes and the town of Le Prêcheur. Fish traps are deployed from Pearl Rock to the tip of Lamare. The FADs are outside the study area of the reserve.

Total catch of fish in these areas was around 85 tonnes in 2009, caught mainly while fishing around FADs and Miquelon fishing using driving lines. The total value of catches amounts to around €750,000. In the study area (Le Prêcheur), around 22 tonnes of mainly small pelagic fish were landed, worth around €180,000. In the absence of long-term monitoring to quantify catches within and outside the boundaries of the reserve, it is not possible to be more precise regarding catch data using gill and trammel nets.

Based on interviews with fishermen, it seems that 2009 can be considered a normal year for catch levels. Therefore, we use 2009 as the baseline for our analysis.

Table 3: Volume and value of total catches and catches in the study area

Fishing technique	Number of fishing trips	Kilo per fishing trip	Price per kilo (€)	Volume (kg)	Value (€)	Volume (kg) in the study area	Value (€) in the study area
Freediving	39	17.75	9.61	694	6671	694	6671
FAD	716	56.05	8.93	40119	358266	-	-
Fish trap	20	14.65	11.25	286	3223	286	3223
Encircling gillnet	21	22.3	6.5	476	3092	476	3092
Deriving gillnet	21	48.76	12.36	400	4946	400	4946
Trammel net	43	14.86	15.04	634	9535	634	9535
Bottom-set longline	21	70.96	9.5	1514	14380	-	-
Driving line	302	72.29	9.13	21845	199449	-	-
Beach seine	241	75.87	7.99	18252	145833	18252	145833
Total	1445	431	95	85664	752365	22186	180270

Source: IFREMER, 2010

Over the last decade, the added value of fisheries in the study area is estimated at about €170,000 per year (with the added value for the entire fishery valued at €646,000). The table

below shows the details of the estimate of the added value for each of the techniques practiced in the study area for 2010.

Table 4: Added value of professional fishing in the study area

Fishing technique	Number of fishing trips	Kilo per fishing trip	Value per kilo (€)	Intermediate uses per kilo	Volume (tons) in the study area	Added value (€)
Freediving	39	17.75	9.61	0.2	694	6532
FAD	716	56.05	8.93	1.2	-	-
Fish trap	20	14.65	11.25	2.5	286	2506
Encircling gillnet	21	22.3	6.5	1.6	476	2331
Deriving gillnet	21	67.66	4.83	1.3	1443	5095
Fixed gillnet	21	18.76	12.36	1.2	400	4466
Trammel net	43	14.86	15.04	1.9	634	8330
Bottom-set longline	21	70.96	9.5	0.6	-	-
Longline line	302	72.29	9.13	2.2	-	-
Beach seine	241	75.87	7.99	0.2	18252	142182
Total	1445	431	95	-	22186	171443

Source: IFREMER, 2010 and own estimations for intermediate uses

Overall, the added value provided by fisheries in the study area was low related to the number of fishermen practicing the selected techniques. This gives an average value per fishing enterprise of around €7,800 per year (€170,000 divided by 22 fishermen who practice the techniques cited above). All techniques and all areas considered; it rises for the 29 professional fishermen to €22,300 per year per enterprise up until 2010.

2.2 Recreational fishing and subsistence fishing

Recreational fishing is practiced in three ways in the study area. The first is performed from the shore on a headland using a fishing rod; the second by boat with lines (bottom longline, troll and jig) and the third diving with a harpoon

gun, either from the beaches of Abymes, Anse Belleville or Anse Céron, or via boat moored to Pearl Rock. About twenty fishermen regularly engaged in line fishing from the coast in 2010. At this time, they were, for most the part, residents of Le Prêcheur; although a small group of 4 to 5 people made the trip from Saint-Pierre. The fish catch was about 40 kg per fisherman per year, giving a total catch weight of around 800-900 kg per year.

Fishermen in boats are more numerous: we estimated there to be around 80-100. The use identification work (Impact-Mer Survey) provides guidance on the volume of catch per fishing trip. From this information, the volume of catch for this type of recreational fishing was estimated to about 3.3 tonnes per year (Table 5).

Table 5: On-board line fishing catches in the study area in 2010

Type of fishing	Number of boats	Weekly frequency	Catch (kg)	Weekly catches (kg)	Yearly catches (kg)
Bottom longline fishing	2	5	5	50	2600
Troll fishing	4	1	2	8	416
Jig fishing	1	1	5	5	260
Total					3276

Source: Impact-Mer survey (2011)

The spearfishing divers are mostly from Le Prêcheur and Saint-Pierre, but on weekends, many divers throughout Martinique gather around Pearl Rock and the “Sous-Marin

Area”. From the information collected on visitation frequency and number of divers, the catch volume for 2010 can be estimated at around 2.5 tonnes per year (Table 6).

Table 6: Spearfishing catches in the study area in 2010

Type of fishing	Number of boats	Weekly frequency	Catch (kg)	Weekly catch (kg)	Yearly catch (kg)
Dives around the “Sous-Marin” Area	10	1	1.5	15	780
Dives at “La Perle” (Pearl Rock)	4	1	2	8	416
Dives at Anse Belleville and Abymes	3	4	2	24	1248
Total					2444

Source: Impact-Mer survey (2011)

Line fishing catches from the headlands, boats or while diving are not subject to commercial transaction: they are intended for personal or family consumption. Nearly 75% of fish caught are consumed in the municipalities of Le Prêcheur and Saint-Pierre, the remaining 25% being consumed in the rest of the island. These are, essentially, resident fishermen who practice one of the three fishing categories observed in the study area of Le Prêcheur. Retired fishermen of Le Prêcheur

are, for instance, the only ones using the *pisine*, this traditional craft having disappeared from the array of professional fishing techniques.

The added value of the recreational and subsistence fishing was about €57,000 per year in 2010. The following table details the calculation. The catch value and the cost of inputs, are based on those registered for commercial fishing at the time.

Table 7: Added value of recreational and subsistence fishing in the study area

Type of fishing	Yearly catch	Value (euro per kilo)	Intermediate uses per kilo	Added value (€)
Rod fishing	800	3.13	0.2	7144
Bottom longline fishing	2600	9.13	0.6	22178
Troll fishing	416	9.13	2.2	2883
Jig fishing	260	9.13	2.2	1802
Dives around “Le Sous-Marin”	780	9.61	0.2	7340
Dives at “La Perle”	416	9.61	0.2	3915
Dives at Anse Belleville and Abymes	1248	9.61	0.2	11744
Total	6520			57005

Source: Author’s own creation




Recreational fishing, largely practiced by retired commercial fishermen and young men of Le Prêcheur and Saint-Pierre, attracts on weekends a more heterogeneous population (of various ages, but all men) from all over Martinique. Coastal troll fishing and bottom longline fishing were significant activities until the late 1980s, respectively accounting for 30% and 10% of Le Prêcheur fishing activity. The implementation of FADs and the development of Miquelon fishing have wiped out, these practices in the professional context. However, they retain a strong appeal for former fishermen because, based on the knowledge of the environment, they are considered (as pinned-up, once practiced) as “true” fishing practices in the sense that fishing around FADs and Miquelon









fishing requires, according to them, no experience or knowledge passed on filially^[13].

3. Assessment of environmental impacts of fishing

Fishing techniques practiced, as well as the impact of each practice on the marine ecosystem in the Le Prêcheur area are listed in the Table 8. The criteria taken into account are habitat destruction, the selectivity of gear used to catch juvenile fish, the selectivity of the gear to non-targeted catch and finally the pressure on the resource. A red star indicates a damaging effect from an environmental point of view, while a blue one indicates environmental neutrality. The right column details the impacts.

Table 8: Impact of fishing techniques on the environment

Fishing techniques		Environmental impact	
Line fishing	Troll fishing		No habitat destruction caused (no anchorage or nets that scrape the seabed) Highly selective in relation to fish size (the size of the fish depends on the size of the hook), thus limiting bycatch
	Jig		As above
	Pisine		As above

	Doucine		As above
	Line fishing from the shore		Few damages except in case of anchoring the hook in the seabed
Surface gillnets (saury nets, garfish deriving nets, fixed gillnet)			No habitat destruction caused Not a very selective method regarding size and fish species
Spearfishing			No habitat destruction caused Extremely selective regarding size and fish species Very high and very concentrated pressure applied on large predators, (e.g.: barracudas); this pressure is all the stronger as it is an easy technique to implement and thus practiced by many people
Fishing with bottom passive gears	Deep longline		Habitat destruction caused by mooring of boats that arrange these gears Selective for size and generally for species
	Lobster passive nets		Habitat destruction caused by mechanically damaging the coral seabed
	Fish traps		Habitat destruction caused when installed on benthic organisms (corals, sponges, gorgonians) that they destroy by mechanical action, scraping the seabed because of the current. Moreover, they are often fixed with a grappling hook that can also damage the seabed.
Beach seine			Habitat destruction caused because it requires scraping of the seabed Non-selective technique on fish species and size Very high pressure applied on the environment because it can happen several times a week on the same beach

Source: Author's own creation

Regarding the creation of a marine reserve in the study area, this assessment indicates areas where actions are required to reduce the effects of the most harmful practices to ecosystems. Further, actions should be taken to promote the most sustainable practices. The status of "neutral environmental practice" (or environmentally friendly) however does not provide freedom of excessive multiplication of the number of fishing trips and effort to catch more fish. Therefore, it is necessary to confine such activities within acceptable biological levels by limiting fishing effort.

3.1 Practices with high negative impact

Trap (or pot), beach seine and lobster net fishing are among the practices that have the highest negative impact on marine ecosystems. Traps, concentrated on areas of high productivity such as coral reefs, exert pressure on the species targeted and incidentally on all species found in this environment. Further, it is not uncommon for the traps to become lost or abandoned. In either case, they then continue to fish, and the so-called ghost fishing can continue for many years before the traps disintegrate.

The beach seine, a traditional fishing activity in Martinique is intensively practiced on the beaches of the study area, having a very significant negative impact on marine ecosystems. Although targeting mainly small pelagic fish (saury, *coulirous*, etc.), this net is not selective regarding the size and species caught, especially because of very fine mesh. Each beach can be exploited several times a week and thus the fishing pressure remains generally high. As the seabed on which seines are used are soft, it may seem that successive passages of the net are without adverse effect: that is not to mention that repeated current action prevents seagrass regeneration.

Lobster trammel nets also have a negative impact on demersal species and habitats. Inadvertently capturing turtles and iconic, but not marketed (parrot fish, for example), demersal fish, they damage the conservation of marine biodiversity, as they are generally discarded.

To limit their impact on marine ecosystems, such practices should be subject to distinctive measures, by type of impact:

- Habitat degradation: limit all activities in areas where habitats are very sensitive to disturbances;
- Gear selectivity: increase the minimum size of mesh to minimize the capture of individuals that have not reached sexual maturity; use traps (in their current build and structure) only on sandy seabed to preserve areas of plant cover;
- Ghost fishing: identification of trap ownership by marking the traps with durable labelling.

3.2 Practices with moderate impact

Surface nets, deep longline and spearfishing can have negative impacts on the marine environment depending on their implementation methods. The nature of the impact differs between practices. For all activities, it relates to wild anchoring of boats. In the case of spearfishing, it can result from accidental deterioration of the seabed because of accidental flipper strokes and repeated grips on fragile natural structures by hand, and the lack of discernment of divers on the other. Indeed, many of them shoot regardless of species and size. It is recommended to use a mooring rather than a bottom anchor (required to stabilize the boat during docking or raising of machines, or while divers get in and out of the boat), as this practice generates little cost and avoids damaging the vegetation cover at each jet and rise of the anchor.

The effectiveness of spearfishing is formidable: the school of hundreds of barracudas near the Pearl Rock have been decimated in recent years. Unlike "blind" fishing techniques (nets, lines, traps and others), which operate by attracting or stopping the prey when traveling, spearfishing involves hunting fish and shellfish into the most remote crevices. In addition to the lack of careful selection of targets - due to amateurs who want at all cost catch something, spearfishing can lead very quickly to the extinction of a fish species through the decimation of juvenile species. It is recommended that to address incompatibilities, it is first required to limit site access to fishermen who have a good knowledge of the species and to regulate the fishing trips, so that only practices

with low environmental impact are allowed. Finally, data collection is necessary, through integrating diving trips and fishing records in a monitoring programme of marine biodiversity, a programme which all fishermen operating in the site of Le Prêcheur must participate.

3.3 Practices with low impact

Various line fishing practices can be highly selective and have no mechanical impact on ecosystems. Empirical knowledge of fishermen is the foundation of these elitist fishing techniques because of the required knowledge of ethno-science. Often operated paddling from a wooden skiff, these fisheries combine scholarly practice and environmental care. However, targeting big fish with high commercial value, they can quickly exert too much pressure on stocks. Also, such practices should be monitored in order to better understand their pressure on fishery resources and to implement and regulate rules of access (according to a management plan developed by fishermen themselves in partnership with the reserve authorities).

3.4 Intensity of practices

All fishing techniques and their capacity for ecological disturbance of the marine environment, become malignant when the level of effort is not in line with resource capacity. For example, pelagic species caught by surface nets (saury, garfish, etc.) are often regarded by fishermen as an inexhaustible resource. However, the high fishing effort exerted on these resources, and the strong recruitment variations under the effect of environmental stresses can have important consequences on stock renewal. Control of fishing effort is therefore crucial. As such, this effort or pressure on the resource must be subject to a continuous assessment based, as mentioned above, on the active participation of fishermen.

3.5 Theoretical benefits of the reserve implementation

While there are few studies on the impact of managed marine protected areas (MPAs) [14], there are numerous studies that discuss the improvement in health status of marine ecosystems in wilderness reserves where fishing is not allowed [15, 16, 17]. The situation is almost always the same: a substantial increase of biomass being observed for most species [18, 19], an increase in populations of large predators [20], an improvement of the quality and increase in surface area of the habitat [21], an important export of larvae and fry outside of the reserve [22, 23] and an increase in the number and size of commercial fish [21]. All these ecological benefits can be summarized under the designation of the, "reserve effect". Within the managed MPAs, it is also noted that overfished stocks can recover to biologically stable levels [24].

On the outskirts of MPAs, a "distributional effect" has been identified [25]. This effect can manifest itself by emigration outside of the managed area of juvenile and adult fish on one hand [26], and net export of pelagic eggs and larvae that are subject to less predation in reserve on the other [21, 22, 23]. To the extent that changes in fishing practices are effective and persist, a significant increase in biomass in the area of Le Prêcheur is expected. The experience of eight fishing no-take zones established in Martinique since 1999 can be used here to illustrate what should be observed in Le Prêcheur. In these no-take zones, destructive environmental practices are in fact entirely banished, similar to what is proposed for the reserve of Le Prêcheur. The reopening of most areas after three years

seems, according to fishermen, "worthwhile" even though the effects wear off in a few months. According to [28], the abundance of aquatic populations can be multiplied by a factor of 2 to 10. The protected area thus experiences a strong increase in biomass and the same increase is expected to occur in the MPA of Le Prêcheur - if the measures in place are observed and enforced.

The increase in biomass within the MPA and its periphery will also mean economic gains for fishermen. First, these gains are realized by higher catch per unit of effort (CPUE) in protected areas, such as in Sainte-Lucie where the CPUE was well above the initial state five years after the implementation of the reserve [22]. This observation has also been demonstrated in other parts of the world such as Africa [25, 28, 29]. Higher CPUE results in shorter fishing time (time saving) and lower operating costs (fuel, ice, etc.). Further, the implementation of a reserve has an impact on the price of catch. This has been verified in the Saba marine park and Hol Chan marine reserve (Belize), where values of demersal catches (mainly snappers) were 2.2 to 3.5 times higher than those of non-protected areas [30]. This increase is the result of an increase in the overall quality of fishery products and an improvement of marketing [31]. This increase is primarily made possible by a larger catch size, which leads to a higher selling price (larger items are more popular than smaller ones for most fish markets, including in Martinique). In addition, it is embodied in the marketing of species with higher commercial value [32]. Fishermen can also benefit economically from the environmental image of the area operators by selling at a better price their catches stemming from sustainable exploitation of stocks [33].

3.6 Management recommendations

The implementation of fishery management measures both inside and at the periphery of the area of Le Prêcheur involves changes in strategies and techniques from professional and amateur fishermen. Practices with a strong to medium impact on ecosystems should be banned or be tightly regulated. This can lead fishermen to three fishing strategies: one is to continue, in the reserve, to target the same species, but with different fishing gear (environmentally neutral). The second is to use new fishing techniques and the third is to relocate to other areas.

3.6.1 Transfer of fishing effort to ecologically neutral techniques

This change consists of abandoning fishing techniques deemed harmful to the marine environment and adopting practices with zero impact on the environment (line fishing). Collaborating with fishermen with extensive experience will be valuable in performing this conversion of techniques on the site of Le Prêcheur. If implemented, this can lead to the return of older fishermen, who have mastered these techniques, but have been neglected since the development of motorized Miquelon fishing techniques. Reviving traditional techniques can be part of a larger project of promoting traditional crafts (like cocoa and coffee cultivation for instance) in Le Prêcheur. The utilization of knowledge and expertise accumulated through generations of fishermen could be communicated widely to promote sustainable fishing practice to the new generation of fishermen. In other words, the creation of the reserve constitutes an opportunity to promote the maritime heritage of Le Prêcheur.

3.6.2 Deployment of new strategies and techniques

New strategies can be developed during the implementation of the reserve, supported by the regional authorities and in close collaboration with scientists from IFREMER in particular. For example, the beach seine is a destructive practice, but very effective for catching saury and *coulirous*. This method alone accounts for 20% of the total value of catches in the area of Le Prêcheur. However, it is possible to develop a less destructive, but equally effective strategy for catching these species. In addition, industry and scientists should work together to improve the efficiency of line fishing techniques. This technique could also be better commercially valued with the development of a 'line fish' label, for example. In a nutshell, the development of these new strategies and techniques should not be left solely in the hands of the industry but should rather be done in close collaboration with scientists and downstream operators, supported by regional authorities.

3.6.3 Transfer of fishing effort to other locations

The redeployment of fishing effort from the area of Le Prêcheur to other places should not be considered as the "best" alternative, as the environmentally harmful gear is just as harmful outside the proposed MPA in Le Prêcheur. However, a transfer of fishing effort to Miquelon fishing and fishing around the FADs (which is economically and ecologically viable) should be envisaged. The opportunity cost of this transfer is relatively low. Indeed, the value of catches in the area of Le Prêcheur prior to implementation is estimated at €170 000 per year from a total value of €646,000. Most of the income from fishing activity does not come from fishing in the area of Le Prêcheur but activities around the FADs and Miquelon fishing. Based on the fact that there are no biological notes binding catches of species targeted by these two techniques to only the targeted species, it is possible to foresee such an effort carry over from the area of Le Prêcheur further out to sea. As a whole, this should not require additional investment, as most fishermen already go out to sea aboard motorized boats, it may however not be possible for fishermen who travel using less powerful motorized skiffs. Research is required to estimate the impact that such changes would have on the economic livelihoods of these fishermen.

4. Management of fishing activity in the marine reserve of Le Prêcheur

The management of fishing activity in the marine reserve should firstly aim to limit activities that are most destructive of the marine environment and secondly to ensure that exploitation levels of ecologically neutral activities are compatible with the renewal capacity of the exploited stocks. The management plan should not stop at the boundaries of the reserve but extend to its surroundings to maximize the reserve effect created. Fishermen focusing on the periphery of MPAs, to benefit from the export of biomass, can indeed annihilate the environmental benefits generated by interfering with migratory fish processes. Fish come and go from the reserve to the periphery and vice-versa during more or less marked migration phases (from simple incursion seasonal migration). It is, therefore, crucial not to impede their free movement. In this regard, it is important that the fishing effort is neither carried out over the border nor extended to the periphery (often on the very boundary line) with gears that have been banned in the reserve or others, as this would be

counterproductive. A "buffer" system should be introduced to avoid over-exploitation in the periphery of the MPA.

To establish the legitimacy of such a management plan, scientific studies must be conducted together with the fishermen (who must play a leading role in developing the working protocol with the help of scientists). In this way, each action will be based on - and supported by - the best available data produced by a researcher-fishermen collaboration. To this end, institutions such as the Martinique Marine Environment Observatory (OMMM) and IFREMER will be heavily involved in the development of monitoring indicators (such as the percentage of mature fish caught, the proportion of fish captured at an optimal size and the percentage of pregnant females captured). More generally - and in the continuity of the spirit of scientific monitoring - decisions relating to the management of aquatic environments must be underpinned by a collaborative process where all stakeholders have a voice: fishermen and other users of ecosystems (diving centres, boat ride tourist operators, managers of beach tourism, etc.). Thus, decisions will be more respected and their impact will be greater.

Finally, the development and establishment of the reserve should be supported by the competent authorities, in order to minimize the economic and social costs of the new management plan. The opportunity cost of abandoning the destructive practices is considered low overall (but may affect some fishermen more than others - particularly the smaller scale operators). However, the assessment of these costs did not include the expenses generated by the adoption of new practices, including fishing further at sea, which can be very expensive depending on the equipment used (net purchase, buying a boat for fishing at open sea, engine purchase and installation of ice facilities, implementation of joint or individual FADs, etc.).

5. Conclusion

The prospects related to the creation of the regional reserve of Le Prêcheur as a managed area are positive for fishing. This will be an opportunity to correct the destructive environmental practices and show that fishing practiced sustainably is both beneficial to the economy of the fishing business and neutral to the marine environment (thus both technically and economically feasible). If certain practices are maintained, a redeployment of fishing effort to Miquelon fishing (between November and June) and fishing around the FADs (depending on sea conditions) will be needed. New practices must be developed to replace those that are highly damaging but traditional, such as the beach seine. In terms of overall perspective, an increase in catches is expected in the months following the implementation of the reserve. It is therefore necessary to agree on the marine ecosystem management arrangements of the site of Le Prêcheur. If the municipality of Le Prêcheur will primarily benefit from the economic benefits linked to the MPA, the rest of the island will also benefit from it. Moreover, economic and social benefits are also expected in the field of ecotourism, development of traditional practices and skills (e.g. handcraft), maintaining or even boosting the population located in the municipality of Le Prêcheur and neighbouring municipalities, development of employment and income, and enhancing the image and reputation of the municipality and of Martinique in general.

To promote the harmonious development of fishing activities in the framework of the MPA in Le Prêcheur when it is

implemented, the reserve managers must ensure the realisation of tasks including good communication with local stakeholders, facilitating changes in practices (financial assistance, training etc.), monitoring and evaluation of fishing-related practices and monitoring the perceptions of locals in the area. Finally, the active involvement of fisheries, diving, recreational, ecotourism and sport fishing professionals is essential to the success of the MPA.

6. Competing Interests Statement

The authors have no competing interests to declare

7. References

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