Working Document for the Working Group on Widely Distributed Stocks (WGWIDE)
30 August - 5 September 2017, Copenhagen (Denmark)

Improvement of the fishery knowledge of striped red mullet of the Bay of Biscay

Nathalie Caill-Milly[1], Muriel Lissardy[1] Jean-Pierre Léauté[2]

[1] Ifremer, Laboratoire Environnement Ressources d'Arcachon, UFR Côte Basque, 1, allée du Parc Montaury, 64600 Anglet, France

[2] Ifremer, Laboratoire Ressources Halieutiques La Rochelle, place Gaby Coll, B.P.7 17137 L'Houmeau, France

Introduction

Striped red mullet (*Mullus surmuletus*) belongs to the species for which individualization of stocks is advanced by ICES in western Europe for areas including the Bay of Biscay and the areas bordering the Iberian peninsula. Since 2012, ICES has provided recommendations with regards to this stock. These recommendations are given for two years and are based on an approach adopted by ICES in 2012 in the case of insufficient data for an analytical evaluation (Data Limited Stocks, DLS). For 2013 and 2014, ICES advice consisted in a 20% reduction in catches (average of the last 3 years:- 2009-2011) as a precautionary measure. Since that, no new advice has been formulated, the advice remains the same. Considering the impacts of such measurements on the French fishing fleet, improvement of the data available for stocks in the DLS category is therefore a priority.

The project ROMELIGO aims to change this situation by contributing to the improvement of the knowledge on three stocks (striped red mullet, whiting and pollack) on the basis of the available data (declaring landing data or sampling data for French fishermen, data from scientific campaigns, etc.) or data to be collected (biological parameters).

The first phase of the project analyzes the catches and the activity of the French professional fishery with regards to the species (composition and evolution of catches, seasonality, spatial distribution, gear used and discards). **This WD provides the results of this phase regarding striped red mullet with as a preamble a bibliographic review on the biology of the species**.

Note that a second phase of the project will focus on the abundance indicators obtained by calculating catches per unit of effort of the vessels, based on data from scientific surveys. Finally, the last phase will concentrate on the collection of basic biological data necessary for the implementation of a subsequent stock assessment: length / weight relationships, growth curves, length at first maturity (L50) and / or sexual maturity warheads. They will rely on various sampling.

Origin of the data used for the analysis of the landings

Several types of data were used:

ICES data:

http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

- Historical nominal catches 1950-2010;

Catches in FAO 27 area by country, species, area and year. Source: Eurostat ICES database on catch statistics - ICES 2011, Copenhagen.
- Official nominal catches 2006-2014.
Catches in FAO area 27 per country, species, area and year as foreseen by national authorities. Source: Eurostat / ICES data compilation of catch statistics - ICES 2016, Copenhagen.

Data from the Ifremer Fisheries Information System (SIH), which has two origins:
- Declarative data per vessel from logbooks and fishing logs, and recorded as "Fishing trips data".
- Sacrois data (Damenèche et al., 2013).

These data (Project Ifremer / DPMA) are the result of a combination of linking, verification and coherence checks of different data flows in order to produce validated, consolidated and qualified series of production and effort data. However, the Sacrois software does not correct the data. The flows used are:

1) "Ships - Ship owners" (Historical property movements of ships);
2) "Fishing trip data";
3) "Sales data" in auctions per vessel and species;
4) "VMS fishing trips" derived from satellite positioning processing of ships;
5) Monthly activity calendar surveys, collect by the Ifremer network of observers.

The linking and integration of the "Sales Data" induces an increase in the values relative to the "Fishing trip data" alone.

The Sacrois data seem to be most complete from 2000 onwards. They also make it possible to present the catch data at a detailed level in terms of gear (DCF level 6 required by ICES).

Sectors studied

Depending on the species, the geographic influence of the stocks, as taken into account by WGHMM 2013, differs (Table 1).

Table 1: Inventories taken into account at the WGHMM 2013 level for red mullet, whiting and pollack.

Species	Stock name	Stock code
Striped red mullet	Striped red mullet areas VI, VIII et sub-areas VIIa-c, e-k et IXa (West area)	mur-west
Whiting	Whiting area VIII et sub-area IXa	whg-89a
Pollack	Pollack area zone VIII et sub-area IXa	pol-89a

The limits of the ICES Western European sectors and the bathymetry of the Celtic Sea and of the Bay of Biscay are provided in Figure 1 and Figure 2.

This western European area is subdivided into subsectors called "statistical rectangles", defined by a grid of half a degree of latitude and one degree of longitude (Figure 3)

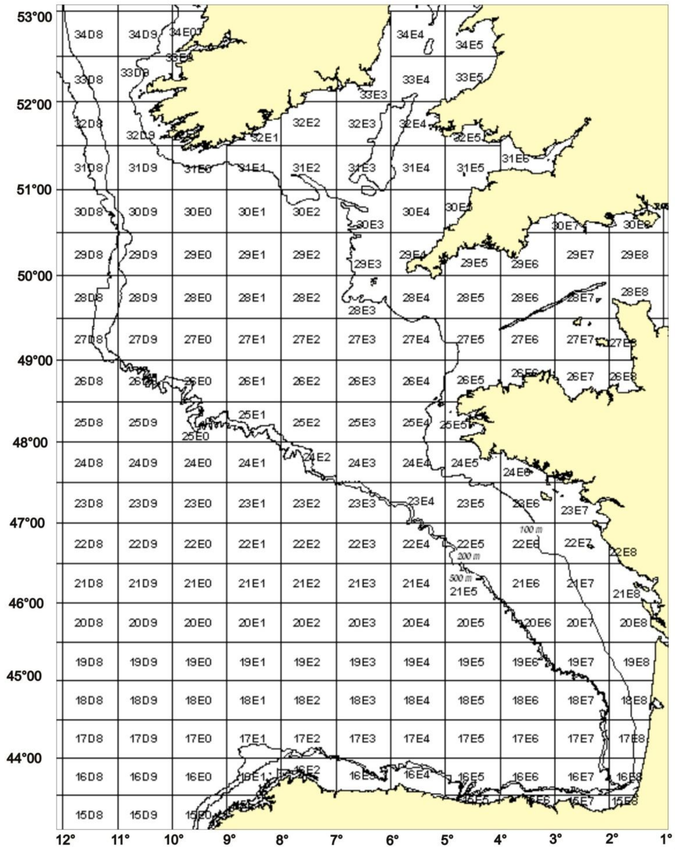


Figure 3 - Location and denomination of the statistical rectangles of the Bay of Biscay and the Celtic Sea.

The statistical rectangles in sub-areas VIIIa and VIIIb of the Bay of Biscay cover the continental shelf down to a depth of 200 m depth (Figure 4).

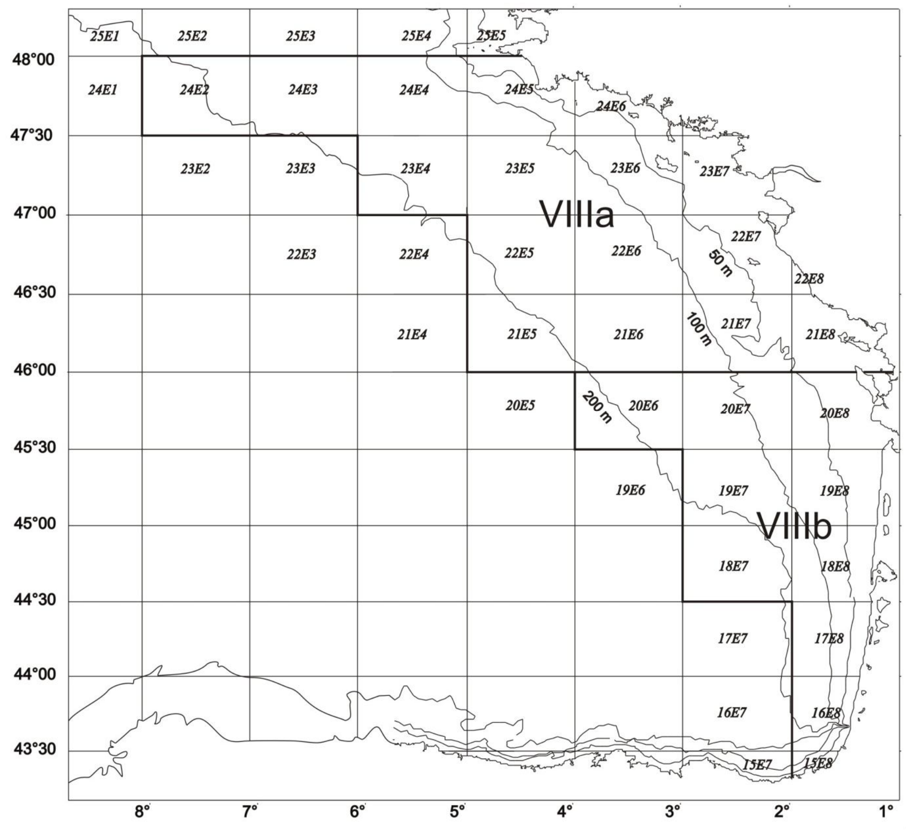


Figure 4 - Location and denomination of the statistical rectangles of the Bay of Biscay.

Results : Striped red mullet (*Mullus surmuletus*)

Name and classification

Binomial name: *Mullus surmuletus* (Linné, 1758)
(Hureau, 1986; Mahé et al., 2005; European Register of Marine Species)

Some vernacular names: Rouget barbet de roche, Rouget de roche, Rouget-barbet and Barbarin in France; Salmonete de rocha, Salmonete in Spain; Salmonete and Salomenete-legίtimo in Portugal; Red mullet, Striped red mullet, and Surmullet in Great Britain.

Classification:

Kingdom	Animal
Phylum	Chordates
Sub-phylum	Vertebrates
Super-class	Gnathostomes
Class	Actinoptérygii
Order	Perciformes
Familly	Mullidae
Genre	*Mullus*
Species	*Surmuletus*

Preamble - General biology

Distribution: The red mullet is found along the coasts of Europe, southern Norway and northern Scotland (northern Atlantic, Baltic Sea, North Sea and the English Channel), up to the Northern part of West Africa, in the Mediterranean Basin, and in the Black Sea (Hureau, 1986; Mahé et al., 2005).

Ecology: This species is essentially benthic, so it evolves on the bottom and in its vicinity and depends partly on a substrate of sandy, gravelly and shell type where it excavates the sediment with its two barbels in order to dislodge the small invertebrates. The eggs and larvae are pelagic.

The depth at which individuals are most abundant is on average in waters less than 100 meters deep (easily observed around 0-30 m) (Mahé et al., 2005), but large specimens were observed down at more than 300 m. In the North Atlantic, mature red mullets are found at depths between 100 and 200 m on average, at temperatures ranging from 9.5 to 11.9°C and salinity of 35.1 to 35.6% (Desbrosses, 1935, in Suquet & Person-Le Ruyet, 2001). In the Bay of Biscay, the bathymetric distribution would depend more on the size of the fish than on its age (Desbrosses, 1933), the individuals living closest to shore in shallow water are mostly juveniles.

It is a predominantly gregarious species living in small groups of up to a dozen individuals but it can also be solitary or live just in pairs. The main natural predators of *Mullus surmuletus* are sea basses, pollacks, barracudas, monkfish, congers and sharks.

Reproduction: Sexual maturity is reached at the beginning of the second year for males which then see their growth slow down suddenly, it is reached at the end of the second or beginning of the third year for females which therefore continue their rapid growth a little longer (Déniel, 1991). For the Bay of Biscay, the sizes of first sexual maturity are given by Dorel (1986): males 16 cm, females 18 cm. The same author indicates a length of 22cm at which 50% of the individuals are mature (the distinction between the two sexes is not mentioned).

Spawning occurs in the spring and early summer (May to June according to Desbrosses, 1935) with a spawning peak in June in the northern Bay of Biscay (N'Da & Déniel, 1993).

The genus *Mullus* has the distinguishing feature of presenting a later appearance of a high value of the hepato-somatic ratio than in the majority of fish. This ratio reaches its maximum values at the end or after the laying period (Bougis, 1952). This would be due to liver function which in the red mullet not only accumulates fat but also transforms it. This hepato-somatic relationship can therefore be used as an indicator of maturity and constitute an interesting parameter for observing the end of the laying period.

Growth / longevity: Up until the 2000s, Suquet and Person-Le Ruyet (2001) note that the majority of research on the growth of (striped) red mullet (*Mullus sp*.) was carried out in the Mediterranean with the exception of the work of Desbrosses (1935), Dorel (1986) and N'Da (1992). Subsequently, work on the northern Bay of Biscay and on the English Channel was undertaken (N'Da and Déniel, 2005 and 2006; Mahé et al., 2005; Mahé et al., 2013).

Eggs and larvae average 2.8 mm and are pelagic (Jones, 1972; Russell, 1976). The hatching takes place after three days at 18°C and after eight days at a temperature of 9°C (Quéro & Vayne, 1997). Juveniles are blue in the pelagic phase (Bougis 1952). It is only after metamorphosis that juveniles become first demersal then benthic. At the age of one month, they measure about 5 cm and weigh 0.9 to 1.6 g. The pink color and the physical appearance are then the same as in adulthood. Juveniles, which migrated to coastal and estuarine habitats, showed rapid growth during their first four months of life between July and October in shallow water. Increases in length and mass are about 7 cm and 25 g on average during this period (N'Da & Déniel, 2005). However, the rate of growth declines sharply in October due to the cooling of water and the scarcity of trophic resources in the environment. These conditions contribute to the initiation of migration of red mullets to greater depths offshore. Until the age of two, there is no significant difference in size between males and females; they then measure 20-23 cm.

In terms of body size, sexual dimorphism is observed from the age of first maturity due to growth rates that will then differ between the two sexes. From age three, females exceed males in length by 4 cm on average and 7 cm beyond 5 years (N'Da & Déniel, 2006).

The maximum longevity of the striped red mullet would be 11 years (Quéro & Vayne, 1997; ICES, 2012). The maximum length usually listed is 40 cm (Hureau, 1986; Bauchot, 1987). A maximum length of 44.5 cm is mentioned by Dorel (1986) for the Bay of Biscay. The maximum mass is 1 kg (Muus and Nielsen, 1999).

Feeding: In addition to the tactile function described above, the red mullet's barbels are also equipped with taste receptors allowing them to taste their prey through sand and gravel (Roule & Verrier, 1927). The search for food is mostly diurnal even if the mullet is also active in the late afternoon (De Pirro et al., 1999). Its diet consists largely of molluscs, worms, and small crustaceans. Labropoulou & Eleftheriou (1997) reported that decapoda accounted for 65% and 89% of ingested prey in number and weight, respectively. The proportion of benthic prey increased from 32% of total prey for red mullets of 8 cm in length to 76% in individuals measuring 13 cm. Beyond 13 cm there is no longer any "preferential prey" (Déniel, 1991).

Several species of fish are observed near the feeding red mullets because they take advantage of too small or too mobile invertebrates that escape the red mullet during its excavations. Most of these species belong to the Labridae, Sparidae and other benthic flatfish families.

Analysis of the landings and activity of the French professional fisheries

Detailed description of the landings and the activity carried out by the French professional fisheries.

The description of landings and activity is carried out at with respect to the defined geographical sectors.

Evolution of landings (Fig. 5)

Extraction with selection on geographical sectors 6, 8 et 7a-c, e-k et 9a (West zone), French vessels:

- Fishing trip data (SIH Harmonie database), from 1985 to 2014;
- Sacrois data (SIH Harmonie database), from 2000 to 2015;
- ICES data, from 1950-2010 and from 2006-2014.

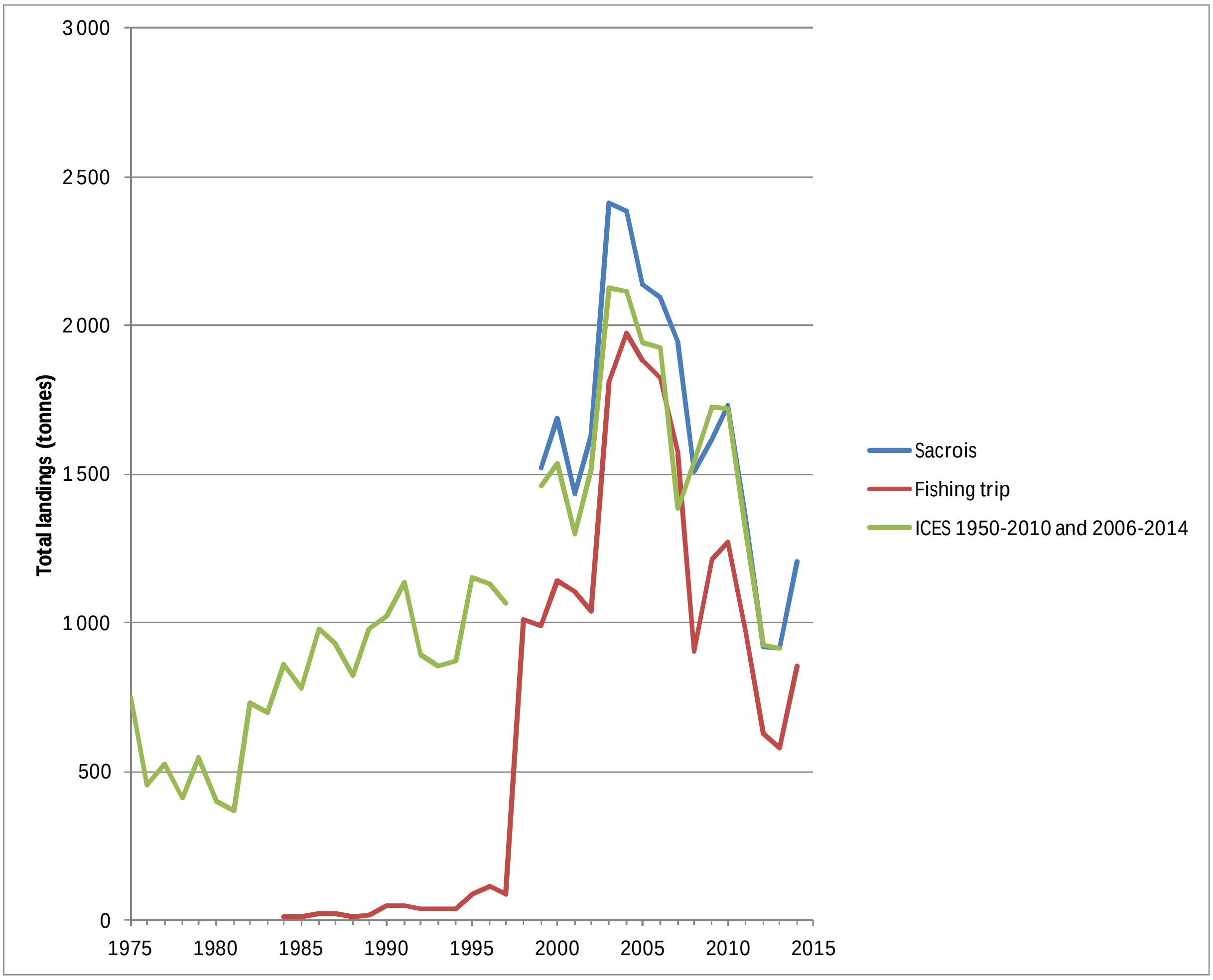


Figure 5– Evolution of total landings from 1975 to 2015 (three data sources used).

For the period from 1975 to 1997, only ICES data are considered to account for the level and evolution of red mullet landings. From 1975 to 1982, landings fluctuated by around 500 tonnes, followed by an increase until 1998 to reach a value close to 1,000 tonnes per year.
1999 was marked by a lack of data for two of the sources. It corresponds to a transition year between two data management systems resulting from the declarative system (Statpêche and Harmonie).
From 2000 to 2003, landings were stable, with high intake from 2004 to 2007-2008, followed by a downward trend. All three data sources show this development; ICES data and Sacrois data stand at some 900 tonnes in 2014, the fishing trip data at some 580 tons. Although the 2015 data

may still be subject to correction, an increase in intakes is observed for the two sources available to date (Fishing trips and Sacrois).
Rq: for 2014, ICES data are the Sacrois data transmitted by Ifremer (via the Crédo cell), hence the concordance of these two data sources.

In view of these graphs, the Sacrois data appear to be the most complete from 2000 onwards. They also make it possible to present the landing data at a precise level in terms of métier or fishing gear, that is to say at DCF level 6, required by ICES. For fishing trip data, communication with ADMINSIH confirmed that the data prior to 2000 raise questions about their completeness for this species and work is under way on the subject. Under these conditions, in the remainder of this document, the SACROIS source is favoured for data after 2000.

Gear used

Extraction with selection on geographical sectors 6, 8 and 7a-c, e-k and 9a (West zone), French ships:

- Sacrois data (SIH Harmonie database), 2000 to 2015.

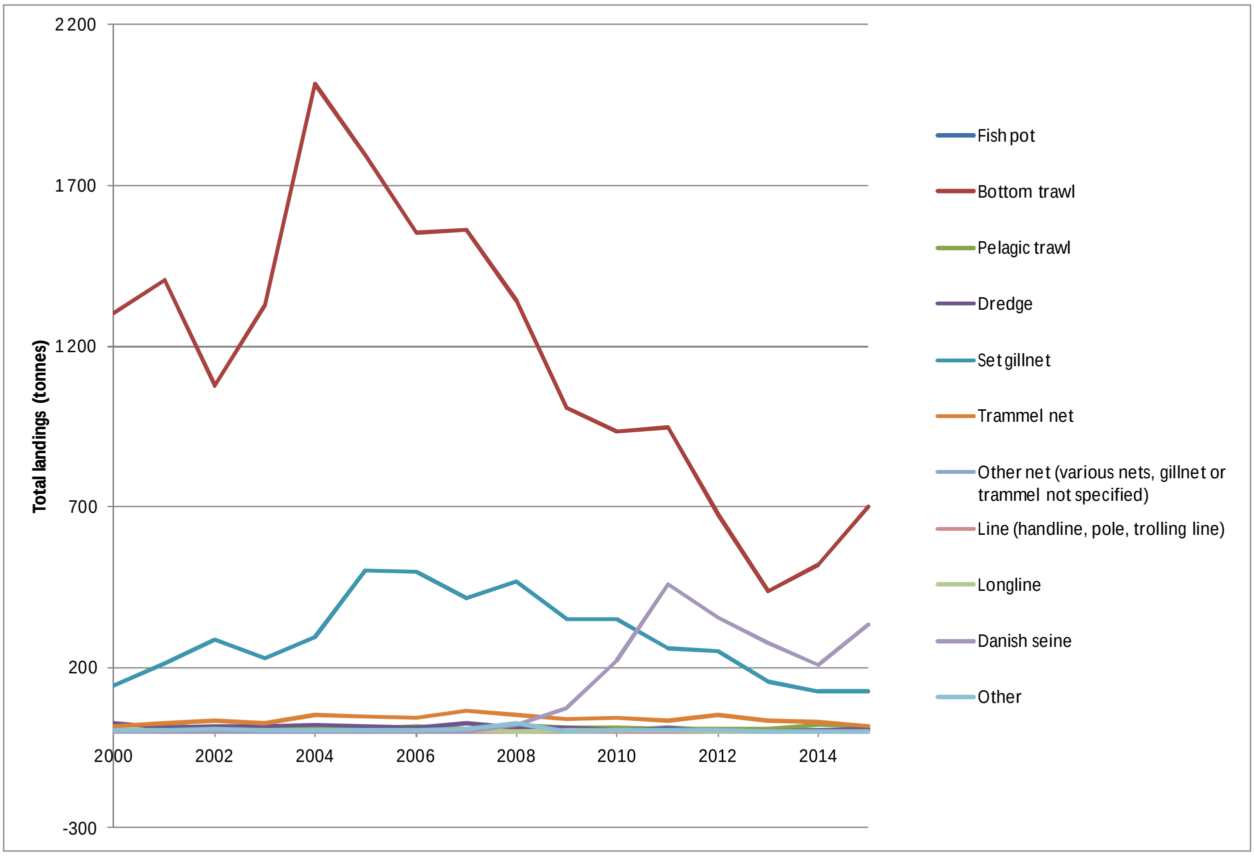


Figure 6 - Evolution of total landings from 2000 to 2015 by gear (Sacrois data). Gear representing less than 0.5 tonnes per year over the period is not specified but grouped under "other".

Around twenty five different gear codes are listed as having allowed the capture of striped red mullet between 2000 and 2015 (Figure 6, full list in Annex 1). However, inputs are largely dominated by bottom trawls, gillnets and seines (Danish). These three combinations of gear accounted for 98% of the landings (for which a gear is specified) over the period (Figure 7).

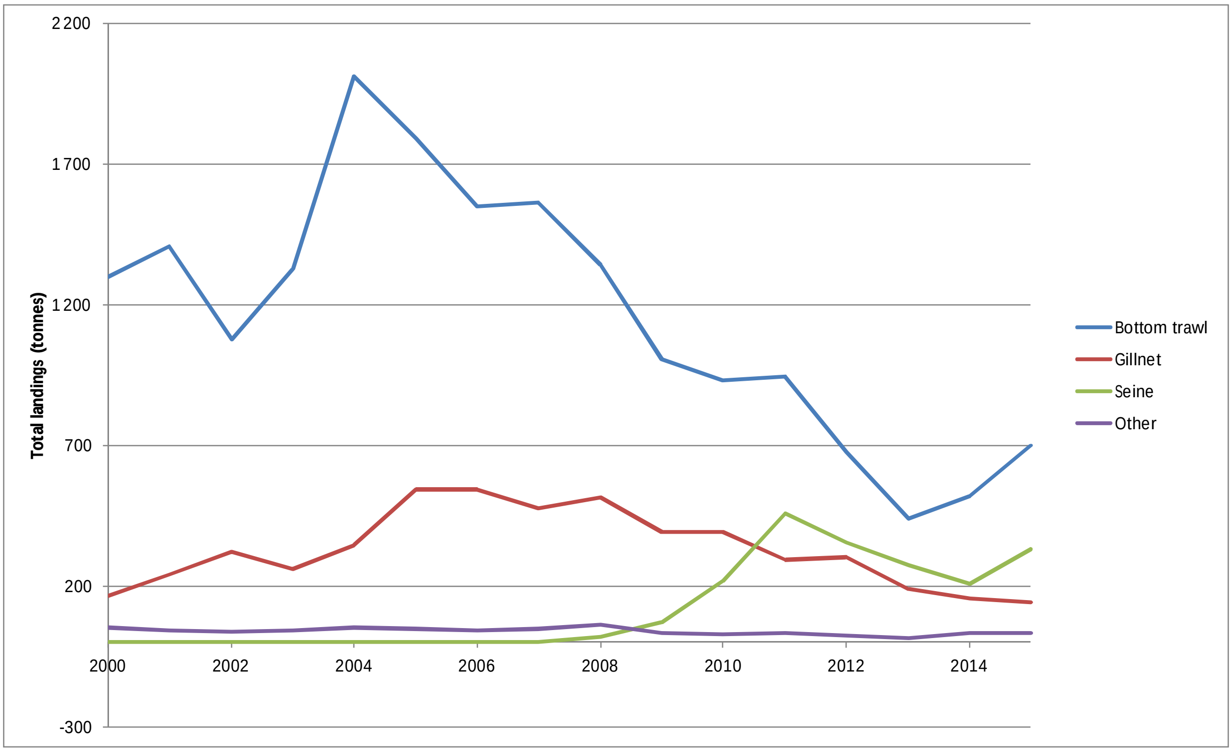


Figure 7 – Evolution of the total landings from 2000 to 2015 by groups of gear (Sacrois data).

Bottom trawls are basically single-vessel otter trawls and otter twin trawls. Trawls were largely predominant until the mid-2000s. A decline in the landings made with this gear had been observed in recent years before a slight recovery since 2014. It now accounts for about half of French ships' red mullet landings.
For gillnets, set gillnets (anchored) make up the majority of this category with, to a lesser extent, trammel nets. During the period under review, the highest net intake was observed between 2005 and 2010 ("plateau").
For Danish seines, landings are recorded from 2008 onwards (for detailed information about this technique and its recent appearance in the Bay of Biscay, see Annex 2). An input peak can be observed in 2011-2012 with this technique and then a decrease until 2014, before a recovery in 2015. Since 2011, these landings are still higher than those made with nets.

At the "métiers DCF level 6", 284 métiers (combination of gear, targeted assemblage species, meshes) are listed as contributing to the landings of red mullet over the 2000-2015 period. The métiers that contributed more than 90% of the annual intake of red mullet were identified. Each year, and over the period 2000-2015, the number is between 17 and 23. The table 2 summarizes the characteristics of "métiers (gear, targeted assemblage species) / mesh".
Over the 2000-2015 period, red mullet intake with set gillnets targeting demersal fishes are mainly made with mesh sizes 60-79 and greater than 100 mm. With trammel nets targeting demersal fishes, the mesh is greater than 100 mm.
For bottom trawls with panels, red mullet intake is mainly carried out by trawls targeting cephalopod assemblages and demersal fish. The meshes are generally greater than 70 mm (of which 70-99 mm).
For otter twin trawls, red mullet landing come from trawls targeting cephalopod assemblages, crustaceans and demersal fish. Mesh greater than 70 mm width is the most present one.
For the Danish seine, red mullet landing come from seines targeting cephalopod assemblages and demersal fish. Here again, the most present mesh is that greater than 70 mm.

Table 2: Mesh characteristics of the métiers (gear/targeted assemblage species) retained for having contributed to the landings of red mullet over the 2000-2015 period (criterion of selection: métiers DCF level 6 having contributed to more than 90% of the annual intake of red mullet).

Gears	Targeted assemblages species	Meshes	Most common meshes, remarks
Set gillnets	Demersal fishes	10-30, 0-40, 50-59, 50-70, 60-79, >= 100, all	60-79, >= 100
Trammel nets	Demersal fishes	>= 100, all	>= 100
Bottom otter trawls	Cephalopods	32-54, 32-69, 55-69, 70-99, 100-119, >= 70, all	70-99, >= 70
	Crustaceans	>= 70, all	>= 70
	Demersal fishes	32-54, 32-69, 55-69, 70-99, 100-119, >= 70, all	70-99, >= 70
Otter twin trawls	Cephalopods	70-99, >= 70	>= 70
	Crustaceans	55-69, >= 70, all	>= 70
	Demersal fishes	70-99, 100-119, >= 70	>= 70
Purse seines	Demersal fishes	70-99	Only for 2008. Corresponds probably to Danish seine
Midwater pair trawls	Cephalopods	>= 70	Only for 2014 and 2015
	Demersal fishes	>= 70	Only for 2014
Danish seines	Cephalopods	100-119, >= 70, all	>= 70, short series
	Demersal fishes	70-99, 100-119, >= 70, all	>= 70, short series

In the recent period, the main level 6 DCF métiers are the Danish seine with demersal fish and the bottom otter trawl with cephalopod and demersal fish. This is followed by the otter twin trawl with demersal fish and the Danish seine with cephalopods. For all these métiers, the mesh size is greater than 70 mm.

Geographical distribution

Extraction with selection on geographical sectors VI, VIII et VIIa-c, e-k et IXa (West zone), French vessels:

- Sacrois data (SIH Harmonie database), 2000 to 2015.

Criteria for spatial clustering in large areas:

- VI (VIa and b): West Scotland;
- VIII (VIIIa, b, d and e): Bay of Biscay (Biscay zone because VIIIe included and is far off shore);
- VIIa-c, e-k : South component of Celtic Sea including West Channel or South Celtic Sea including West Channel;
- VIIIc et IXa (West zone): Atlantic Iberian waters including Portuguese waters.

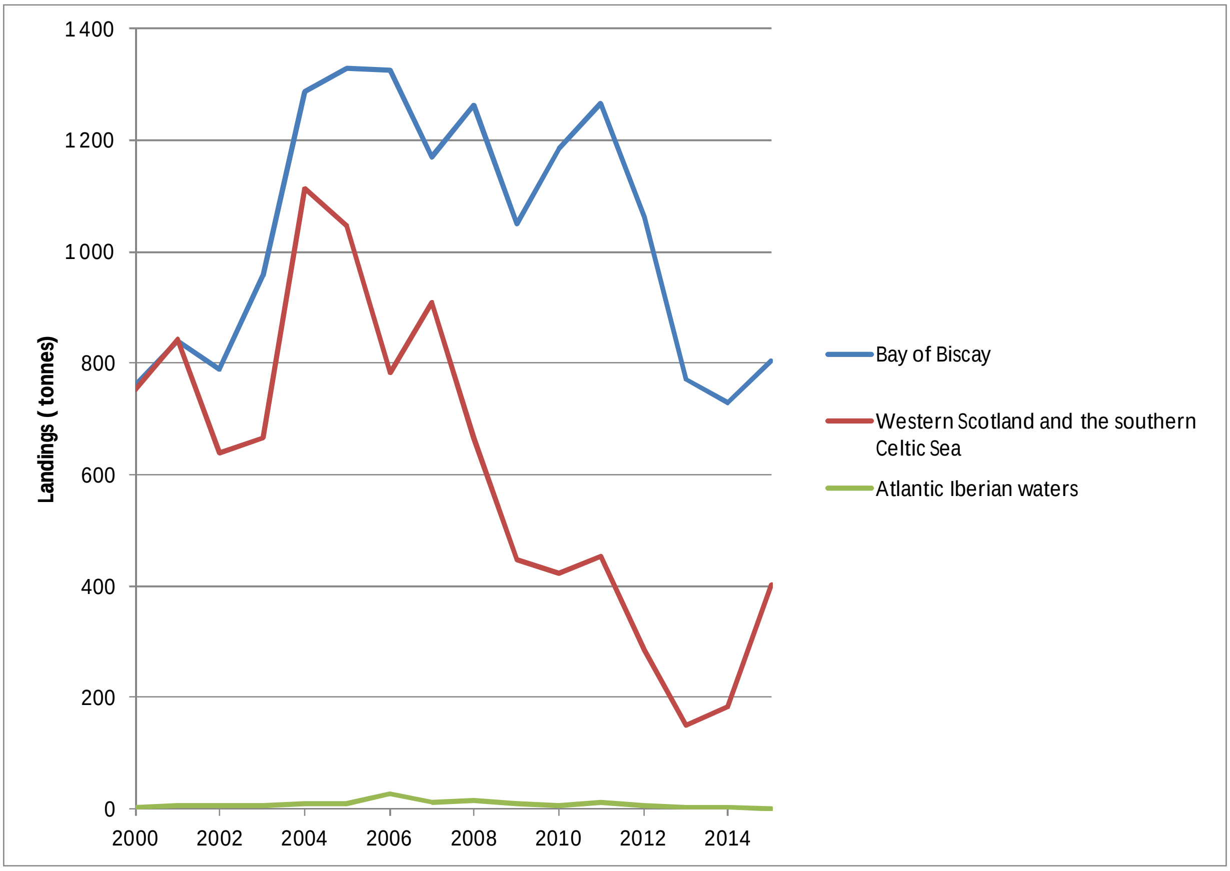


Figure 8 - Origin of the red mullet intake.

Between 2000 and 2004, landing from western Scotland and the southern Celtic Sea on the one hand and the Bay of Biscay on the other hand were substantially equivalent. Since 2005, the scales have tipped towards the Bay of Biscay. Since 2009 it has occupied a predominant position, accounting for between 67% and 84% of the total intake considered. However, it should be noted that the contribution from western Scotland seems to be recovering in 2015 (Figure 8). French intake from Atlantic Iberian waters are very restricted (maximum of 27 tonnes per year); it concerns Spanish waters.

Within the Bay of Biscay, ICES Subarea VIIIa contributes 61 to 83% of landings over time (Figure 9). Since 2011, there has been a decrease in its intake. ICES sub-area VIIIb is in second place with an annual contribution of between 153 and 375 tonnes.

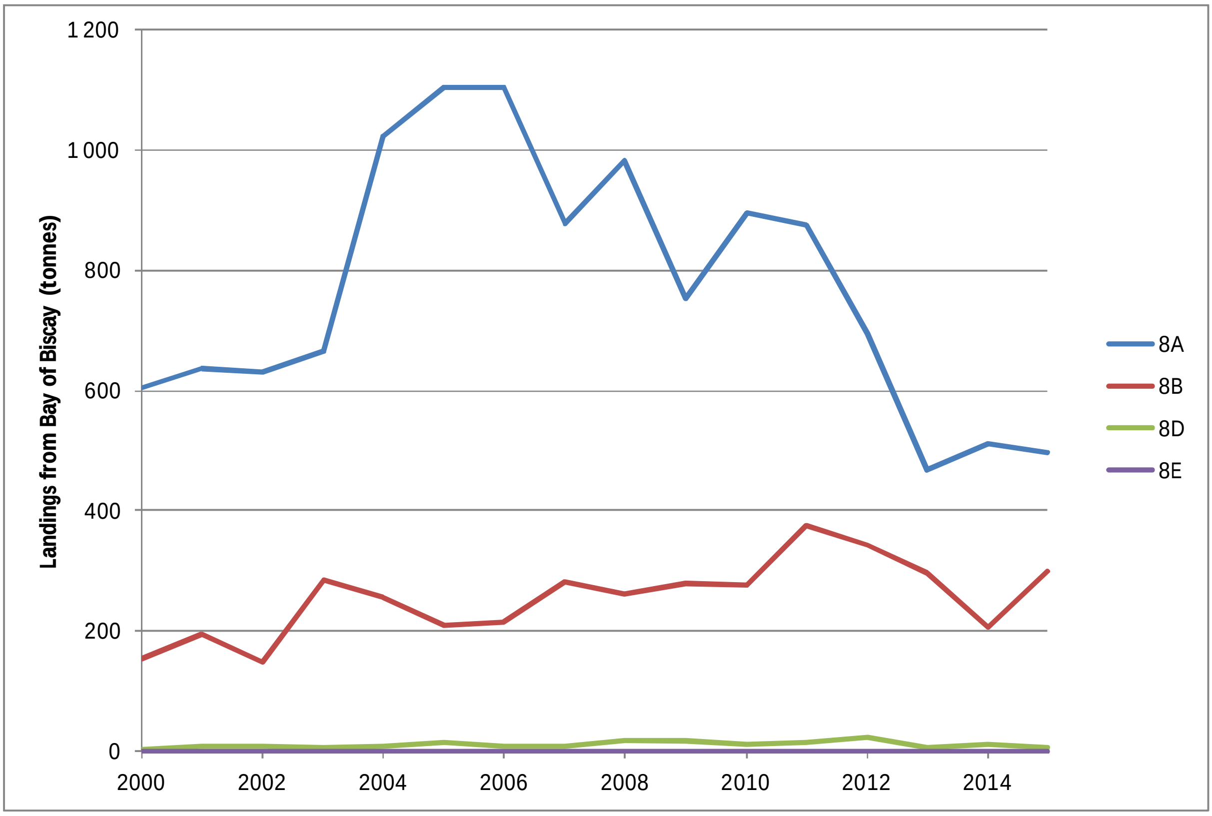


Figure 9 - Origin of the red mullet intake from the Bay of Biscay.

The breakdown of the intakes of all métiers (cumulative 2000 to 2015) by statistical rectangle is presented in Figure 10. A presentation for the three main "métiers" is given in Figure 11 (a, b, c).

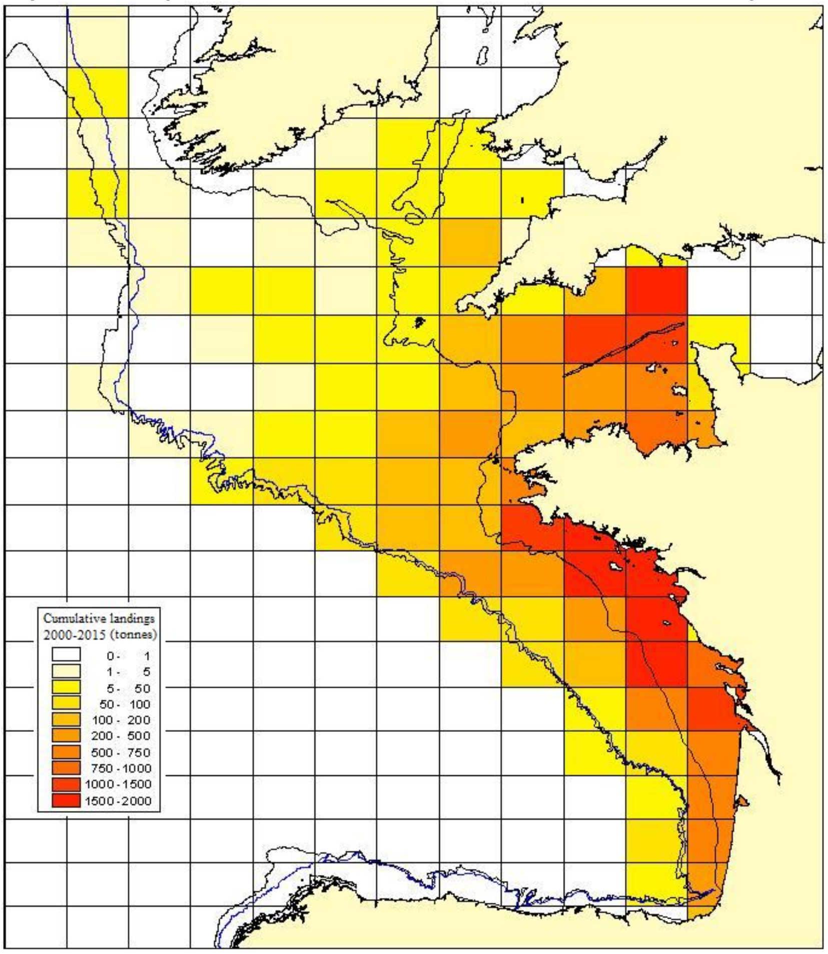


Figure 10 - Cumulative landings of red mullet from 2000 to 2015 by statistical rectangle.

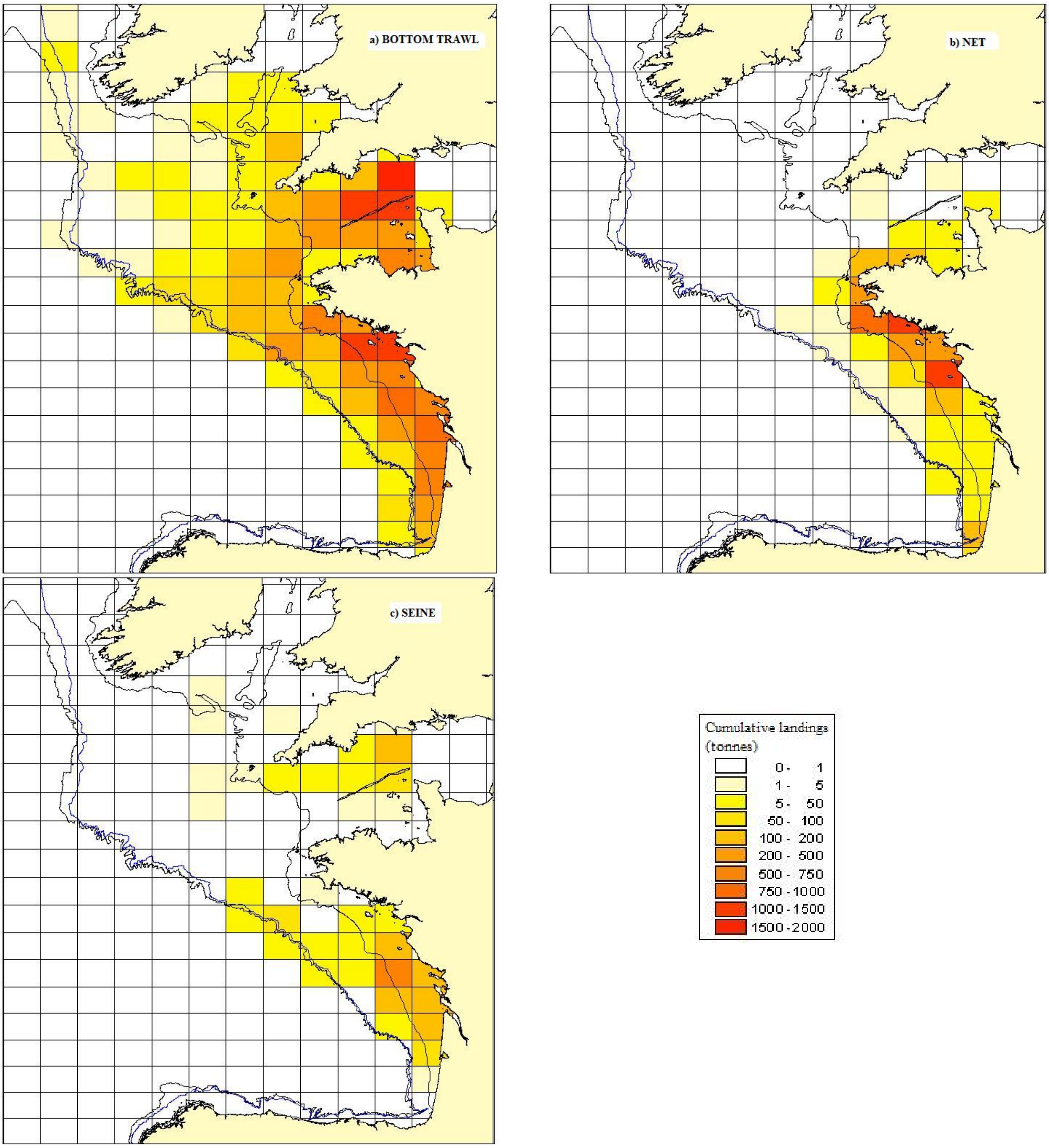


Figure 11 - Spatial distribution of the catches of the three main métiers (cumulative landings 2000-2015).

Evolution of each métier's catches by statistical rectangle (cumulative 2000-2015)

In Figure 12 and for the Bay of Biscay (a), coastal statistical rectangles (indicated by a ▲) appear to be the ones with the largest catches during the 2000-2015 period. Rectangle 21E7 and to a lesser extent 20E7 also appear as rectangles contributing strongly to the intakes. For the Celtic plateau (Figure 12 b), the rectangles contributing the most to the intakes are: 29E7, 28E7, 28E6 and 26E7. For this zone, a slight recovery appears to have begun to take shape in 2015 after a clear downwards trend had been observed over the last decade.

Figure 13 (a and b) illustrates the catch seasonality differences (monthly cumulative 2000-2015) from one rectangle to another.

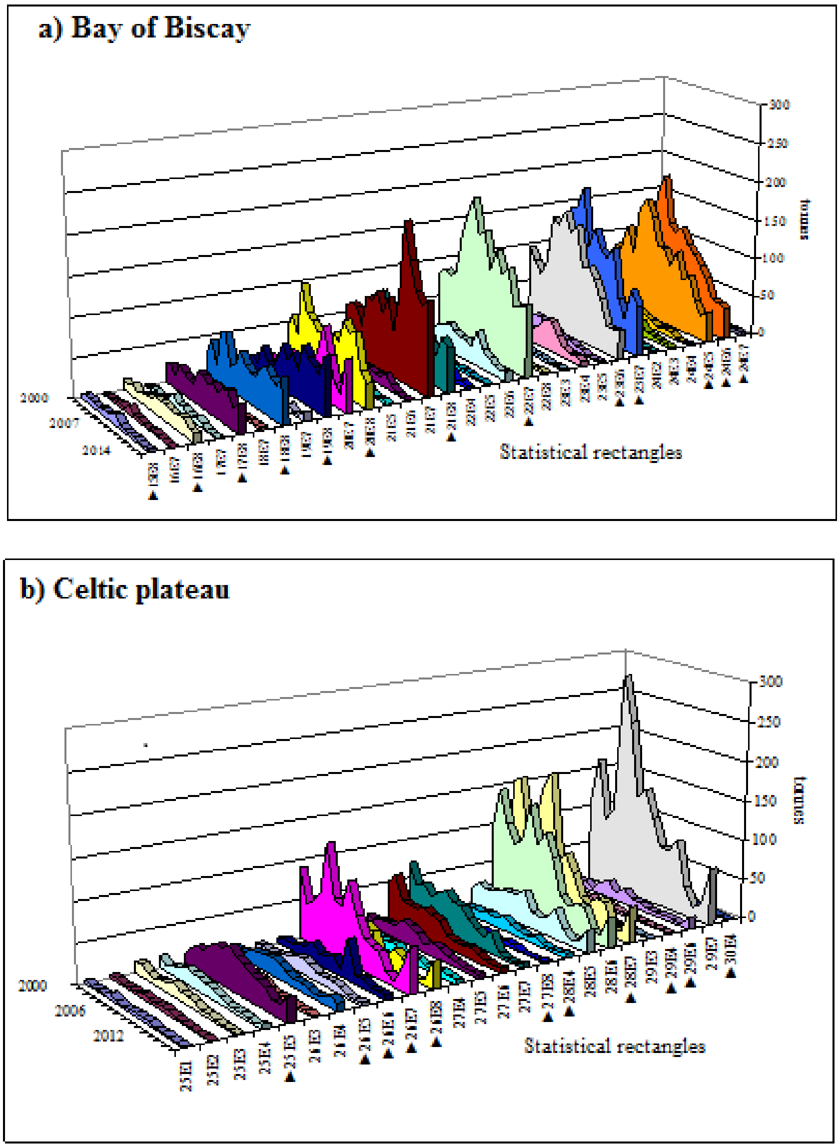
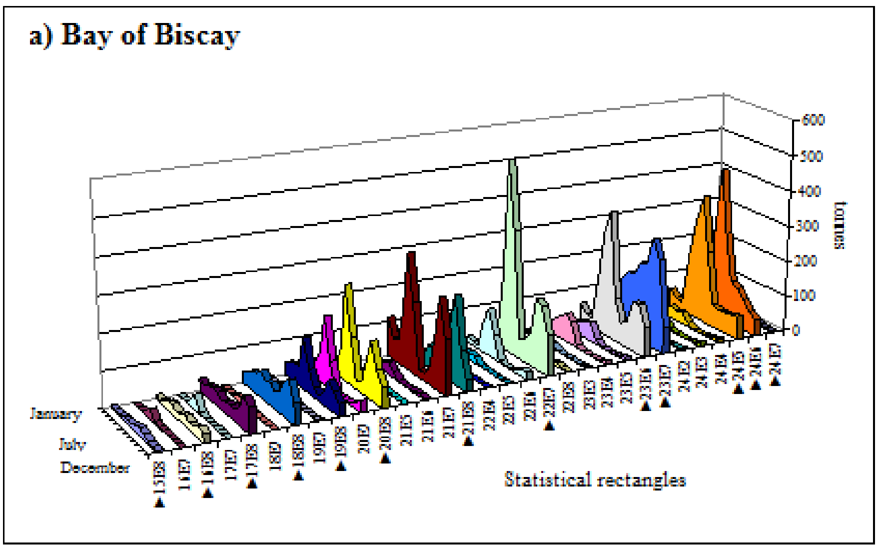


Figure 12 - Evolution of catches (in tonnes) per statistical rectangle of all red mullet landing (all gears) from 2000 to 2015.



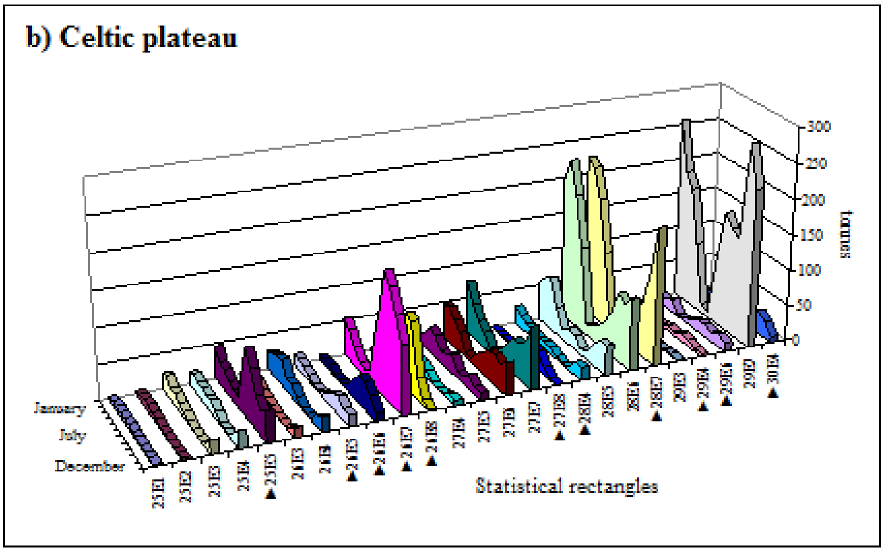


Figure 13 - Monthly change in catches (in tonnes) per statistical rectangle of all red mullet landing (all gears) (cumulative 2000-2015).

Monthly evolution of landings by group of gears (2000-2015 period) and per statistical rectangle (Bay of Biscay and Celtic plateau) are detailed in Annex 3.

Importance and evolution of landings according to the ports of registration of ships
Extraction with selection on geographical sectors VI, VIII and VIIa-c, e-k and IXa (West zone), French vessels:
- Sacrois data (SIH Harmonie database), 2000 to 2015. Data regarding port registration extracted from the Harmony ship files from 2000 to 2015 (date of extraction 07/06/2016).

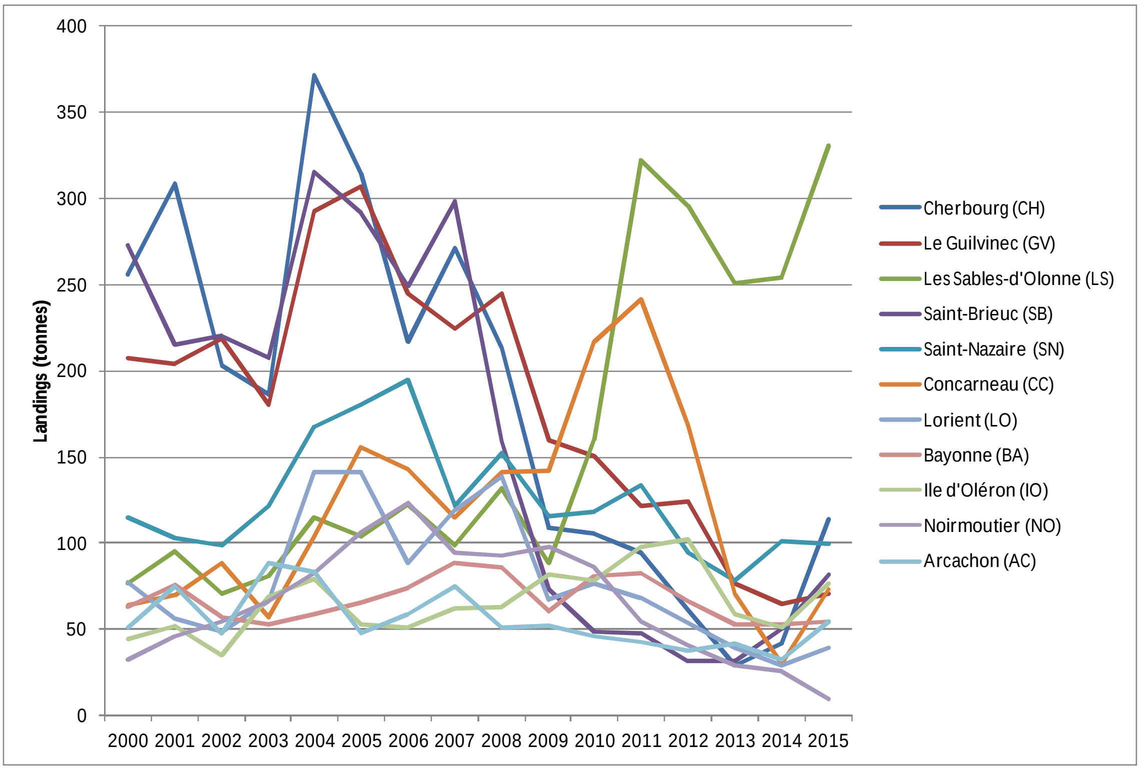


Figure 14 - Evolution of red mullet landings (in tonnes) according to the port of registration of the vessels. Only the main districts are represented (they represent three-quarters of the cumulative contributions over the 2000-2015 period).

During the period under consideration, seventy-five per cent of the landings were made by vessels registered in Cherbourg, Guilvinec, Sables d'Olonne, Saint-Brieuc, Saint-Nazaire, Concarneau, Lorient, Bayonne, Island of Oléron, Noirmoutier and Arcachon (Figure 14).

In the first half of the period, between 33 and 48% of the landings came from ships registered in Cherbourg, Saint-Brieuc and Guilvinec. These contributions have decreased sharply since 2009. The Concarneau vessels experienced a landing peak between 2010 and 2012, but since 2011, landings made by vessels from Les Sables d'Olonne have been largely predominant.

Figure 15 shows very clearly that the registration area of the vessel affects the fishing zone of red mullet (threshold of representation:> 20 tonnes cumulated over the 2000-2015 period). The vessels registered in the ports located north of Audierne capture red mullet almost exclusively in West Scotland and in the southern Celtic Sea while those of the south work in the Bay of Biscay. Only Le Guilvinec and to a lesser extent Concarneau show a mixed distribution but in favor of the Gulf.

Rq: It is understood that attention is paid to the catches for the geographical area defined by ICES for the so-called "South" unit of the European northern red mullet stocks. Vessels, especially those north of Audierne, can also exploit the red mullet of the so-called "North" unit.

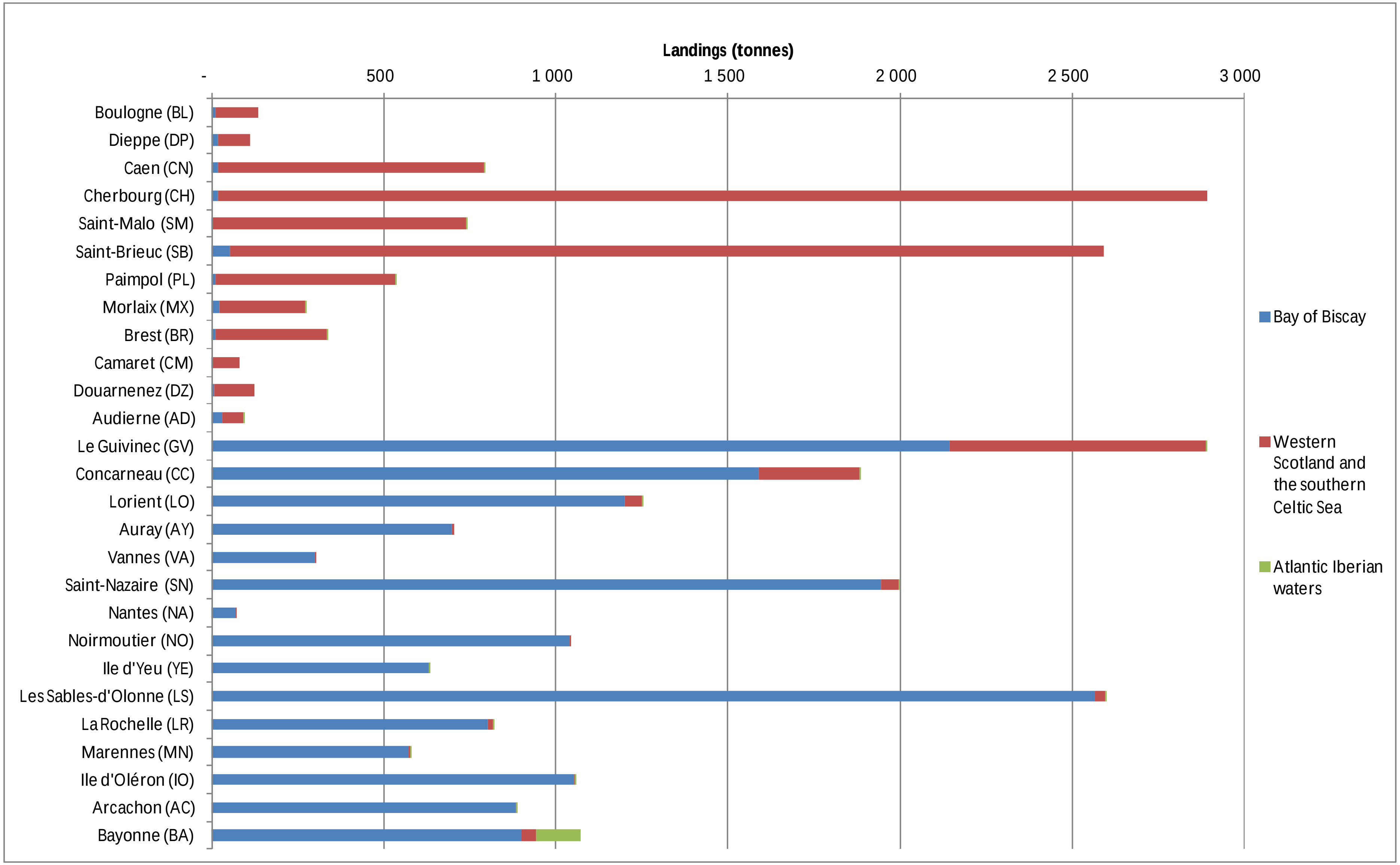


Figure 15 – Red mullet landings (in tonnes, cumulated over 2000-2015) per large fishing zone according to vessels' port of registration. Landings representing less than 20 tonnes cumulated over the 2000-2015 period are not presented.

The breakdown of catches by port of registration and by group of gears (Figure 16) also shows different operating systems between ships registered north or south of Audierne.

Thus north of Audierne:

- from Boulogne to Saint-Brieuc, the contribution of bottom trawls is largely dominant;

- Paimpol and Morlaix display catches by trawls but also gillnets;

- from Brest to Audierne, the exploitation of the red mullet is practically exclusively with gillnets.

South of Audierne:

- from Guilvinec to Les Sables d'Olonne, the landings come from at least two groups of gear per port except Vannes and Ile d'Yeu which are very specialized in nets and trawls for Saint-Nazaire. Catches by seine are carried out by the vessels from Concarneau and Les Sables d'Olonne;

- from La Rochelle to Bayonne, trawls contribute mainly to the intake of red mullet. The district of Bayonne stands out with the presence of contributions from nets too.

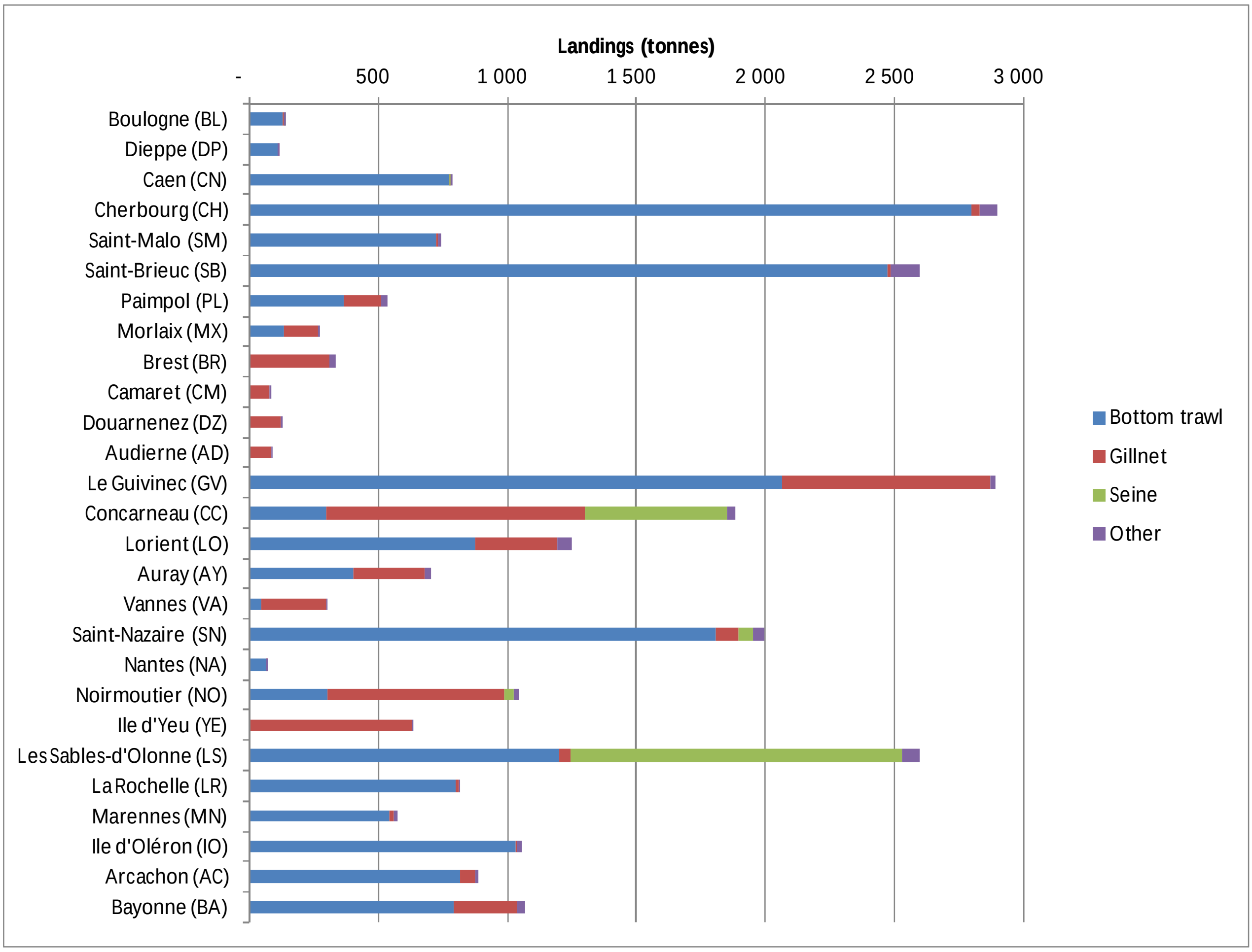


Figure 16 - Red mullet landings (in tonnes, cumulated over 2000-2015) by grouped gear according to the vessels' port of registration. Registrations representing less than 20 tonnes cumulated over the period 2000-2015 are not presented.

In view of these operating differences linked to the vessel's registration, the evolution of landings by group of gears between 2000 and 2015 is seen in the following section in a globalized manner and then distinguishing the ports situated to the north and south of Audierne.

Characteristics of red mullet landing vessels (between 2000 and 2015)

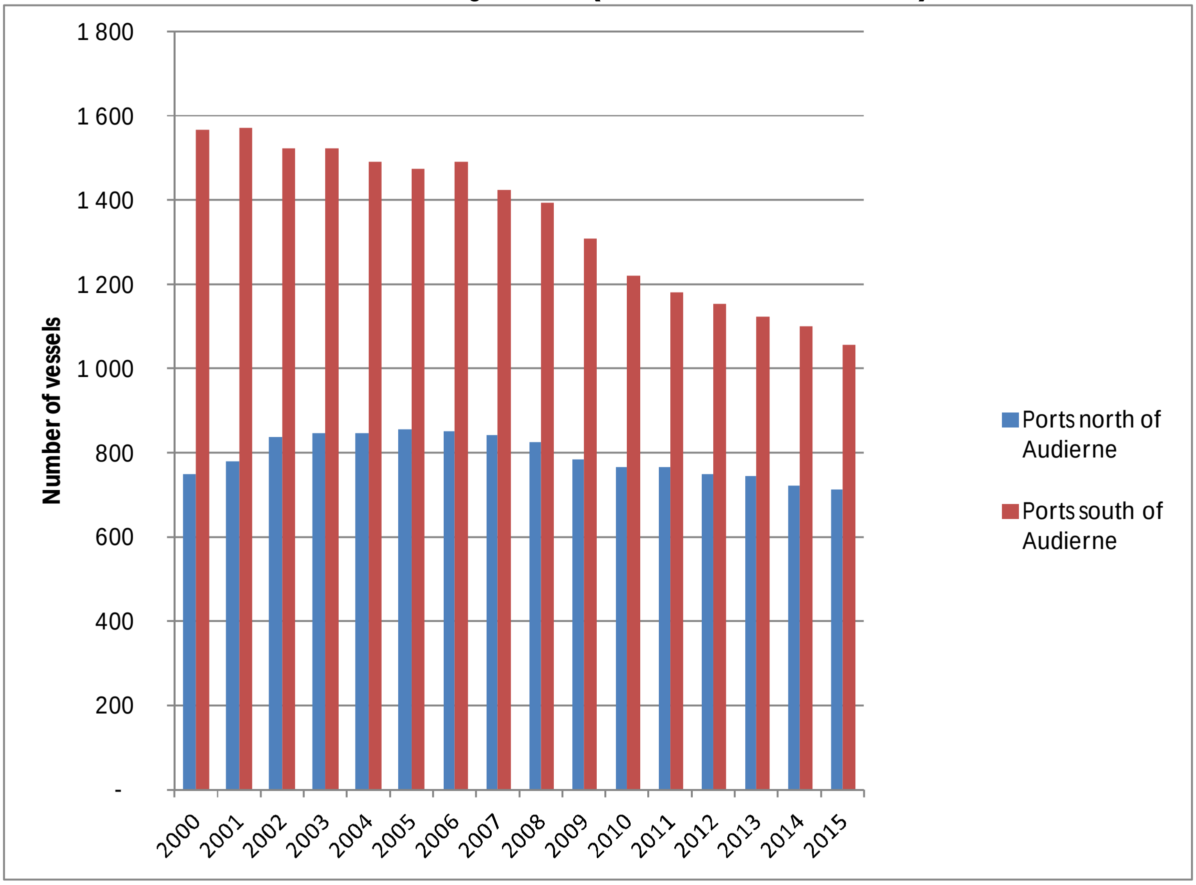


Figure 17 - Evolution of the annual number of vessels that landed red mullet between 2000 and 2015.

Between 2000-2015, between 1,796 and 2,380 vessels landed red mullet each year (Figure 17). A general decrease in the number of vessels has been observed in recent years. In more detail, this decrease affects vessels registered in ports south of Audierne, while those registered in ports north of Audierne have a more stable headcount.

The average characteristics of vessels in fleets that caught red mullet from 2000 to 2015 are: 41.1 GRT, 191.1kW engine power, 12.9 m length and 22 years of service.
In more detail of the three gear groups selected (Table 3), net vessels are made up of the smallest units (85% are less than 12 m long), while 52% of bottom trawlers are less than 15 m; the seiners are by far the largest and the oldest[1].

Table 3 - Average vessel characteristics landing red mullet by main métier

Group of gears	**Number of vessels**	**Gauge (tjb)**	**Engine power (kW)**	**Length (m)**	**Years of service**
Bottom trawl	786 *(110)*	63,6 *(4,0)*	261,3 *(6,7)*	15,8 *(0,3)*	22 *(2)*
Net	516 *(42)*	19,2 *(1,7)*	127,1 *(4,6)*	10,4 *(0,2)*	22 *(3)*
Seine	5 *(6)* 10 *(4)* sur 2008-2015	186,3 *(23,7)*	495,2 *(28,0)*	25,7 *(2,2)*	17 *(2)*
Total	**2 158** ***(215)***	**41,1** ***(67,4)***	**191,1** ***(156,3)***	**12,9** ***(5,9)***	**22 ans** ***(10)***

(Standard deviations in brackets and in italics)

[1] The same vessel is accounted for several times if it operates several gear combinations (eg bottom trawl and gillnet in the same year).

Figure 18 illustrates the evolution of the number of vessels using the three main groups of gears and that of the catches made with these groups.

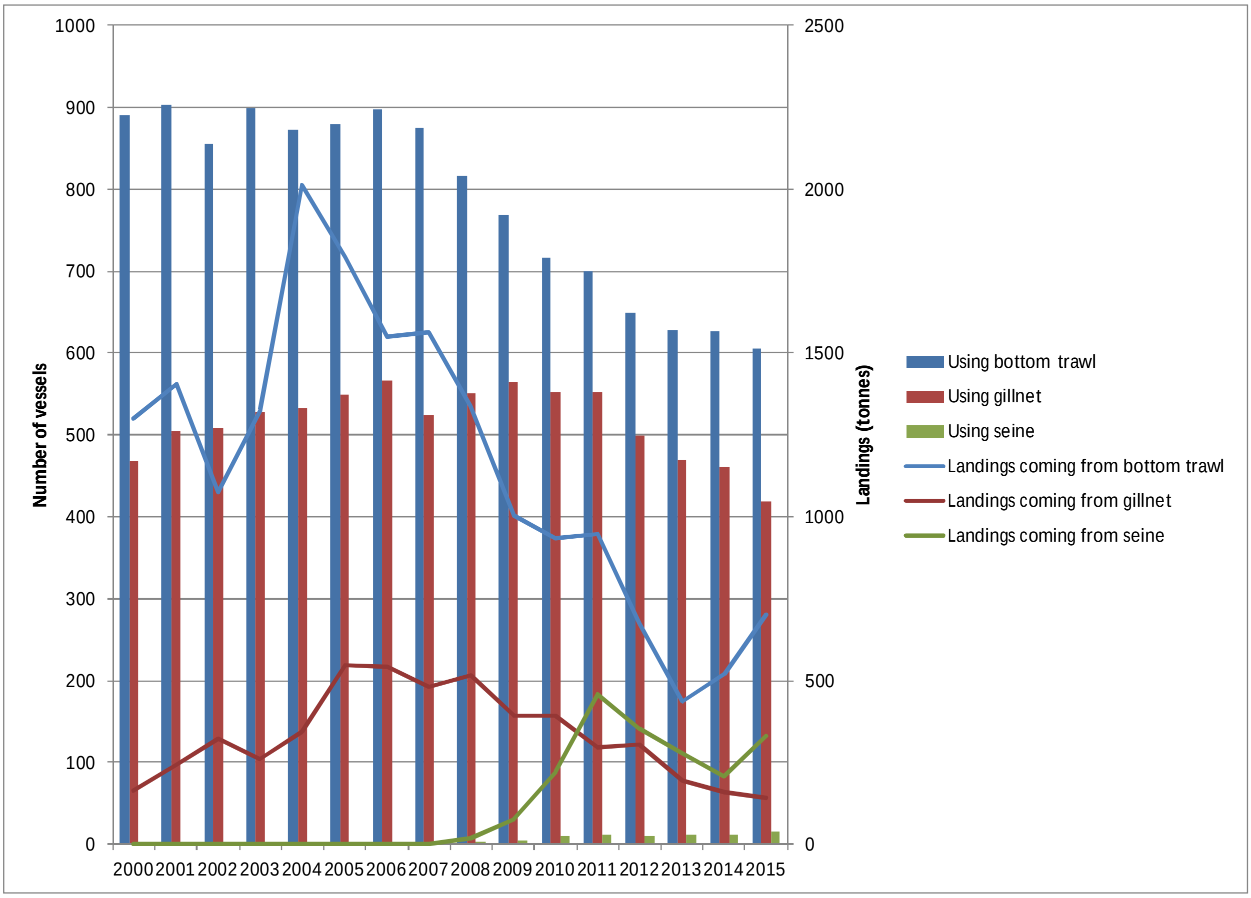


Figure 18 - Evolution of the number of vessels using the three main groups of gears and that of the catches made with these same groups

For bottom trawl and for gillnet, the monthly and the annual evolutions of the number of vessels by length (2000-2015 period) are given in Annex 4 and Annex 5.

The dependence of vessels expressed in red mullet weight relative to the total weight of the catches is limited since most of the observations are between 0 and 2.5% (Figure 19). For ships registered in ports on the Atlantic coast, red mullet represents on average 2% (standard deviation 6) of the annual landings in weight and 4% (standard deviation 10) of the annual landings in values. These dependency averages have significant differences if the location of the registration area is considered. These results show a greater reliance on red mullet (both weight and value) for vessels registered in the Bay of Biscay ports than for those registered in northern ports.

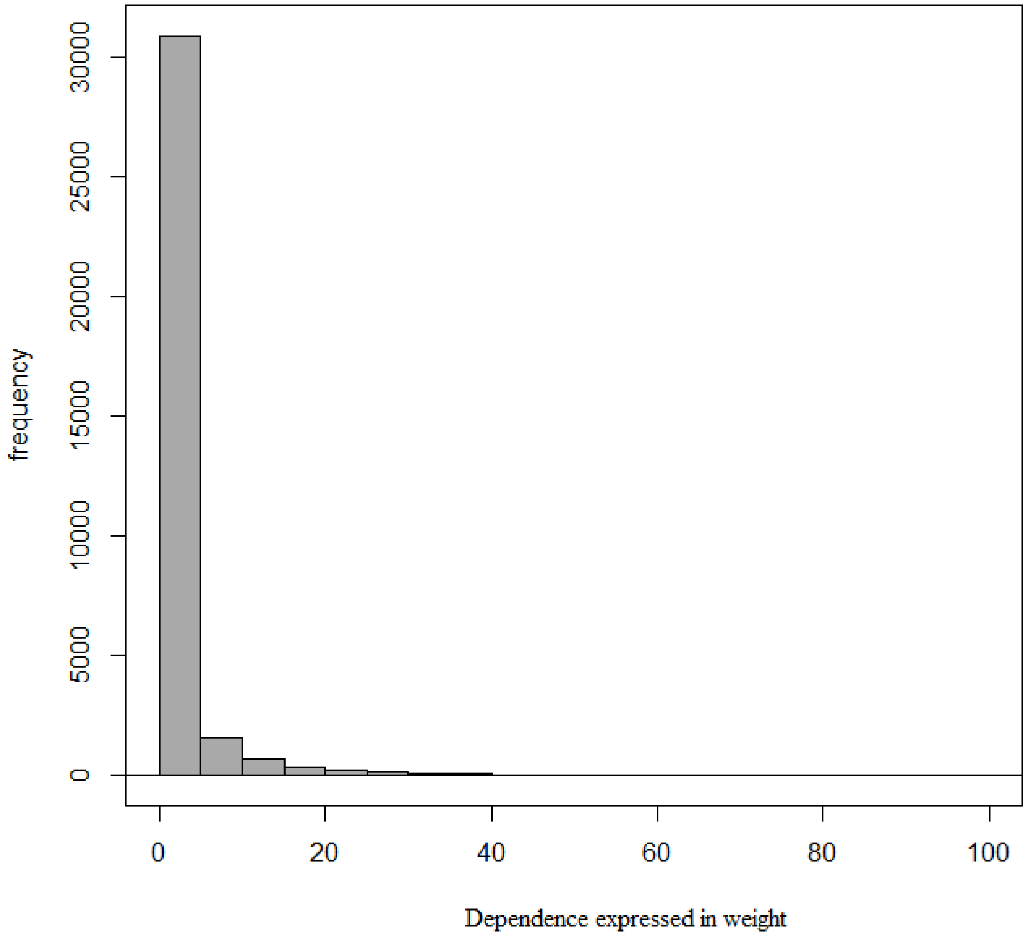


Figure 19 - Distribution of dependence on red mullet by weight over the 2000-2015 period.

Acknowledgments

This work is part of the ROMELIGO project that has been funded by FFP (France Filière Pêche) on the thematic focus - acquisition of knowledge on the fishery resources.

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ANNEX 1 - Striped red mullet: Landings by gear and combined gear (2000-2015)

FRENCH GEAR NAME	GEARS FAO	Combined gear	Landing weight(t)	%
Single boat bottom otter trawls	OTB	BT	14214.1	53.7
Set gillnets (anchored)	GNS	GE	4664.3	17.6
Twin bottom otter trawls	OTT	BT	4252.8	16.1
Danish seine	SDN	SE	1943.2	7.3
Trammel nets	GTR	GE	609.9	2.3
Towed dredges	DRB	OT	196.4	0.7
Midwater pair trawls	PTM	PT	178.4	0.7
Bottom pair trawls	PTB	BT	89.3	0.3
Pots	FPO	PO	75.7	0.3
Purse seines	PS_	SE	41.2	0.2
Single boat midwater otter trawls	OTM	PT	36.6	0.1
Set longlines	LLS	HL	30.4	0.1
Beam trawls	TBB	OT	29.6	0.1
Drift gillnets	GND	GE	15.4	0.1
Handlines and hand-operated pole-and-lines	LHP	HL	14.3	0.1
Drifting longlines	LLD	HL	4.7	0.0
Trolling lines	LTL	HL	3.3	0.0
Gear nei	MIS	OTH	2.1	0.0
Combined gillnets-trammel nets	GTN	GE	2.0	0.0
Encircling gillnets	GNC	GE	1.4	0.0
Fyke nets	FYK	OP	0.9	0.0
Beach fishing	FOO	OTH	0.8	0.0
Mechanized lines and pole-and-lines	LHM	HL	0.3	0.0
Lift nets (nei)	LN_	OP	0.0	0.0
Others		OTH	40.6	0.2
TOTAL (t)			**26447.38**	**100.0**

Combined gear	Landing weight(t)	%
BT	18556.2	70.2
GE	5292.9	20.0
SE	1984.4	7.5
OT	226.0	0.9
PT	214.9	0.8
PO	75.7	0.3
HL	53.0	0.2
OTH	43.4	0.2
OP	0.9	0.0
TOTAL (t)	**26447.4**	**100.0**

BT	Bottom trawls
PT	Pelagic trawls
GE	Gillnets and entangling nets
HL	Hooks and lines
SE	Seines
PO	Pots
OT	Other towed gears
OP	Other passive gears
OTH	Others

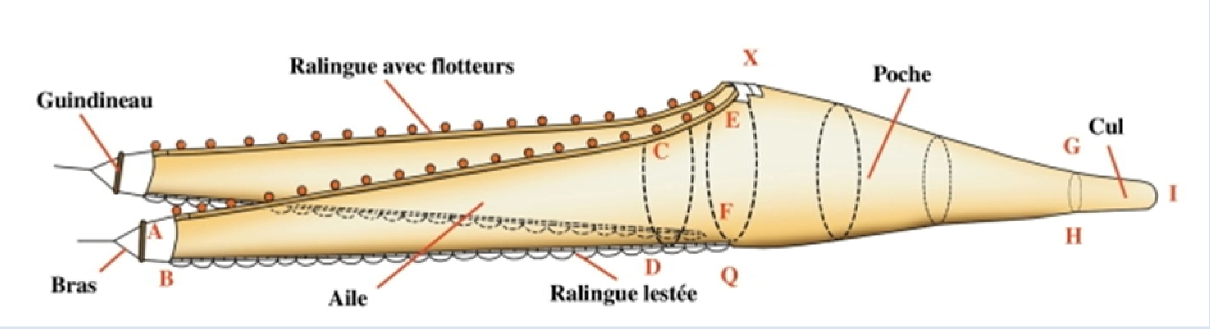
ANNEX 2 - Danish seine: description of the technique and its recent appearance in the Bay of Biscay.

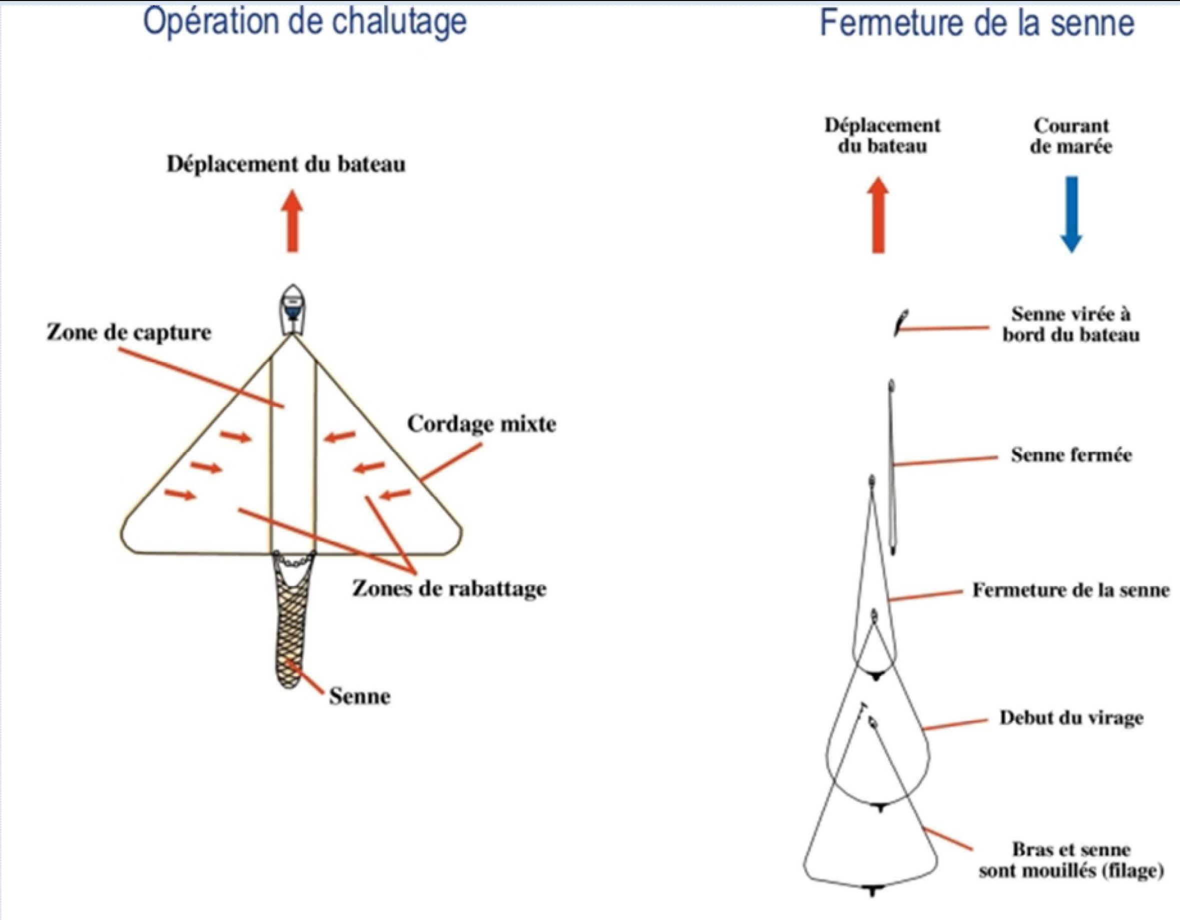
"Appearance of the Danish seine in the Bay of Biscay"

The sharp increase in the price of diesel oil in the 2000s has economically weakened the fishing fleets that used dragging techniques requiring energy-intensive engines (Planchot and Daurès, 2008). In response to this, some fishing companies in the Bay of Biscay have adapted by abandoning trawls and implementing Danish seines from 2007. Its introduction was controversial and caused tension between fishermen notably because of problems of cohabitation with the others because of its necessary deployment over a large area. This technique originates from Nordic countries and is now used in French waters, particularly in the Pays de Loire, by a dozen ships.

"The Danish or Scottish seines are nets formed by two wings, a body and a pocket, whose general design resembles in many respects that of the trawl; this similarity explains why seines are deemed to be a type of trawl according to official regulations. At each end of the wing a cable is attached. The vertical opening is ensured by floats on the headrope and by selvedge weighted in the lower part. The cables or warps ensure that the fish is herded towards the opening of the net. A buoy is lowered into the water and then the first warp is deployed, the end of which is connected to the buoy. The boat runs through a triangle or a square (in France) and the net is launched in the middle of the base of the triangle, or in the opposite corner of the square with respect to the buoy. The second warp closes the device and when the buoy is attached, the hauling itself begins with the vessel stopped (Danish seine) or sailing slowly (Scottish seine). During the hauling, the triangle formed during the shooting process is closed and the movement of the warps bends the fish towards the net until it is completely closed and the gear is back on board.

The fishing operation is usually shorter than the average trawl haul (about an hour and a half) and if the net itself moves relatively little (at the top of the triangle for the Danish seine and slightly more movement for the Scottish seine) the "exploited surface" is greater during an operation than that of an equivalent bottom trawl; this is essentially the result of the sweeping and herding motion of the warps. The surface swept for the same duration is of the order of two for the Scottish seine. However, unlike bottom trawling, the practice of the Danish or Scottish seine is carried out only by day (due to the behavior of the fish in relation to the gear) and on fairly calm seas. On a one-year scale, it is likely that the total surface area swept by a vessel using these gears does not differ significantly from those swept by a bottom trawler "(Biseau et al., 2016).





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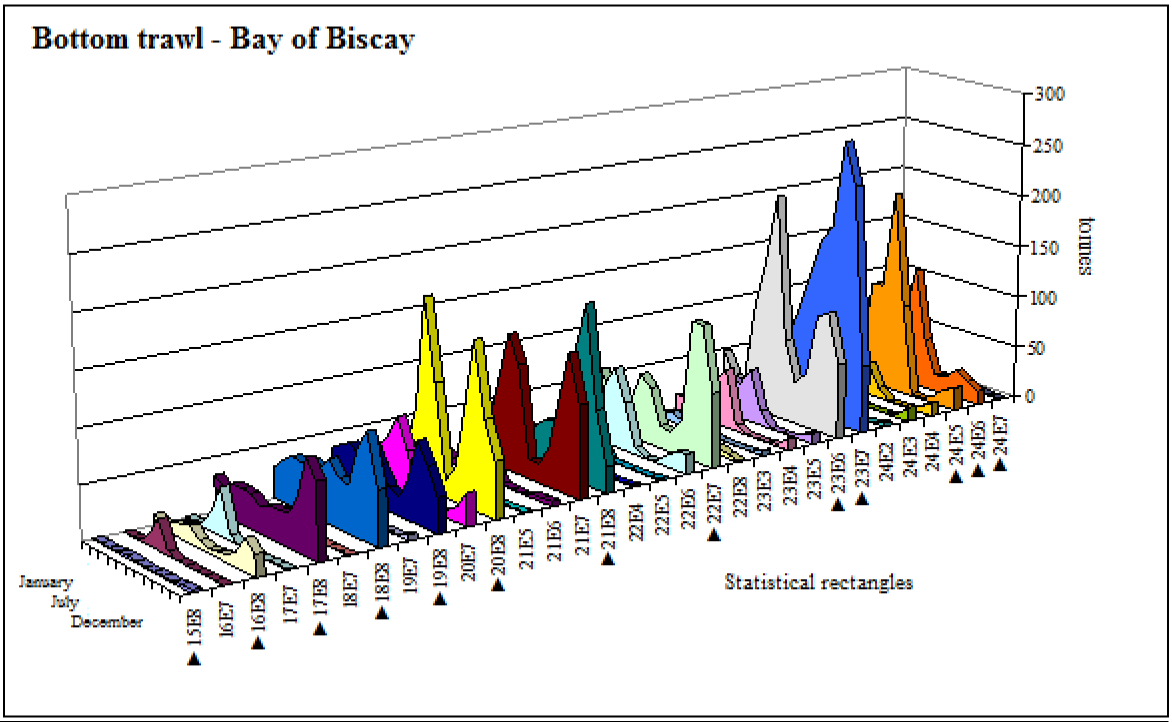
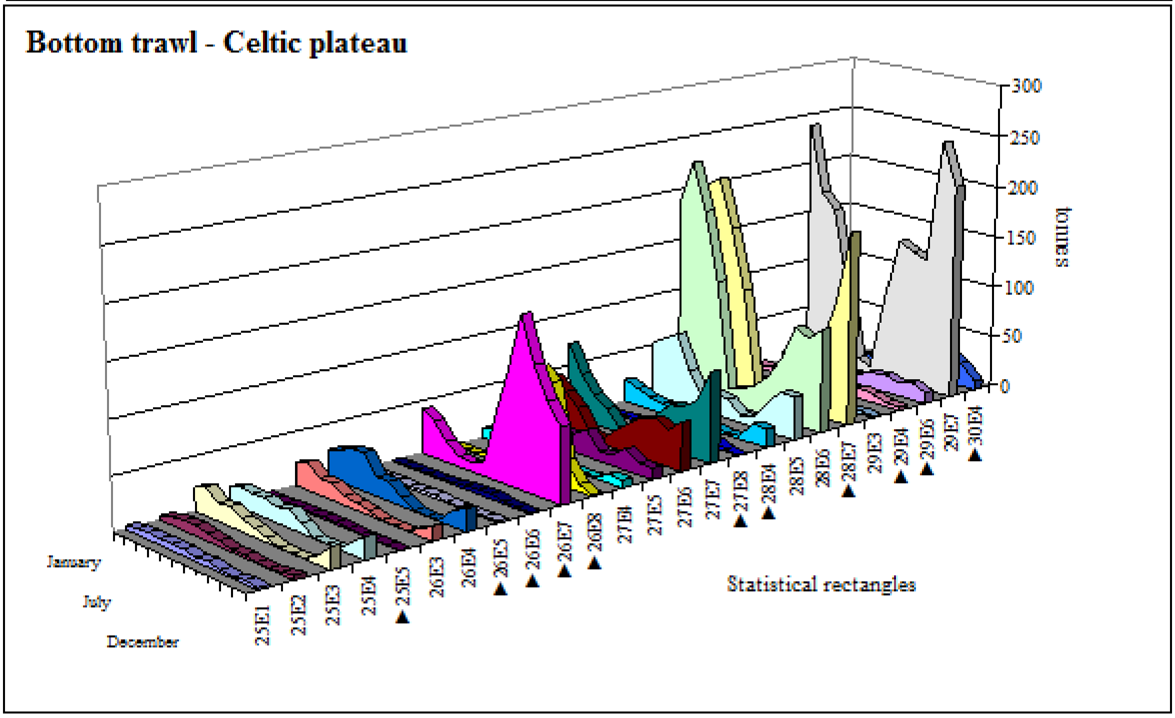
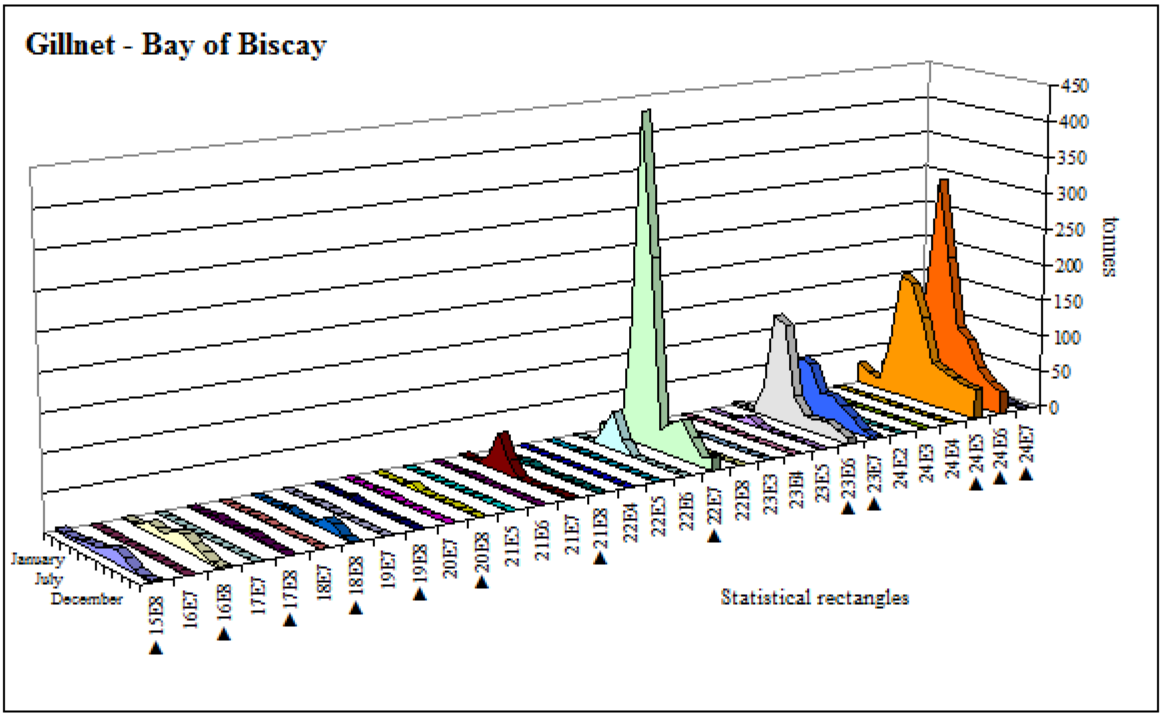
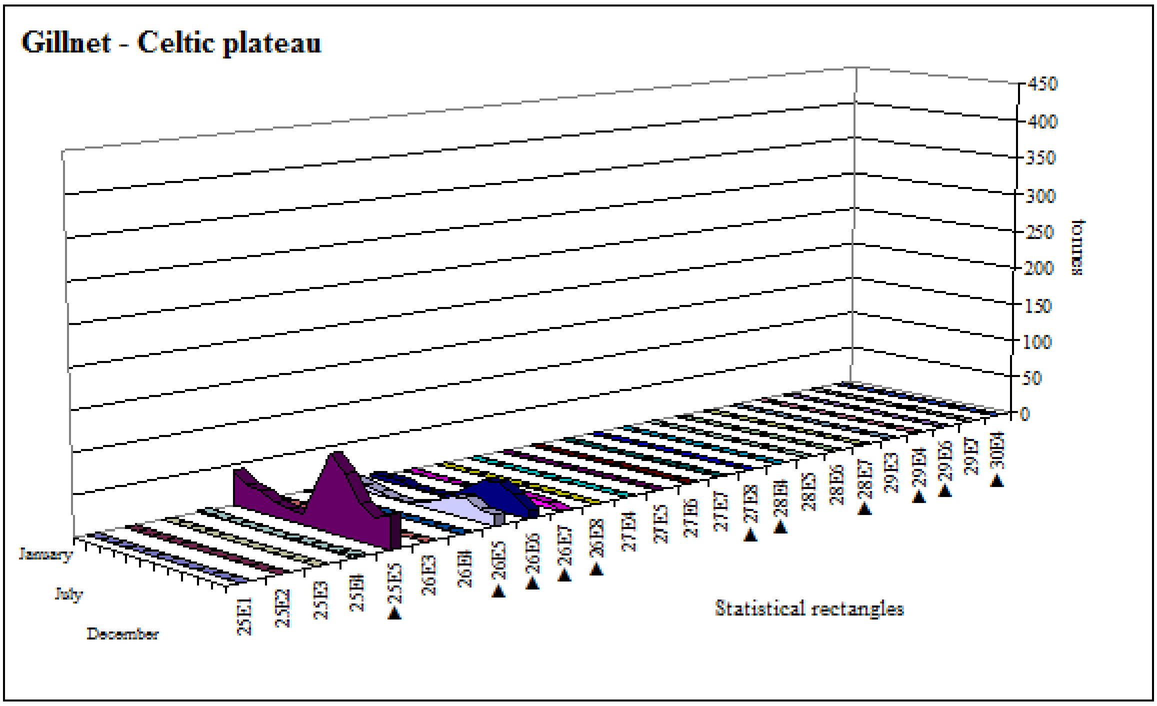
ANNEX 3 - Monthly evolution of landings by group of gears (2000-2015 period) and per statistical rectangle (Bay of Biscay and Celtic plateau).



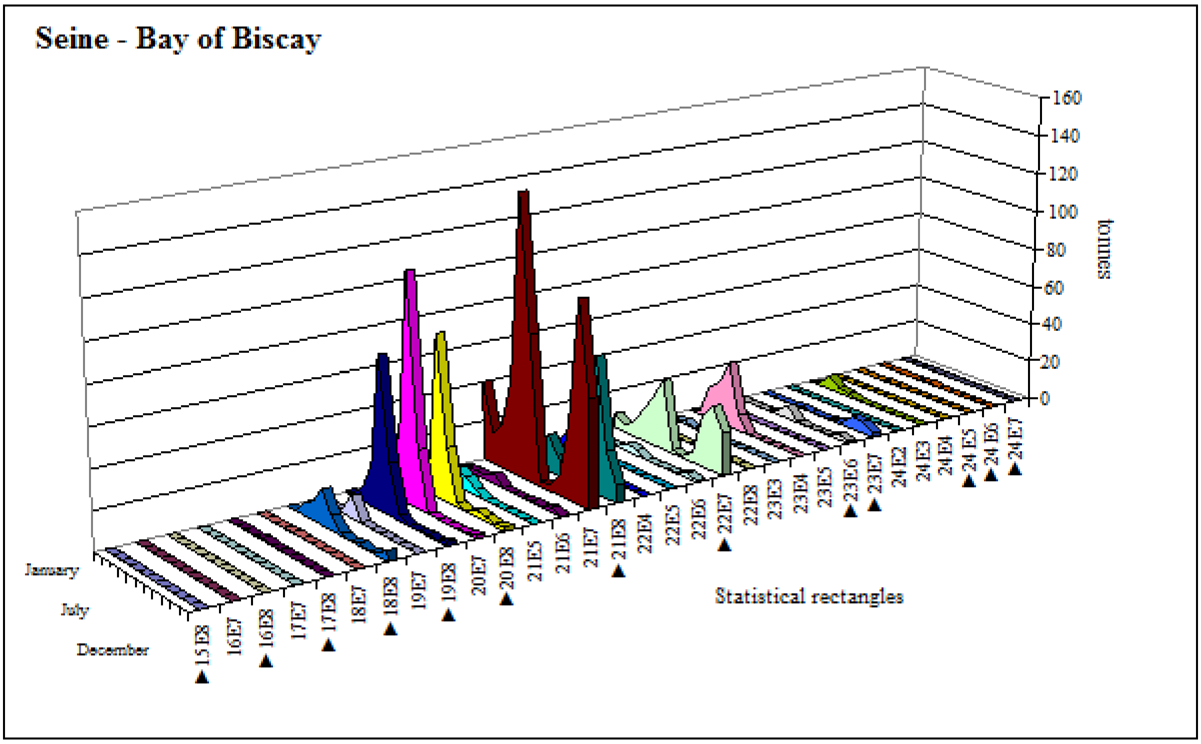




Gillnet - Bay of Biscay
tonnes
Statistical rectangles
January
July
December



Gillnet - Celtic plateau
tonnes
Statistical rectangles
January
July
December



Seine - Bay of Biscay
160
140
120
100
80
60
40
20
0
tonnes
January
July
December
Statistical rectangles
15E8
16E7
16E8
17E7
17E8
18E7
18E8
19E7
19E8
20E7
20E8
21E5
21E6
21E7
21E8
22E4
22E5
22E6
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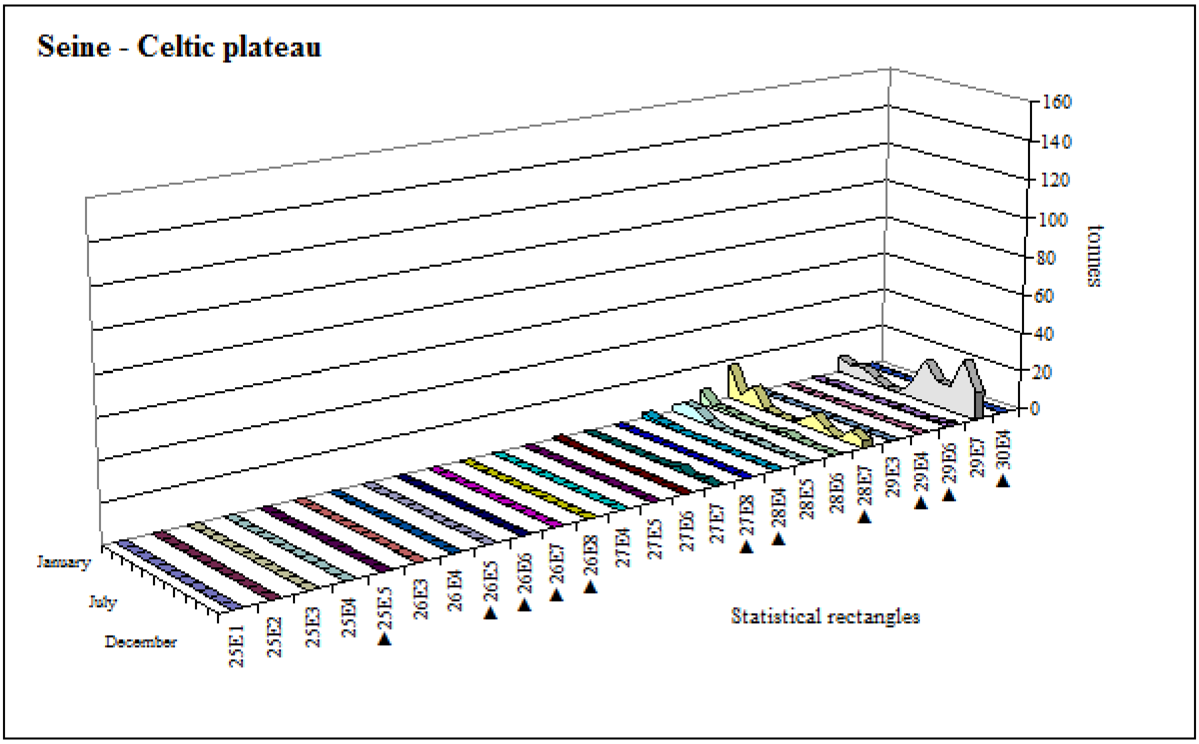
24E7



Seine - Celtic plateau
160
140
120
100
80
60
40
20
0
tonnes
January
July
December
Statistical rectangles
25E1
25E2
25E3
25E4
25E5
26E3
26E4
26E5
26E6
26E7
26E8
27E4
27E5
27E6
27E7
27E8
28E4
28E5
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29E3
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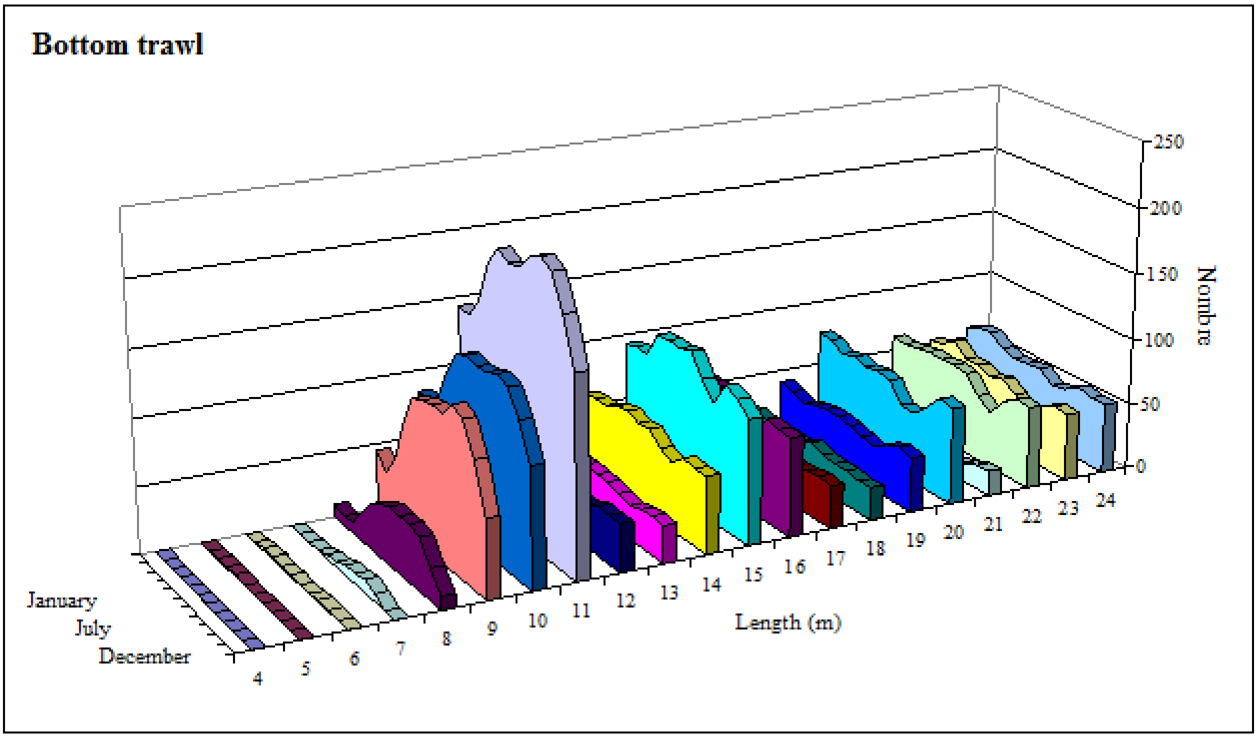
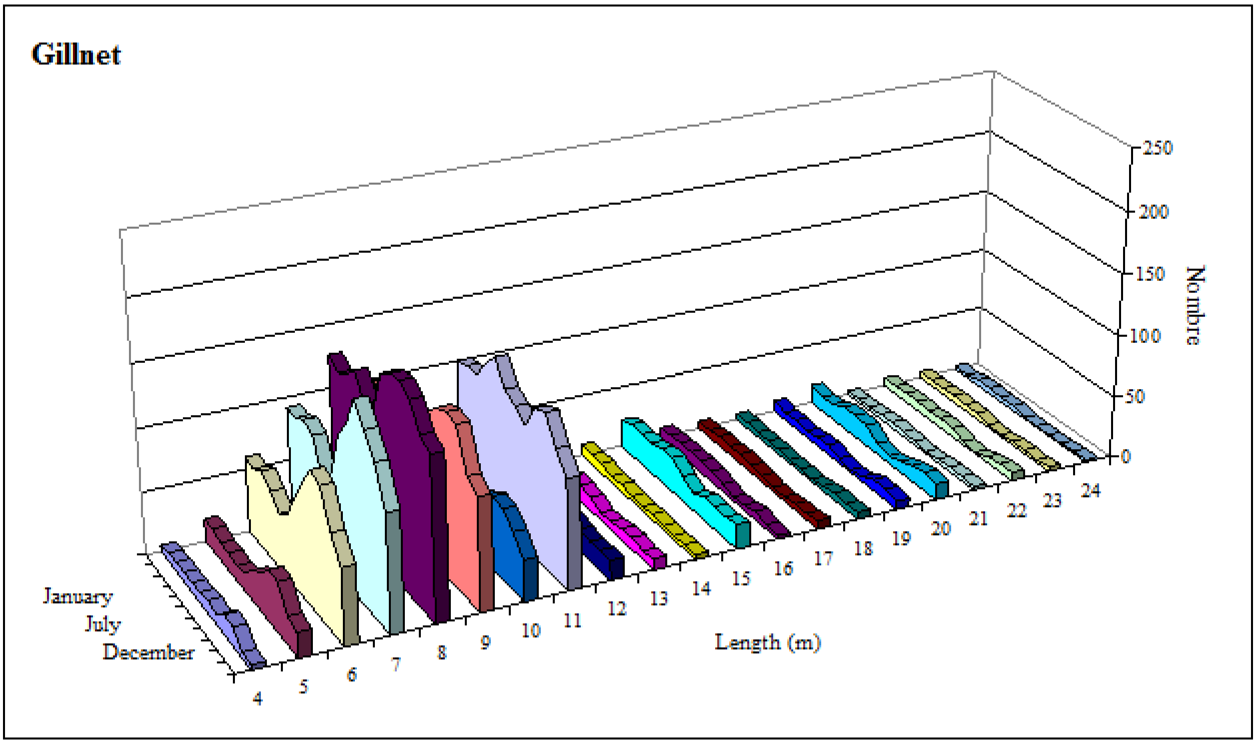
30E4

ANNEX 4 - Monthly evolution of the number of vessels by length (2000-2015 period).





ANNEX 5 - Annual evolution of the number of vessels per length (2000-2015 period).