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Rational Exploration of Northeastern Madagascar Halieutic Resource

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International Journal of Marine Science, 2024, Vol.14, No.2, doi: [10.5376/ijms.2024.14.0017](https://doi.org/10.5376/ijms.2024.14.0017)

Received: 15 Apr., 2024

Accepted: 10 May., 2024

Published: 24 May., 2024

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Preferred citation for this article:

Jao H.J., Soambola L.A., and Roger, 2024, Rational exploration of northeastern Madagascar halieutic resource, International Journal of Marine Science, 14(2): 134-154 (doi: [10.5376/ijms.2024.14.0017](https://doi.org/10.5376/ijms.2024.14.0017))

Abstract The artisanal fishing activity has existed since long time in the Madagascar northeastern coast. The fishing activity contributes economically to the reduction of poverty in rural areas in this country. But a notable change on local fishing method which attracts marine science researcher attention was encountered by the habitants especially from the Loky-Manambato marine protected area (MPA). The present research work studies the fishing method case in the area located in Antsampilay Fokontany, rural municipality of Ampisikinana belonging to the district of Vohemar. The proposed research work was developed with the aim of ensuring the rational exploitation of fishery resources by ensuring an increase in catch yields of fishermen in the Loky-Manambato MPA. The research results are susceptible to improve the rational exploration possible to know the different types of fishery resources. The present survey exploited the different types of gear and catching methods used by fishermen within the Loky-Manambato MPA. The local survey research result reveals a strong potential marine resource in this area. Furthermore, fishing methods continue to evolve over time, the threatening change is due to the increase in the number of fishermen. The traditional practice of new destructive methods which further accentuate the reduction in fishing products. It is therefore important to educate fishermen to no longer use this fishing method to further guarantee the ecological and environmental safety of Loky-Manambato MPA.

Keywords Fishery artisanal method; Halieutic resource; Loky-Manambato marine protected area (MPA); Northeastern Madagascar coast; Rational exploration

Over the age, the various oceanic and marine biodiversity's constitute the most prestigious of mankind richness (Beedessee et al., 2015; Castejón-Silvo et al., 2023; Karuppiah et al., 2023; Kihia et al., 2023; Roy, 2023; Madadecouverte, 2024). Many populations and socio. economy of urban cities and rural villages living in continental and also island coasts around the world depends on the artisanal fishing activities which requires naturally the biodiversity safety. It is worth to emphasize that nowadays, the fishing sector is one of the economical resource pillars of many countries (Henderson et al., 2008; Akhilesh et al., 2011; Ontomwa et al., 2019; Gore et al., 2019). In the other words, the marine resource allows us to meet the needs of many coastal populations through fishing, processing and the sale of fishery products (Gerami and Dastbaz, 2013; Obiero et al., 2019). Indeed, the marine activities constitute an important source of income for fishermen and the supply of proteins of animal origin for the population (Henderson et al., 2008; Akhilesh et al., 2011; Gerami and Dastbaz, 2013). Therefore, it contributes systematically to the fight against poverty in the country (MPRH, 2012).

Today, based on different scientific forecast (Wu, 2024), the environmental biodiversity is threatened by various factors as the marine litter (IUCN, 2014; Jaquemet, 2024) and climatic change (Badjeck et al., 2011). One of the most threatened consequences is the distribution of water on the Earth (Lefevre, 2013). Therefore, worldwide governmental and international action plan is deployed for the ecological protection of this continental shelf rich in marine biodiversity (FAO, 2009; Fischer et al., 2012; Spalding and Leal, 2021; Ntibona et al., 2023; Rumisha et al., 2023). Scientific method establishing conservation factors were recently featured (Paudyal et al., 2018). Standard classifications and main characteristics of marine ecosystems were adopted by local, national and international groups (Kaaya, 2019; Wu and Jin, 2023).

To face up the natural marine biodiversity degradation (Davis et al., 2022), national directives on the fishing data were promulgated by different countries as Madagascar (MAEP, 2003; National Assembly, 2015; MPRH, 2021). According to scientific surveys (MPRH, 2012; Chauveau, 2024), the Malagasy marine resources are faced with overexploitation. Subsequently, the environmental condition deterioration leads to a reduction in fishery products and the scarcity of certain species. Thus, withdrawals from resources have exceeded the capacity to renew stocks which is synonymous with overexploitation caused by demographic pressure on coastal zones, insufficient resources for coastal surveillance, and the evolution of climate change (Climate Data, 2021). Hence, to react against the Madagascar report threatening as published by World Bank (Mosse and Sontheimer, 2010), the interest in using certain types of fishery resource management justifying the necessity of protected areas (MAEP, 2003; MPRH, 2012; National Assembly, 2015; Chauveau, 2024).

By aiming to study the fishing activity protection objective of Madagascar northeastern coast, the present research work focuses on the fishery resources of villages belonging to the Loky-Manambato marine protected area (MPA) (FAPBM, 2014). Despite the Madagascar development objectives (MAEP, 2003; MPRH, 2012; National Assembly, 2015) on fishing method, further scientific study on marine science is necessary to overcome problems relating to the difficulty of respecting the mandatory regulations and the overexploitation of fishery resources. The rational exploitation of fishery resources is investigated by considering qualitative research inquiry (Hartas, 2015; Lugen, 2015) by ensuring an increase in catch yields of fishermen in the Loky-Manambato MPA. With this in mind, the specific objectives consist of: Know the different types of used fishing products and to face up to the insufficiencies data necessary must be acted effectively; Understand the different types of gear and the capture methods used by considering qualitative inquiry approach (Hartas, 2015; Lugen, 2015); Know the problems related to the way aquatic resources are exploited; Determine the current state of resources in order to elaborate the relevant measure enabling to reduce the quality and quantity of fishing products, and development of efficient idea of the existing type of management in order to put forward recommendations for its improvement.

Doing this, the present paper is structured into five main sections as follows: The fishing zones under study are described in Section 2; Section 3 focuses on the exploration of the fishing zone environmental parameters; Section 4 investigates on the research methodology and the introduction on the employed materials in the Loky-Manambato MPA considered zone areas; The fishing activity results are discussed in Section 5; and Section 6 is the conclusion.

1 Description of Study Zone Area

The geographic situation of the study zone area of Loky-Manambato MPA and especially the fishing zones in the villages is described in the present section.

1.1 Geopolitic description of the considered zones under study

Ampisikinana is being one of the 19 municipalities of the Voahemmar district and it is among one of four limited rural municipalities of the Loky-Manambato MPA. The fishing zones of the villages under study are located in the Madagascar northeastern coast of the SAVA region. The considered areas of the villages are particularly situated in the marine coastal part of Fokontany Antsampilay. All the villages are located in the rural municipality of Ampisikinana and the district of Voahemmar is no exception to this situation.

This municipality moves 70 km to the northwest from the Voahemmar town whose geographical coordinates are 49°48'17"E and 12°56'57"S.

It should also be noted that several Fokontany exist in this Municipality and fishing is the main activity of the population of the "Antsampilay" fokontany. This is also the criterion for the choice of this fokontany for the study of the management of fishery resources. This fokontany is located approximately 5 km north of Ampisikinana and includes several islets including Nosy Satrana, Nosy Ankao, Nosy Manampaho, Nosy Ratsy and Nosy Manambiby. Thus, the reef flats of these islands are characterized by the abundance of resources. During this study, we chose six villages in the Fokontany of Antsampilay as study sites (Figure 1).



Figure 1 Location of study areas

Image caption: The village of Antafiamivony, located 2.5 km as the crow flies northeast of Antsampilay; The village of Ambanifony, located 8.8 km as the crow flies north of Antsampilay; The village of Ambanifilao, located 11.2 km as the crow flies north of Antsampilay; The village of Ambavarano which is located 12.7 km north of Antsampilay; The village of Ampasimadera, located 18.1 km as the crow flies north of Antsampilay; And the village of Nosy-Ankao, located 12.5 km as the crow flies northeast of Antsampilay

The villages of Antafiamivony, Ambanifony, Ambavarano and Ampasimadera, all with mangroves, are where crab and shrimp fishing activities take place. The presence of the mangrove forest and the coral ecosystem (FAO, 2009; Ntibona et al., 2023) testifies to the richness of marine biodiversity in these areas. For this reason, the areas are selected to carry out this study.

1.2 Description of Antafiamivony fishing zones

The fishing zones of Antafiamivony are characterized by the existence of a vast mangrove ecosystem on the one hand (Figure 2). This determines the presence of numerous flora and fauna species such as gastropods, fish as well as crustaceans, particularly crabs and shrimps. In addition, these areas are dominated by a large area of seagrass. Which makes shrimp fishing easier. Given that the coral ecosystem is very distant from the village, this forces fishermen to go further to catch fish, cephalopods and echinoderms.

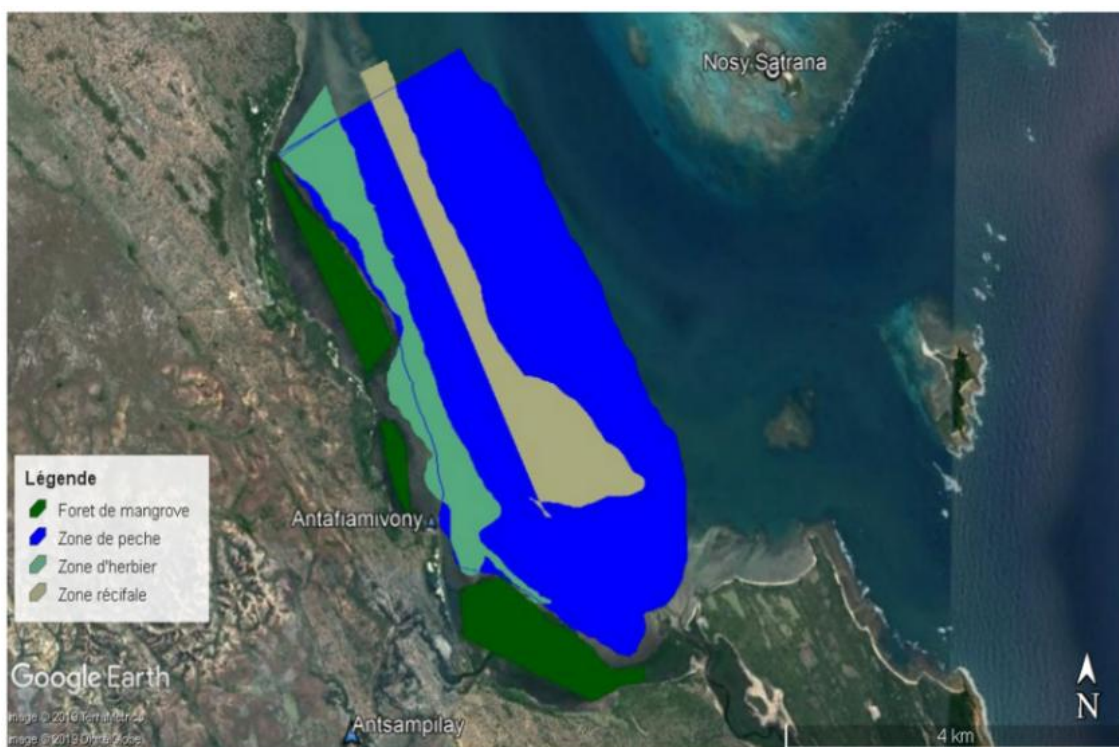


Figure 2 Antafiamivony fishing areas

1.3 Ambanifony fishing area

The fishing areas of Ambanifony are characterized by the existence of mangrove ecosystems and coral reef (Figure 3). These two ecosystems play an important role in the spawning grounds of various marine animals. Thanks to these two ecosystems, Ambanifony fishermen can fish for various species of fish, crustaceans, gastropods, cephalopods as well as echinoderms.

These fishing areas are located to the east of this village and are more productive thanks to the presence of seaweed farming next to the coral ecosystem.

1.4 Ambanifilao fishing zone

Being provided with the closest fishing zone, the coastal zone of Ambanifilao is covered by reef barriers (Figure 4). The presence of the coral ecosystem in this fishing area indicates that the fishermen of this village have advantages in fishing for several species of fish, cephalopods and echinoderms (sea cucumber). Indeed, the non-existence of mangrove forest around this village prevents fishermen from fishing for species such as crabs, gastropods, etc.



Figure 3 Ambanifony fishing areas

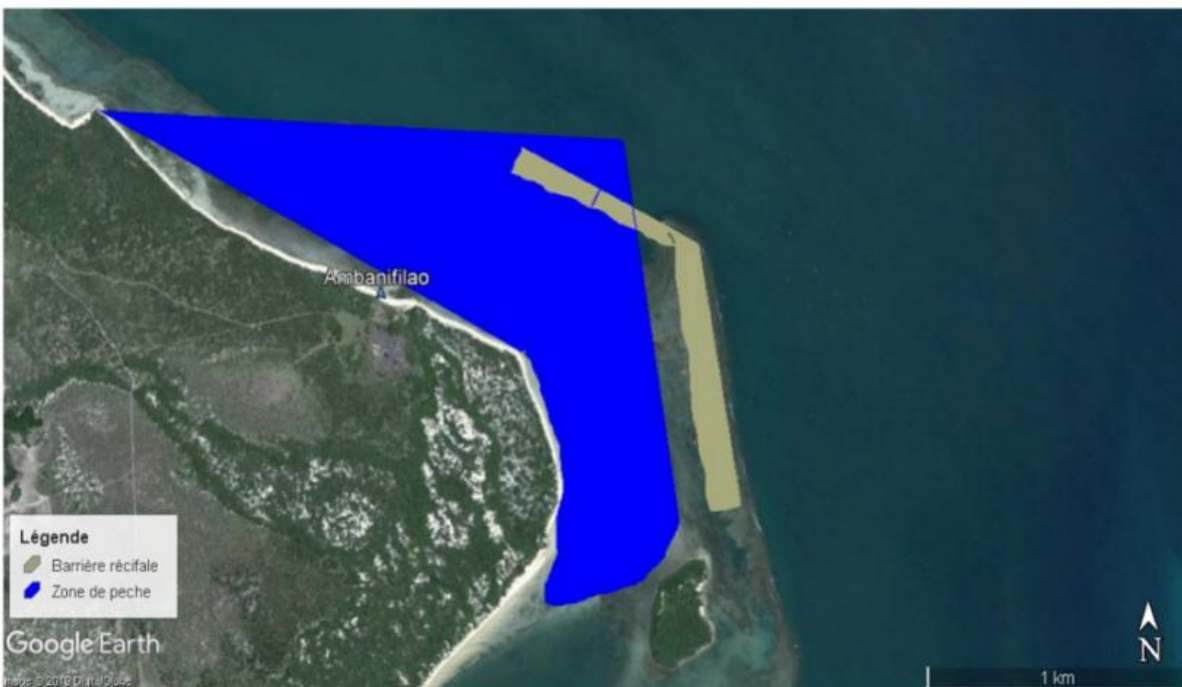


Figure 4 Ambanifilao fishing zones

1.5 Ambavarano fishing zone

The Ambavarano fishing areas are occupied by two types of ecosystems (Figure 5). One of these ecosystems is the mangrove which is home to numerous flora and fauna species such as crustaceans, gastropods and fish. The other zone is the coral ecosystem which is the richest of marine ecosystems so that it is a real center of exchange for thousands of animal and plant species, cohabiting to feed, reproduce and develop. Thanks to these advantages, the fishermen of this village can fish for various species of fish, cephalopods and echinoderms etc.



Figure 5 Ambavarano fishing areas

1.6 Ampasimadera fishing zone

The Ampasimadera fishing grounds are located within Ampasimadera Bay (Figure 6). They are made up of seagrass areas where the algae from the seaweed farming program are spread out and reef areas which are home to several species of reef fish and cephalopods such as octopuses, etc. In addition, these fishing areas are covered by a small area of mangrove forest what makes shrimp fishing happen at night in these fishing grounds.



Figure 6 Ampasimadera fishing zones

1.7 Nosy Ankao fishing zone

Surrounded by the sea, Nosy Ankao is for tourism on the one hand and fishing on the other. However, fishermen are mainly concentrated in the village of Ampasimangidy (Figure 7). Their fishing zones are the largest and are covered by coral ecosystems, of which a hard core of the MPA is located in the north western part of the island (Figure 7). Which justifies the richness of fish species in the surrounding area. Thus, the Fishermen's Association in this village has set up their reserve into two large reserves as follows: the first reserve is located at the hard core where only sport fishing for tourists can be carried out. This technique consists of releasing the fish after being

captured. The second is a buffer zone which is located south of the Village of Ampasimangidy (Figure 7) and where all destructive fishing techniques and gear are prohibited.

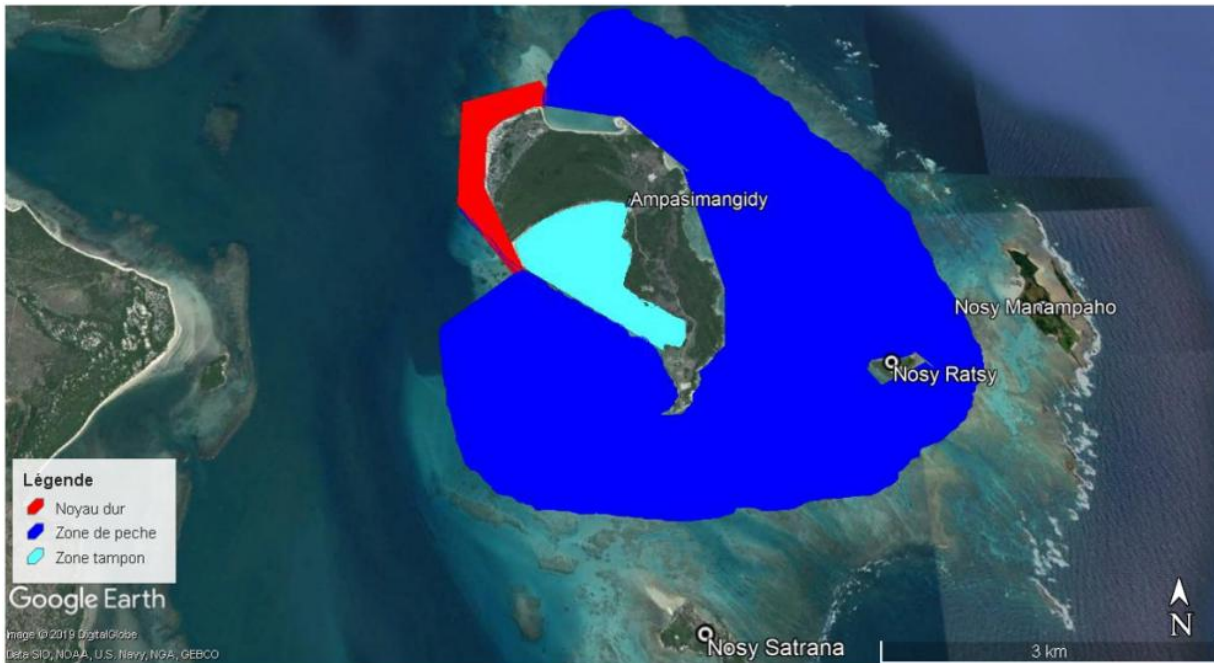


Figure 7 Fishing zones of Nosy Ankaon

After the geographic description, the fishing zone environmental parameters are reported in the following section.

2 Description of Environmental Parameters

The environmental parameters of fishing zones geographically defined previously are studied in this section.

2.1 Climatology

The climatology of fishery resources study was carried out in the Loky-Manambato MPA. According to the climate classification, the considered area one is classified as a savannah climate with dry winter and known to be tropical. There are two alternating seasons, that is to say the cooler and drier season which extends from the beginning of May until the end of October and a hot and humid season (with a lot of rain) from the beginning of November until the end of April. It should also be noted that climate is a primordial factor which conditions the existence of resources and their distribution.

2.2 Temperature

The thermal regime of the Madagascar northeast region is governed by the alternation of these two seasons. The temperatures denoted by T vary from 19.5 °C to 31.5 °C (Figure 8). The lowest temperature value is recorded in the month of July (cool season) while the highest value is observed in the month of December (hot season). However, the average temperature of Ampisikinana varies from 27.3 °C to 23.8 °C. In February, the average temperature is 27.3 °C. This means that February is the hottest month of the year. And the month of July is the coldest month of the year with an average temperature of 23.8 °C.

2.3 Pluviometry

The Atmospheric precipitation appears in the form of water drops. The latter result from the rise of air caused by water vapor and as they cool, these water drops fall back. In the present study area, the rainy season begins in November and ends around April, often accompanied by a major storm (Climate Data, 2021). In a year, the average precipitation is 112.75 mm. Precipitation ranges from 245 mm to 37 mm. The lowest value of precipitation is recorded in the month of September while the highest value is observed in the month of January (Figure 9).

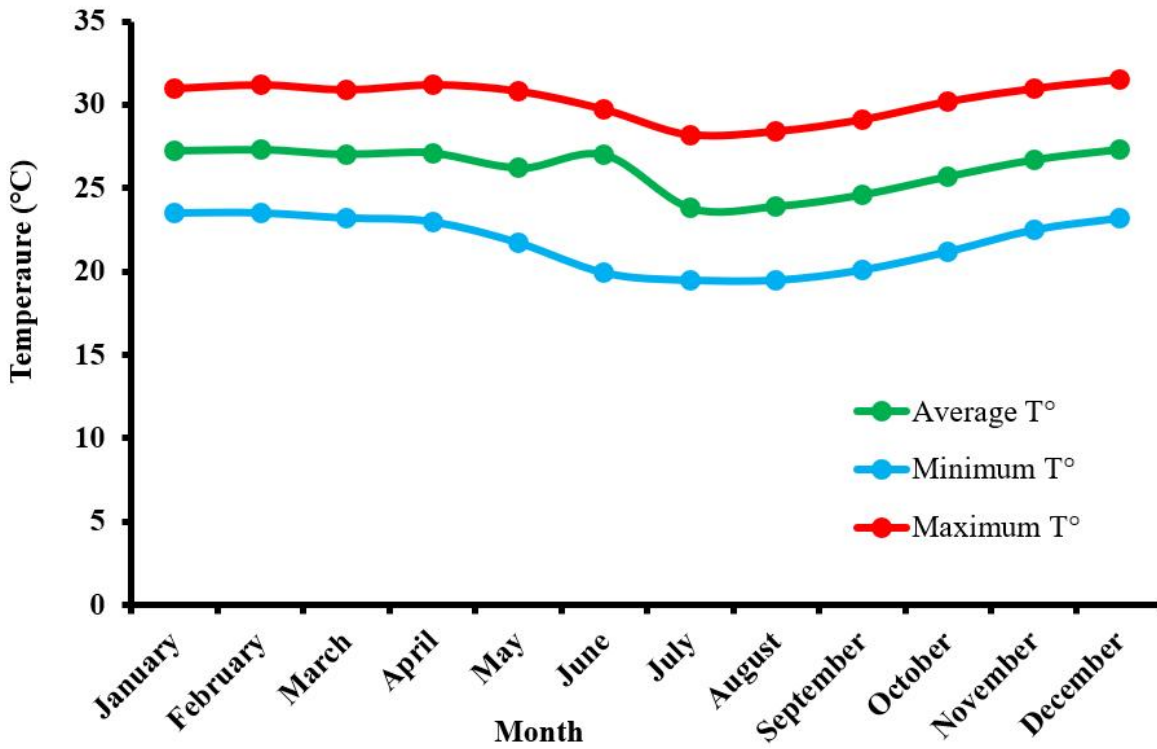


Figure 8 Temperatures recorded in the Rural municipality of Ampisikinana

Image caption: Source: <https://fr.climate.data.org/afrique/madagascar/ampitsikinana/ampitsikinana.762358/>; Between the lowest and highest temperature of the year, the difference is 3.5 °C

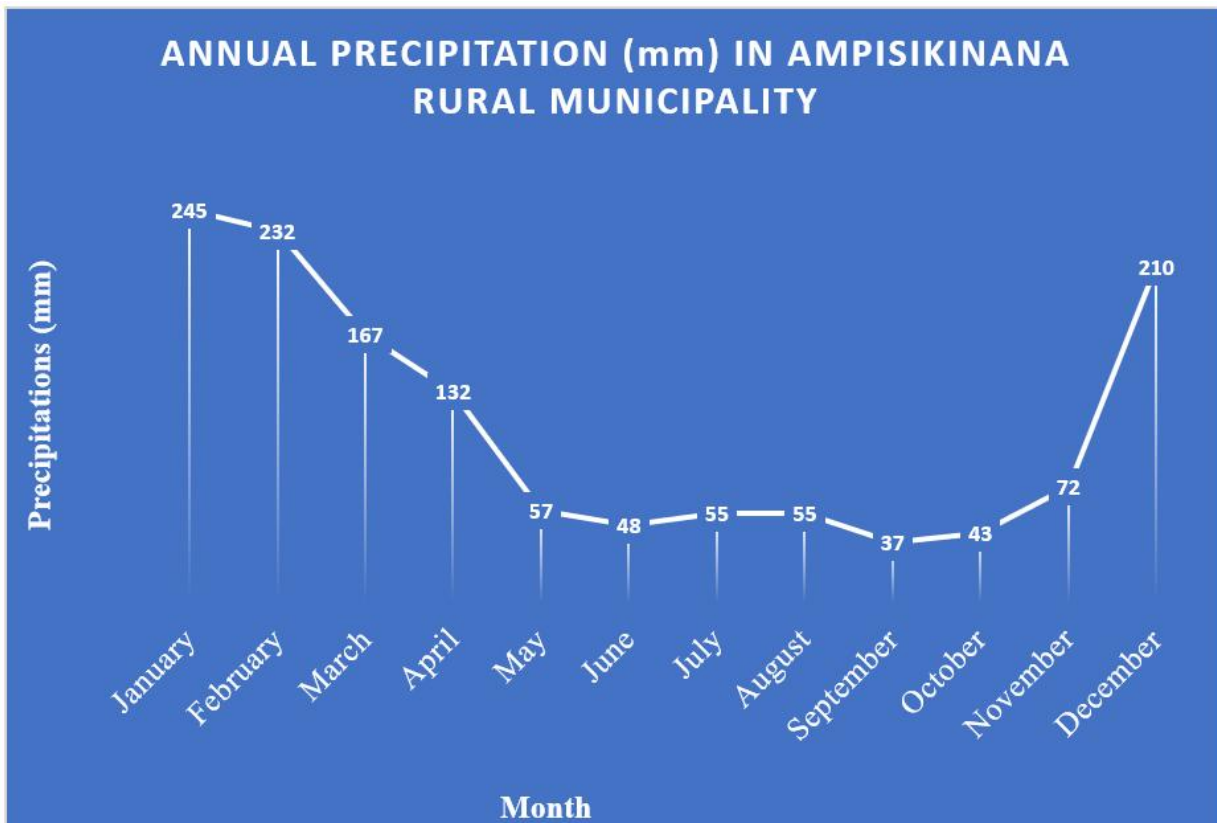


Figure 9 Annual precipitation (mm) in the rural municipality of Ampisikinana

Image caption: Source: <https://fr.climate.data.org/afrique/madagascar/ampitsikinana/ampitsikinana.762358/>

2.4 Wind

Wind is a movement of air within the atmosphere. It plays a very important role in fishing activities because it determines whether fishermen go fishing. In the North-Eastern part of Madagascar, the strong trade wind locally called “Varatraza” which blows from the East to the West was observed from the month of May until the end of October. This period corresponds to the decrease in fishing products in this north-eastern part of Madagascar and including the Rural municipality of Ampisikinana. In addition, the west wind called the Monsoon locally called “Talio” which brings rain accompanied by storms extends from the beginning of November to April. In the rainy season, the majority of winds in this region do not exceed 25 km/h, except during cyclones (SAVA region monograph) which determines the abundance of fishing products.

2.5 Hydrography

The Loky-Manambato MPA entire region benefits from a dense hydrographic network (monograph of the SAVA region) of which several rivers bring nutrient salts to all fishing areas. The noted most important rivers are that of Manambato in the South; the Andravina and Manankolana rivers in the center and the Loky river in the north. These four rivers provide the renewal of nutrient salts almost throughout the year, especially the two rivers at the southern and northern ends of the MPA. The existence of these rivers is an important indicator for the management of fisheries resources. Because these rivers not only play the role in the renewal of nutrient salts but also they hold the irreplaceable and unique ecosystem sheltering incredible biodiversity and are among the most productive ecosystems in the world (FAO, 2009) thanks to their mouth provided with mangrove ecosystem.

Knowing the environmental parameters of the understudy zones, the research methodology considered for the present work is discussed in the next section.

3 Investigation on Research Methodology and Used Materials

The methodology adopted and deployed in order to obtain the data and information necessary to resolve the problem of our research subject is investigated in this section. To have information and knowledge on the theme of the study and the study area, it was necessary to carry out bibliographic readings. These must be done before, during and after field work. The bibliography before the field trip above all makes it possible to properly prepare data collection strategies in order to obtain reliable results. These bibliographic searches are carried out not only on the internet but also in the University of Antsiranana libraries.

3.1 Decision making and information sharing

One reminds that the rural municipality under study belongs to the district of Vohemar (SAVA region monograph). It recorded a total of 4,000 inhabitants according to the monograph of the SAVA region in 2003. The population of the rural municipality and including Fokontany Antsampilay is made up of various ethnic groups but the Sakalava ethnic group largely dominates with more than 80%. It should also be noted that Fokontany is marked by a high proportion of “non-natives”. This requires the establishment of a fisheries management policy as well as fisheries resources in order to increase fishing products while reducing overexploitation. The Antsampilay fokontany, even if it is part of the rural municipality, the information system keepspace with the advancement of modern technology. In addition to the meeting of the village community, the information and fishing regulations adopted can be communicated by telephone “Orange and Telma operators”. The aim of sharing information in the context of resource management is to improve transparency on the management method and the structure that we will adopt in the fishing sector. The success of fishing activities depends on the used physical materials as specified in the next subsection.

3.2 List of physical materials

During field trips, numerous fishing products were captured and exploited. They belong to the groups of pisces, shellfish and cephalopods.

These types of fishing technique are practiced mainly by men who have been able to dive with equipment (Figure 10) such as fins, mask and tubas. To carry out this work, certain materials are necessary described as follows: A camera equipped with a GPS to take the geographic coordinates of these study sites as well as photos of the

products; A speedboat which is used to move from one village to another village where fishermen live; Specific software called QGIS 3.4 and Google Earth which are used to clearly specify the location of these study areas, and XLSTAT software was used to process the statistical data.



Figure 10 Material used as fishing gear

Image Caption: Gill net: (a) 25 mm mesh size and (b) specific gill net forg. naso. (c) Fishhook. Monoxyll canoe (d) without balance and (e) with outrigger. Diver materials: (f) rifles, (g) masks and snorkels, and (h) fins

For further understanding on the use of materials, different types of fishery capture methods are addressed in the next subsection.

3.3 Different types of gear as well as capture methods

The fishing technique is a very varied activity. The very young beginner fisherman must know the equipment, accessories and methods used, develop his know-how and learn some techniques and tactics to capture fishery resources. The possibilities are so vast and varied depending on the villages where the species are found. Indeed, certain villages like Nosy Ambanifilao and Nosy Ankaos are impossible to fish for crabs due to the lack of mangroves. On the other hand, for the other villages, the abundance of mangrove forests indicates that it is possible to fish for all qualities of fishery products found in this FKT, including crustaceans, gastropods, and cephalopods as well as fish, etc.

3.3.1 Angling

It is an active fishing method for catching fish species and squid. This technique consists of letting the line go down with the hook (metal hook that is put at the end of a line for fishing fish) towards the bottom of the sea. The hook used by fishermen is no. 20 minimum and on this the bait is hung or not. As soon as the fish or squid are caught by the trap, they are quickly brought to the surface.

3.3.2 “Magnera”

The fishing technique called “magnera” is one of the most used fishing methods in all the fishing zones of FKT Antsampilay. Mostly, it is practiced with gillnets greater than 25 mm mesh size (3 fingers) and 1,000 m long at least with 0.5 m height. This fishing technique is generally practiced during neap water. And the nets are placed around 1 a.m. to 2 a.m. during the ebb or ebb and will be brought back around 5 a.m. to 6 a.m. at the time of low water. The target fish are there (Table 1).

Table 1 Crustaceans exploited in the Loky-Manambato MPA

Scientific names	Family	Local name	Category
Scylla serrata	PORTUNIDAE	Drakatra	Crustaceans
Penaeus sp	PENAEIDAE	Makamba	
Panulirus sp	PALUNIRIDAE	Komajiva	

3.3.3 Sleeping net

The standing net fishing technique locally called “sovy” consists of fishing for fish in the shallower area of the reef flat. It is practiced with gillnets with mesh sizes greater than 25 mm and 200 to 1 000 m long with 0.5 to 2 m height. Sovy is generally practiced during high water and the nets are set down around 3 p.m. and will be brought back the next day around 8 a.m. This technique is favorable in all study areas where the target species are numerous and very varied. This technique uses not only gillnets but also fins, masks and snorkels for Naso fishing.

3.3.4 “Serisery”

The new fishing technique is introduced by non-native fishermen in the rural municipality of Ampisikinana since 2009. This fishing is generally practiced during neap water. To do this, place the large mesh nets during high water then closed, and then tightened with small mesh nets and will be brought back during low water. This fishing technique requires the use of the following equipment (Figure 1) as gillnets of 25 mm mesh measuring 1000 m minimum length with 0.5 m to 2 m height, mask, tubas, fins and rifles. The use of “serisery” in all study areas in 2018 and 2019 (Figure 11).

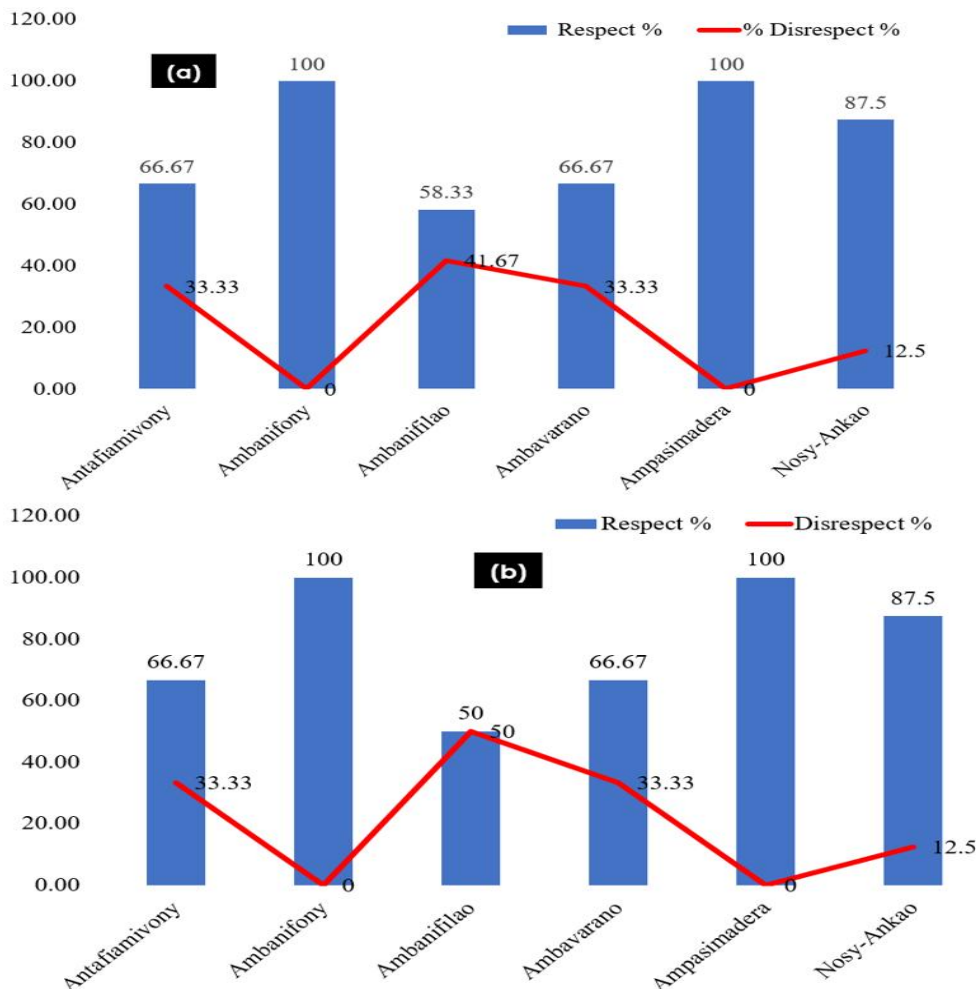


Figure 11 Use of Serisery in (a) 2018 and (b) 2019

3.3.5 Fishing on foot

This fishing technique also exists in the study areas. It is practiced during periods of low water at the time of spring tide. During this time, the majority of women and children and also men set out with harpoons (a weapon made up of a point fitted with hooks) in search of octopuses and with landing nets in search of shrimp.

In addition to the fishing technique, the data collection and investigation strategy are described in the following subsection.

3.4 Collection of data in the field and investigation strategy

This section describes all the techniques that can be used when collecting data in the study area. These include surveys, surveys, direct observation and monitoring of fishing catches and compliance with ministerial regulations relating to fishing. The data collection lasts two years starting from 2018 until 2019 in order to know the progress in the modes of exploitation of fishery resources within the Loky-Manambato MPA. However, it is noted that the data for the year 2019 is the data from January to July 2019. Before carrying out the field trip, an authorization request was sent to the Mayor of the Rural municipality of Ampisikinana, given that he is the first person responsible at the local administrative level. It was carried out via a courtesy visit which also made it possible to explain the objective of the study. During this meeting at the Town Hall, two officials were interviewed with the aim of knowing their ideas on the state of current fishing resources and especially the actions already carried out or still envisaged by the Municipality on the rational management of aquatic resources. In addition, to find out the current fishing situations in the study area, surveys were carried out with the Head of the Regional Fisheries and Aquaculture Service SAVA; of the president of the fishermen's association, the Komity Miarony Tontoloianana (KTM) leader of FKT Antsampilay within Loky-Manambato MPA and the leader Fokontany Antsampilay. Fishermen and collectors were also surveyed to find out the types of marine resources exploited, the different types of gear and capture methods used as well as the problems linked to the mode of exploitation of aquatic resources. This survey is accompanied by the socio.economic survey which was financed by the Time+Tide Miavana Foundation, located in Nosy Ankaos. It aims to answer clear questions. It is indeed necessary to ensure that the language is adapted to that of the respondent because the formulation of questions is a crucial stage of the investigation (Lugen, 2015). For this, simple and unambiguous vocabularies were used to facilitate understanding. In addition, when urgent data were needed, certain questionnaires were sometimes administered by telephone, obtaining quick and short responses. This technique avoids surprise and reduces the negative reaction itself. In other words, the questionnaire survey is an instrument for gathering information based on the analysis of responses to a series of questions asked. The developed technique has advantages in term of the expected information as discussed in the next section.

4 Discussion on the Results

The results of methods previously deployed for data collection and analysis are explained in this section.

4.1 Types of exploited marine resources

4.1.1 Echinoderms: Sea cucumber

Previously, sea cucumber fishing was practiced in all parts of the fishing zone of our study site. It was carried out during the period when the wind is calm in order to facilitate diving. These types of fishing are practiced mainly by men who have been able to dive with equipment (Table 2). From the point of view of echinoderms, only the group of sea cucumbers are exploited in the Loky-Manambato MPA.

4.1.2 Cephalopods

Fishing for cephalopods, particularly octopus, is carried out in all parts of the FKT Antsampilay fishing zone by traditional fishermen on foot during periods of low water at the time of spring tide. It is practiced mainly by women, men and children with the harpoon (weapon consisting of a spear whose tip is fitted with hooks) as fishing equipment whose species targets *Octopus cyanea* (Figure 12).

Table 2 Summary of information collected in the field

Type of surveyed people	Inexpected informations
Town halls	Action plan already carried out or still envisaged by the municipality on the management of marine resources The benefits for good management of maritime fishing
President of Fokontany	The number of the population Problems encountered in the maritime fishing sector
Fisheries manager	Legislation relating to the exploitation of maritime resources
KTM	Actions already taken and planned on the protection of reefs and rational management of resources in our study area. The problems of fishing on the environment
Collectors	The purchase prices of the products The factors that lead to variations in the prices of fishing products
Fishermen	The types, techniques, materials, species caught and fishing seasons, Sales prices, fishing area, production level, buyers, problems encountered



Figure 12 Octopuses (*Octopus cyanea*) in bulk

4.1.3 Crustaceans

The exploited crustaceans belong to three families, each of which has a species subject to exploitation (Table 1). The studied crustaceans are described in the following items:

Shrimp: Traditional shrimp fishing occupies an important place from the social and economic point of view of many fishermen in the coastal villages of the Loky-Manambato MPA. Because it is found in almost all parts of the study area except Nosy Ankaos. Traditional shrimp fishing requires the use of a landing net as fishing gear (Figure 13(a)) and is done on foot. It is carried out during low tide at night, known locally as “magnilo”. This night fishing (magnilo) consists of searching for shrimp (Figure 13(b) and Figure 13(c)) which feed on the mud using traditional techniques (fishing on foot). This term “magnilo” is used for fishing, especially at night, using a flashlight to immobilize prey and illuminate the fishing field.



Figure 13 (a) Net (shrimp fishing gear), and shrimp (b) before and (c) after treatment

Mangrove crabs: The places of crab production in our study areas are concentrated in the mangrove areas located mainly in the villages of Antafiamivony, Ambanifony and Ambavarano. The presence of these mangrove forests in these villages indicates the importance of fishing area and the abundance of the *Scylla serrata* species in these areas (Figure 14). The main fishing technique adopted by fishermen in these areas is shore fishing carried out during low water using the fishing technique (magnilo). The latter consists of searching for crabs feeding on the mud, between the roots of mangrove trees using a harpoon.



Figure 14 *Scylla serrata* (a) muddy and (b) cleaned crabs

Lobsters: Langoustine fishing is even less exploited in our study area due to the insufficiency of collectors. While these products could bring great growth to the areas (Figure 15). This fishing is practiced only by men whose equipment used during the diving fishing operation as nets, landing nets, mask, fins, tuba and gloves (Figure 10).



Figure 15 Lobster species encountered in the Antafiamivony fishing zone

4.1.4 Gastropods: *Pyrazus palustris* “Voronana”

Pyrazus palustris fishing with results is practiced in the mangrove forests of Antafiamivony, Ambanifony and Ambavarano (Figure 16). This method is based on fishing on foot and does not require any special fishing gear. This fishing is carried out during the low water period. These types of fishing are mainly practiced by men, women and children.



Figure 16 *Pyrazus palustris* in the substrate

4.1.5 Pisces

From the point of view of specific richness of the fish exploited (Figure 17), the subjects of capture belong to 19 families and 35 species of fish (Table 3). The family *Lethrinidae* is the richest in species, with 5 species encountered. Fishing method for fishes is practiced in any part of the fishing zone in the FKT. Antsampilay, by traditional and artisanal fishermen throughout the year. These types of fishing are practiced mainly by men and children without limiting the ages, the methods and techniques of which are differentiated according to the target species (Figure 18).

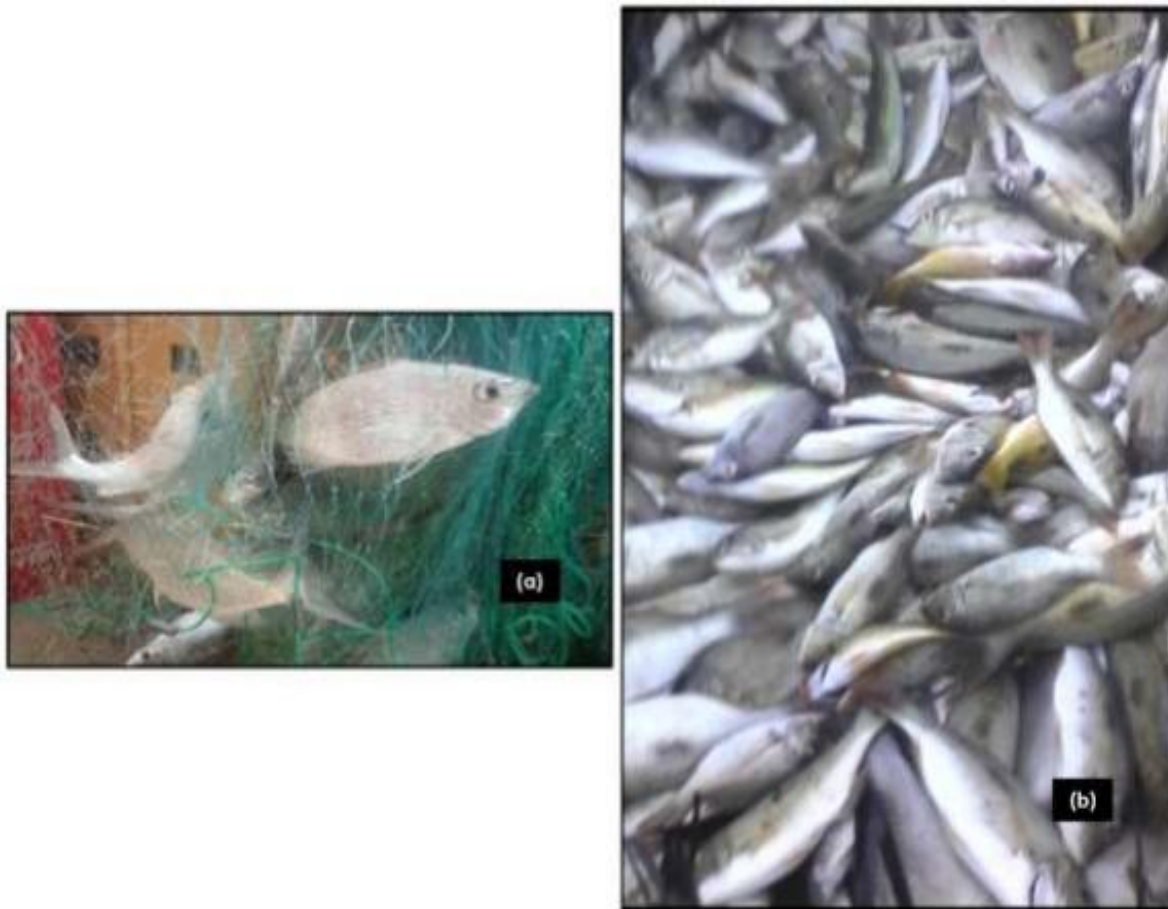


Figure 17 (a) White rudder *g. Gerres* after capture and (b) fish abundance in the study sites

Based on the identified marine biological species, the regulation perspectives on Loky-Manambato MPA fishing activities and recommendations are indicated in the next subsection.

4.2 Regulation perspectives and recommendations on Loky-Manambato MPA fishing activities

4.2.1 Establishment of DINAs and sanctions

In order to improve the management system in the Loky-Manambato MPA, it is recommended to put in place different DINAs followed by sanctions for all fishing villages. These DINAs will be carried out based on the ideas of fishermen in order to facilitate the method of monitoring fishing by avoiding conflicts between fishermen and managers.

4.2.2 Standardization and approvals of DINA

Before releasing the regional DINAs, it is essential to standardize all the DINAs and sanctions by the general assembly of the Fishermen's Associations in this environment with the municipal advisors in order to have issued the municipal decree. Then, the municipal DINAs will have to be approved by the Court of this region in order to have control of the equality of these DINAs in relation to the laws which constitute the mode of management of the resources of the Malagasy state. Finally, after the approval of these DINAs, all fishermen's associations will be able to apply them according to the sanctions.



Figure 18 Species of fish names and photos

Image caption: (a) *Lethrinus harak* (Mandriantognony ou ceinta), (b) *Lujtanus erythropterus* (Tsivarivaragna), (c) *Lujtanus fulviflamma* (Karangamena), (d) *Lethrinus buccanella* (Fiamena), (e) *Lethrinus olivaceus* (Ambitsy lavalava), (f) *Lethrinus absoletus* (Ambitsy), (g) *Plectorhinchus* (Tsimitsao), (h) *Lujtanus kasmira* (Karanga misoritry), (i) *Oligolites pelometa* (Talantala), (j) *Plecto lethrinus absoletus* (Mandriantognony ou ceinta), (k) *Halichoereshortulamus* (Tabaka lavalava), (l) *Parupeneus fraserorum* (Mondrazy), (m) *Scarus russelii* (Tabaka), (n) *Scarus chameleon* (Tabaka), (o) *Lethrinus harak* (Angotra), (p) *Siganus sutor* (Henjy), (q) *Centrolabrus exoletus* (Riandriaka), (r) *Scarus fuscopurpureus* (Tabaka mahitso), (s) *Caranx heberi* (Batola), (t) *Naso unicornis* (Fiatandroko), (u) *Epinephelus fuscoguttatus* (Alovo), (v) *Chaetodon rainfordi* (Takobatra), (w) *Gerres oyena* (Fiampotsy), (x) *Trichinotus falcatus* (Batola andrian.doham.bato), (y) *Abudedefduf abdominalis* (Tible), (z) *Chaetodon trifasciatus* (Tatangy), (aa) *Myripristis pralinia* (Dangereux), (ab) *Hemiramphus far* (Antseraka), (ac) *Cheilio inermis* (Samy miarony aigniny), (ad) *Sphyræna barracuda* (Janogno), (ae) *Pateobatis fai* (Makoba), (af) *Boleophthalmus* (Ambanilakana), (ag) *Penaeus sp* (Makamba), (ah) *Panulirus sp* (Langoustes), (ai) *Scylla serrata* (Drakatra) and (aj) *Octopus cyanea* (Orita)

Table 3 List of fish exploited in the rural municipality of Ampisikinana

Family	Scientific names	Local name
ACANTHURIDAE	<i>Naso unicornis</i>	Fiatandroko
BALISTIDAE	<i>Balistapus undulatus</i>	Angotra
BATOIDAE	<i>Pateobatisfai</i>	Makoba
	<i>Trachinotusfalcatu</i>	Batola andrian.doham.bato
CARANGIDAE	<i>Caranx heberi</i>	Batola
	<i>Oligoplites palomata</i>	Talantala
CHAETODONTIDAE	<i>Chaetodon rainfordi</i>	Takobatra
	<i>Chaetodon trifasciatus</i>	Tatangy
GERREIDAE	<i>Gerres oyena</i>	Fiampotsy
GOBIIDAE	<i>Boleophthalmuspoti</i>	Ambanilakana
HAEMULIDAE	<i>Plectorhinchus gibbosus</i>	Tsimitsao
	<i>Plectorhinchus gaterinus</i>	Tsimitsao
HEMIRAMPHIDAE	<i>Hemiramphus far</i>	Antseraka
HOLOCENTRIDAE	<i>Myripristis pralinia</i>	Dangereux
	<i>Centrolabrus exoletus</i>	Tabaka lava vava
LABRIDAE	<i>Halichoereshortulanus</i>	Tabaka lavavava
	<i>Cheilio inermis</i>	Samy miarony aigniny
	<i>Lethrinusarboineusis</i>	Menahisa
LETHRINIDAE	<i>Lethrinus letjan</i>	Menaheliky
	<i>Lethrinus absoletus</i>	Ambitsy
	<i>Lethrinus harak</i>	Mandriantohogno
	<i>Lethrinus olivaceus</i>	Ambitry lava vava
LUTJANIDAE	<i>Lutjanus erythropterus</i>	Tsivarivaragna
	<i>Lutjanus fulviflamma</i>	Karangamena
	<i>Lutjanus buccanella</i>	Fiamena
	<i>Lutjanus kasmira</i>	Karangamisoritry
MULLIDAE	<i>Parupeneusfraserorum</i>	Mondrazy
SCARIDAE	<i>Scarus chameleon</i>	Tabaka
	<i>Scarusfuscopurpureus</i>	Tabaka
	<i>Scarus russelii</i>	Tabaka
SIGANIDAE	<i>Siganus sutor</i>	Henjy
SERRANIDAE	<i>Epinephelusfuscoguttatus</i>	Alovo
SPHYRENIDAE	<i>Sphyaena barracuda</i>	Janogno
POMACENTRIDAE	<i>Abudebduf abdominalis</i>	Tible

4.2.3 Management transfer to local fishermen

Given that the local management of communities has effects on the sustainable management of resources, it is important for the manager to transfer management to the Fishermen's Associations within the villages in the Loky.

Manambato MPA by strengthening their capacities in sustainable management and rational use of resources through the training of fishermen in all coastal villages.

4.2.4 Product circuit

Before setting up the management control and surveillance system, it is necessary to know the product circuits in these study areas in order to check whether the fishermen respect the minimum size as well as the seasonal closure of fishing without poaching aquatic resources. Since compliance with these regulations ensures the regeneration of resources. This sales circuit for these products in the fokontany of Antsampilay (Figure 19).

We notice that the products of fishermen in our study area follow 2 types of circuits: A short circuit, that is to say the production of fishermen goes directly to consumers; A long circuit, it starts from the fishermen, then the products are bought by the local collectors and they sell to the city collectors and finally the latter sell them to

consumers. It should also be noted that the price to consumers can be affected by these two types of sales channel and generally, the price of products to consumers is high for the long channel.

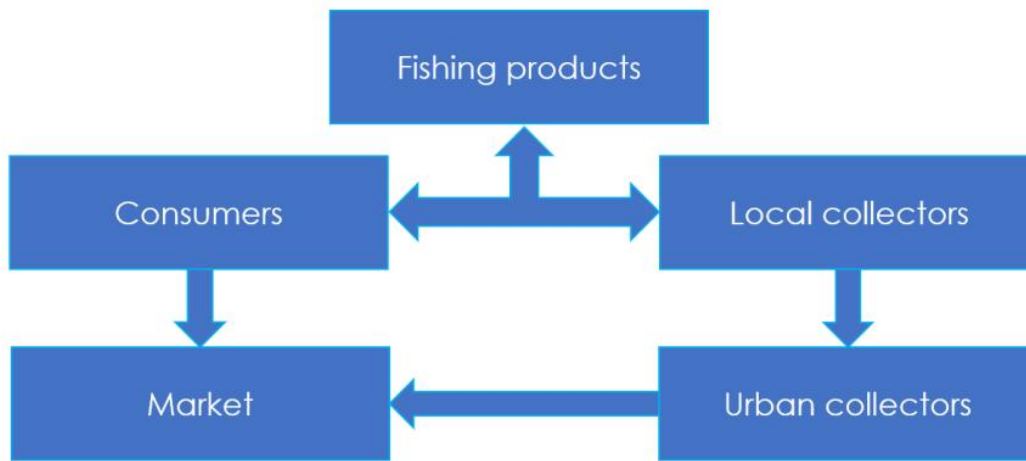


Figure 19 Sales circuit for fishing products

4.2.5 Management control and monitoring

To control and monitor the management method of these fishery resources within the Loky-Manambato MPA, it is important to set up the local Fisheries Monitoring Center (CSP). Their residence must be accessible to sea and land transport so that all fishermen can go there not only by sea but also by land. Within CSP is the fishing brigade to ensure security by avoiding clandestine exploitation of resources by revising regulatory texts relating to these resources.

In summary of the overall study, a conclusion is drawn in the following last section.

5 Conclusions

Surrounded by the sea, Madagascar has a significant number of coastal communities which depend on the fishing sector to meet the food needs of their populations and a source of income. This is also the case for the rural municipality of Ampisikinana and the fokontany of Antsampilay. Thus, the fishing sector plays an important role for the economy of fishermen in the coastal villages within the Loky-Manambato MPA. Because it provides considerable foreign exchange earnings for their lives. But the current production trend is towards a decrease in terms of quantity and quality of fishing products, in the case of fish, cephalopods, crabs, shrimps, lobsters, etc.

The sea is still free access for all Malagasy citizens, so everyone can go fishing. The lack of suitable means to go fishing a little further from the coast (motorized canoe equipped with refrigeration) and especially equipment that does not destroy natural habitats are the problems raised by the fishermen. The latter fish and exploit the shallower zone and within a small radius. Indeed, signs of overexploitation of fishing products have been noted. However, for the development of the sector to be sustainable and rational, it is essential to stop the clandestine exploitation of fishery resources by revising the regulatory texts relating to these resources, namely: the revision of the minimum catch size, the setting of periods closures for laying. In addition, stock assessment studies must be carried out during a certain fishing closure period accompanied by awareness raising among fishermen for sustainable management.

Acknowledgement

The authors are grateful to thank Dr. Blaise Ravelo from NUIST, China, Marie Berthina Sambimiasa from University of Antsiranana, Madagascar, and Valencia Lala from ENAC, France, for their advice and their help to write the manuscript.

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