Description of environmental issues, fish stocks and fisheries in the EEZs around French Guyana, Martinique, Guadeloupe and La Reunion

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October 2012

Report for the European Commission, Directorate-General Maritime Affairs and Fisheries, B-1049 Brussels, Belgium

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1. INTRODUCTION

1.1. CONTEXT

According to Article 33 of Council Regulation (EC) 2371/2002, the STECF shall be consulted regularly on the status of EU fisheries including biological, economic and social aspects. Information on fish stocks and fisheries around the outermost regions (OR's) is limited and have not been assessed systematically. This prevents the Commission to fully implement the CFP in these regions, which on the other hand deserve a differential treatment by reason of their special geographical characteristics (insularity, remoteness, etc.).

1.2. TERMS OF REFERENCE

For fishery resources in the EEZs around French Guyana, Martinique, Guadeloupe and La Reunion, it is requested:

To describe the main stocks and fisheries (differentiating between local, resident and others) within the EEZs. The description should cover fish stock status, fishing fleets, fishing techniques, yields and the economic and social performances of these fisheries.

To describe the main environmental issues related to these fisheries; by-catch of sensitive species, effects of fisheries on natural habitats and influence of the environmental quality of the water on fisheries performance.

This report is written with this aim in view.

1.3. MATERIALS AND METHODS

The French institute for the exploitation of the Sea (Ifremer) has progressively implemented fisheries information systems (FIS, or SIH in French) in Martinique, Guadeloupe, French Guyana and Réunion. A part from industrial fisheries such as the trawlers and the handliners in French Guyana that were followed up since the 80s', the implementation of the FIS began around 2005.

Since then, the fleets are now quite well described and quantified as well as the fishing effort. However, it is more difficult to obtain production at the fleet scale for several reasons : declaration documents are not always implemented, especially for the small boats (most of the fleets are constituted of very small boats), and in other cases, fishermen are tempted to under-report, declare less catches than it is really produced. To avoid this problem, observers were employed to carry out daily enquiries about production. But the sampling is complex because of the heterogeneity of the fleets, the high diversity of exploited species, the low activity rate in some cases, and the numerous fishing harbors identified.

For the same reasons, stock assessments are not always done, knowing that, moreover, the stocks exploited by the fleets operating from Martinique, Guadeloupe, French Guyana and La Réunion are also exploited by fleets of other countries. In French Guyana, stock assessment is done for shrimps and Lutjanids independently from the neighboring countries. Regarding the Martinique and Guadeloupe stocks, the flyingfish stock is internationally assessed, but with a low participation of the Martinique and Guadeloupe fleets to the exploitation of this stock. It is the same case for the swordfish stock exploited by some fleets from La Réunion.

A fortiori, results on economic and social performances are scarce despite that economic enquiries have also been implemented, allowing to bring diagnostics in French Guyana or at less, indicators in Guadeloupe.

This report bring a synthesis of analyses carried out from FIS data, published by the Ifremer as well as of analyses carried out within international working groups for stock assessment.

2. FRENCH GUYANA

The French Guyana is an overseas region of France on the North Atlantic coast of South America. It has borders with two nations: Brazil to the east and south, and Suriname to the west. Its 83 534 km² have a very low population density of less than 3/km², with half of its around 236 000 people in 2011 living in the metropolitan area of Cayenne, its capital. The extent of the surface area of the EEZ is about 134 000 km². The coastal waters are very turbid because of the large amount of sediments coming out from the Amazon river mouth inducing muddy bottoms and low salinity. The influence of the Amazone decrease going from coastline to more offshore areas.

2.1. FLEETS

2.1.1. Coastal small-scale fisheries

2.1.1.1. Vessels

The coastal small-scale fishery is very diverse by the vessel's technical characteristics, but also by fishing strategies that result. Classification of the boats was established according to their architecture (Bellail and Dintheer, 1992). Four types of vessels have been identified: canoe, Creole canoe, improved Creole canoe and tapouille.

The canoe (figure 1) consists of a hull lined with a monoxyle enhanced, with a bow whose height is equal to or greater than that of the watch and whose back is closed by a vertical array that receives the caliper of the outboard engine. The canoe is not suitable for navigation at sea and is used in estuaries.


Figure 1. Traditional canoe (Ifremer picture)

The Creole canoe (figure 2) differs from the canoe by the presence of larger lined. These boats are often larger than traditional canoes. They are adapted to marine sailing.


Figure 2. Canot créole (Ifremer picture)

The improved Creole canoe (figures 3 and 4) is a framed boat, equipped with outboard motors or fixed diesel engines. At the rear, a bridge supporting a deckhouse serves cockpit and navigation it isolates the engine compartment and fuel tank. The bridge stops at the isothermal hold that occupies the middle of the canoe. The front-decked, covered with a simple floor, used for the gear use.


Figure 3. Canot créole amélioré (Ifremer picture)


Figure 4. Plate (Ifremer picture)

The tapouille (Figure 5) is a boat typical of the Amazon region of Brazil, with a wood framed hull and fully bridged. At the rear, the engine and fuel compartment is located under the bridge. The deck is surmounted by a deckhouse which includes the gateway and the cockpit sometimes surrounded by a corridor outside. The work deck is located on the front above a storage compartment for fishing materials. The isothermal hold, integrated, is located below the deck.

Figure 5. Tapouille (Ifremer picture)

En 2008, the fleet was composed by 26% of canoes, 36% of Creole canoes, 34% of improves Creole canoes and 5% of tapouilles. A 39.5% increase of the number of canoes was observed between 2006 and 2008.

This increase reflects the addition of new units since the average age of this type of boat decreased of approximately 1 year between 2007 and 2008. The increase between 2006 and 2007 of the number of improved Creole canoes (17%) is also due to the contribution of new vessels. The 18 % decrease of Creole canoes is linked to the disappearance of occasional landings in Saint-Laurent du Maroni from vessels less active (less than 7 days in the year) who had helped to increase the number of this category in 2006 (Vendeville et al., 2008).

Table 1 : Number of active boats (including informal ones)

	Canoes	Creole canoes	Improved Creole canoes	Tapouilles	Total
Active in 2006	38	89	54	10	181
Active in 2007	39	66	63	10	178
Active in 2008	53	73	69	10	205

2.1.1.2. Fishing gears

Various fishing gears are used: nets, drift nets, trammel, longlines, Chinese barrier, fishing rod, angling. Drifting nets are used in 80% of cases, all types of ships combined. The fixed net is used at 18%. Although the use of the net is fairly common, fishing strategies are not necessarily identical. Indeed, different mesh sizes of nets are used (30 mm to 110 mm). They vary depending on the species and size of target species.

2.1.1.3. Species

The coupa weakfish or acoupa rouge (*Cynoscion acoupa*). The maximum reported observed size is 110 cm and the maximum weight is 17 kg. It forms schools and is common on depth of less than 20 m on muddy or sand-muddy grounds, close to river mouths. Its diet consists of shrimp and fish.

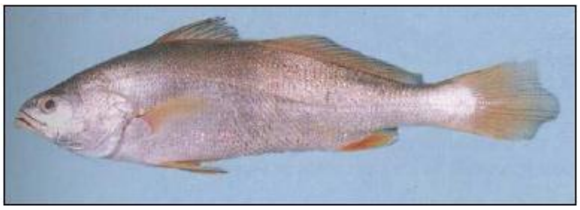


Figure 6 : Acoupa weakfish (*Cynoscion acoupa*), Ifremer picture.

The smalltooth weakfish or acoupa blanc (*Cynoscion steindachneri*). Its maximum size reported in the literature is 110 cm. He lives in the littoral zone at depth of less than 10 m. It enters estuaries. Its diet consists of shrimp and fish.

Figure 7 : Smalltooth weakfish (*Cynoscion steindachneri*), Ifremer picture

The green weakfish or acoupa aiguille (*Cynoscion virescens*). Its maximum size is 95 cm and maximum weight is 3.8 kg. It forms schools and lives above muddy and sand-muddy bottoms, from the coastline up to 50 m deep. Its diet consists of shrimp and fish.

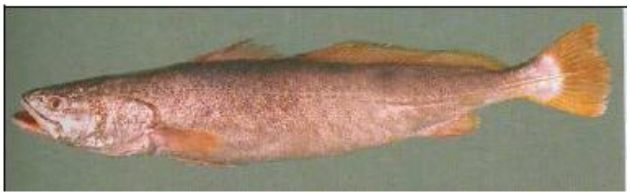


Figure 8 : Green weakfish (*Cynoscion virescens*), Ifremer picture

The south American silver croaker or acoupa rivière (*Plagioscion squamosissimus*). Its maximum size is 74 cm and maximum weight is 4.5 kg. It lives in estuaries and rivers. Its diet consists of shrimp and fish.

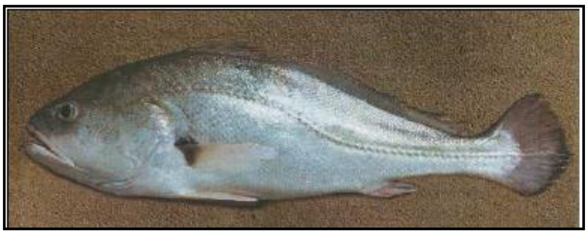


Figure 9 : South American silver croaker (*Plagioscion squamosissimus*), Ifremer picture

The Tripletail or croupia grande mer (*Lobotes surinamensis*). Its maximum size is 100 cm and maximum weight is 19 kg. It is a more marine fish and comes sometimes near the coast, up to estuaries. It is carnivorous.

Figure 10 : tripletail (*Lobotes surinamensis*), Ifremer picture

The Torroto grunt or croupia roche (*Genyatremus luteus*). Its maximum size is 37 cm and maximum weight is 0.8 kg. It lives on muddy or sand-muddy grounds of estuaries and near the coast. Its diet consists mainly of shrimps.

Figure 11: Torroto grunt (*Genyatremus luteus*), Ifremer picture

The Fat snook or loubine rivière (*Centropomus parallelus*). Its maximum size is 64 cm and maximum weight is 5 kg. It lives on muddy or sandy grounds in or near estuaries. Its diet consists of shrimp and fish.

Figure 12 : Fat snook (*Centropomus parallelus*), Ifremer picture

The Commin snook or loubine noire (*Centropomus undecimalus*). Its maximum size is 125 cm and maximum weight is 24.5 kg. It lives in the littoral waters on muddy and sandy grounds. Its diet consists of shrimp and fish.

Figure 13 : Common snook (*Centropomus undecimalus*), Ifremer picture

The Gillbaker sea catfish or machoiran jaune (*Arius parkeri*). Its maximum size is 190 cm and maximum weight is 40 kg. It lives on grounds from 0 to 20 m deep. Its diet consists of shrimp and fish.

Figure 14 : Gillbaker sea catfish (*Arius parkeri*), Ifremer picture

The Crucifix sea catfish or machoiran blanc (*Hexanematichthys proops*). Its maximum size is 100 cm and maximum weight is 9 kg. It lives on muddy grounds up to 20 m deep. Its diet consists of shrimp, fish and worms.

Figure 15 : Crucifix sea catfish (*Hexanematichthys proops*), Ifremer picture

The Bressou sea catfish or petite gueule (*Aspistor quadriscutis*). Its maximum size is 45 cm and maximum weight is 1 kg. It lives in turbid waters on muddy grounds. Its diet consists of shrimp, fish and worms.

Figure 16 : Bressou sea catfish (*Aspistor quadriscutis*), Ifremer picture

The Scalloped hammerhead shark (*Sphyrna lewini*). Its maximum size is 420 cm. It is a pelagic fish that can live in coastal waters but stays offshore when growing older.

Figure 17 : Scalloped hammerhead shark (*Sphyrna lewini*), Ifremer picture

The Blacktip shark or requin pointe noire (*Carcharhinus limbatus*). Its maximum size is 275 cm and maximum weight is 123 kg. It is a coastal shark that can live up to 60 m deep. It is a predator.

Figure 18. Blacktip shark (*Carcharhinus limbatus*), Ifremer picture

The Smalleye smooth-hound shark or émissole ti-yeux (*Mustelus higmani*). Its maximum size is 70 cm and maximum weight is 3.8 kg. It lives from 20 m deep up to à 100 m.

Figure 19. Smalleye smooth-hound shark (*Mustelus higmani*), Ifremer picture

The giant grouper or mérou géant (*Epinephelus itajara*). Its maximum size is 260 cm and maximum weight is 455 kg. It lives on rocky grounds on the coast. It is an opportunist feeder, but large adults eat mainly fish.

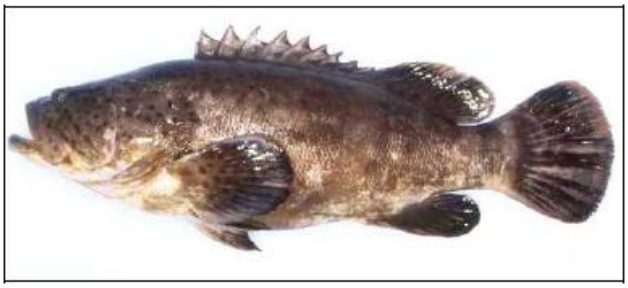


Figure 20. Giant grouper (*Epinephelus itajara*), Ifremer picture

The white mullet or mulet blanc (*Mugil curema*). Its maximum size is 45 cm. It eats fish.

Figure 21. White mullet (*Mugil curema*), Ifremer picture

The Flathead grey mullet or mulet cabot (*Mugil cephalus*). Its maximum size is 120 cm and maximum weight is 8 kg. It lives in and near estuaries. Its diet consists of plankton and vegetal detritus, small crustaceans and worms.

Figure 22. Flathead grey mullet (*Mugil cephalus*), Ifremer picture

The Parassi mullet or parassi (*Mugil incilis*). Its maximum size is 45 cm. It lives in estuaries and near beaches. Its diet consists of vegetal detritus and plankton.

Figure 23. Parassi mullet (*Mugil incilis*), Ifreemr picture

2.1.1.4. Fishing effort and production

Effort and production data obtained are tabulated for the years 2008, 2009 and 2010. Production shifts from 2 400 tons in 2008 up to 2800 tons in 2009 and 2010 and the estimated effort, from approximately 14 000 days at sea up to 15 000 in 2009 and 16 000 days at sea in 2010.

The effort and production are spread over the entire coastline but with their main areas of production, Cayenne / Remire-Montjoly and Sinnamary (figure 24).

The red weakfish (*Cynoscion acoupa*) which represents approximately 40% of the landings, is the species most exploited. Other species are weakfish, sea catfish, snooks, sharks, groupers, rays (figure 25) ... On average half of the landings (47%) is provided by improved Creole canoes. The tapouilles, Creole canoes and canoes each perform about 23% of the landings. Cayenne is the main center of landing with about 40% of the landings. Sinnamary and Rémire-Montjoly, follow with 25.5% and 15.5% on average over the three years.

Table 2. Production (in tons) of the coastal small-scale fishery in 2010, Ifremer SIH.

Number of landings sampled	4070	
Estimated production (in tons)	2831	
Weakfishes	1802	64%
Sea Catfishes	456	16%
Tripletail, grunts	102	4%
Sharks	102	4%
Snooks	96	3%
Palikas	53	2%
Others	70	2%
Mullets	35	1%
Groupers	33	1%
Rays	26	1%
Sardines	25	1%
Scombrids	20	1%
Carangids	10	0%

It should be noted that until 2009, the entire production of Saint-Laurent-du-Maroni, of Awala-Yalimapo and Saint-Georges is the result of an informal activity. The lack of availability of authorization to exploit (PME) up to 2010 failed regularization of these vessels. Additional quota of PME are now available, and these fleets are partly being regularized.

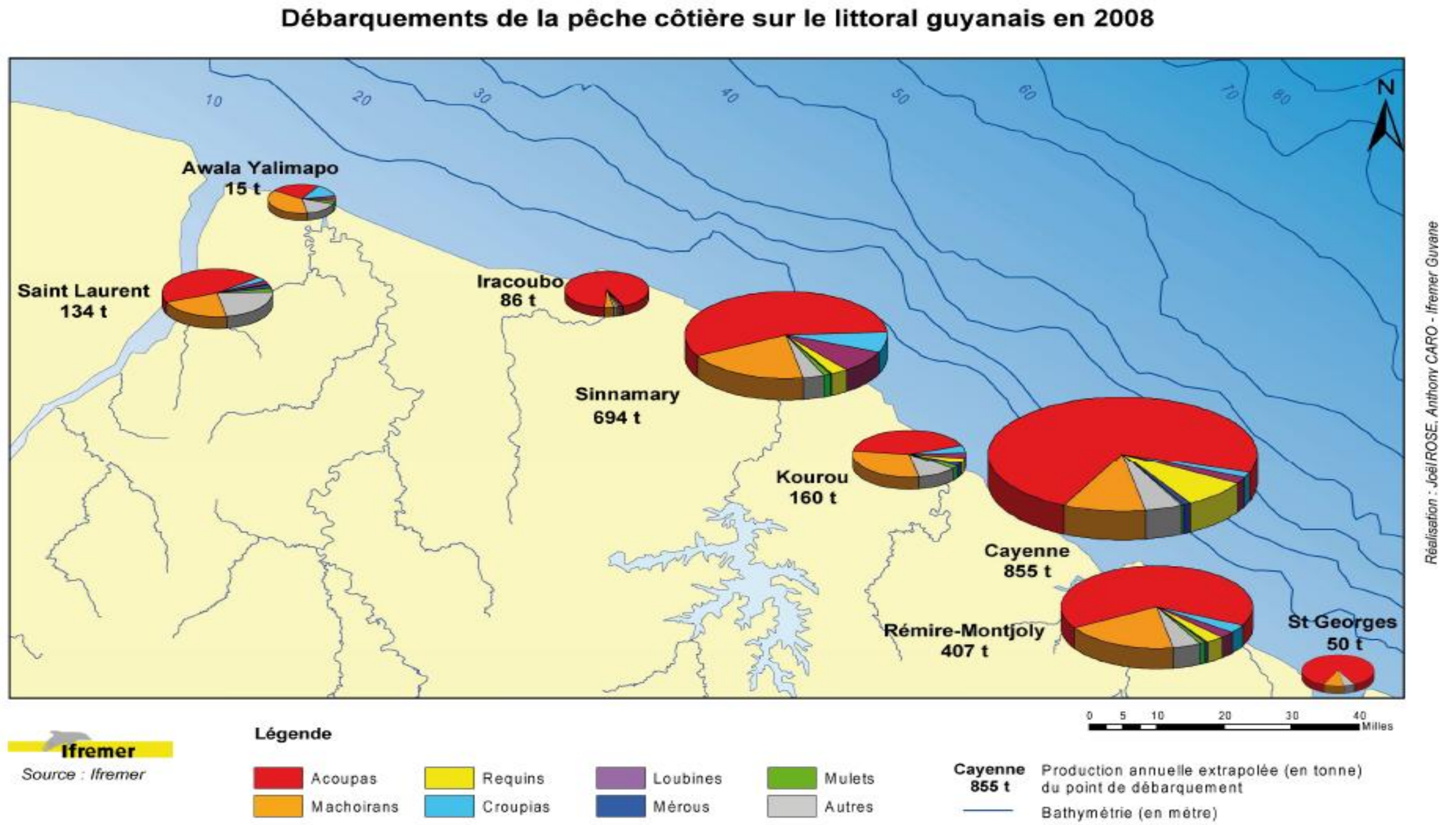


Figure 24. Spatial distribution of the landings of the small-scale fisheries in 2008. For Awala And St-Georges, the estimation was done only for one semester, Ifremer Guyane.

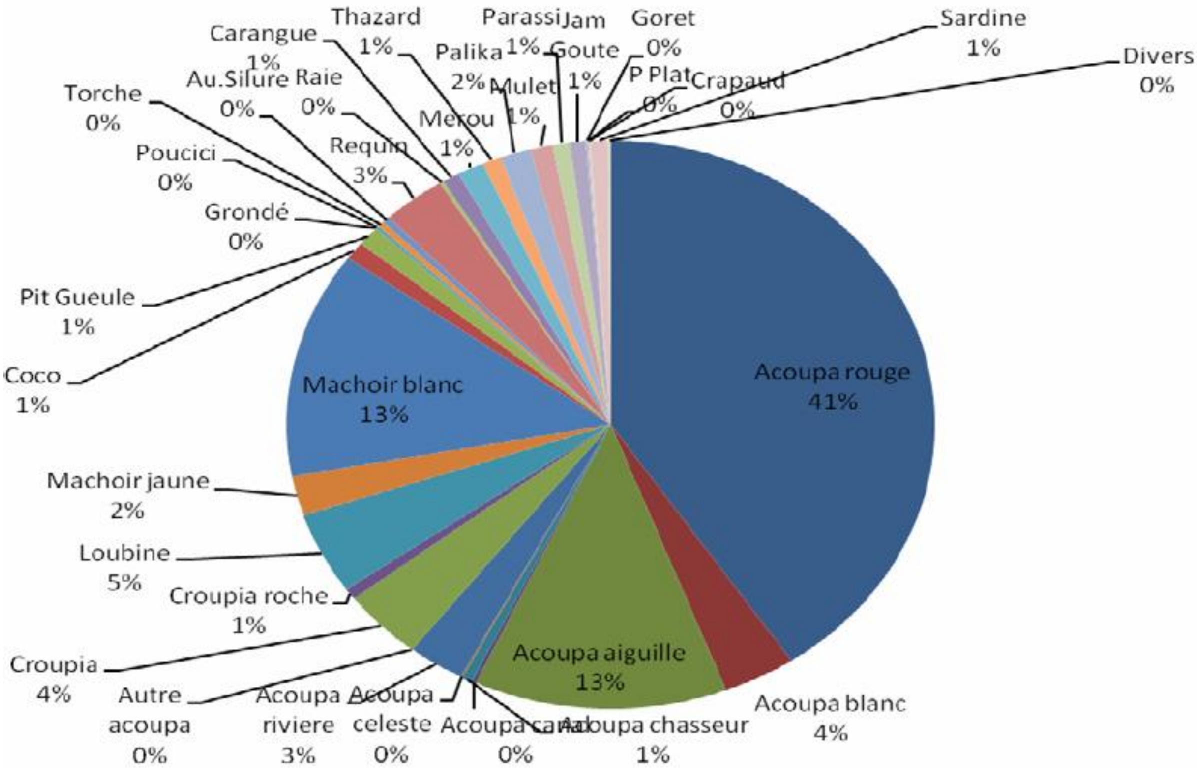


Figure 25. Average composition of the landings between 2006 and 2008 (Gourguet, 2009).

2.1.2. Handlines and pots for red snapper

2.1.2.1. Vessels and fishing gears

The venezuelian handline fleet has fishing licenses granted individually by Europe (45 licenses) under the double condition that 75% of catches are landed in French Guyana and the owner or skipper-owner has established a contract with societies of sea products transforming identified by Europe in Guyana. Production is partly landed at Cayenne, where it will then be exported to the West Indies in frozen form and partly in Venezuela. Units constituting the fleet are traditional for the majority of wood, with a length of 13 to 25 m, coming from the ports of the island of Margarita in Venezuela. The power of these boats varies mostly between 200 and 400 hp and 11 to 17 sailors are generally shipped on board. Fishing is done in small groups of 4 to 5 boats. Once spotted rocky bottoms (45 to 100m deep), the boat is drifting in the current. 8-12 lines are placed in the water, each carrying a nylon bottom line fitted from 4 to 7 hooks ranging in size from No. 6 to No. 8. Fishing operation are done during day hours

Figure 26. Venezuelian handline vessel (on the left) ; handline fishing (on the right), Ifremer pictures

The fleet based in the French Antilles (mainly Martinique but also Guadeloupe) using pots have free access to the resource of the French Guyana EEZ which is attached to the European EEZ, this resource under European jurisdiction which are not subject to control access to resources for countries of Europe. The vessels forming the fleet are usually of aluminum or resin for a length ranging from 16 to 21 m, power ranging from 300 to 500 hp and shipping between 6 and 8 fishermen. Traps used are shaped arrowhead, 1.5 m wide, 1 m deep and 0.5 m high. The opening of the spout is 30 cm by 10 cm. The iron grating or plastic, is composed of hexagonal mesh whose size can vary from 25 to 50 mm side (campaigns conducted on two fishing boats from Martinique in 2005 and 2007). The number of traps used may vary depending on the available space on the ship from 60 to over 150. The bait used is the same as this used for line (sardines or small snappers). Pots are put on the ground in the early morning hours, between 6 and 8 hours, then they are picked up in the afternoon to be returned on the water between 17h and 18h30 for the night.

Figure 27. Pot vessel for red snaper (on the left) and pots (on the right), Ifremer pictures

2.1.2.2. fishing effort and production

Fishing effort expressed as a number of days fishing in the EEZ of French Guyana is the only data provided for both fleet segments (handline fleet and pot/trap fleet) in the logbooks. It is around 3800 days fishing. The activity of the Martinique pot fleet fishing in the EEZ of French Guiana is variable depending on the year with 1 to 6 vessels operating for 250 fishing days in total.

The handline fleet for red snapper catches *Lutjanus purpureus* at 90%, while the pot fleet catches about 70% of *lutjanus purpureus* and more than 25% of the snapper *Rhomboplites aurorubens*. The production landed in French Guyana fluctuates between 800 and 1600 tons, about 90% done by the handline fleet (figure 28).

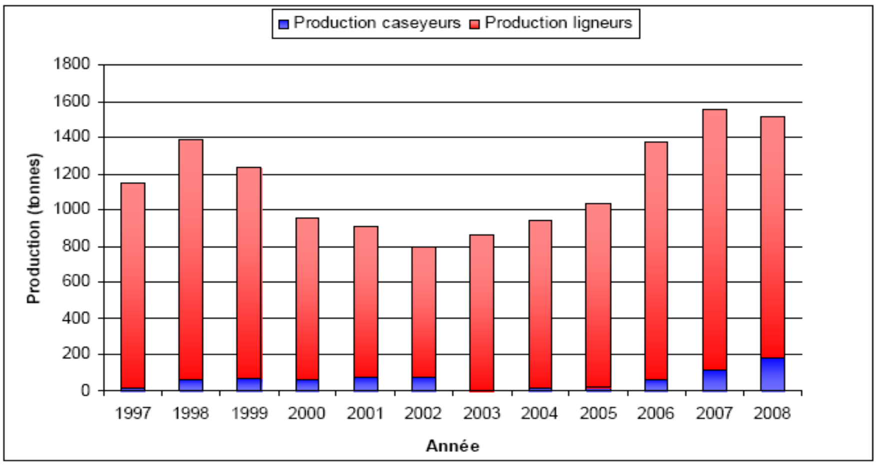


Figure 28. Landings of red snappers by the handline fleet (red) and the Martinique pot fleet from 1997 to 2008 in French Guyana, in tons (Caro et al., 2009).

2.1.3. Shrimp trawling

2.1.3.1. Vessels, fishing gears and species

The shrimp trawler fleet is composed of vessels of 23 meters on average (about 100 GRT) and engine power of the order of 400-500 hp (294-368 kW). They are all equipped with freezer units with a capacity of 6 to 10 tons. VMS9 system is mandatory on February 1, 2004 and allows automatic monitoring of the position of each fishing vessels.

The only fishing technique used is bottom trawling of Florida type. An outrigger rigged on each side of the vessel, each towing a trawl, and working simultaneously. The mesh in the codend is 45 mm. An Turtle Excluding Device (TED) is used since 2010.

Figure 29. Shrimp trawler, Ifremer picture.

The catch consists mainly of two species, *Farfantepenaeus subtilis* and *Farfantepenaeus brasiliensis*. The first is the main targeted species. It represents more than 85% of shrimp landings in Cayenne. The species *F. brasiliensis*, is fished more offshore and at the eastern boundary of their spatial distribution.

2.1.3.2. Fishing effort et production

The French fleet progressively took over USA and Japan and reached 60 to 70 boats between 1990 and 2005. The low catches and economic difficulties (see 2.3.2) in the recent years pushed the owners to stop their activity or reducing the number of fishing boats. Sharp increases in fuel prices are also causing shift from offshore fishing to areas closer to 30m deep, below which shrimp trawling is prohibited by the regional representative of the French

State (Préfet). This decrease in the average number of shrimp boats in the area, results in a decrease of their effort in days at sea and landings (figure 30). The number of active vessels is now less than 15.

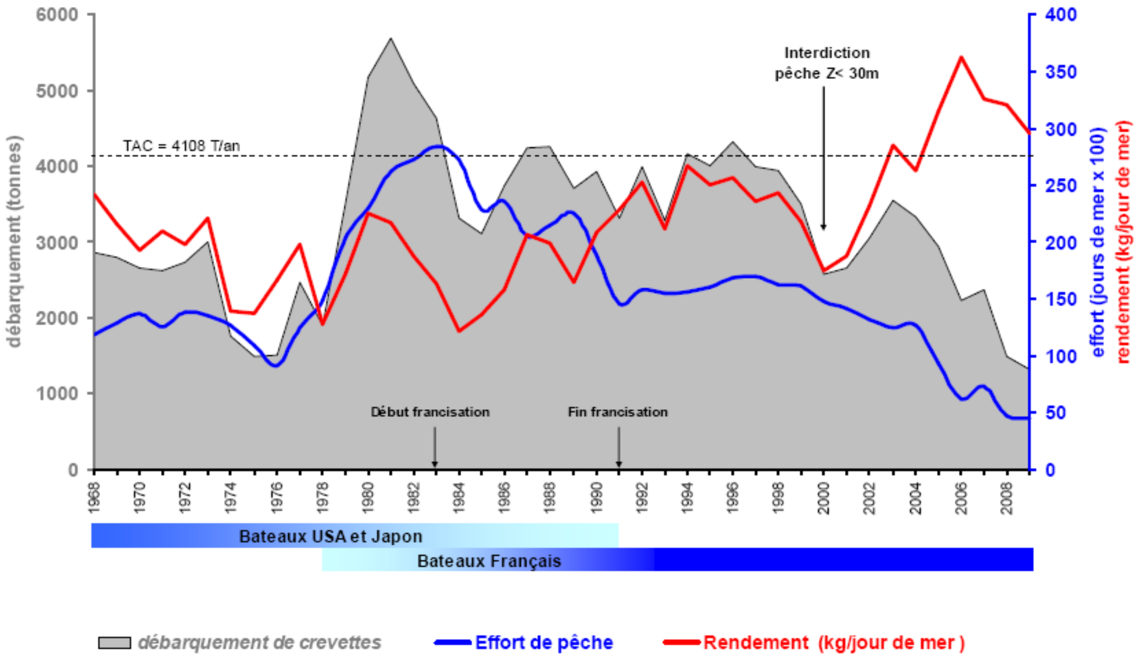


Figure 30. Temporal variations of the landings in tons (in grey), the fishing effort in days at sea*100 (blue line) and CPUE in kg per day (red line) from 1968 to 2009 (Lampert 2011).

2.2. STOCKS

2.2.1. Red snappers

Since 1985, Ifremer has developed a system of monitoring of landings of red snapper fishery practiced by the Venezuelan handline fleet. The purpose of this monitoring is to estimate the landed weight each month, from which the weight caught and catch per size class are deduced. These data are required for stock assessment..

If the Venezuelan handline fleet has been monitored for a long time, the Martinique and Guadeloupe pot fleet remained until recent years less well known. Production data of ships from Martinique and Guadeloupe was collected since 1997, and have been completed since 2007 by a generalization of sampling landings within the framework of the implementation of the Information System Fishery. However, some questions remain about the representativeness of the data collected by sampling (including the breakdown of catches by commercial category). For this is the reason, the stock assessment considered considered only data from handline fishing.

The size compositions of Venezuelan production of red snapper have been sampled since 1986. Growth parameters and the value of natural mortality are those determined by Rivot (2000). A new study of these parameters was carried out more recently in the project DuHal (Vendeville et al., 2008) and found very similar results to those of 2000. However, the method used by Rivot seems more robust thanks to the correction of catch data by the selectivity factor. This is why these are the parameters that have been selected for this present evaluation.

The method used in the stock assessment of red snapper is the Virtual Population Analysis (VPA). The software used for the calculations is the software FiSAT II (FAO - ICLARM Stock Assessment Tool) published by FAO in 2005. The method used is that of the virtual population analysis based on the ages described in the FAO Manual (Sparre and Venema, 1996).

Annual catch data by size class are grouped into age using growth parameters. Redistribution of catches is made at the terminals of the age class. This transformation assumes that the individual variability of growth is negligible. In the case of red snapper whose longevity is more than ten years, this requirement only applies for the first three age classes but not beyond according Pérodou (1994). He recommends using this method in the absence of other more relevant procedures. Previously, an analysis based on cohort sizes (LCA) was launched on an average size compositions from 1986 to 2008, to estimate fishing mortality by size class and determine the best F terminal parameter necessary to analysis of cohort ages.

A preliminary study comparing the results of the methods based on the sizes and ages was conducted during this evaluation. It suggests that the trends obtained are similar whatever the method used. In addition, the method using VPA-catch data by age and the results of this has been confirmed by Mr. André Forest and Mr. Alain Biseau, responsible for the coordination unit of fishing expertise Ifremer, during their mission in Guyana in April 2009.

The results of the VPA based on ages show that the red snapper recruitment in recent years seems to remain at a high level (the last 2 years subject to some reservations due to the low number of data used in the analysis) with a value of around 6 million recruits at age 1. Total biomass increased steadily since 2003 and reached in 2010 the value that was observed in the 90s, before the collapse of the stock. Spawning biomass also increases, but less rapidly than the total biomass. Average fishing mortality F on ages 2-5, is maintained at a much higher level compared to the average F on ages 6 to 11.

In the early 2000s, the stock had been declared in over-exploitation by the relevant Working group of the Committee on Fisheries of the west-central Atlantic (FAO). After 2002, recruitment and spawning biomass re-grow. In 2010, the total biomass is at the same level as that observed before the fall of the stock but with a different age composition: recruitment is higher but the spawning biomass is less. The stock appears to be restorating.

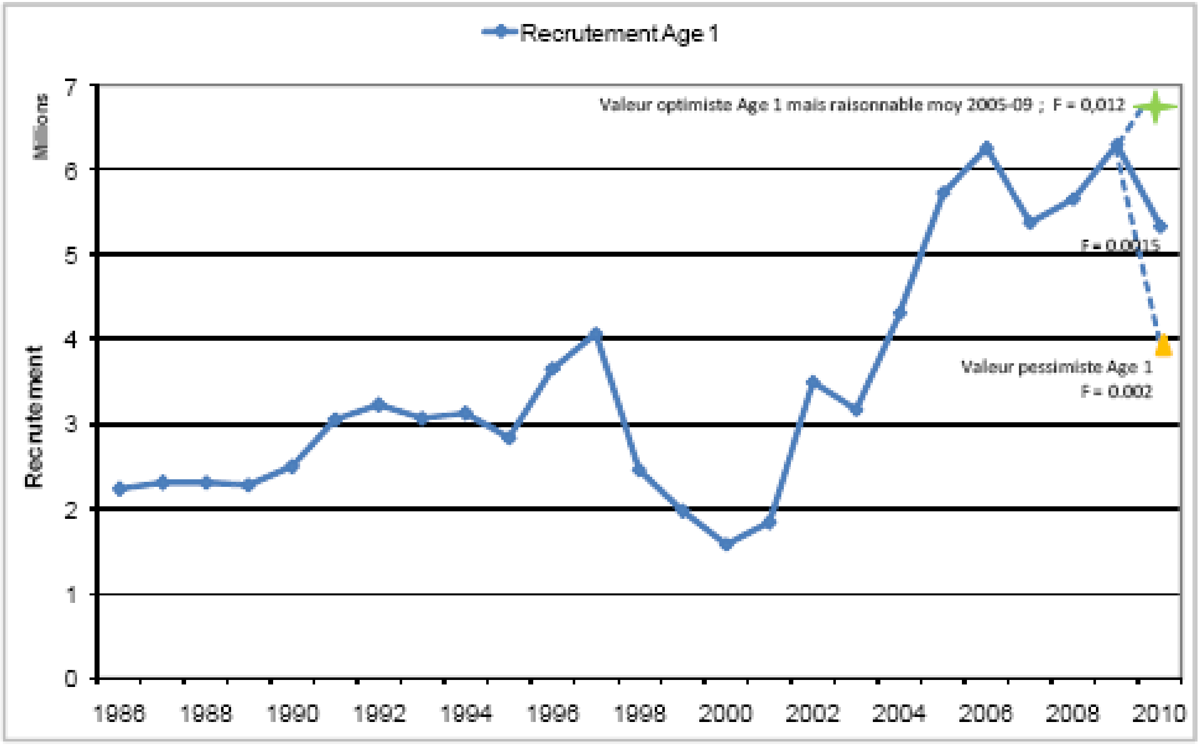


Figure 31. Temporal variation of the recruitment of *Lutjanus purpureus* in millions of individuals (VPA outputs) from 1986 to 2010 (Lampert 2011).

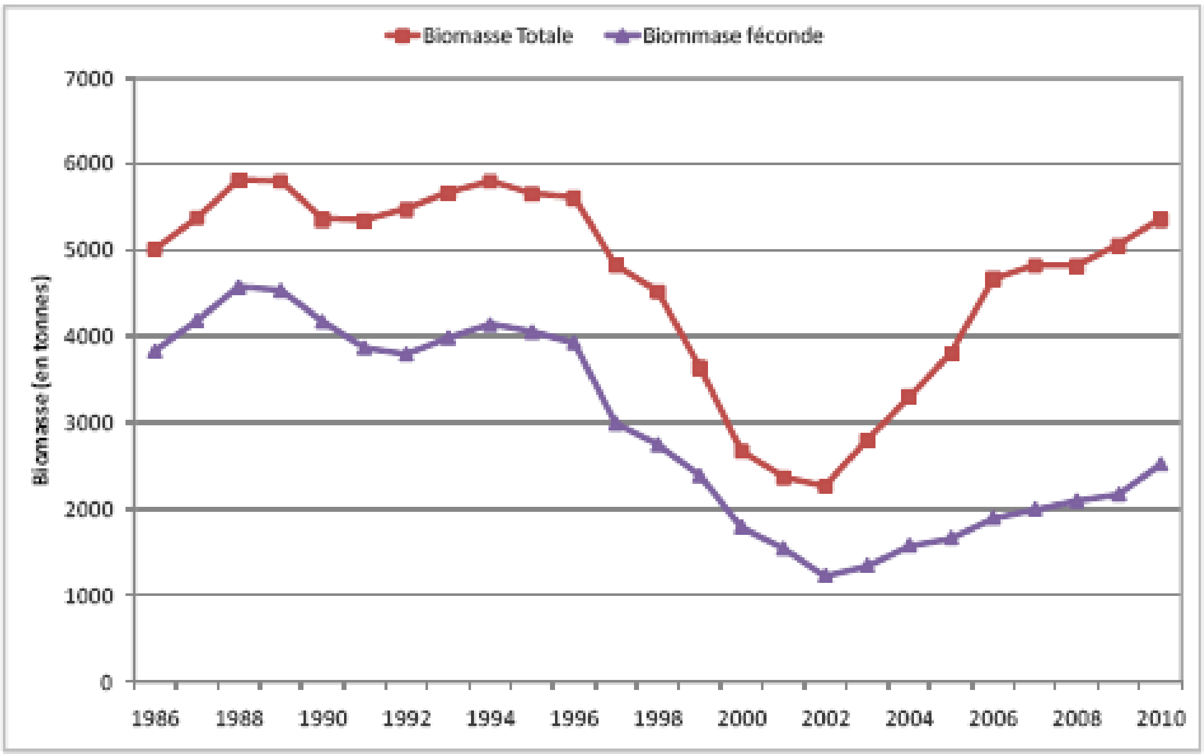


Figure 32. Temporal variation of the spawning stock biomass in tons (in blue) and of the total biomass (in red) of *Lutjanus purpureus* (VPA outputs) from 1986 to 2010 (Lampert 2011).

2.2.2. Shrimps

A new estimate of the shrimp stock of *Farfantepenaeus subtilis*, was conducted in early February 2012 by Ifremer using an, analytical model (VPA on a monthly time step). The general conclusions are identical to the previous yeraly assesments: stock biomass remains at the lowest level of the series, and it is the same for the recruitment that continues to decline since the mid-2000s (figures 33 and 34).

Examination of the results of this analysis did not show a change in fishing mortality may explain the collapse of the stock: monthly fluctuations in mortality that are very important but the trend is downward in recent years (figure 35). Since 1999, the monthly variations in recruitment are lower than in the past and the high values are no longer observed. Since 2006, a sharp recruitment decline is estimated. Moreover, the collapse of recruitment does not seem caused by a decline in spawner abundance (figure 36), although, obviously, in recent years, the low spawner abundance produce small amounts of recruitment. In contrast, the spawning biomass is directly related to the recruitment (figure 37). It thus appears that the fishing is not the main cause of the collapse of the stock biomass and recruitment.

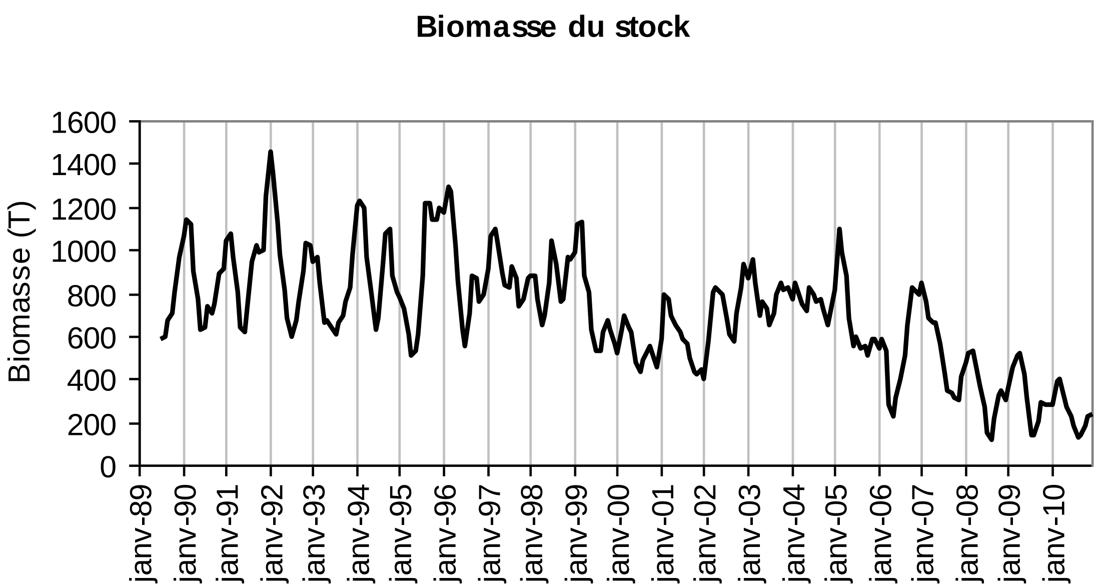


Figure 33. Temporal variations of the total biomass of the stock in tons of *Farfantepenaeus subtilis* (VPA outputs) from 1989 to 2010 (Lampert 2011).

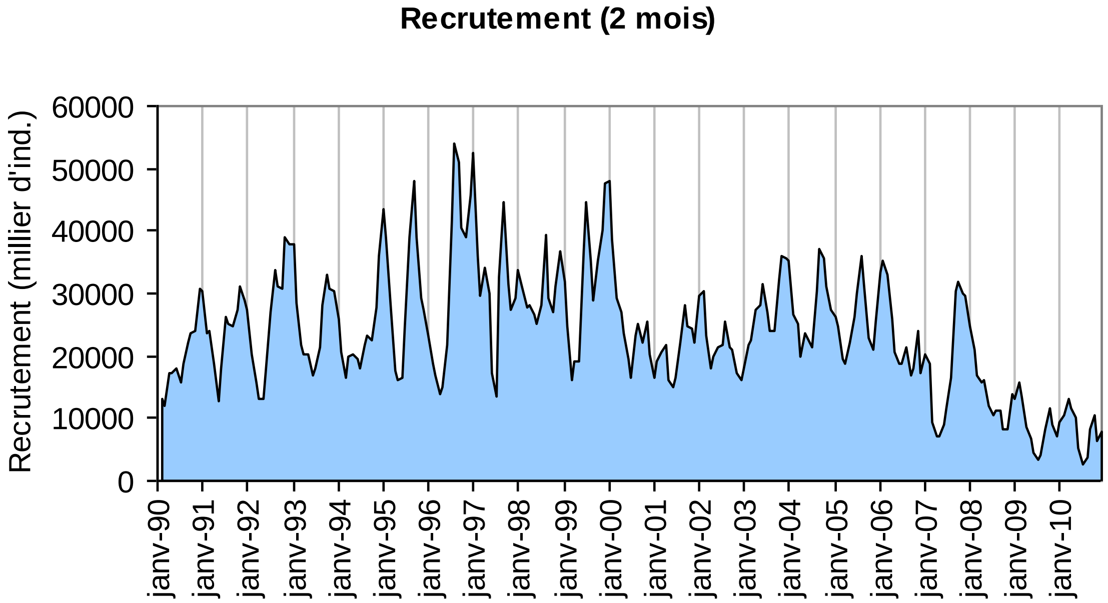


Figure 34. Temporal variations of the recruitment in thousands of individuals of *Farfantepenaeus subtilis* (VPA outputs) from 1990 to 2010 (Lampert, 2011).

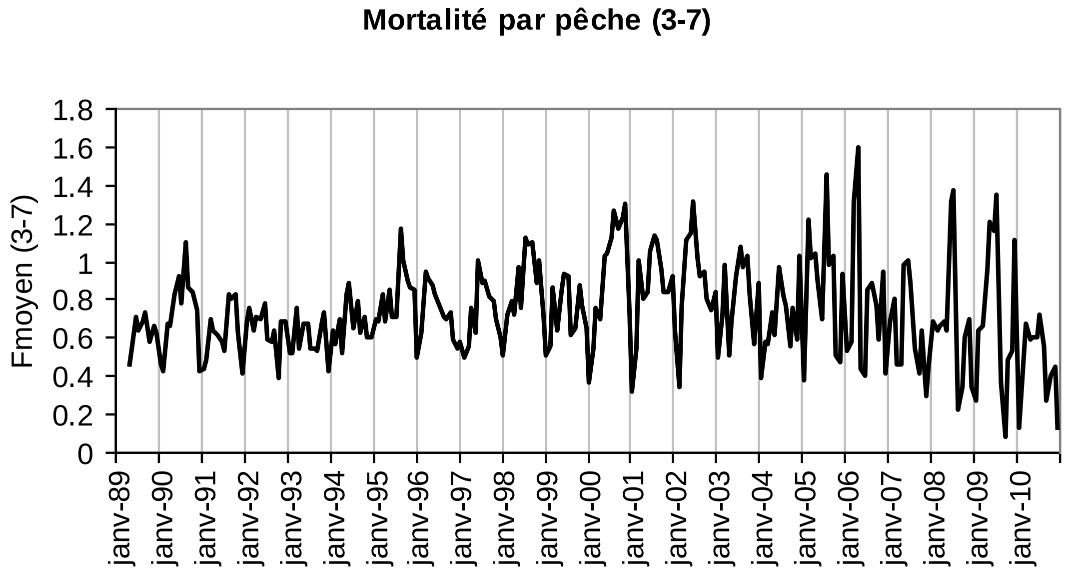


Figure 35. Temporal variations of the fishing mortality F of *Farfantepenaeus subtilis* (VPA outputs) from 1989 to 2010 (Lampert, 2011).

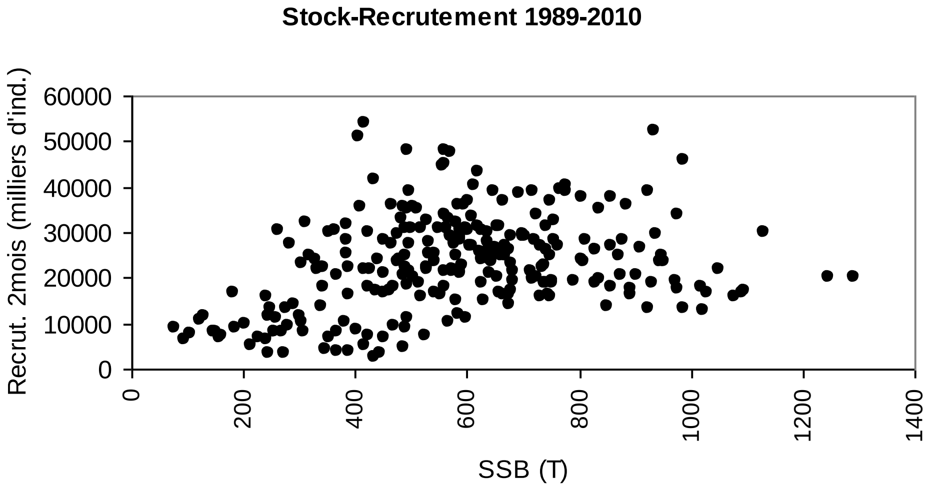


Figure 36. Recruitment (thousands of individuals) *vs.* spawning stock biomass in tons (Lampert, 2011) .

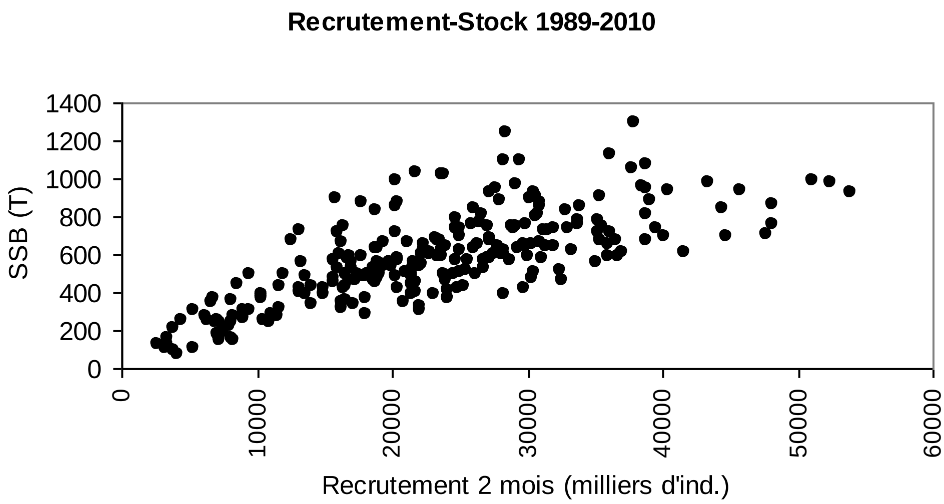


Figure 37. Spawning stock biomass (in tons) *vs.* recruitment, in thousands of individuals (Lampert, 2011).

Explanations of the collapse of recruitment remain uncertain. The assumption of hydro-climatic changes, mentioned in the past, seems to be robust, but possible processes explaining causal relationships remain to understand and demonstrate. Furthermore, a new hypothesis is to study: mortality of young snappers related to bycatch of shrimp trawlers decrease due to lower activity. Shrimp enter into the composition of the diet of the red snapper juveniles that live and grow on soft bottoms before going off gradually. Thus, predation by shrimp snapper increase significantly.

Recommendations

It should be noted that if the fishing does not seem to be the main cause of the collapse of the stock, it should ensure that it does not exacerbate a fragile situation. If the conditions again become favorable, maintaining a minimum of shrimp is essential. In this regard, the maintenance of moderate fishing effort and/or catches is probably the most relevant measure. It should also ensure that preservation of juveniles in coastal waters (below 30 m) thanks to the fishing ban is effective.

In recent years, the number of licenses does not appear to be a factor of control of fishing since the number of shrimp trawler in activity is much lower than the licenses granted. The TAC, has also rarely been achieved (figures 30, 39). It has been shown that the conditions of profitability vessels contribute to the self-regulation of the fishery today given the low yields.

In conclusion, and in the case of a stock situation in 2012 comparable to recent years, it is likely that the fishery regulates itself regardless of the number of licenses granted. To give the stock a chance to improve if conditions again become favorable, it may be desirable to consider a revision of the TAC, and consequences of the licenses to ensure that the catches remain moderate to ensure a sustainable renewal of the stock.

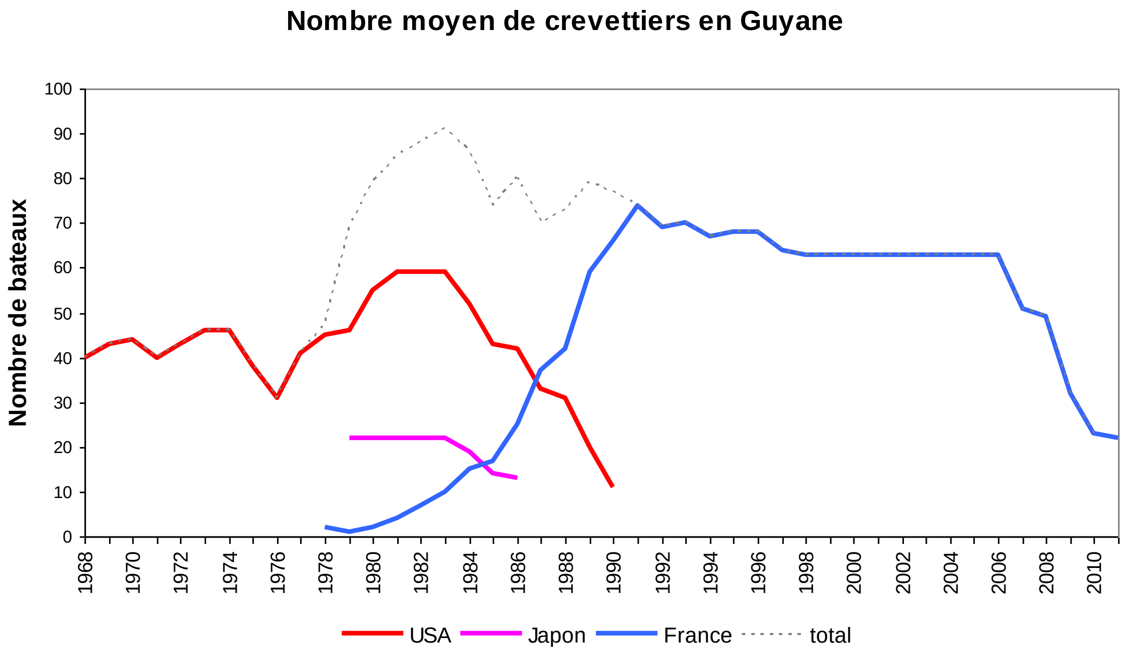


Figure 38. Temporal variations of the number of shrimp trawlers in French Guyana by nationality from 1986 to 2010 (Lampert, 2011).

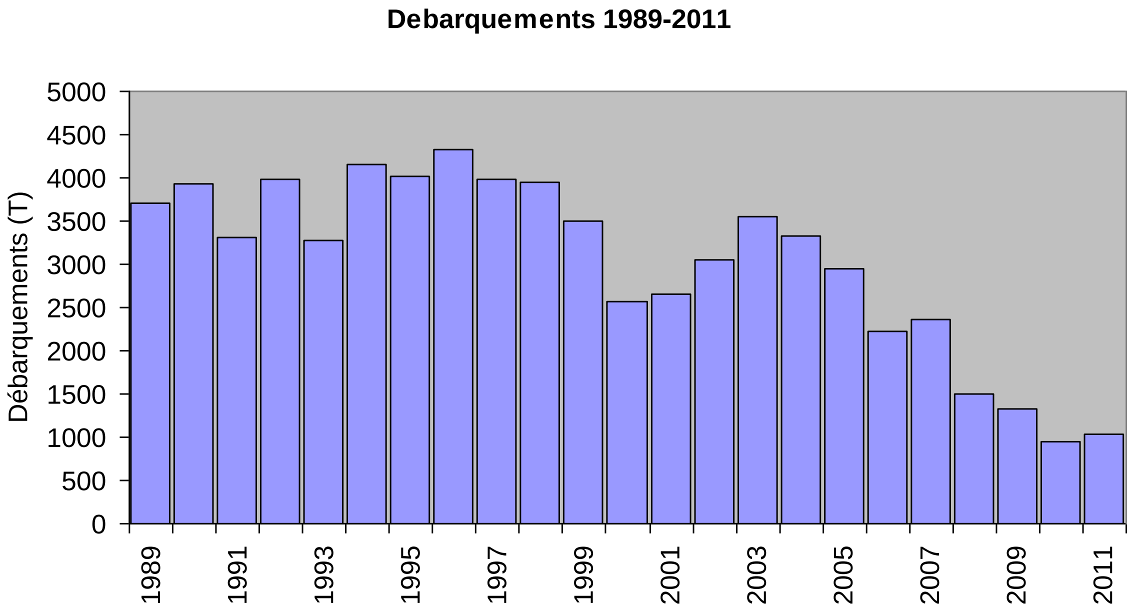


Figure 39. Temporal variations of the shrimp landings in French Guyana from 1999 to 2011 (Lampert, 2011).

2.3. ECONOMIC AND SOCIAL PERFORMANCES

2.3.1. Coastal small-scale fisheries

This work is based on a survey carried out in 2009 about the economic situation of this fishery in 2008, with vessels owners. In total, 49 of 177 active vessels were surveyed either a sampling rate of 27.7%. Vessels surveyed are based on Cayenne and Rémire-Montjoly (27 vessels), Kourou (8), Sinnamary (5) and St. Laurent (9).

Data on Saint Laurent have not been fully used in this work. Costs incurred by vessels based in St. Laurent are very different from those based on other municipalities. Because of the distance from Cayenne and lack of infrastructure, some owners actually supply in ice, fuel and fishing gear in Suriname (on the other side of the river).

2.3.1.1. Methods

2.3.1.1.1. Fishing effort and production

Database available at Ifremer can learn the technical characteristics of the most active vessels. The fishing effort in number of days at sea is also available for most vessels. This effort is obtained from the daily record of absences and presences of the vessels. Production data of ships are also available (for more than 50% of the known trips). Ship production was obtained by extrapolating known production by the number of days at sea observed. Only vessels that have more than 50 fishing days in the year was considered here.

2.3.1.1.2. Turnover

Information about the turnovers are crucial. However, such information is sensitive and te French experience in economic surveys showed that in general, fishermen are refractory to communicate about this. Only selling prices by species and marketing channels have been completed. Turnover was calculated from these prices and total production by species obtained by extrapolation.

2.3.1.1.3. Intermediate consumptions

Data on annual expenditures for intermediate consumption (fuel, ice, oil and food) were calculated on the basis of expenditure per trip multiplied by the number of trips made. The number of trips made was estimated from the average duration in days of a trip and number of days at sea observed. The drop in fuel prices that occurred in December 2008 was taken into consideration.

2.3.1.1.4. Payroll

The amounts of expenditure in total annual payroll, were not always provided. For those who were able to pay the amounts, they do not necessarily linked to the activity in 2008. Payroll amounts for 2008 have been calculated using tax rates provided by the Maritime Affairs (now Department of the Sea) and the number of days of enrollment reported by shipowners. The fishermen aboard vessels surveyed are foreign nationals. It was assumed that all shipowners performs a "half-role" as often observed.

2.3.1.2. Results

2.3.1.2.1. Fishing effort and yields

For our sample (34 vessels), the annual average effort is low, 124 fishing days with a coefficient of variation of 38% (Figure f0). This effort is on average the same for all categories except for tapouilles at which it stood at 176 days. The average daily yield is 227 kg / fishing day but with a coefficient of variation of 52% (figure 41). Indeed, tapouilles have a much higher yield to other categories of ships: 431 for the latter against yield values ranging from 156 to 222 kg per fishing day.Pour notre échantillon (34 navires), l’effort moyen annuel est faible, 124 jours de pêche, avec un coefficient de variabilité de 38 % (figure 40).

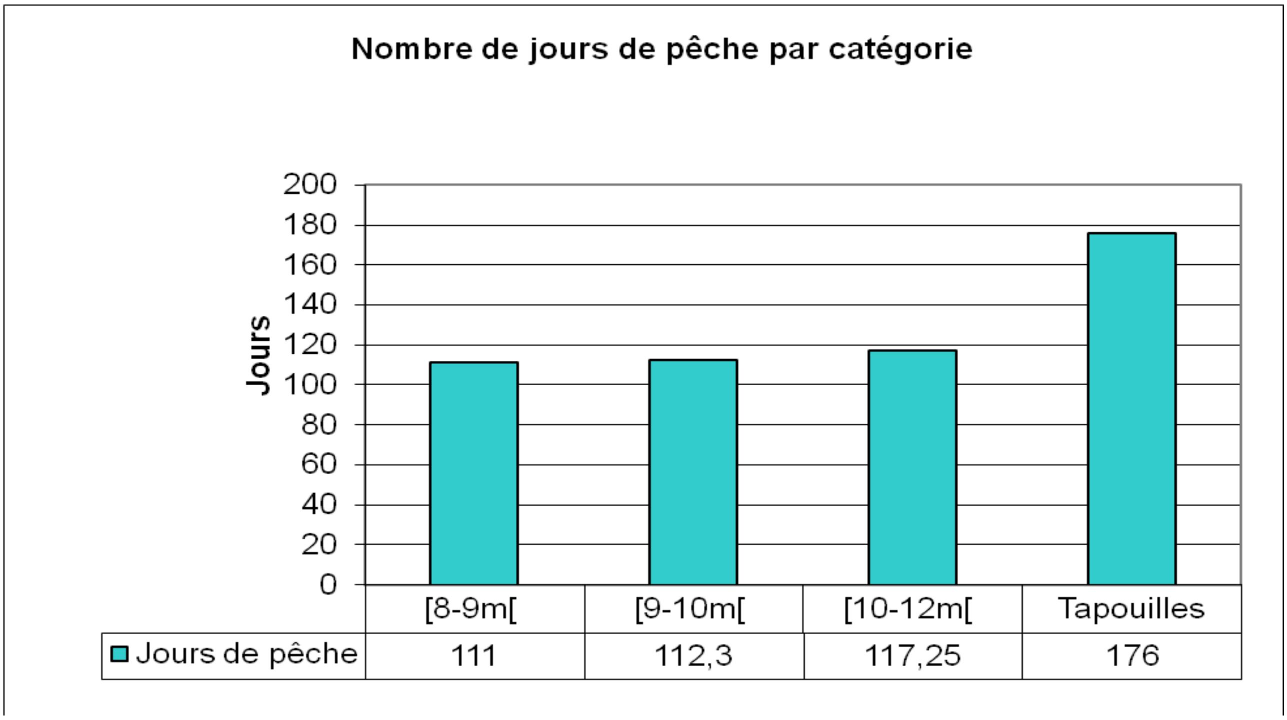


Figure 40. Nombre de jours de pêche des navires par catégorie de longueur (Cissé, 2009).

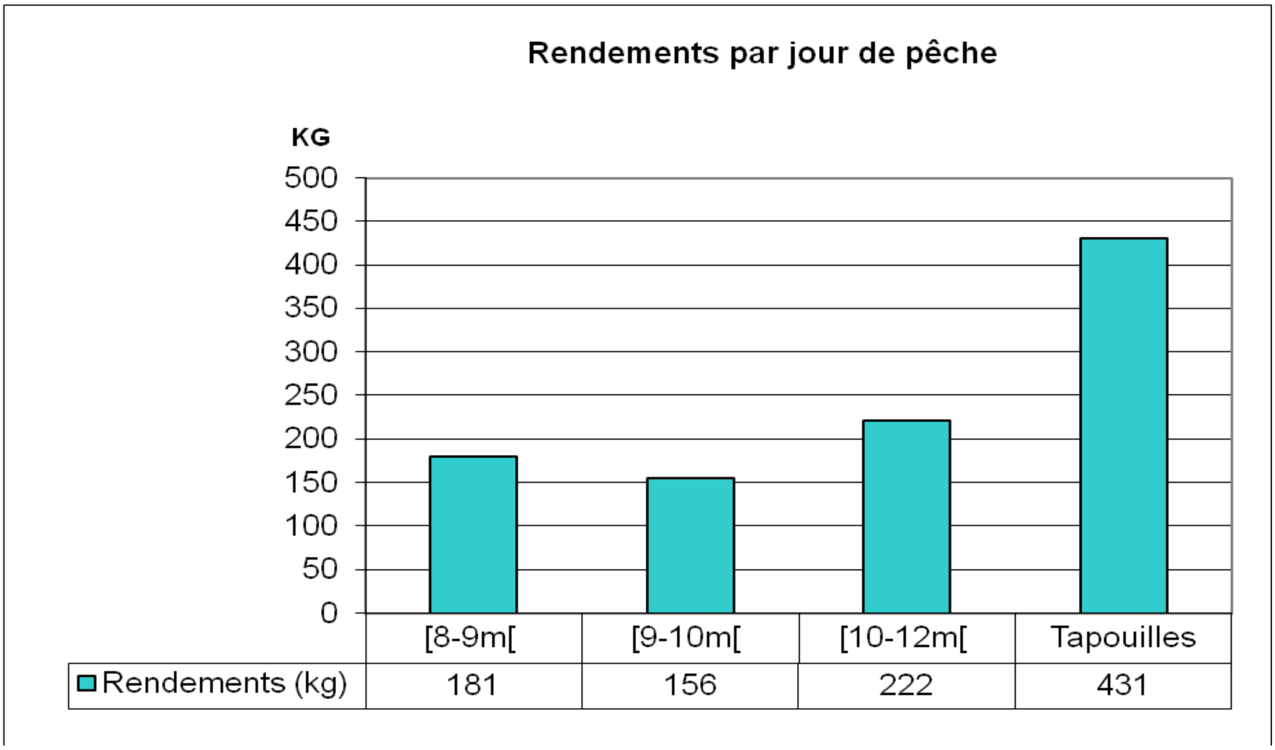


Figure 41. Rendements par jour de pêche (Cissé, 2009).

2.3.1.2.2. Mode of commercial distribution and selling prices

Once landed, the production may follow three channels. It can be either sold directly to consumers (direct selling) or to wholesalers, or to processing factories. Direct sales for 60%

of ships surveyed, selling to wholesalers and millers for respectively 50 and 35%. A Cayenne sales to wholesalers predominates (85%), unlike other towns where direct selling is the most observed.

The selling price per kg varies greatly depending on the mode of distribution. Generally, the price per kg in direct sales is logically higher, representing double the sale to wholesalers or factories. Thus the value of production of each vessel is related to the mode of distribution used. In direct sales, the market is quickly saturated, hence the requirement for owners to use the wholesalers and millers to sell their production.

The highest price in direct sales is 6.86 euros per kilo for “machoiran jaune” (a sea catfish), whose production is mainly carried out after trips in the western waters of French Guyana. The price is low when compared to prices in France or the Caribbean. Under these conditions, it seemed appropriate to analyze the impact of the sale price on the profitability of vessels.

Tableau 3: Mean selling price according to the mode of commercial distribution (Cissé, 2009)

Species	Acoupa Rouge	Acoupa blanc	Acoupa aiguille	Acoupa rivière	Croupia mer	Croupia roche	Loubine
Direct[1]	4,6 €	4,25 €	3,13 €	3,5 €	5 €	5,6 €	4,6 €
Short[2]	2,31 €	2,17 €	1,47 €	1,45 €	1,53 €	3,89 €	2,23 €
Species	**Machoiran Jaune**	**Machoiran blanc**	**Requin**	**Carangue**	**Mérou**	**Tarpon**	**Mulet**
Direct	6,86 €	2,7 €	3,25 €	3,67 €	5,71 €	2,8 €	4,86 €
Short	4 €	1,41 €	1,17 €	1,28 €	3,37 €	1,38 €	2,54 €

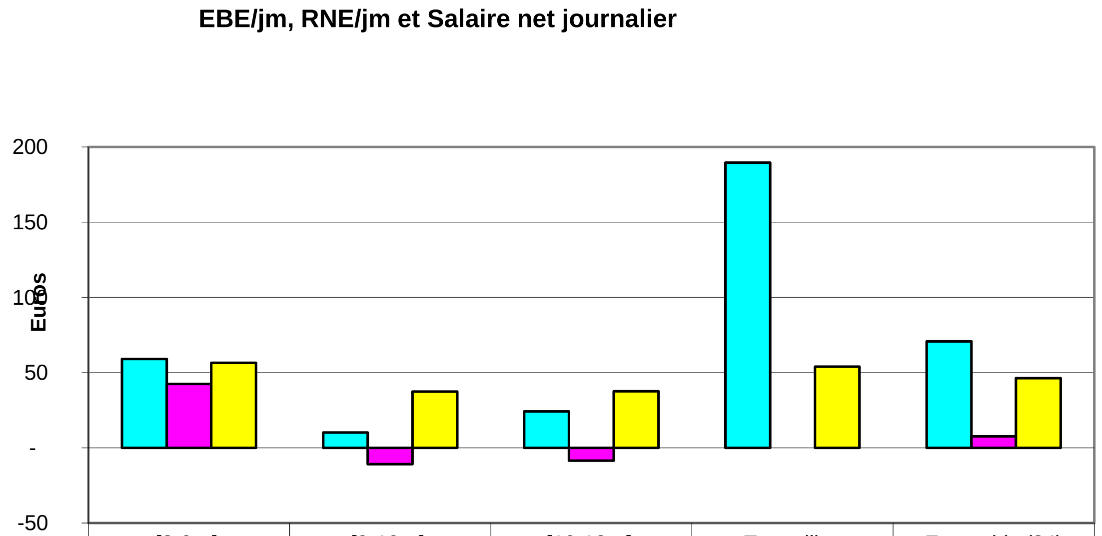
2.3.1.2.3. Gross operating surplus, net operating income and net daily salary

Two intermediate balances were calculated for the entire sample, the gross operating surplus (GOS) and the net operating income (NOI). GOS represents what remains in the company after deducting turnover intermediate consumption and personnel expenses. NOI is GOS minus depreciation. Depreciation is calculated on the straight-line method and lifespan is considered to 10 years for the ship's hull, 5 years for the ice blocks and 3 years for the engines. To make comparisons between classes of ships, we reported these indicators the number of days at sea carried out in the year. NOI average for the category "tapouilles" could not be assessed due to lack of information on the value of invested capital.

Thus, a day at sea, the average GOS stood at 71€, NOI at 8 € and net pay by fisherman to 46 euros (figure 42). A negative daily average NOI was observed for the categories [9-10m[and [10-12m[. However, we note in each category of vessel, a high variability of these indicators.

[1] Direct is direct sale to consumers without intermediaries.
[2] Short involves an intermediary, which may be the fishmonger or processing factories.

Thus, 62% of our sample has a positive GOS, 46% a positive NOI and only 38% are able to offer a daily net income above the minimum wage (SMIC in France). Results for category [8-9m[be explained by the fact that most of the vessels in this category sell their produce directly to consumers and therefore with a higher selling price.



	[8-9m[	[9-10m[	[10-12m[	Tapouilles	Ensemble (34)
EBE/jm	59	10	24	190	71
RNE/jm	42	-11	-9	-	8
Sal_net/jm	56	37	38	54	46

Figure 42. GOS (EBE in French), NOI (RNE in French) and net salary per daya t sea (Cissé, 2009) for each category of vessel and for the total (Ensemble).

2.3.1.2.4. Sensitivity analyses of NOI and net daily salary according to fish selling prices

Fuel costs represent on average a quarter of the costs of intermediate inputs[3]. The sensitivity analysis is made taking into account the untaxed gasoline prices that prevailed before December 2008, 1.17 euros / liter. The prices are average prices considered all species and it is assumed that all vessels comply with the same price.

It is observed that with 2,20 € / kg, the average NOI is positive (figure 43) and the average daily net wage is higher than the minimum french wage (figure 44), for all categories. However, at this price, only 46% of our sample is concerned (figure 45). If we set a goal of 75% of positive NOI, an average price of € 2.70 is necessary and then 74% offers a daily net income exceeds the minimum wage.

[3] Fuel prices in 2008 was considered in this study as 2008 was in fact the reference year of the survey in 2009. The general strikes in November and December 2008 resulted in obtaining a reduction in fuel prices effective at the beginning of 2009. However, it re-increased steadily since and it is reasonable to assume that this global trend due to declining stocks of hydrocarbons will probably not reverse. The fuel price is in 2012 at the same level than that observed before the strike.

The average selling price in our sample is 2.15 € / kg. Achieving an average price of 2.70 € / kg, is equivalent to increasing the overall average prices per species by 25%.

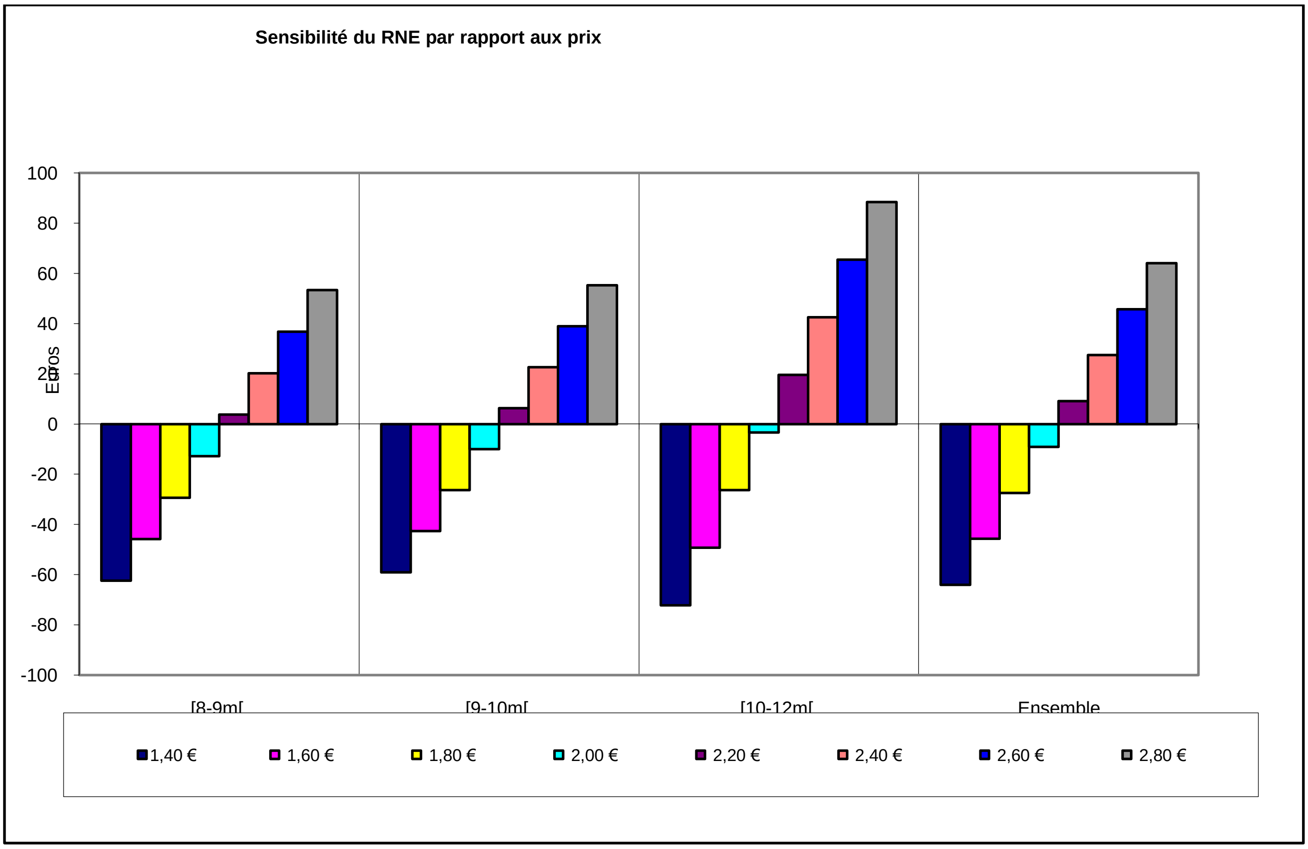


Figure 43. Sensitivity of the mean daily Net Operating Income (RNE in French) according to selling price all species considered (Cissé et al., 2010).

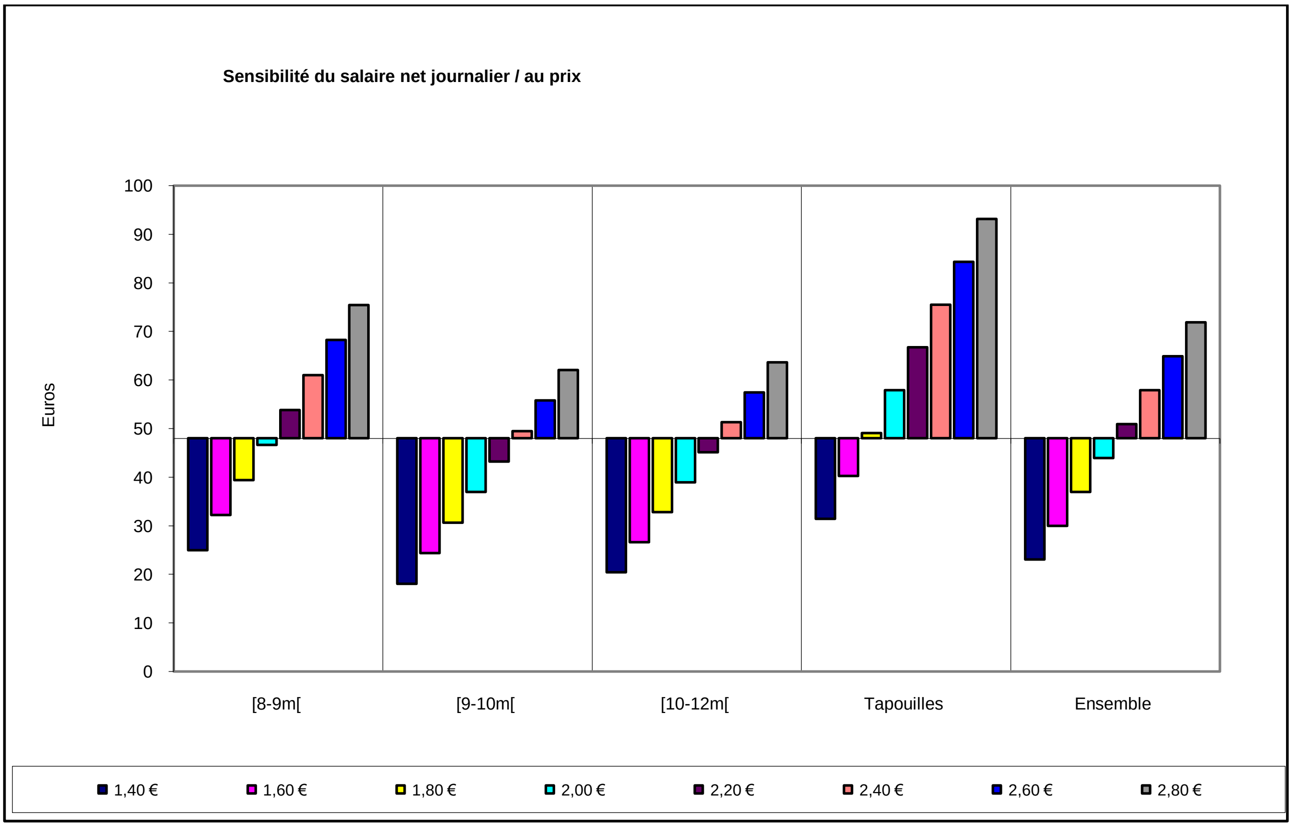


Figure 44. Sensitivity of the daily net salary / selling prices in euros (Cissé et al., 2010).

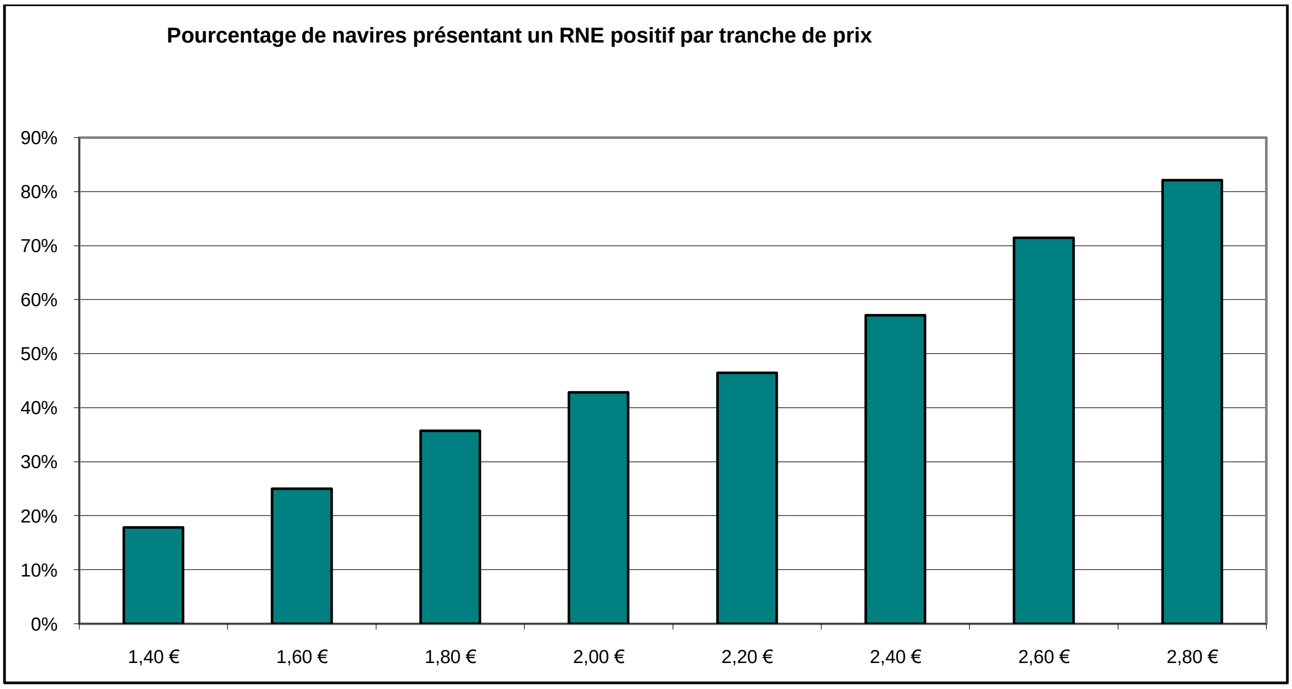


Figure 45. Ratio (%) of vessels with positive NOI (RNE) according to the mean selling price all species considered (Cissé et al., 2010).

2.3.1.3. Synthesis

54% of the vessels show a negative result. Three solutions are possible to improve the situation: increase the level of production, reduce costs or increase prices.

Apart from considerations on the status of exploited stocks, increasing the level of production through the fishing effort is only possible if new opportunities are created. Currently, a small portion of the production is exported and the local market is quickly saturated. Increased landings shall have the effect of decreasing the price.

Cost reduction that can only be effective through the establishment of a co-provisioning with a cooperative, and management of fuel prices by the government. Currently, the existing cooperative offers only ice and fuel to its members. Untaxed fuel prices reached a record in 2008 with a price of 1.17 € per liter. Following the social movement in December 2008 the price rose to € 0.61.

The increase in selling price raises the issue of the impact of the rise at the consumer level. Is the consumer willing to buy most expensive fish? Can intermediaries afford to reduce their margin?

Under the assumption of a fuel price equal to that observed before December 2008, an increase of 25% of the selling price, all other things being equal, allows more than 75% of our sample to have a net positive operating income. However, assuming a fuel price corresponding to that observed after December 2008, an increase of 12% of the sale price just to get a similar result. Note that these price increases have a positive effect on the level of remuneration of the sailors. This could reduce the turnover rate of umployed fishermen, and thus retain the workforce that is sometimes lacking.

2.3.2. Shrimp trawlers

The project « CHALOUPE » funded by the Ifremer and the French National Agency for Research (ANR), allowed to carry out enquiries on economics questions about shrimp trawling and to implement a bioeconomic model.

The bioeconomic model of the shrimp fishery of French Guyana has been developed according to three main objectives:

Represent the dynamics of the fishery earlier through the period 1994-1996. This period was chosen because of the availability of robust data on effort and catches, collected by Ifremer scientists in charge of scientific aspects of the fishery.

Simulate the impact of exogenous changes in the fishery. These changes may be economic (mainly the world price of shrimp and fuel costs) and environmental. We use the assumption that variations in recruitment of shrimp are representative of changes in the environment.

Test the impact of changes in management or public policy more generally. This concerns policy instruments already used but the impact of some decisions, such as the adoption of selective gear to reduce fishing capture and reduce mortality caused by the shrimp fishery on endangered species such as sea turtles were also simulated.

The software Vensim ® has been chosen as a modeling tool. Several analyses of data on catches and fishing effort have been made to supply the data and model parameters. Some specific studies were needed to obtain the parameters of cost and price for the year 2006. The model is composed of different modules involved. All monetary variables are expressed in constant terms (€ 2006), using the price index for deflation. Firstly, the model provides representions of the dynamics of fisheries for the period 1994 to 2006. Projections can be done for a period of 10 years from the previous period, based on assumptions about the biological and economic parameters. The time step of the model is one day.

The resource module used a model of age structure for both target species (*F. subtilis* and *F. brasiliensis*), with monthly cohorts of males and femelles. Two types of fishing strategy were identified: coastal fishing (30 to 50 m deep) and large (more than 50 m deep). Strategies are characterized by different capacities to catch target species. A calculation is done for each cohort by species and sex, and the instantaneous total catch is obtained by a sum among the different cohorts.

Model quality is assessed by its ability to reproduce the dynamics of the fishery earlier period of 1994-2006. Through this period, the model gives quite good results on the total catch in shrimp and stock biomass (figures 46, 47). On the economic point of view, the two main crises (2000-2001) and 2006 are also recreated by simulation. Scenarios can then be tested.

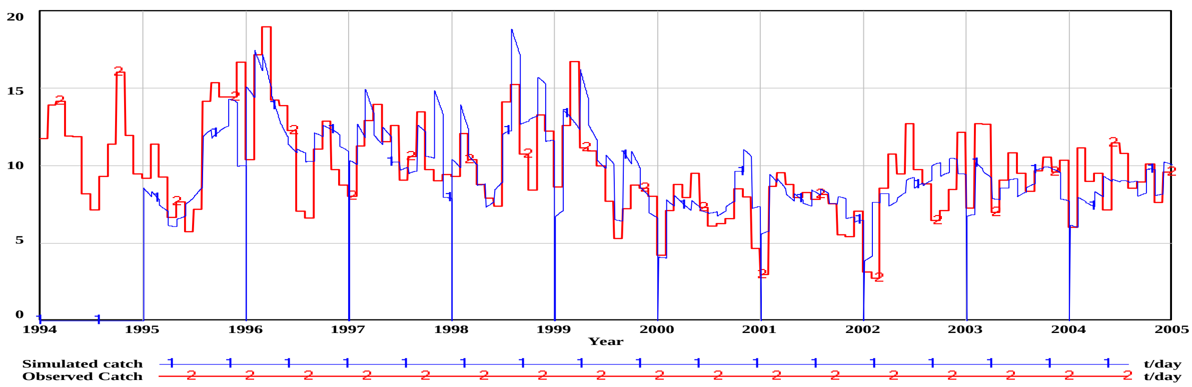


Figure 46. Model outputs compared to observations : total catches observed (in red) and simulated from the model (in blue), in tons per day (From Chaboud et al., in Lampert, 2011).

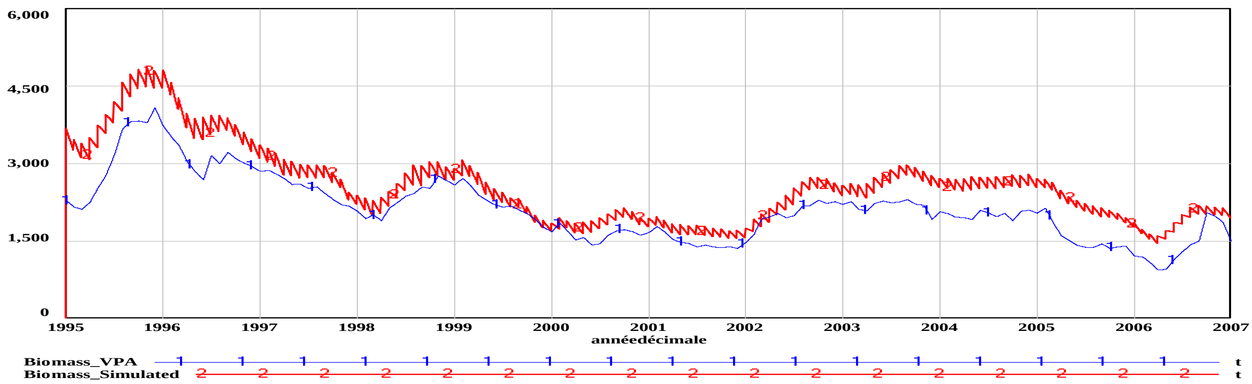


Figure 47. Model outputs compared to observations : total biomass computed from VPA (in blue) and simulated from the model (in red), in tons (From Chaboud et al., in Lampert, 2011).

The model shows that with the decrease in the value of shrimp (due to high intake of farmed shrimp, mainly from South-East produced at lower cost in a internationalized market that does not distinguish aquaculture products and livestock), the stock decrease, the increasing costs, the number of vessels economically viable has declined. The use of the model also shows an economic over-exploitation. Only the results of two management scenarios combining ecological and economic changes are shown here. On the one hand, a decrease of 50% of the grant “Poseidom” is simulated, and secondly a change in the subsidy to encourage less catches of small shrimps. For the price of diesel, we used a growth rate of 15% per year. These economic scenarios are complemented by a shrimp recruitment scenario based on data from the period 2004-2007, that is to say very bad ones. The simultaneous consideration of both types of change leads to a reduction of the fleet from 18 to 10 vessels in 2016 (figure 48). Self-regulating behavior allows a very significant renewal of the resource, despite a low recruitment regime used in this simulation. This result underlines the risk of non economic viability for the fishery if current trends in shrimp prices and diesel does not stabilize or not reverse.

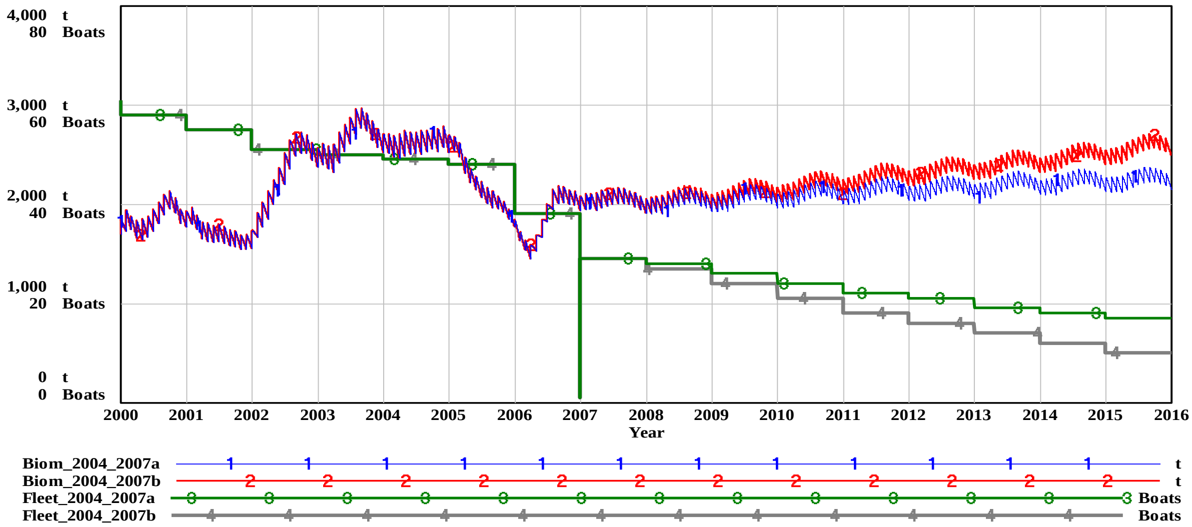


Figure 48. Model outputs from economic and environmental scenario total stock biomass (1 and 2) and number of vessels (3 and 4) according to scenarios : fuel cost increase and grant Poseidom decrease (1 et 3), fuel cost increase and increased grant only for large shrimps (2 et 4) (From Chaboud et al., in Lampert, 2011).

2.4. ENVIRONMENTAL ISSUES

2.4.1. By-catch and discards

2.4.1.1. Coastal small-scale fisheries

The coastal small-scale fishery is studied since 2006 by the establishment of a network of observers in coastal communities. Observers of Sinnamary, Kourou and Cayenne have made 31 shipments between September 2008 and July 2009, representing 52 fishing operations at sea observed.

For sampling on vessels of Kourou, fish biomass discarded is 1342 Kg while the catches retained are 4775 Kg The discarding rate is then 22% of the catches. For sampling on vessels of Sinnamary, the fish biomass discarded is 2224 Kg while the biomass retained is 4365 Kg The discarding rate is then 33.75% of the catches. The sampling of the ships of Cayenne is too low to make an estimate.

On a total of 12 769 Kg of fish caught, 3 374 Kg were discarded, representing a little more than 25% of discarding rate.

Even if the biomass of fish kept is about three times higher than the biomass of fish discarded, discarding is not negligible. Based on the information gathered from various fishermen, several hypotheses could explain the discards. Firstly, it could be explained by the effective fishing duration. Indeed the fishermen may leave their nets in the water more than 5 hours and some time, for fixed nets, up to 15 hours, which is too much. If, for example, a fish is caught in the net after the first three hours, then it may well be rotten. Otherwise, the fish trapped can be bitten by another fish, so the fish bite is no longer marketable.

Importance of the mesh size: the height and width of the meshes are very important factors for releases. Indeed, if the fisherman has a small mesh, it has a high potential to catch small fish, too small to be consumables thus causing discarding.

2.4.1.2. Shrimp trawling

The exploitation of the shrimp with trawls induces important by-catches, evaluated between 7 and 12 kg per kg of shrimp (Harness et al., 2006), nearly 40 000 tons per year for an average annual production of 3800 tons of shrimp. The main part of these by-catches are discarded. By-catches are higher in coastal areas where small shrimp are more abundant as well as fish biomass. However, a current annual production of 1000 tons (in 2011), discards are reduced to about 10 000 tons.

Since 2010, a selectivity device, the turtle excluding device is required to obtain a fishing license. This device also reduces by-catches, and thus discards, especially larger fish species. This device should be associated with a by-catch reducing device (BRD), but this is not yet the case.

2.4.1.3. Red snapper fishery

The issue of compared intra-specific selectivity for the pot fishery and the handline one is raised. An analysis of structures of size of red snapper landings (*Lutjanus purpureus*) by the handline fleet and the pot fleet showed no statistically significant differences, despite pots seem to catch more small sizes than handlines (figure 49). Both fisheries catches small individuals. In addition, the fishing practiced by the pot fleet can induce ghost fishing (pots lost on the bottom). This difficulty could be resolved by implementing a pot that could deteriorate after a time on the bottom after being lost, and with larger mesh size.

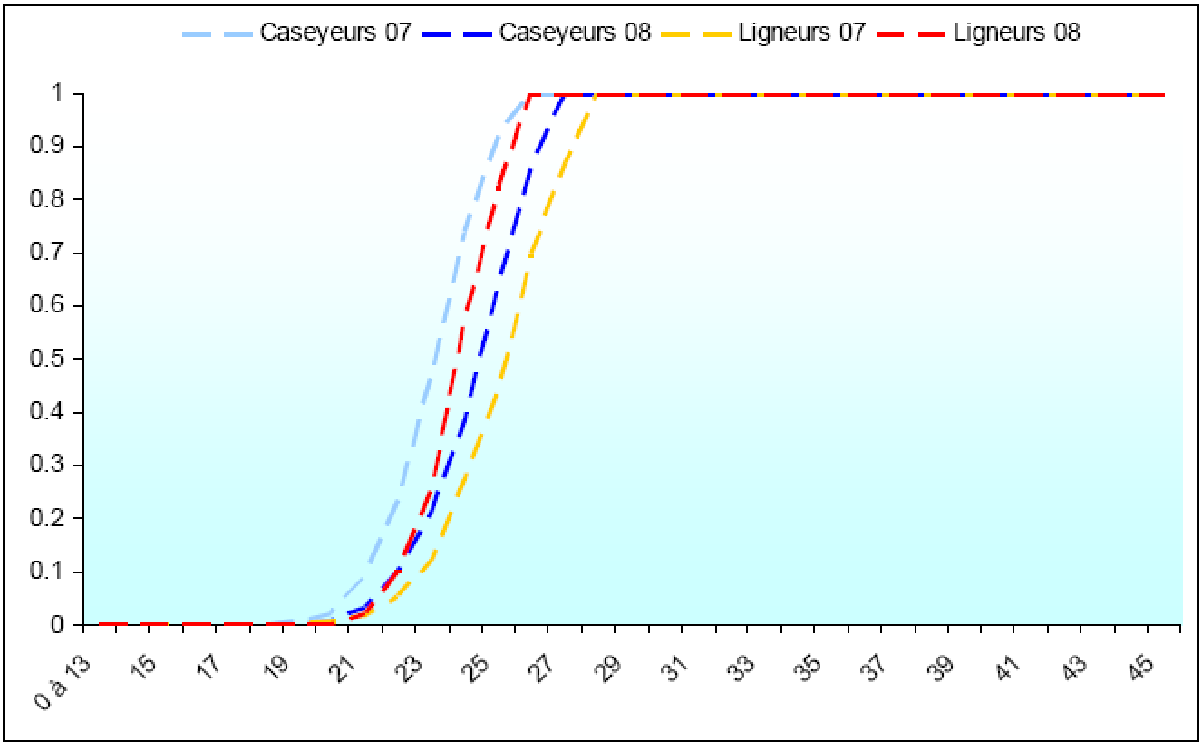


Figure 49. Selectivity curves for the Martinique and Guadeloupe pot fleet (in blue, "Caseyeurs") and for the venezuelan handline fleet (in red and yellow, "Ligneurs"), for samples get in 2007 and 2008 (Caro et al., 2010).

2.4.2. Environmental issues

Shrimp trawlers

The renewal capacity of this stock does not depend on the spawning biomass (*cf.* 2.2.2.), up to a certain limit (no reproduction if no spawner). Environmental, climatic and trophic factors may then be the cause of the fall of shrimp recruitment in French Guyana.

The drift of eggs and larvae from the AMAPA. The littoral drift of ocean waters to the NW is the main cause of the arrival of Amazonian sediments shaping the French Guyanese coast. We can imagine that this also brings the eggs and larvae of shrimp from northern Brazil to the coasts of Guyana:

Currents. If we consider the area that stretches from Suriname to the mouth of the Amazon as a biological continuum for *F. subtilis*, we could imagine the drift of larvae and eggs from Brazil to Guyana following the ocean currents. Then, the larvae may feed the local stock (figure 50). The journey undertaken by eggs and larvae then varies between 100 and 500 km. That way, if it must be done in 21 days (larval development time), it implies an average speed of 5-25 km / day (respectively 6 and 30 cm / s), which is perfectly compatible with the velocity measures in the area, which are of the order of 30 to 200 cm / s (Baklouti et al. 2007; Rockwell Geyer et al. 1996).

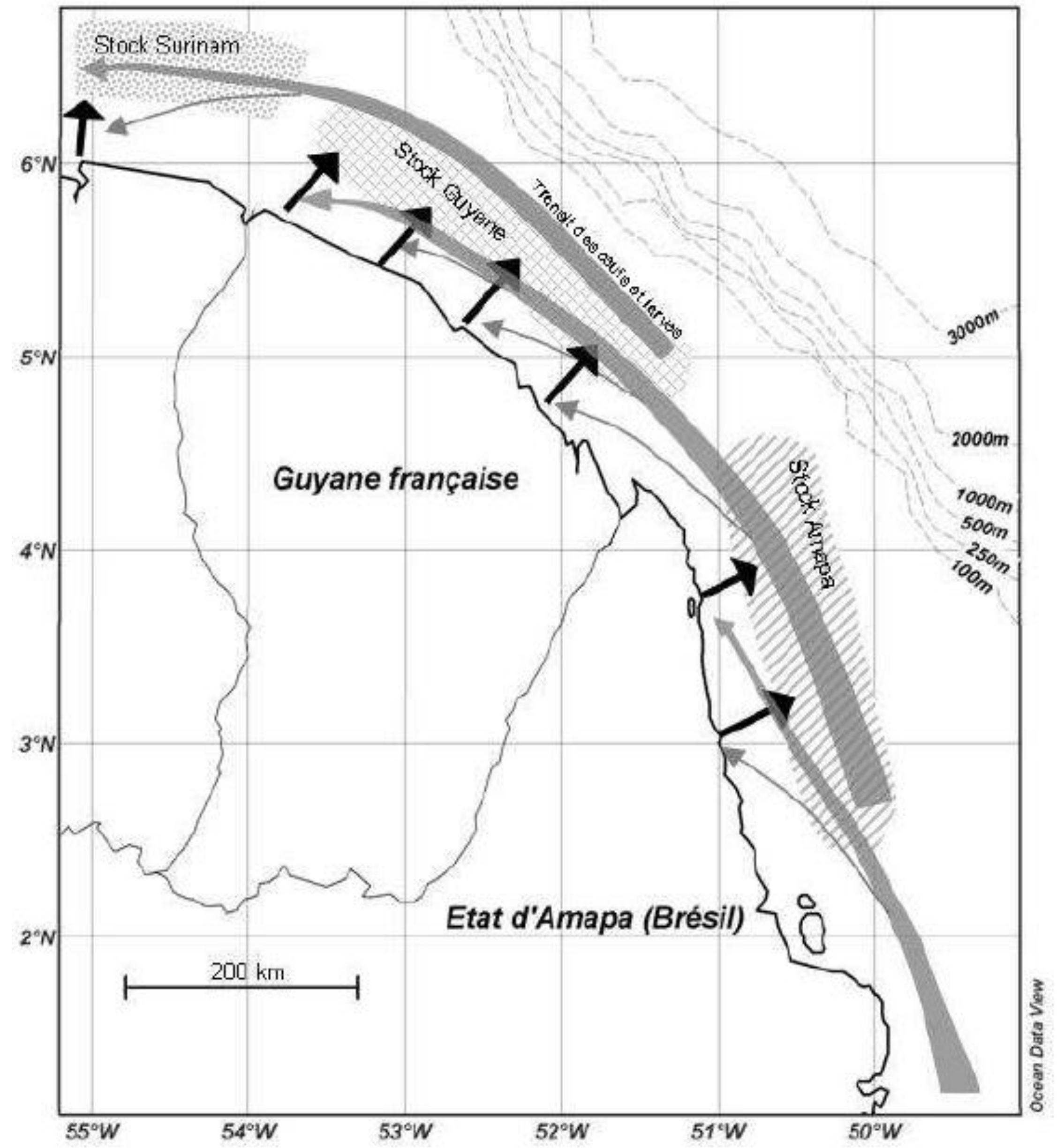


Figure 50. Hypothesis of shrimp larval drift from Amapa (Brasil) to French Guyana (grey arrows) and recruitment to the adult stock (black arrows) (Lampert, 2011).

Winds. If the winds are southwards, they influence the drift of surface water, blocking the drift of the Amazon plume in coastal Guyana (Rockwell Geyer et al. 1996). Our study of changes in environmental factors (SST, winds) and in particular wind conditions in French Guyana (Blanchard and Thebaud, 2009) shows that the wind regime changed in recent years, with increased frequency of winds blowing from sectors NE and NNE, and a small increase of their strength, and also a decrease of the frequency and strength of winds from ENE and ESE. This could then have adverse consequences for the arrival of larvae and eggs from northern Brazil.

3. MARTINIQUE and GUADELOUPE

Martinique is an island in the Lesser Antilles in the eastern Caribbean Sea, with a land area of 1 128 km². Like Guadeloupe, it is an overseas region of France, consisting of a single overseas department. To the northwest lies Dominica, to the south St Lucia, and to the southeast Barbados. With around 404 000 people living in Martinique, Fort-de-France is its capital. The surface area of the EEZ is about 47 600 km².

Guadeloupe, is also an island in the Lesser Antilles in the eastern Caribbean sea, with a land area of 1 628 km² and a population of 400 000. It is an overseas region of France, consisting of a single overseas department. Besides Guadeloupe island, the smaller islands of Marie-Galante, La Désirade, and the Îles des Saintes are included in Guadeloupe. Pointe-à-Pitre is the capital of Guadeloupe. The surface area of the continental shelf is about 96 000 km².

The continental shelf of these two regions is short and the ocean waters are oligotrophic, with clear waters and coral reef ecosystems.

3.1. FLEETS

3.1.1. Martinique

In 2010, the number of vessels listed is 1111. Nearly 80% of the vessels are small, between 6 and 8 meters in length, with an outboard engine for an average power between 39 and 90 kW. The number of men on board varies on average between 1.7 for smaller vessels and 5.8 for the largest, which represents all 1743 sailors. These numbers have remained relatively stable since 2007. 75% of the vessels fish on the coastal area (within 12 miles) and 46% fish more offshore. These vessels are distributed all along the coast of Martinique with 23 main operating ports.

Table 4. Number of boats and mean engine power in 2010, Ifremer-SIH

Boat length (in m)	Number of boats	Engine power (kW)
< 5	14	16
5-6	87	24
6-7	278	39
7-8	609	90
8-9	73	172
9-10	24	205
10-11	5	227
11-12	13	187
>12	8	330

Figure 51. Fishing boats in Martinique, Ifremer pictures.

14 fishing gears used have been identified. Pots or traps, are the more used (62%), then, trolling line (37%), fishing on fish aggregating devices FAD (35%), fixed net (26%) and beach seine (11%).

71 commercial species or groups of species have been identified among which 56 are landed. The total production, by species and fishing gear should be provided in the next coming months.

Tablea 5. Fishing devices used in Martinique in 2010, Ifremer-SIH

Fishing device	Number of boats
Pot/Trap	555
Trolling line	331
FAD	311
Fixed gillnet	229
Beach seine	96
Drifting gillnet	83
Trammel	82
Bottom set longline	77
Encircling gillnet	61
Handline	55
Free diving	42
Drifting longline	3
Pelagic purse-seine	2
Other nets	1

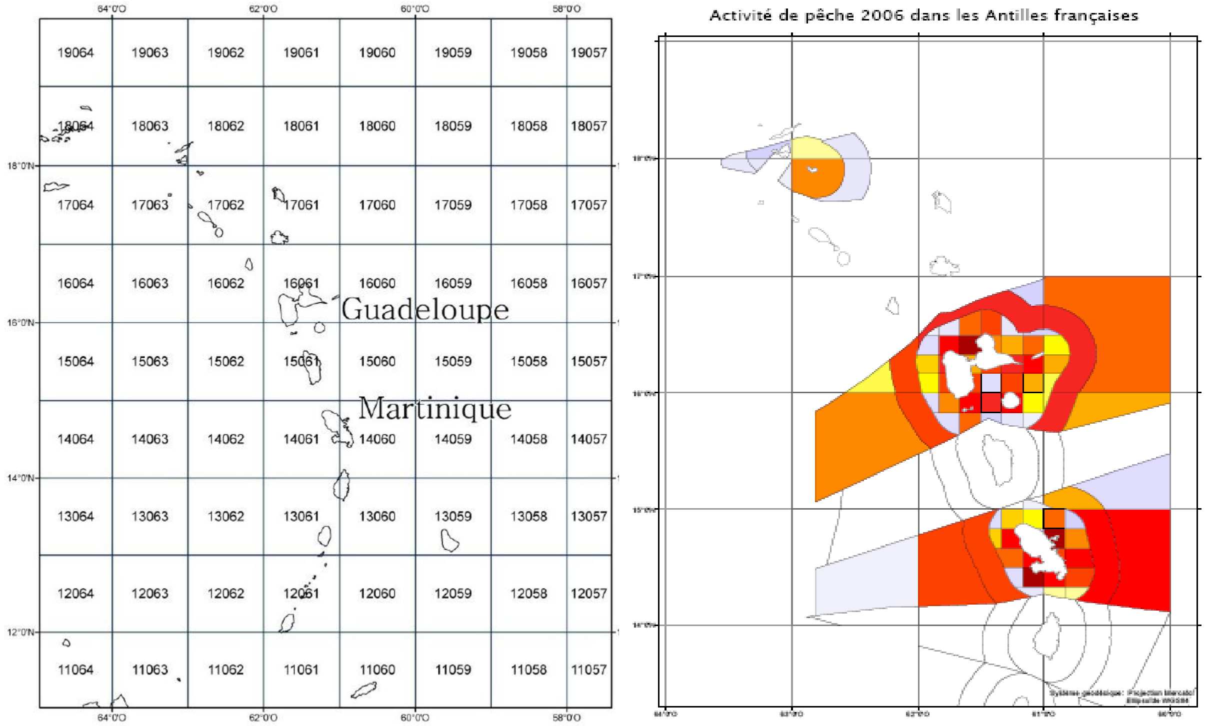


Figure 52. Fishing areas around Martinique and Guadeloupe (left) and use of fishing areas for the fleets operating from Martinique and Guadeloupe (right), Ifremer-SIH.

Table 6. Fish species identified, Ifremer-SIH

Code	Nom français	Groupe Martinique	Familles (F), Genres (G) ou Espèces (E)
1410	Poissons-bourses	Bous	Balistidae, Monacanthidae (F)
1569	Poule de mer	Poul	Dactylopteridae (F) (*Dactylopterus volitans*)
1689	Daubenets	Sad-a-plim, Ron-do	Sapridae (F)
1700	Beauclaires	Juif, Soley	Priacanthidae (F)
1799	Perroquets	Kap (et/ou Parotché)	Scaridae (F)
3305	Marignans ou Marignan mombin	Mariyan + (Moubin)	Holocentridae (F)
3317	Mérous (rougettes, cabots)	Vièj, Kouroné (mérou en Guyane), watalibi	Serranidae (F)
3321	Vivaneaux divers	Sad	Lutjanidae (F), sauf *O. chrysurus et E. oculatus*
3330	Gorettes (Tambours)	Gorèt	Haemulidae (F)
3334	Crossies divers	Broché	Centropomidae (F)
3344	Capucin (Rougets-souris)	Souri, Barbarin	Mullidae (F)
3359	Labres	Parotché	Labridae (F)
3368	Chirurgiens	Chirujien, Bayol	Acanthuridae (F)
3403	Demi-becs	Balarou	Hemiramphidae (F)
3404	Carangues	Karang (autres)	Carangidae (F) sauf Decapterus, Selar (G), Elagatis (G)
3405	Comète maquereau	Makriyo, Makro	*Decapterus macarellus (E)*
3406	Comète	Tchatcha	*Decapterus punctatus (E)*
3408	Sélar coulisou	Koulirou	*Selar crumenophtalmus (E)*
3410	Coryphène commune	Dorad	Coryphaenidae (F)
3413	Bécunes	Bétchine, Barakouda	Sphyraenidae (F)
3416	Mulets divers	Milé	Mugilidae (F)
3419	Orphies, Aiguilles (Caraibes)	Zôfi	Belonidae (F)
3444	Comète saumon	Somon	*Elagatis bipinnulata (E)*
3501	Tarpon argenté	Gran-tékay	*Megalops atlanticus (E)*
3503	Chardin fil	Aran	*Opisthonema oglinum (E)*
3520	Harengules	Sardine*	*Harengula spp (G)*
3599	Harengs, sardines, anchois, etc. divers	Pisièt	Clupeidae (pro parte), Engraulide (F)
3599	Harengs, sardines, anchois, etc. divers	Sadine*	Clupeidae (pro parte) (F)
3601	Bonite à ventre rayé (Listao)	Bariolé	*Katsuwonus pelamis (>= 2kg)*
3605	Albacore (Thon à nageoires jaunes)	Ton-zèl-jône	*Thunnus albacares (>= 2kg)*
3608	Thon à nageoires noires (Antilles)	Ton nwè	*Thunnus atlanticus (>= 2kg)*
3609	Thazards	Taza	*Scomberomorus spp (G)*
3611	Thazard-bâtard	Taza-rélé, Taza-gran-dlo, Taza-Miklon	*Acanthocybium solandri*
3616	Makaire bleu	Marlin blé (Varé)	*Makaira nigricans*
3619	Espadon	Espadon (Varé)	*Xiphias gladius*
3620	Voilier de l'Atlantique	Mè-balarou	*Istiophorus albicans*
3690	Divers Marlins, Makaires	Varé	Istiophoridae autres
3699	Thons pélamides divers	Tons (autres)	*Thunnus* autres
3699	Thons pélamides divers	Bonits [*Catégorie de poids*]	Petits Thunnini mélangés (Euthynnus (G), Sarda (G), Auxis (G) + [TN, TJ, Autres thunnus, (<= 2kg)])
3720	Poisson-volant (Exocet)	Volan	Exocetidae (F)
3890	Squales divers	Rétchin	Hexanchidae, Charcharhinidae, Ginglymostomatidae, Lamnidae, ... (F) [Chondrichthyes]
3892	Raies diverses	Ré	Rajidae (F), Dasyatidae (F), Myliobatidae (F)
3912	Anges	Portugé (Poisson-ange)	Pomacantidae (F)
3913	Blanches	Blanch	Gerreidae (F)
3914	Coffres	Kof	Ostraciidae (F)
3919	Demoiselles	Dimwazèl (Poisson-demoisselle)	Pomacentridae (F)
3925	Tambour rouge	Loup des Caraïbes	*Sciaenops ocellatus*
3929	Porcs-épics	Pwason-armé, Boubou	Diodontidae (F)
3939	Papillons	Dimwazèl (Poisson-papillon)	Chaetodontidae (F)
3950	Vivaneau queue jaune	Sad Kola ou Keu jône	*Ocyurus chrysurus*
3951	Vivaneau royal	Gran-zié	*Etelis oculatus*
3989	Murènes divers	Kong, Moring	Muraenidae, Congridae (F)
3999	Poissons divers	Pwason (divers)	Poissons divers
4204	Araignée de mer	Areignées	Majidae (F)
4212	Crabe Cyrique	Krab - Sirik	
4213	Crabe moro	Touto	
4299	Araignées, crabes, etc. divers		
4306	Langoustes diverses des Antilles	Ronma (autres)	Palinuridae autres
4310	Langouste blanche	Ronma-blan	*Panulirus argus*
4311	Langouste brésilienne	Ronma-bisié	*Panulirus guttatus*
4312	Cigale marie-carogne	Manman-ronma, Savat	Scyllaridae (F)
4410	Langoustine sculptée	Langoustines	Nephropidae (F)
4599	Crevettes diverses	Kribich-lanmè (Crevettes)	
4710	Bathynome géant		
		Tôti	Chelonidae (F)
7502	Oursin blanc	Chadron-blan (Oursin blanc)	*Tripneustes ventricosus (E)*
5206	Lambi (strombe rosé)	Lanbi	Strombidae (F)
5208	Troque des Antilles (Burgo)	Brigo	*Gasteropodes autres que lambi*
5699	Clams, coques, arches, etc. divers	Soudon, Paloud, Zuit	*Bivalves*
5701	Seiches diverses	Chès (Seiche)	Seiche
5702	Calmars	Chès (Calmar)	Calmar
5705	Poulpe	Chatou, Walay	Octopus (G)

3.1.2. Guadeloupe

At 31/12/2008, the fleet of maritime district of Pointe-à-Pitre (Guadeloupe) was composed of 878 vessels officially registered at the national level, for 1677 sailors. The average crew size is 2.1 men per ship. With an average length of 7.4 meters, the fleet of Guadeloupe is characterized by a predominance of small units. With the exception of a ship, all the vessels have a length less than 12 meters. Power and average tonnage of fishing vessels amounted respectively to 136 kW (185 hp).

The evolution of the number of vessels per length categories, both in numbers and percentage reflects significant changes in the structure of the fleet during the recent years. The fleet of less than 5 meters and 5 to 7 meters has been a significant decline in these numbers (54% and 26%), while the number of vessels in 7 to 9 meters and 9 to 12 meters respectively increased 13% and 87%. There are no more ships over 12 meters in 2008.

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Figure 53. Fishing boats in Guadeloupe, Ifremer pictures

61% of the vessels exploit the coastal area (within 12 miles) and 10% the offshore area. These vessels are distributed all along the coast of Guadeloupe with 32 main operating ports. The pot is the most used gear to nearly 60%. Trolling line, fishing on FADs and fixed gillnets are the main fishing methods used. The landing of 46 species or groups of species was observed. It allowed to carry out a preliminary evaluation of the total production around 4 000 tons per year.

Table 7. Fishing devices used in Guadeloupe in 2010, Ifremer-SIH

Fishing device	Number of boats
Pot/trap	451
Trolling line	327
FAD	290
Fixed gillnet	221
Botom set longline	184
Trammel	152
Handline	146
Encircling gillnet	72
Free diving	61
Purse seine	23
Recreational fishing	3

3.1.3. Martinique and Guadeloupe fishing fleets targeting Dolphinfish, Flyingfishes and Blackfin tuna

During the year 2008 and 2009 in Martinique, 1084 and 1098 boats were registered as commercial fishing boats and in Guadeloupe 878 and 903 respectively. Within the same years, 85% and 82 % (916 & 896) of the vessel fleet were active in Martinique and in Guadeloupe 90% and 86 % (794 & 778) were active. Most of the boats are between 5 to 9 m total length. The 7 to 9 m boats are more frequent in Martinique. During the last decade, the number of 7 to 9m boats increased in Guadeloupe while the number of 5 to 7 m boats decreased. The average length of the boats is similar between the two French Antilles, but the engine average power is higher in Guadeloupe (139 kW vs 80). The total power of the fleets had increased steadily from 56,788 to 87,420 kW in Martinique between 1993 and 2009 and at the same time, from 84,240 to 125,874 kW in Guadeloupe. The average age of the boats are 16 years in Martinique and 11 years in Guadeloupe.

Dolphinfish, flyingfish and blackfin tuna are mainly targeted using the following:

- High sea hand lines and trolling lines for large pelagic fishes,
- Trolling lines and drifting vertical lines around FADs for large pelagic fishes,
- High sea drifting nets for flyingfish (Martinique only),
- Nets for flyingfish during High sea lines for large pelagic fishes (Martinique only).

Flyingfish are not targeted by the commercial fishing boats of Guadeloupe. This is practiced mainly by high sea fleets. Related to the typology made by IFREMER, 10 different fleets are distinguished (table 1) totaling 464 boats in Guadeloupe and 435 in Martinique (2008).

The boats of these high sea fleets share their activities between high sea and the insular shelves. The seasonal activity of the high sea hand and trolling lines which are targeting mostly dolphinfish between December to June, impacts others activities which are higher from July to November. The total number of trips per year on the insular shelves is higher than at high sea (figure 4). The drifting nets for flyingfish are used on the west coast of Martinique inside the 24 NM limit. FADs are mainly exploited inside the 24 NM while high sea hand and trolling lines are fishing outside the 24 NM.

Fishing around Moored Fish Aggregating Devices (FADs) took place in Martinique and Guadeloupe during the 90’s and seems to have changed the activity and the seasonality of the high sea fishing. The data from enquiries made in 1979 and 1989 show a high proportion of boats practising high sea lines during the first half of the year and a sharp decline in the second half of the year. In 2006, this seasonality is less definite. The high sea boats share their activities between high sea lines and FADs. Fishing is practised all year long; as a result some of the high sea boats stay offshore between June to December.

Annual catch estimates for 2008, the period for which there is more reliable data, range from 393 to 561 t (metric tons) per year, which represents an estimate of 474 t (metric tons) for dolphinfish in Guadeloupe and 12 to 17 t for blackfin tuna (estimate 14 t).

In Martinique, for 2009 estimates range from 23 to 64 t (estimate 40 t) for dolphinfish and from 9 to 29 t (estimate 18 t) for blackfin tuna.

The final estimates of historical harvest for both islands therefore start from a small catch rate around FADs of 3 tons of dolphinfish and 1 ton of blackfin tuna in 1985. made in Martinique to 377 t of dolphinfish and 20 t of blackfin tuna for both islands in 1997, to the present estimate of between 416 to 625 t of dolphinfish and 21 to 46 for blackfin tuna in 2008.

Table 8. Number of trips, catches and CPUE per gear used to target the fishes for Martinique 2009 (a) and 2010 (b) – Data to be validated (Medley et al., 2010)

	No trips	Martinique 2009 - Landings (kg)				Martinique 2009 - CPUE (kg)			
Metier	Martinique	Flyingfish	Dolphinfish	Blackfin tuna	Small thunnini (<+2 kg)	Flyingfishe	Dolphinfishe	Blackfin tuna	Small thunnini (<+2 kg)
Drifting net Flyingfish	2 571	34 199			170	13.30			0.07
FADs	6 088	612	40 406	17 571	49 773	0.10	6.64	2.89	8.18
High Sea lines (+Drifting nets)	6 388	4 434	192 806	9 442	13 459	0.69	30.18	1.48	2.11
other lines	595		472	242			0.79	0.41	
Total estimate		**39 577**	**234 689**	**28 913**	**69 823**				
Low		*14 407*	*144 417*	*13 939*	*34 251*				
High		*81 445*	*351 159*	*50 801*	*126 930*				

(a)

	No trips	Martinique 2010 - Landings (kg)				Martinique 2010 - CPUE (kg)			
Metier	Martinique	Flyingfish	Dolphinfish	Blackfin tuna	Small thunnini (<+2 kg)	Flyingfish	Dolphinfish	Blackfin tuna	Small thunnini (<+2 kg)
Drifting net Flyingfish	1 816	67 607				37.23			
FADs	6 120	308	12 334	9 066	46 253	0.05	2.02	1.48	7.56
High Sea lines (+Drifting nets)	4 709	3 786	124 268	5 794	19 525	0.80	26.39	1.23	4.15
other lines	304			881	551			2.90	1.81
Total estimate		**84 674**	**153 136**	**17 215**	**66 140**				
Low		*44 248*	*104 207*	*7 892*	*49 504*				
High		*138 177*	*217 540*	*29 842*	*85 475*				

(b)

Table 9. Number of trips, catches and CPUE per gear used to target the fishes for Guadeloupe 2008 – Data to be validated (Medley et al., 2010)

	No trips	Guadeloupe 2008 - Landings (kg)			Guadeloupe 2008 - CPUE (kg)		
Metier	**Guadeloupe**	Flyingfish	Dolphinfish	Blackfin tuna	Flyingfish	Dolphinfish	Blackfin tuna
Decked boat	559		119 752			214.23	
FADs	14 110	88	474 231	14 030	0.01	33.61	0.99
High Sea lines (+Drifting nets)	8 055	248	553 711	1 177	0.03	68.74	0.15
Total estimate		**336**	**1 147 694**	**15 207**			
Low		*1 209*	*945 883*	*12 567*			
High		*2 408*	*1 397 258*	*18 016*			

3.2. STOCKS

Some stock assessments are done internationally within the context of the CRFM (Carribean Regional Fisheries Mechanism). Among the stocks assessed, some are also exploited in Martinique and Guadeloupe, but not only. Hence these stocks are not assessed at the scale of Martinique or Guadeloupe. The status of one of them, the flyingfish (*Hirundichthys affinis*) is reported here.

Flyingfish (*Hirundichthys affinis*)

Estimates of annual total flyingfish landings for the eastern Caribbean are available in FAO (2010). The landings, estimated for Barbados, Trinidad and Tobago, St Lucia, Grenada, St Vincent and the Grenadines, Dominica and Martinique vary considerably from year to year. These estimated landings ranged from 1,025 to 2,523 tons per year between 1950 and 1979 and appeared to increase thereafter, ranging from 2,121 to 4,725 tons per year between 1980 and 2007. The estimated average annual landing between 2002 and 2007 was 2,512 tons. These data are, however, to be treated cautiously as they are likely underestimates of the true catches in the region. Grenada has developed a significant bait fishery for the species, the catches of which are not well documented. In addition, landings from Martinique and other countries in the Eastern Caribbean likely to be harvesting the species are not available. There are also gaps in available data which required interpolation to estimate landings for years without data. Generally several countries lack a clear methodology for estimating total catches from recorded data. Consequently, there is tremendous uncertainty in the level of historical catches of flyingfish for the Eastern Caribbean. Estimates of fishing effort are also uncertain.

Three stock assessments of the flyingfish fishery within the Eastern Caribbean have been conducted (Mahon 1989; Oxenford et al., 2007; Medley et al., 2008) and extensive research undertaken on the fishery by the Eastern Caribbean Flyingfish Project (Oxenford et al., 2007). In addition, a preliminary trophic model constructed for the Lesser Antilles Pelagic Ecosystem (LAPE) project examined impacts of predator-prey and technological interactions in the fishery (Mohammed et al., 2008) and a preliminary bio-economic model for the eastern Caribbean flyingfish fishery was developed (Headley, 2009).

The most recent stock assessment (Medley et al., 2008) considered a wider spatial range of landings data than the previous assessments (Barbados, Trinidad and Tobago, St Lucia, Grenada, St Vincent and the Grenadines, Dominica and Martinique) for 1955 to 2007 and catch and effort data from Barbados, Trinidad and Tobago and Saint Lucia from 1994 to 2007. A Beverton and Holt Stock Recruitment model was used with the possible oceanographic effects on the population accounted for by inclusion of process error in the analyses and uncertainties in biological parameters accounted for using a Bayesian approach. The stock assessment suggested that the stock of flyingfish in the eastern Caribbean is not overfished and that overfishing is not occurring.

The assessment, however, could not be used to determine whether or not “local depletion” may be occurring as the data are not available in the level of detail required to do so. Catch rates have remained fairly stable even with increased overall catches. Given the potential stock area, and estimates of a relatively large stock size from tagging and survey data, it is unlikely that the catches have ever exceeded the maximum sustainable yield from the stock. Consequently, there is no evidence that the stock has ever been overfished.

The model estimated, for 2007, MSY at between 3,312 and 36,291 tons; B/Bmsy at between 1.97 and 4.17; and F/Fmsy at between 0.03 and 0.5 (0.05 and 0.95 confidence intervals respectively). The model projections show that keeping the fishing effort and capacity or catch at about 2,500 tons (the maximum recorded catch to date has been 4,700 tons) should be safe with overfishing very unlikely even with stock fluctuations due to environmental influences. Given the uncertainty in the MSY value, attempts to fix the fishing mortality in relation to MSY or set catches at or above 5,000 tons led to prediction of significant risks in overfishing. Consequently, it was suggested that a trigger point should be established at 5,000 tons, such that when catches consistently exceed this figure management should take action to safeguard the stock from overfishing.

3.3. ECONOMIC AND SOCIAL PERFORMANCES

There is an ongoing work based on economic enquiries carried out by Ifremer. Only some economic indicators are yet available for Guadeloupe. The indicators are given according to the class size of boat length, coastal or off-shore fishing zone for the year 2008.

Table 10. Economic performances of coastal boats (turnover in euro) in 2008 (Guyader et al., 2010).

Coastal vessels < 7 m	Moyenne	Ecart-type	C.V.
Length (m)	5,8	0,7	11%
Engine power (kW)	61	34	56%
Crew number	1,8	1	56%
Number of days at sea	128	60	46%
Turnover per employed people (€)	20442	10618	52%
Turnover per people per day (€)	173	87	50%

Coastal vessels [7-9[	Moyenne	Ecart-type	C.V.
Length (m)	7,6	0,5	6%
Engine power (kW)	136	62	46%
Crew number	2,2	1,2	54%
Number of days at sea	151	62	41%
Turnover per employed people (€)	27381	20256	74%
Turnover per people per day (€)	177	105	59%

Coastal vessels [9-12[m	Moyenne	Ecart-type	C.V.
Length (m)	9,5	0,3	3%
Engine power (kW)	249	97	33%
Crew number	2,3	0,6	25%
Number of days at sea	157	42	27%
Turnover per employed people (€)	27757	13635	50%
Turnover per people per day (€)	175	94	54%

Table 11. Economic performances of boats fishing off shore (turnover in euro) in 2008.

Offshore vessels < 7 m	Moyenne	Ecart-type	C.V.
Length (m)	6,4	0,4	6%
Engine power (kW)	93	37	40%
Crew number	1,9	0,5	28%
Number of days at sea	119	57	48%
Turnover per employed people (€)	31767	21380	67%
Turnover per people per day (€)	288	131	46%

Offshore vessels [7-9[m	Moyenne	Ecart-type	C.V.
Length (m)	7,8	0,6	7%
Engine power (kW)	163	50	31%
Crew number	2	0,7	35%
Number of days at sea	143	44	30%
Turnover per employed people (€)	40186	17134	43%
Turnover per people per day (€)	293	137	47%

Vessel with deck	Moyenne	Ecart-type	C.V.
Length (m)	11	1	6%
Engine power (kW)	227	70	31%
Crew number	3,5	0,8	24%
Number of days at sea	204	35	17%
Turnover per employed people (€)	27589	8599	31%
Turnover per people per day (€)	134	26	20%

3.4. ENVIRONMENTAL ISSUES

Chlordecone is an organochlorine insecticide that has been used in the West Indies from 1972 to 1993 to fight a weevil attacking banana roots. Very persistent in the environment, the molecule is transported from the contaminated lands to aquatic systems through fine particulate matter, thus contaminating the coastal marine environment. A preliminary study was conducted in 2010 to characterize the fate of chlordecone in food webs of coastal macrofauna. The objective was in particular to identify pathways from terrigenous maters and spread within these networks. The case study is a bay of Martinique, with seagrass areas as primary production system.

The results showed that the terrigenous incomes influence the levels of contamination of the marine fauna, individuals of the same species and with similar characteristics appearing most contaminated when they are near outfalls of rivers than when they are further away. This contamination has biomagnification along food webs, from primary producers to higher trophic position species such as carnivorous of second order (biomagnifications trophic factor estimated between 1.4 and 1.9). Place of life and mode of food supply have been identified as playing an important role on the levels of contamination.

Bioaccumulation phenomena have been found in two species for which the level of contamination by chlordecone is high, *Callinectes danae* (a crab species) and *Chloroscombrus chrysurus* (a fish species). But this does not apply to all species studied. Decreased levels of contamination were observed even during the life of the spiny lobster *Panulirus argus*. It is mainly attributed to the migration of the species seaward between the juvenile and adult phases. The results are still very fragmentary.

4. LA REUNION

La Réunion is a French island of 2 512 km², with a population of about 800 000 located in the Indian Ocean, east of Madagascar, about 200 kilometers south west of Mauritius, the nearest island. Its capital is Saint-Denis. The surface area of the EEZ is around 323 000 km².

The continental shelf of La Réunion is short and the ocean waters are oligotrophic, with clear waters and coral reef ecosystems.

4.1. FLEETS

4.1.1. Boats and fishing devices

In 2010, the number of vessels listed is 279. Nearly 67% of the vessels are small, between 5 and 7 meters long, with an outboard motor for an average power between 29 and 71 kW. The number of men on board varies on average between 1 to smaller vessels and 7 for the largest, representing a total of 415 sailors. 60% of the vessels exploit the coastal area (within 12 miles) and 12% the offshore area. These vessels are distributed along the entire coastline of the island with 11 major operating ports. The main fishing method is the use of hand lines (82% of vessels).

Table 12. Number of boats and mean engine power in 2010, Ifremer-SIH

Boat length (in m)	number of boats	Engine power (kW)
5-6	144	29
6-7	42	71
7-8	22	100
8-9	15	132
9-10	21	219
10-11	2	228
11-12	4	300
>12	29	397

Table 13. Fishing devices used in La Reunion in 2010, Ifremer-SIH

Fishing device	Number of boats
Handline	173
Longline	63
Fishing from shore	43
Swordfish drifting longline	39
Gillnet	87
Pot/trap	12

4.1.2. Typology

This section provides a typology of the fleet of La Réunion, taking into account the main combinations of “métiers” (métier is a combination of a gear and a species or a group of species), carried out during the year 2006. Active fleet can be divided into major fleets, using same fishing strategies

This classification of vessels by type allows to structure the fleet, which at first sight seems very heterogeneous with diversity of metiers performed, and the polyvalent characters of the coastal units. It should be noted that a ship may performs several metiers during the year, but is assigned to a single fleet.

Table 14. Fleets (typology Ifremer) in La Réunion in 2006, according to the metiers performed (combination of gear and group of species) (Miossec et al., 2007)

Fleets	groups	Vessel number	Mean length (cm)	Tonnage (1/10è GT)	Mean engine power(kW)	Mean crew number	Total employed people number
Hooks targeting demersal species	Hooks targeting demersal species	11	554	55	20	1.3	14
Handlines targeting demersal and large pelagic sp.	Handlines targeting demersal and large pelagic sp.	14	574	103	30	1.3	18
	Handlines targeting demersal and large pelagic (and also small pelagic sp.)	54	575	98	32	1.2	67
	Handlines-Longlines targeting demersal and large pelagic sp.	32	635	206	62	1.3	42
	Handlines-Longlines targeting demersal and large pelagic (+ small pelagic sp.)	59	630	172	55	1.3	77
Hooks targeting large pelagic sp.	Handlines targeting large pelagic sp.	17	810	487	162	1.5	26
	Handlines-Longlines targeting large pelagic sp.	15	799	409	164	1.4	22
Shore activity	Shore activity	2	575	51	15	2.0	4
Swordfish longlines	Coastal swordfish longlines	12	887	432	168	1.8	22
	Offshore swordfish longlines	28	1550	5591	260	4.2	117
Austral pots-longlines	Austral poit-longlines	1	7660	234300	2610	30.0	30
Inactive	Inactive	43	621	163	41	0.0	0

4.1.3. Fishing effort and production

The production and the fishing efforts for the year 2006 available for some fleets. They are presented in the following figures and tables.

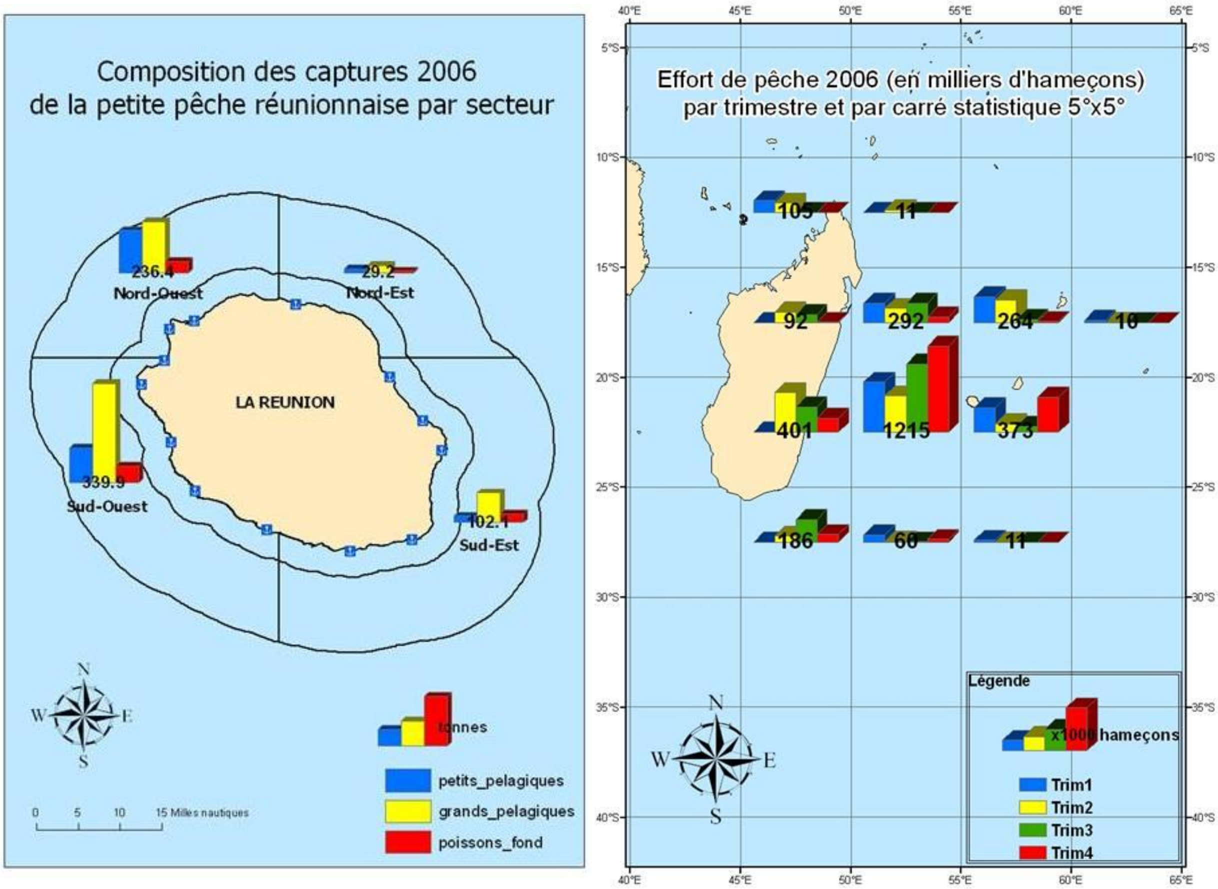

Figure 54. On the left, composition of the catches of the coastal small-scale fisheries in 2006, targeting small pelagics in blue, large pelagics in yellow and groundfishes in red. On the right, fishing effort (in thousands of hook) of the offshore fleet using longline in 2006 for each trimester (Miossec et al., 2007).

Table 15: Production by species obtained from extrapolation for the handlines targeting demersal and large pelagic species in 2006 (Miossec et al., 2007)

Species	Estimated number of fishing trips (N)	Number of sampled trips (n)	Quantity of landings sampled (in Kg)	Mean Kg sampled	Variance Kg sampled	Estimated variance mean Kg	Est – mean Kg	Est +	Est – total number of trips	Est +	Est - total quantity	Est total quantity species	Precision	Est +
Bigeye scad	2016	37	501	13.5	6756.4	179.3	0.0	39.8	1940	2092	501	27270	99%	83196
Sphyraena sp.	2016	37	160	4.3	608.6	16.1	0.0	12.2	1940	2092	160	8718	93%	25522
Coryphaena	2016	37	74	2.0	38.7	1.0	0.0	4.0	1940	2092	74	4032	51%	8337
Wahoo	2016	37	68	1.8	24.6	0.7	0.3	3.4	1940	2092	495	3705	44%	7156
Lutjanids)	2016	37	39	1.0	13.2	0.3	0.0	2.2	1940	2092	39	2098	57%	4602
Albacore	2016	37	35	0.9	14.4	0.4	0.0	2.1	1940	2092	35	1880	66%	4484
Groupers	2016	37	27	0.7	10.9	0.3	0.0	1.8	1940	2092	27	1466	74%	3727
Other demersals	2016	37	23	0.6	3.3	0.1	0.0	1.2	1940	2092	71	1248	48%	2513
Skipjack tuna	2016	37	21	0.6	2.3	0.1	0.1	1.0	1940	2092	172	1144	43%	2190
Capucins	2016	37	20	0.5	3.1	0.1	0.0	1.1	1940	2092	20	1090	53%	2315
Groupers (red)	2016	37	19	0.5	1.5	0.0	0.1	0.9	1940	2092	223	1019	39%	1874
Herrings, sardines, etc.	2016	37	15	0.4	6.1	0.2	0.0	1.2	1940	2092	15	817	99%	2495
Crabs	2016	37	11	0.3	1.7	0.0	0.0	0.7	1940	2092	11	599	72%	1497
Sky emperor	2016	37	11	0.3	1.0	0.0	0.0	0.6	1940	2092	11	572	56%	1245
Poulp	2016	37	8	0.2	1.3	0.0	0.0	0.6	1940	2092	8	436	87%	1226
Cardinal fish	2016	37	7	0.2	1.3	0.0	0.0	0.6	1940	2092	7	398	95%	1181
Lobsters	2016	37	5	0.1	0.7	0.0	0.0	0.4	1940	2092	5	289	93%	849
Thonine orientale (Bonite la côte)	2016	37	4	0.1	0.4	0.0	0.0	0.3	1940	2092	4	218	99%	665

Table 16: Production by species obtained from extrapolation for the handlines targeting demersal and large pelagic species and also small pelagic sp. in 2006 (Miossec et al., 2007)

Species	Estimated number of fishing trips (N)	Number of sampled trips (n)	Quantity of landings sampled (in Kg)	Mean Kg sampled	Variance Kg sampled	Estimated variance mean Kg	Est – mean Kg	Est +	Est – total number of trips	Est +	Est - total quantity	Est total quantity species	Precision	Est +
Albacore	8527	114	306	2.7	56.6	0.5	1.3	4.1	8369	8684	10966	22866	26%	35195
Lutjanids	8527	114	174	1.5	10.6	0.1	0.9	2.1	8369	8684	7807	13019	20%	18415
Other demersal	8527	114	89	0.8	3.2	0.0	0.5	1.1	8369	8684	3801	6650	21%	9600
Bigeye scad	8527	114	77	0.7	4.8	0.0	0.3	1.1	8369	8684	2308	5759	30%	9337
Groupers (red)	8527	114	66	0.6	1.3	0.0	0.4	0.8	8369	8684	3086	4929	18%	6838
Coryphaena	8527	114	54	0.5	13.0	0.1	0.0	1.1	8369	8684	54	4039	71%	9814
Thon Germon	8527	114	45	0.4	17.8	0.2	0.0	1.2	8369	8684	45	3366	99%	10102
Skipjack tuna	8527	114	44	0.4	4.0	0.0	0.0	0.7	8369	8684	153	3261	49%	6484
Groupers	8527	114	34	0.3	0.9	0.0	0.1	0.5	8369	8684	1063	2539	29%	4069
Carangids	8527	114	32	0.3	2.3	0.0	0.0	0.6	8369	8684	56	2409	50%	4848
Wahoo	8527	114	32	0.3	3.7	0.0	0.0	0.6	8369	8684	32	2356	65%	5440
Capucins	8527	114	28	0.2	0.9	0.0	0.1	0.4	8369	8684	624	2079	35%	3588
Sky emperor	8527	114	28	0.2	0.5	0.0	0.1	0.4	8369	8684	937	2057	27%	3217
Bancloche Mackerel scad	8527	114	25	0.2	1.8	0.0	0.0	0.5	8369	8684	25	1833	58%	3983
Sharks, rays, skates	8527	114	12	0.1	1.3	0.0	0.0	0.3	8369	8684	12	898	99%	2694
Green jobfish	8527	114	11	0.1	0.5	0.0	0.0	0.2	8369	8684	11	823	71%	1996
Crab	8527	114	11	0.1	0.5	0.0	0.0	0.2	8369	8684	11	823	70%	1991
Cardinal fishes	8527	114	8	0.1	0.0	0.0	0.0	0.1	8369	8684	271	576	27%	892
Bonite gros yeux (T. dents de chien)	8527	114	7	0.1	0.4	0.0	0.0	0.2	8369	8684	7	524	99%	1571
Phyraena spp.	8527	114	5	0.0	0.2	0.0	0.0	0.1	8369	8684	5	374	99%	1122
Thonine orientale (Bonite la côte)	8527	114	4	0.0	0.1	0.0	0.0	0.1	8369	8684	4	299	78%	772
Poulp	8527	114	4	0.0	0.1	0.0	0.0	0.1	8369	8684	4	262	71%	636
Moontail bullseye	8527	114	1	0.0	0.0	0.0	0.0	0.0	8369	8684	1	37	99%	112
Brème noire (Mochong ou Zambas)	8527	114	0	0.0	0.0	0.0	0.0	0.0	8369	8684	0	22	99%	67
Comètes	8527	114	0	0.0	0.0	0.0	0.0	0.0	8369	8684	0	22	99%	67

Table 17 : Production by species obtained from extrapolation for the handlines-longlines targeting demersal and large pelagic species in 2006 (Miossec et al., 2007)

Species	Estimated number of fishing trips (N)	Number of sampled trips (n)	Quantity of landings sampled (in Kg)	Mean Kg sampled	Variance Kg sampled	Estimated variance mean Kg	Est – mean Kg	Est +	Est – total number of trips	Est +	Est - total quantity	Est total quantity species	Precision	Est +
Thon Albacore	4976	84	669	8.0	276.4	3.2	4.4	11.5	4899	5052	21746	39630	23%	58046
Thon Germon	4976	84	444	5.3	369.3	4.3	1.2	9.4	4899	5052	5933	26302	39%	47289
Brème noire (Mochong ou Zambas)	4976	84	226	2.7	67.0	0.8	0.9	4.4	4899	5052	4649	13358	33%	22330
Skipjack tuna	4976	84	195	2.3	27.5	0.3	1.2	3.4	4899	5052	5928	11551	24%	17343
Coryphaena	4976	84	119	1.4	45.4	0.5	0.0	2.8	4899	5052	119	7049	51%	14371
Lutjanids	4976	84	88	1.0	10.8	0.1	0.3	1.7	4899	5052	1712	5213	34%	8820
Sharks, rays, skates	4976	84	78	0.9	28.4	0.3	0.0	2.1	4899	5052	78	4591	62%	10368
Sky empror	4976	84	64	0.8	14.2	0.2	0.0	1.6	4899	5052	64	3791	54%	7886
Carangids	4976	84	51	0.6	10.7	0.1	0.0	1.3	4899	5052	51	3021	58%	6579
Swordfish	4976	84	48	0.6	27.4	0.3	0.0	1.7	4899	5052	48	2843	99%	8497
Groupers (red)	4976	84	45	0.5	3.5	0.0	0.1	0.9	4899	5052	684	2666	38%	4707
Other demersal sp.	4976	84	44	0.5	3.6	0.0	0.1	0.9	4899	5052	596	2618	39%	4702
Bonite gros yeux (T. dents de chien)	4976	84	29	0.3	3.8	0.0	0.0	0.8	4899	5052	29	1718	61%	3824
Bancloche Mackerel scad	4976	84	27	0.3	2.3	0.0	0.0	0.6	4899	5052	27	1599	51%	3246
Wahoo	4976	84	26	0.3	2.9	0.0	0.0	0.7	4899	5052	26	1540	60%	3393
Groupers (rougettes, cabots)	4976	84	23	0.3	1.6	0.0	0.0	0.5	4899	5052	23	1333	51%	2695
Crab	4976	84	15	0.2	2.7	0.0	0.0	0.5	4899	5052	15	889	99%	2655
Bigeye scad	4976	84	15	0.2	0.6	0.0	0.0	0.3	4899	5052	66	889	47%	1736
Capucins	4976	84	13	0.2	1.2	0.0	0.0	0.4	4899	5052	13	770	77%	1961
Thonine orientale (Bonite la côte)	4976	84	6	0.1	0.2	0.0	0.0	0.2	4899	5052	6	355	70%	854
Green jobfish	4976	84	3	0.0	0.1	0.0	0.0	0.1	4899	5052	3	178	74%	441
Herrings, sardines, etc.	4976	84	2	0.0	0.0	0.0	0.0	0.1	4899	5052	2	118	99%	354
Cardinal fishes	4976	84	1	0.0	0.0	0.0	0.0	0.0	4899	5052	1	30	99%	89

Table 18 : Production by species obtained from extrapolation for the handlines-longlines targeting demersal and large pelagic species and also small pelagic sp. in 2006 (Miossec et al., 2007)

Species	Estimated number of fishing trips (N)	Number of sampled trips (n)	Quantity of landings sampled (in Kg)	Mean Kg sampled	Variance Kg sampled	Estimated variance mean Kg	Est – mean Kg	Est +	Est – total number of trips	Est +	Est - total quantity	Est total quantity species	Precision	Est +
Thon Albacore	8470	156	849	5.4	236.9	1.5	3.0	7.8	8356	8584	25452	46069	22%	67232
Coryphaena	8470	156	580	3.7	197.8	1.2	1.5	5.9	8356	8584	12819	31513	30%	50705
Skipjack tuna	8470	156	249	1.6	133.7	0.8	0.0	3.4	8356	8584	249	13492	58%	29103
Wahoo	8470	156	185	1.2	15.1	0.1	0.6	1.8	8356	8584	4842	10017	26%	15330
Lutjanids	8470	156	182	1.2	11.4	0.1	0.6	1.7	8356	8584	5376	9898	23%	14540
Thon Germon	8470	156	165	1.1	46.0	0.3	0.0	2.1	8356	8584	165	8959	51%	18126
Bigeye scad	8470	156	145	0.9	5.4	0.0	0.6	1.3	8356	8584	4730	7846	20%	11043
Groupers (red)	8470	156	123	0.8	3.8	0.0	0.5	1.1	8356	8584	4042	6678	20%	9384
Carangids	8470	156	90	0.6	13.6	0.1	0.0	1.1	8356	8584	90	4870	51%	9852
Brème noire (Mochong ou Zambas)	8470	156	65	0.4	9.7	0.1	0.0	0.9	8356	8584	65	3529	59%	7725
Other demersal sp.	8470	156	39	0.3	1.2	0.0	0.1	0.4	8356	8584	685	2118	34%	3589
Groupers (rougettes, cabots)	8470	156	30	0.2	0.6	0.0	0.1	0.3	8356	8584	647	1634	31%	2648
Bancloche	8470	156	29	0.2	1.0	0.0	0.0	0.3	8356	8584	269	1575	42%	2916
Sky emperor	8470	156	21	0.1	0.2	0.0	0.1	0.2	8356	8584	487	1146	29%	1821
Green jobfish	8470	156	16	0.1	0.9	0.0	0.0	0.3	8356	8584	16	869	74%	2157
Bonite gros yeux (T. dents de chien)	8470	156	15	0.1	1.4	0.0	0.0	0.3	8356	8584	15	814	99%	2428
Capucins	8470	156	14	0.1	0.2	0.0	0.0	0.1	8356	8584	208	738	36%	1283
Comète saumon	8470	156	7	0.0	0.1	0.0	0.0	0.1	8356	8584	7	353	61%	786
Sphyraena	8470	156	5	0.0	0.2	0.0	0.0	0.1	8356	8584	5	271	99%	809
Crab	8470	156	4	0.0	0.1	0.0	0.0	0.1	8356	8584	4	190	99%	567
Cardinal fish	8470	156	3	0.0	0.0	0.0	0.0	0.0	8356	8584	22	174	45%	330
Moontail bullseye	8470	156	3	0.0	0.0	0.0	0.0	0.0	8356	8584	3	163	70%	391
Sharks, rays and skates.	8470	156	2	0.0	0.0	0.0	0.0	0.0	8356	8584	2	81	99%	243
Thonine orientale (Bonite la côte)	8470	156	1	0.0	0.0	0.0	0.0	0.0	8356	8584	1	54	99%	162

A strong decreasing temporal trend of the annual production is observed for the small scale fisheries between 2005 and 2010. It is assumed that this decline of the production can't be explained by changes in the fishing effort as the CPUEs decline also.

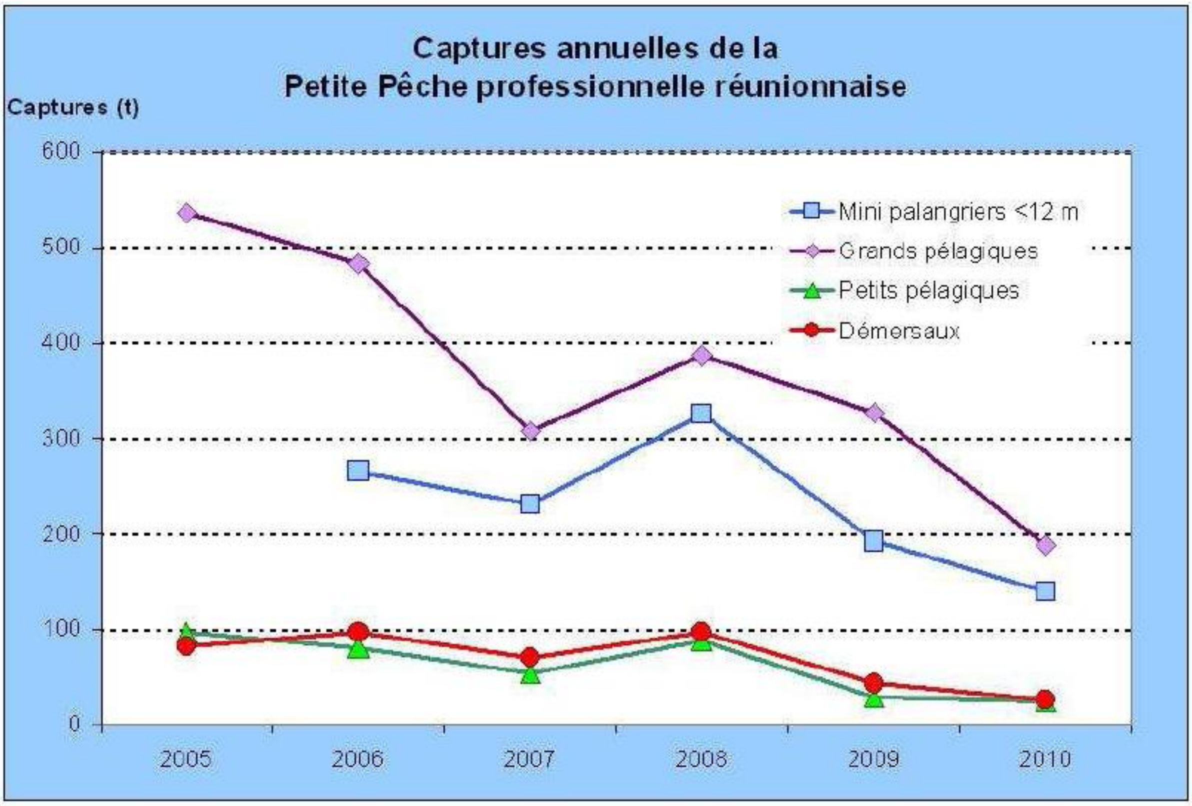

Figure 55. temporal variations of the annual catches of the coastal small-scale fisheries : longlines (squares), targeting large pelagic (lozenges), small pelagic (triangles) and demersal species (rounds) from 2005 to 2010 (Fleury et al., 2012).

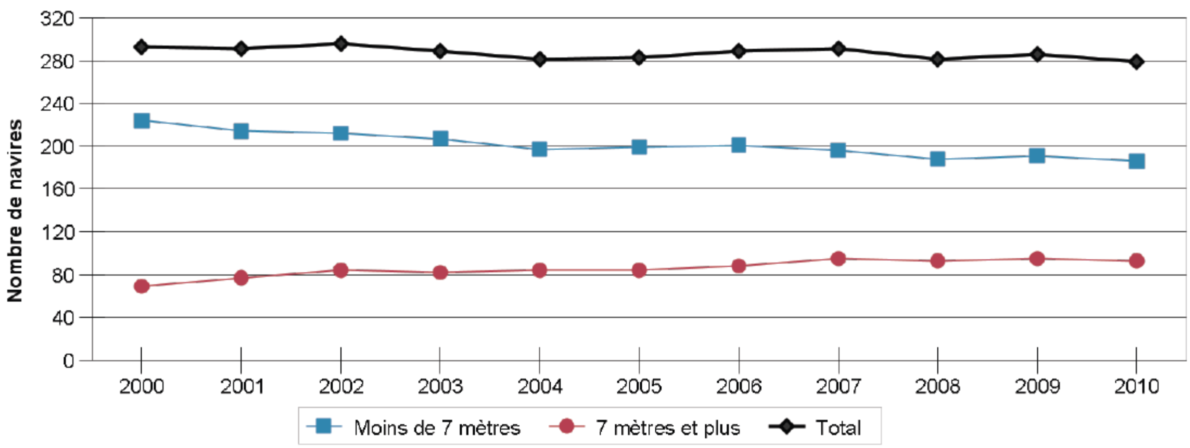

Figure 56. Temporal variations of the whole fleet (lozenges) in number of boats and according to size, of less than 7 m (squares) and greater than 7 m (rounds) (Fleury et al., 2012)

4.2. STOCKS

Swordfish (*Xiphas gladius*)

From Le Couls and Bourja, 2010.

Until the early 1990s, swordfish was mainly a bycatch of the industrial longline fisheries targeting tunas. Swordfish catches significantly increased after 1990, reaching a first peak of 35 000 t in 1998 and 36 000 t in 2003 and 2004. The current catch levels are around 30 000 t. This sharp increase is due to the change of target species of tuna to swordfish, the Taiwanese fleet and the arrival of new fleets targeting swordfish in the Indian Ocean (Reunion, Spain ...). In 2007, 29 892 tons of swordfish were caught in the Indian Ocean. Longline is the main fishing gear used (95%) followed by gillnet (5%). Taiwan, Spain, Indonesia and Japan are the major fishing countries in the Indian Ocean in 2007 respectively, 26.5%, 16.5%, 6% and 4.5% of the total catch of swordfish. The fleets operating from La Reunion represent only 4% of the total swordfish caught in the ocean. Fishing effort and catches are mainly focused on the north-west and south-west Indian Ocean.

The last stock assessment for swordfish in the Indian Ocean was carried out in 2009 (IOTC, 2009). Two types of models were used for the evaluation: age-structured models (ASIA, SS3) and a production model with aggregated age (ASPM, ASPIC). Given the heterogeneity of the available data by region, date, fleet, the working group recommended to continue to use these different models for stock assessment of swordfish in the years to come.

The conclusion of the work carried out in 2009 is that the current catch level (the last year considered is 2007) is probably close to the maximum sustainable yield (MSY), suggesting a stock fully exploited. However, considerable uncertainty persists on the stock structure of swordfish in the Indian Ocean, particularly because of contrasted evolutions of catch per unit of effort (CPUE) and catch levels based on different zones. These indicators suggest a heterogeneous stock (or even the existence of several stocks) and finally a possible over-exploitation of swordfish stocks in the north-west and south-west Indian Ocean.

4.3. ECONOMIC AND SOCIAL PERFORMANCES

No elements were found for the fisheries operating from La Réunion.

4.4. ENVIRONMENTAL ISSUES

The monitoring of marine biocenoses made since the 80 on reef areas on the west coast of the island of Reunion show that coral structures are affected by chronic enrichment in nutrient salts. This degradation of reef ecosystems seems partly due to contributions from watersheds adjacent to the reef platforms. Phenomena generated by chronic pollution of the reef ecosystem were described and quantified in part from the early 1980s in La Réunion (Guillaume et al., 1983; Cuet 1989; Cuet and Naim, 1992; Naim, 1993 a and b). These enhancements are mainly related to groundwater infiltration that provide significant amounts of nitrogen and to a lesser extent phosphate (Cuet et al., 1988; Naim et al., 2000). This enrichment of water reef in La Réunion linked to human activities, induce an increase in the abundance of algal stands (Cuet et al., 1988; Naim, 1993b; Semple, 1997).

In Reunion, the algal facies pollution mainly occur during the warm season and disappear with the return of the cool season. In recent years, an extension in time and space of algal blooms is noticed (Chabanet, 1994). Actually, the analysis for 10 years showed an increase of algal cover that seems significant in the majority of the sites sampled between 1998 and 2009. Algal cover have doubled or tripled in some sites, and most sites present today an algal cover of more than 50%, which is characteristic of a bad ecological status (Bruno et al., 2009).

This habitat modification is probably not without consequences for fish populations wich dynamics depends on this habitat quality, especially for demersal species which yields seem to decrease (Fleury et al., 2012)

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