
A restricted fishing area as a tool for fisheries management: Example of the Capbreton canyon, southern Bay of Biscay

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Abstract:

Marine Protected Areas (MPAs) are generally considered as one of the most important tools, among the many regulations, designed to preserve marine resources as well as enhance fisheries. In the southern Bay of Biscay, local French fishermen requested creation of a restricted area to help settle disputes between the various métiers operating there. This restricted area, which lies mainly in French waters, covers part of a deep submarine canyon off the French and Spanish coasts, known to have a large population of mature hake. This study aims to better understand the effects of a restricted area upon French fleets operating there, particularly upon three main métiers—longliners, gillnetters and trawlers. The study area includes three ICES statistical rectangles. The data, based upon reported landings and auctions sales for the period 1985–2008, were analyzed using multivariate analysis. The fishing activity is more important in one rectangle which includes the restricted area. Bottom longliners and gillnetters, operate mainly in this one while trawlers are less dependent. The first métier concentrates particularly on hake and the second has targeted other species and has become less dependent on hake. Trawlers target a wider range of species. Over the past ten years, the restricted area has contributed to maintain the fleets operating here. The border with Spain adds other constraints over the issue of access to regional fisheries and makes management a little more complicated.

Highlights

► Effects of the regulation upon fleets operating in the Capbreton canyon are examined. ► The circumstances that led to a restricted area creation for gillnetters are showed. ► The access regulations to fishing areas have maintained the different métiers. ► The choice of restricted area location allowed the maintain of longliners.

Keywords: Bay of Biscay ; Restricted area ; Submarine canyon ; Economic dependence ; Métiers' dynamics

37 **1. Introduction**

38 Fishery management is organized around regulations which concern fishing effort
39 such as vessel number and their technical characteristics, gear prohibition, quotas, closed
40 seasons and area restrictions. The European Union (EU) sets annual catch limits by species
41 (TAC), and national quotas as well as minimum size species. It also issues fishing licenses,
42 regulates mesh sizes and publishes Multi-Annual Guidance Programs under the Common
43 Fisheries Policy (CFP). Specific national or regional licenses are also issued. Among
44 management measures, Marine Protected Areas (MPAs) are increasingly important. They
45 were introduced to protect local marine resources as well as enhance fisheries. However,
46 because they are open to the effects of multiple uses and to external pollution [1], special
47 attention must be paid to their selection if reserves are to be managed efficiently [2]. This
48 concerns both their size and the fishing practices in place as well as specification of the
49 particular protections objectives required. Although MPAs certainly improve fishing practices
50 by promoting best practice and better conservation of biodiversity, their benefits are limited
51 by their number and size [3]. While their role in the protection of species and habitats is clear
52 [4], uncertainty in larval dispersal and adult biomass exportation makes it difficult to measure
53 their full effect upon population and yield sustainability [5].

54 In France, other spatial management measures are used such as “Restricted Areas”
55 which could be considered as a specific form of MPA. Created on the initiative of
56 professional fishermen, these areas are delimited areas at sea, within which some particular
57 types of fishing gear are temporarily or permanently prohibited in order to protect certain
58 species and/or métiers (according to ICES - the International Council for the Exploration of
59 the Sea – there are three types of fishing unit: the fleet, the fishery, and the métier. The last is
60 defined by ICES as “groups of homogeneous fishing activity, targeting the same (assemblage
61 of) species, using similar gear, during the same period of the year and within the same area”

62 [6]). These restricted areas are set up either by ministerial decree (Order of the Ministry of
63 Public Works and Transport dated the 4th of June 1963) or come under prefectural legislation.
64 Today, there are 47 fishing restricted areas in French waters with 57% located in the Atlantic
65 coast [7].

66 The Bay of Biscay is a typical mixed fishery with a large variety of species exploited
67 by a wide range of fishing gears such as trawls, longlines, gillnets, pots and dredges [8]. The
68 presence of several métiers in the same area using different techniques has led to the need to
69 regulate their use in the coastal zone. A restricted area was established near Spanish waters by
70 prefectural legislation, at the request of local French fishermen prohibiting gillnet fishing.
71 Most of it is under French control, the rest being within the Exclusive Economic Zones
72 (EEZ). This cross-border location makes management complicated. The original aim was to
73 resolve conflicts between two métiers (bottom longliners and gillnetters) targeting the same
74 species such as hake. This is an old issue dating as far back as 1727 [9]. More important, this
75 restricted area is located on a deep coastal canyon, the Capbreton Canyon, easily accessible
76 by the different fleets.

77 This article seeks to better understand the circumstances that led to the restricted area
78 creation and its effects upon French fleets operating in this area. Catch statistics together with
79 a detailed description of regulatory events and minutes of discussions of the local fishing
80 committee have been used to examine changes in fishing activities (vessels number, landings
81 and turnover).

82 **2. Material and methods**

83 **2.1. Study area**

84 The southern part of the Bay of Biscay is characterized by a narrow shelf with a sandy
85 bottom along the Landes plateau and a rocky littoral on the Basque coast. This region is

86 crossed by the Capbreton canyon (Fig. 1a), which includes the restricted area studied in this
87 paper.

88 This canyon is a submarine valley, classified as a “gouf” which begins less than 400
89 m from the shoreline and extends from east to west, parallel to the Spanish coast for over 250
90 km. It is subjected to the combination of river plumes and ocean currents i.e. local upwellings
91 and poleward coastal currents along Basque and North Aquitaine coast [10,11,12]. The
92 Capbreton canyon is active with a high amount of organic matter transported toward the
93 abyssal plain [13,14]. The canyon’s geomorphological and hydrological characteristics favor
94 species diversity and biological production of plankton and micronecton aggregations [15,16],
95 as well as megafaunal and scleractinian diversity [17,18,19] and bird and marine mammal
96 concentrations [20,21]. Several studies confirm that submarine canyons are highly productive,
97 hosting a wide variety of benthic, demersal and pelagic fauna [22,23,24].

98 Such conditions enhance local fishery production [23]. The Bay of Biscay is known to
99 have the biggest nurseries of European hake with adult concentrations in canyons and on the
100 rocky seabed of the shelf break area [25]. In the case of the Capbreton Canyon, the fishing
101 grounds are very localized, particularly for European hake which is targeted by bottom
102 longliners, gillnetters and trawlers.

103 This study focuses on the area containing this canyon and covers 3 statistical
104 rectangles 15E8, 16E8 and 16E7 [surface 1° longitude x 0,5° latitude] located in the Bay of
105 Biscay (ICES Division VIIIb and VIIIc). Hereafter, these rectangles are denoted R15E8,
106 R16E8 and R16E7. The combination of these three statistical rectangles forms the study area.
107 They delimit three zones with differing access for French and Spanish fleets. The area has a
108 maritime border with Spain and Spanish territorial waters (representing 5.5% of the studied
109 area) which are inaccessible to French fleets.

110 **2.2. Fishing activity**

111 2.2.1. Fleets operating in the study area

112 This maritime space is mainly characterized by pelagic and demersal fisheries.

113 The fleets exploiting pelagic fish are purse seiners, baitboaters and pelagic trawlers
114 targeting mackerels (*Scomber scombrus*, *Scomber japonicus*), sardine (*Sardina pilchardus*),
115 horse mackerel (*Trachurus trachurus*), anchovy (*Engraulis encrasicolus*) and tunas (*Thunnus*
116 *alalunga*, *Thunnus thynnus*). In terms of tonnage, pelagic species constitute the most
117 important landed fishes [26].

118 The gillnetters, longliners and bottom trawlers fish for demersal species such as hake
119 (*Merluccius merluccius*), monkfish (*Lophius piscatorius* and *Lophius budegassa*), sea bass
120 (*Dicentrarchus labrax*), common sole (*Solea solea*), turbot (*Scophthalmus maximus*) and
121 sparidean. In addition, potters target other benthic species such as large crustaceans (*Cancer*
122 *pagurus*, *Homarus gammarus*). Most of species as sole, hake, monkfish, anchovy...are
123 managed by TAC - under the Common Fisheries Policy (CFP) of the European Union – and
124 by gears restrictions. Hake and sole have been both subject to management plan since 2002
125 and since 2006 respectively to increase the spawning stock [8].

126 In 2008, about 118 French vessels and 350 fishermen were fishing in the study area.
127 They landed 3190t of sea products for a total value of 3700k€ [26,27]. To increase income,
128 30-35 vessels sell directly to consumers (into 3 local ports: Capbreton, Bayonne, Saint-Jean-
129 de-Luz, see Fig. 1a), avoiding the whole sale market. The fleet consists mainly of single
130 owner operators whose crews are paid under a “shared-wage” system. Bottom longliners
131 hake, gillnetters, pelagic and bottom trawlers represent around 79% of the total French fleet
132 operating in this area. Gillnets and longlines are considered as passive gears but pelagic and
133 bottom towed by boats are considered as active.

134 This study concentrates upon the main gear types used in the study area: bottom
135 longline, nets (gillnet and trammel net) and trawls (pelagic and bottom trawl). These represent

136 about 93 boats in 2008: of which longliners represent 19% of this total number, gillnetters
137 44%, pelagic and bottom trawlers 37%. Bottom longline hake fishing takes place at the edge
138 of the Capbreton canyon. Gillnetters operating in the coastal area use several types of nets
139 (gillnet and trammel) targeting several species. Coastal netters predominate in the sector
140 although large netters are also present. Bottom trawlers operate mainly in the northern sector.
141 While fishing in the canyon itself is excluded both by topography and regulation, they are
142 able to work along the shelf break. The detailed characteristics of the métiers based on gear
143 dimension, location, yields and main target species are shown in table 1.

144 The fishery data are extracted from the database of the French Fisheries Information
145 System (SIH) of Ifremer. The data are based on landings (in weight) – of all vessels working
146 at least once in these statistical rectangles - and upon whole sale market (in value). Two
147 different datasets were compiled:

- 148 • The first (from official logbooks and catch reports) contains information on fishing
149 area, landing dates, landing port and landed weight of species by fishing days. Vessel
150 activity is linked to fish market location until 1989 and since 1990 it has been
151 dissociated from the type and place of sale;
- 152 • The second dataset (from fish markets) contains the landed value and quantity by
153 species for each vessel and fishing trip. Current prices for landings were converted to
154 constant prices, using the French consumer price index, with 1985 as the base year.
155 Direct sales are not considered in this study but represent about 28% of the total
156 landed value in local harbors [28].

157 The data used covers a 24-years period (1985-2008) for the main métiers cited above.
158 The study excludes results of 1999 due to a change in the data recording system which
159 resulted in the loss and degradation of data. The analysis relies upon data for the French fleets
160 as Spanish data are not available.

161 2.2.2. *Local fishing organizations*

162 French professional fishermen are organized nationally and locally. There are the
163 National Committee of Marine Fisheries and Aquaculture (CNPMEM) as well as their
164 regional committee (in this case, CRPMEM Aquitaine) and their local office (in this case,
165 CIDPMEM Pyrénées Atlantiques Landes)¹. Membership is mandatory for professionals.
166 Their committee members integrate all sea workers such as fishermen, ship-owners, others
167 representing fish traders and the processing industry. These committees are under the
168 authority of the French State. Their role is to improve coexistence between métiers and
169 includes allocation of fishing rights (licenses, quotas ...), supervision of fishing effort (gear
170 and authorized areas, fishing period...). The local fishing committee has a consultative role in
171 fisheries management applying regional decisions and making propositions about sensitive
172 issues in their circumscription that are forwarded to regional level.

173 **2.3. Access regulation**

174 The main legislation concerning the fishing practices in the area is summarized in
175 table 2 and involves the following levels of authority:

- 176 • European legislation requires vessels to report catches in their logbooks and also
177 covers stock recovery plans;
- 178 • National legislation, presented in this article, adapts or adds to European directives;
- 179 • Regional regulations manage the various fishing practices and cover access to fishing
180 grounds and the prohibition of certain types of gear.

181 Changes to maritime areas accessible to different métiers are listed in table 2 and
182 mapped in figures 1a and 1b above. Different regulatory documents and the work of Tixerant
183 have been used [29].

¹ Those types of committees were created by Order n°45-1813 of August 15, 1945.

184 Historically, the study area was often the source of conflict between French and
185 Spanish fishermen regarding access to and sharing of fishery resources as well as competition
186 for the same market [30,31] (despite signature of a fisheries agreement by both governments
187 in 1967) [32].

188 Introduction of new gear or technology (for example the pelagic trawl in 1976 or the
189 tuna driftnet in 1986) has led to improvements in catches and turnover. However, it has also
190 resulted in sometimes violent confrontation between the “old” and the “new” métiers (for
191 example, purse seine and pelagic trawl) over the same coveted fishing ground due to its effect
192 upon particular species such as anchovy [33,34].

193 Two examples of regulation access regarding the studied area are shown below. In the
194 first case, bottom longliners requested closure of some areas to netters because they targeted
195 the same species (hake) in the same area - the canyon - without any possibility of
196 redeployment for the longliners. So, a restricted area was established in 1985 included in 4
197 rectangles R16E8, R17E8, R17E7 and R16E7 (by prefectoral order Ord. n°40 March 5, 1985)
198 prohibiting gillnet fishing in two (rectangular) sections of the canyon including a large part of
199 the continental shelf, which had been traditionally exploited by longliners (Fig. 1a). From
200 1985 until 1999, the size of this restricted area was 1305 km² (of which 1190 km² lies in the
201 study area). The greater part was located close to the coast with 21% inside the 6 nautical
202 miles limit. Table 3 summarizes the prohibited maritime surface by gear in each studied
203 rectangle. Net fishermen claimed that the restricted area and its location close to the coast
204 strongly handicapped net fishing and caused shortfalls in their catches (Minutes No. 232 of
205 March 17, 1986 – Local fishing committee currently called CIDPMEM Pyrénées Atlantiques
206 Landes). Over the years, they have maintained pressure to obtain a revision of the regulation
207 in this area. They succeeded in reducing this surface in 1999, to 332 km² with a location in
208 R16E8 only: as shown in the figure 1b 65% are in French territorial waters with 3% inside the

209 6 nautical miles. A portion of the restricted area is also located in the EEZ: French regulations
210 do not apply to foreign vessels (mostly Spanish) which fish there.

211 In the second case, in addition to the national regulations prohibiting fishing within 3
212 nautical miles, netters obtained exclusion of trawlers within 6 miles of the coastline from
213 1981 (by Order n°88 of April 27, 1981 and Order n°21 of February 8, 1993) due to
214 destruction of passive gear by towed gear. The cumulative effect of these regulations (see
215 Table 2) results in limited trawler access in part of the restricted area.

216 **2.4. Main indicators of fishing activity**

217 To better understand and better compare the métiers, a reference trip lasting ten hours
218 was made, entitled hereafter “unit trip (UT)” was used. This choice is considered to be a
219 typical trip for a coastal vessel.

220 Three families of indicators were retained:

- 221 • Fishing Activity Dynamic: the number of vessels and their distribution by rectangle
222 (chosen because this reveals attractiveness of sectors), landings in weight by vessel
223 and by crew member (tonnes vessel⁻¹.crew⁻¹); landings in weight by vessel and by UT
224 (tonnes vessel⁻¹.10h⁻¹);
- 225 • Métier Accessibility: the theoretical maritime surface available expressed in percent
226 by métier. This indicator is built from different regulations mapped in figures 1a and
227 1b. The spatial boundaries of each regulation were used to calculate the surface of
228 regulated areas in km². The percentage of maritime surface available for each métier
229 (“Accessibility”) is calculated using the information and the surface of the ICES
230 rectangles.
- 231 • Economic Dependence upon sectors expressed in value: turnover by vessel and by
232 crew member (in k€ vessel⁻¹ crew⁻¹), turnover by vessel and by UT (in k€ vessel⁻¹ 10h⁻¹)

233 ¹). To better understand the relationships between economic indicators, the percentage
234 of turnover due to the main species has been added in order to highlight those fleets
235 which are vulnerable through dependence upon few species [8].

236 **2.5. Statistical approaches**

237 An explanatory multivariate analysis e.g. normalized principal component analysis
238 (PCA) has been applied to the dataset containing all indicators from the three families
239 described above. It is performed using R packages Rcmdr and FactoMineR [35]. Information
240 about métiers and sectors is added as supplementary factors. All graphs contain variables with
241 $\cos^2 > 0.2$. Evolution of indicators is also presented in classical statistical graphs.

242 **3. Results**

243 **3.1. Distribution of vessels in the study area and evolution of the presence of main** 244 **métiers**

245 The low activity level of bottom longliners in R16E7 is noticeable despite the fact that
246 a part of the restricted area (which was reserved for them) was contained within this rectangle
247 until 1985. In R15E8, the limited activity of a few bottom longliners varies between 4 to 9
248 vessels from one year to another during the study period.

249 The greatest proportion, more than 60%, of total vessels are active within R16E8 (Fig.
250 2) which contains the restricted area, partially from 1985 to 1999 and entirely thereafter.

251 During the initial period from 1985 to 1998 (Fig. 3), the presence of each métier in the
252 study area is equivalent in number of boats and trends are similar. For the second period, the
253 number of vessels differs depending on the métier. Bottom longliners are the least represented
254 but their number grew significantly from 2 to 18, between 2000 and 2008. Netters are greater
255 in number and increased from 20 to 41 between 2000 and 2008. The presence of pelagic
256 trawlers is very variable and the number of bottom trawlers remains stable on the second

257 period. However, the number of gillnetters is twice as large as bottom longliners by 2008
258 (Fig. 3).

259 **3.2. Economic dependence according to spatial occupancy and fishing activity** 260 **criterion**

261 The first three principal components coming from PCA give 37% of total inertia. This
262 seems low but reveals few significant linear correlations between the chosen descriptors and
263 emphasizes their variability from year to year.

264 Bottom longliners and gillnetters have a high turnover by vessel and by crew member
265 in R16E8. Turnover, especially for bottom longliners, is highly dependent upon R16E8 and
266 upon hake (Fig. 4a and Fig. 4b). Bottom trawlers' turnover hardly depends at all on R15E8
267 while sole contributes highly to the gillnetter's turnover (Fig. 4b). Pelagic trawlers have high
268 levels of landings and turnover by vessel by UT (Dim1) on R16E7 and a turnover strongly
269 dependent on mackerel, bluefin tuna and albacore tuna (Fig. 4a).

270 Focusing on the sector R16E8 which contains the restricted area, one can notice that
271 more than 75% of bottom longliners' annual turnover is generated by hake (Fig. 5a) with
272 conger being the second most important contributor. Hake and sole contribute equally to
273 gillnetters' annual turnover during the first period. However, in the second period hake drops
274 to the same level as gilthead sea bream and sea bass while sole remains stable (Fig. 5b).
275 Pelagic trawlers are less dependent on hake but more on the pelagic species such as anchovy
276 and mackerel (Fig. 5c). For bottom trawlers, hake is the main contributor in the first period
277 but this changes for the second period in favor of other species such as monkfish, squid and
278 red mullet (Fig. 5d).

279 The evolution of turnover per boat and per crew member is shown for the main
280 métiers in R16E8 (Fig. 6). In the first period, there was an equivalent turnover between
281 gillnetters and pelagic trawlers while bottom longliners realized a high turnover (max. 25 k€

282 in 1991) before decreasing from 1992. Trends changed in the second period. Bottom
283 longliners' turnover is equivalent to that of trawlers while gillnetters' turnover is higher than
284 the others (between 15 and 20 k€). Bottom trawlers realized the lowest score.

285 *4.1. Quality and available data*

286 Different approaches are usually used to assess the effect of MPAs. Most studies
287 concentrated on the „effects on population or assemblages“ or other topics such as fishing
288 yields, indirect socioeconomic effects and ecological indirect effects [36]. These need data
289 detailing results inside and outside the MPA or before and after its establishment [36,37,38].
290 In this study, the lack of statistical series by vessel before the establishment of the restricted
291 area in 1985 did not allow modeling to simulate the consequences of its creation or to do a
292 comparative empirical study before and after or inside/outside.

293 Although the first three years of the series are incomplete due to the small number of
294 vessels submitting logbook information, the trends in reported catches do reflect the reality of
295 fishing activity and match the evolution of the fishing fleet in the Bay of Biscay [8,26,39].

296 *4.2. Fishermen conflicts*

297 The study area is subject to different types of fishing and in the past the use of
298 different gears in the same fishing grounds has led to conflicts between fishermen. The
299 restricted area was established to resolve conflicts between bottom longliners and gillnetters
300 while sustaining the practice of bottom longline hake fishing. Its location on the canyon
301 covers an area mainly exploited by bottom longliners due to the large presence of adult hake
302 there. The surface of this box enclosure was reduced in 1999 at the request of gillnetters and
303 trawlers. Generally, most conflicts focus on the active against the passive. For example in the
304 Gulf of Mexico, the Fishery Management Council created a MPA to resolve conflict between
305 shrimp and stone-crab fishermen [40]. However, in this case, two passive métiers oppose each
306 other. Other MPAs, with such objectives as increased fishery yields, reduced fishing effort or

307 ecological protection, have been implemented with varying degrees of success [1,40,41]. In
308 some cases, MPAs simply caused fishermen to move elsewhere rather than reduce the fishing
309 activity [42]. With a rights-based approach, Mascia and Claus [43] studied the consequences
310 of effort displacement during the creation of MPAs. These consequences are classified
311 according to the criteria: gained, lost and secured, which allowed assessing the equity of the
312 MPA. The dimensions considered are welfare, economic well-being, health, education, social
313 capital and culture. In this case study, the size of the restricted area for gillnetters, was too
314 large and was not well accepted, due to loss of fishermen's earnings. Consequently, they
315 obtained a reduction of the area. Since this took place, the competition to access this space has
316 been reduced and the conflict between longliners and gillnetters has been resolved. In the
317 same period, gillnetters took advantage of prohibited areas for trawlers inside 6 miles, by
318 having more space to spread their nets and to increase their own productivity (Table 2 and
319 Table 3). As mentioned above, the displacement of fishing effort can have economic, social
320 and environmental consequences. There are few analytical studies which quantify the impact
321 of these movements. The concentration of boats into areas outside restricted areas has the
322 potential to increase competition and conflict especially in a context of declining yields [44].
323 In this case study, trawlers could have been impacted by regulatory measures due to the
324 importance of the prohibited areas for them (around 17%), but they could easily move
325 elsewhere; due to their size, they are able to operate in a wider area and also further offshore,
326 without creating new problems for other boats.

327 These examples show how each *métier* within the fisheries committee is able to
328 influence decisions. Conflicts of interest between committee members can lead to ad hoc
329 alliances aimed at influencing decisions in a direction more favorable to some than others and
330 that bargaining powers of different *métiers* (represented by elected fishermen and ship-
331 owners) can fluctuate greatly over time.

332 The restricted area established in 1985 was intended to protect the longliners' hake
333 fishing. It has since evolved into a significant shrinkage of the most important area for this
334 métier and in combination with other national regulations, has mainly released space for
335 netters. The geographic distribution of the various competitors' métiers has improved, thus
336 promoting better relations between them.

337 Although the management of this area was achieved gradually step by step rather than
338 as the result of an elaborate plan, the end results appear satisfactory. Fishermen believe that
339 without the restricted area, the métier of longliners would have disappeared (Minutes No. 232
340 of March 17, 1986 - Local fishing committee CIDPMEM Pyrénées Atlantiques Landes).

341 Agardy et al. [44] found that the absence of a comprehensive and coordinated strategy
342 over a wide coastal area has often caused the failure of MPA. They suggest it should be
343 implemented with an ecosystem approach to optimize the result of MPA and to avoid creating
344 new problems.

345

346 *4.3. Economic dependence*

347 The contribution of species to turnover differs according to métier. The results of PCA
348 demonstrate the high contribution of hake to bottom longliners' turnover. The same for
349 gillnetters although the common sole and others species are also important contributors. In the
350 Bay of Biscay, most fleets derive their main income from one or two species [8]. In this
351 analysis, more than 75% of bottom longliners' turnover comes from hake. Conger is the
352 second most important, especially during "bad" periods. This makes this métier highly
353 selective but more vulnerable because more sensitive to changes in targeted stock and in
354 prices. Many authors establish that small-scale fisheries are sustained by only a few species
355 and note that some fishing tactics are relatively "clean" with a clear target species

356 representing most of the catch [45,46]. In this study, the increasing number of bottom
357 longliners in recent years with a turnover equal to that of other métiers, underlines this
358 métier's strength. The sustainability of the bottom longliner métier is also related to the status
359 of stocks. Hake stocks collapsed in 1980 and a recovery plan was finally agreed by the EU in
360 2002 (EC Reg. 494/2002). The increase of the Spawning Stock Biomass (SSB) observed
361 since 2005 can explain that the bottom longliner métier again became more attractive as
362 yields improved [47]. Price variation of species is also an important factor underlying the
363 changes in value of landings [39,48]. The market crisis that occurred in France in the mid-
364 1990s led to a sharp drop in prices of the main landed species in the Bay of Biscay (including
365 hake) between 1991 and 1994. In this study, the decrease observed in the number of bottom
366 longliner vessels during the first period is probably attributable to the drop in hake prices
367 which contribute such a high proportion of landing values.

368 Although the contribution of hake to the turnover of netters and trawlers has declined,
369 it has been offset by a change in strategy to capture other species. Consequently, the
370 establishment of the restricted area does not seem to have affected their economic viability.

371 **5. Conclusion**

372 Suuronen et al. [41] emphasized that the MPAs in the Baltic Sea were implemented
373 without consulting the fishermen or heeding scientific advice. According to these authors,
374 there should have been better communication between fishermen and other stakeholder
375 groups. This would have resulted in sustainable harvest policies, before implementation of
376 any major management action. This study suggests that the restricted area is appropriately
377 located in the canyon for several reasons: (i) Fishermen were behind the proposal; (ii)
378 Emerging conflicts have been resolved through compromise between them (iii) Bottom
379 longliners operate mainly on the edge of the canyon and the choice of the restricted area

380 location has enabled maintenance of this “emblematic” métier: which was already practiced
381 by Basque fishermen in the eighteenth century [9,49]; (iv) Today, local fishing committee
382 strongly support and publicize this métier and have begun a process of eco-labeling. Thus the
383 restricted area will enhance the traceability process; (v) It is located on a canyon known to be
384 a productive system with major adult hake concentrations (containing several localized
385 fishing grounds).

386 Moreover, the adoption by Authority of different regulations governing access to
387 fishing areas according to different métiers (often after consultations or stakeholders“
388 proposals), has contributed to a better distribution of the fishing effort, thus promoting the
389 viability of different fleets. Other factors which must be taken into account to explain the
390 results of this study include the recovery plans for different halieutic stocks, the multi-annual
391 guidance programs (regulation of fishing effort) and indeed the market conditions.

392 Part of this restricted area is located in the EEZ (Fig. 1b) and French fishermen
393 complain about the presence there of foreign gillnetters who are permitted under the EU law
394 to use gear otherwise forbidden to the French. Indeed, the study area straddles the Spanish
395 border and approximately 175 Spanish coastal fleet vessels operate there. They also use a
396 wide range of gear during the year: handlines and trolling predominate (respectively 38% and
397 34%), nets represent 29% whereas longlines are less used (14% of vessel) [50].

398 In this context, in 2009, the local fishing committee requested application of the
399 French regulations to foreign vessels entering the EEZ part of the restricted area. The French
400 proposal was supported by the South Western Waters Regional Advisory Council
401 (SWWRAC) and is reinforced by another request of the Federation Cofradias from
402 Guipuzkoa (Regional Fishermen Guild Organization of the Basque country in Spain), which
403 represents the interests of the Spanish ship owners and fishermen [30]. This type of cross-
404 border fishery management had already been negotiated between France and the United

405 Kingdom in the context of the Bay of Granville (in the Channel). Fishermen from Jersey and
406 France succeeded in resolving their historic conflicts by concluding such an agreement in
407 2000 ratified in 2004. This is based on the possibility (under certain conditions) for fishermen
408 to access fishing areas located in or near the territorial waters of either nation. Application of
409 this treaty is placed under the control of a Joint Advisory Committee of the Bay of Granville,
410 composed of representatives of fishermen, officials and scientists from each state [51]. In the
411 case of Spanish fisheries in the southern Bay of Biscay, their management is slightly different
412 from France. There is an overlap of competences in Spanish territorial waters between the
413 Spanish government, the Basque government (Autonomous Regional Authority) and the
414 Fishermen Guild Organizations, the Cofradias [30]. In 1992, the fishermen of the two nations
415 were able to reach an agreement to end their conflicts about fishing for anchovy known as the
416 “Accord d’Arcachon”; it introduced a quota exchange and included restricted seasons for the
417 fleets of both countries [30,52,53]. The extension of such an area into the EEZ raises the
418 question of its legal status, its control and also its scientific monitoring.

419 As Forcada et al. [54] point out, efficient management needs a better understanding of
420 the dynamics of artisanal fisheries, the conservation of key habitats and the study of
421 interactions with other activities. A multidisciplinary and cross-border project with strong
422 involvement of French and Spanish stakeholders is in progress in order to improve knowledge
423 and optimize management of this cross-border area.

424

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590

591 **Figure Captions**

592 **Fig. 1. a)** Introduction in 1985 of restricted area for gillnets (1 305 km²). The pelagic trawlers
593 are prohibited in the 3 miles limits.

594 **Fig. 1. b)** In 1993, additional prohibition was introduced in the 6 miles limit of for pelagic and
595 bottom trawlers. In 1999, the restricted area for gillnets decreased to 332 km².

596 **Fig. 2.** Evolution of active vessels number at least once by rectangle (in %). The total number
597 of vessels is mentioned on the right side in italic.

598 **Fig. 3.** Evolution of active vessels number by métier in the study area.

599 **Fig. 4a.** PCA Analysis: correlation circle and individuals plot on axis Dim1 and Dim2. The
600 contribution of species in the turnover are presented : ALB = albacore; HAK = hake; SAR =
601 sardine; MAC = common mackerel; MAC_ESP = spanish mackerel; THU = tuna. Métiers
602 and sectors are added as supplementary factors.

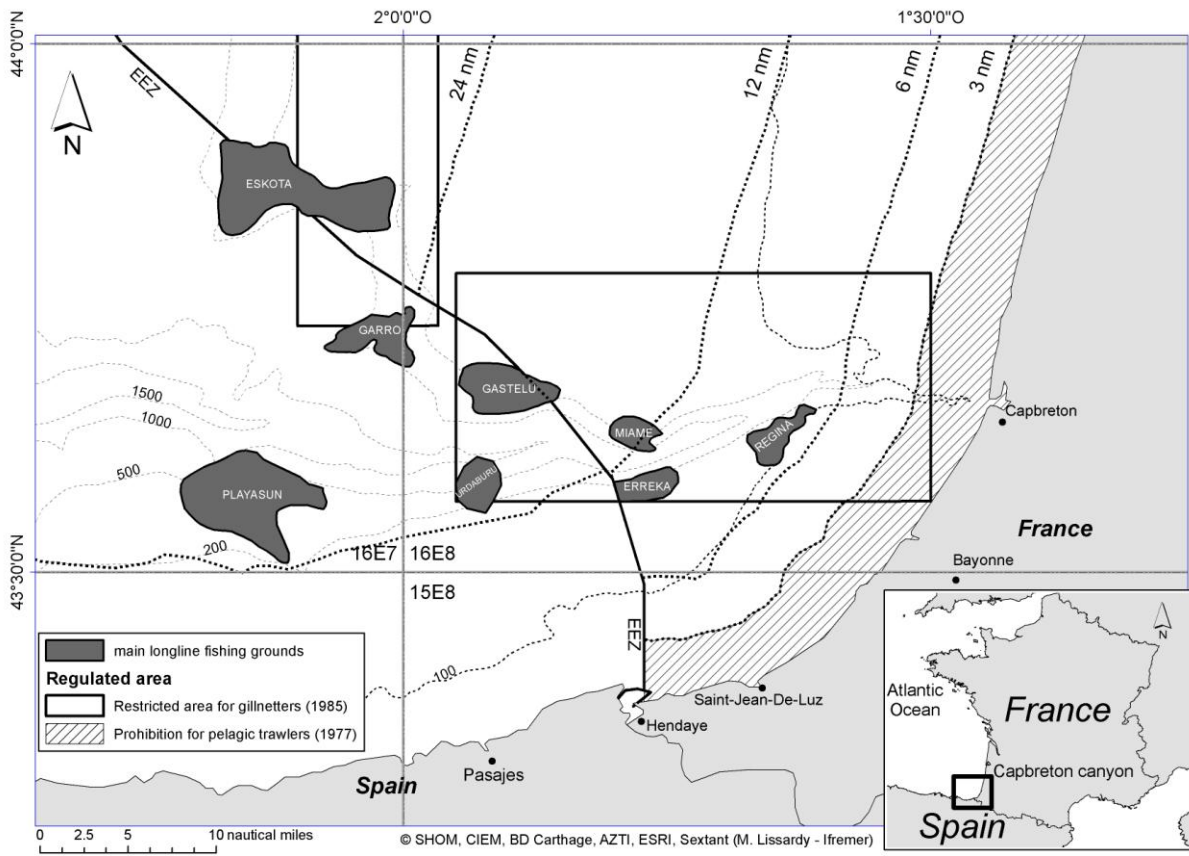
603 **Fig. 4b.** PCA Analysis: correlation circle and individuals plot on axes Dim2 and Dim3. The
604 contribution of species in the turnover are presented: ALB = albacore; HAK = hake; SOL =
605 common sole; THU = tunas. Métiers and sectors are added as supplementary factors.

606 **Fig. 5.** Contribution of 4 main species to turnover, in percentage a) for bottom longliners, b)
607 for gillnetters, c) for pelagic trawlers, d) for bottom trawlers

608 **Fig. 6.** Evolution of turnover by vessel by crew member for main métiers in R16E8 (in k€
609 constant).

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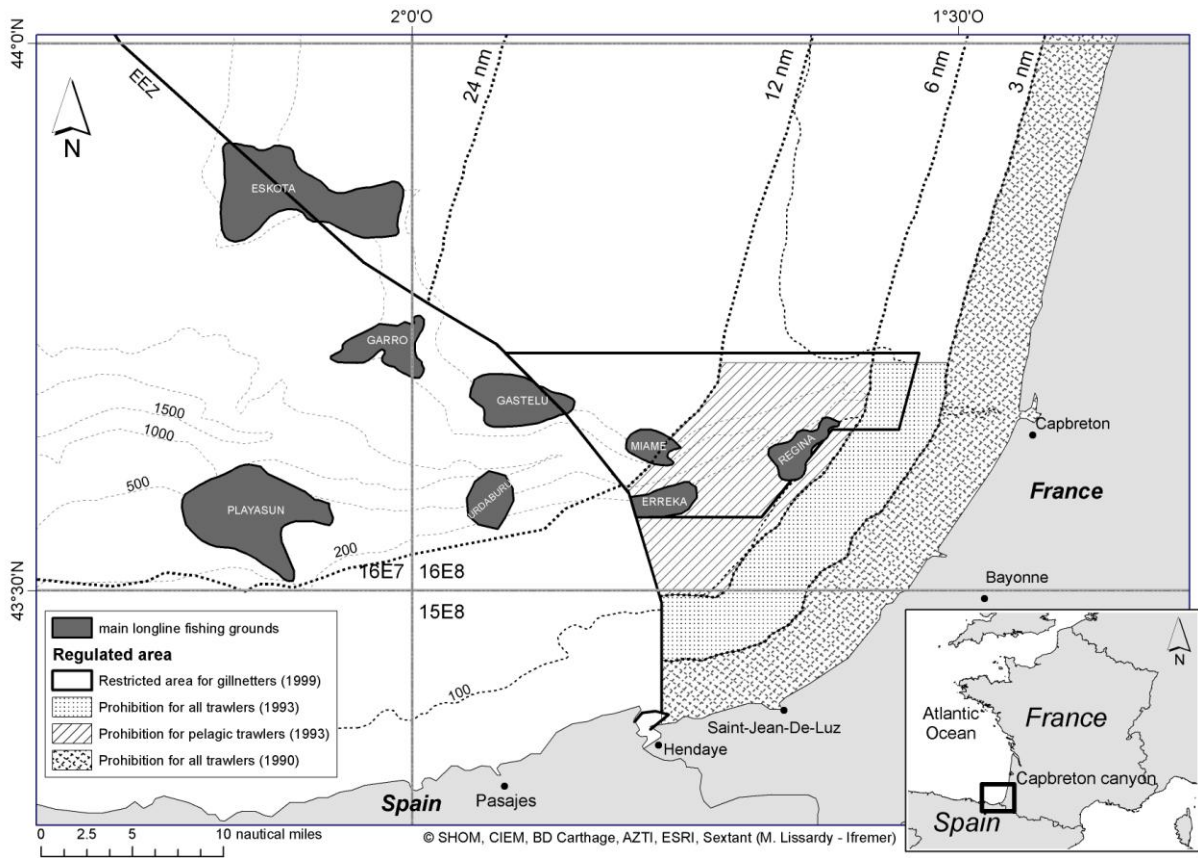
611 Fig.1 a



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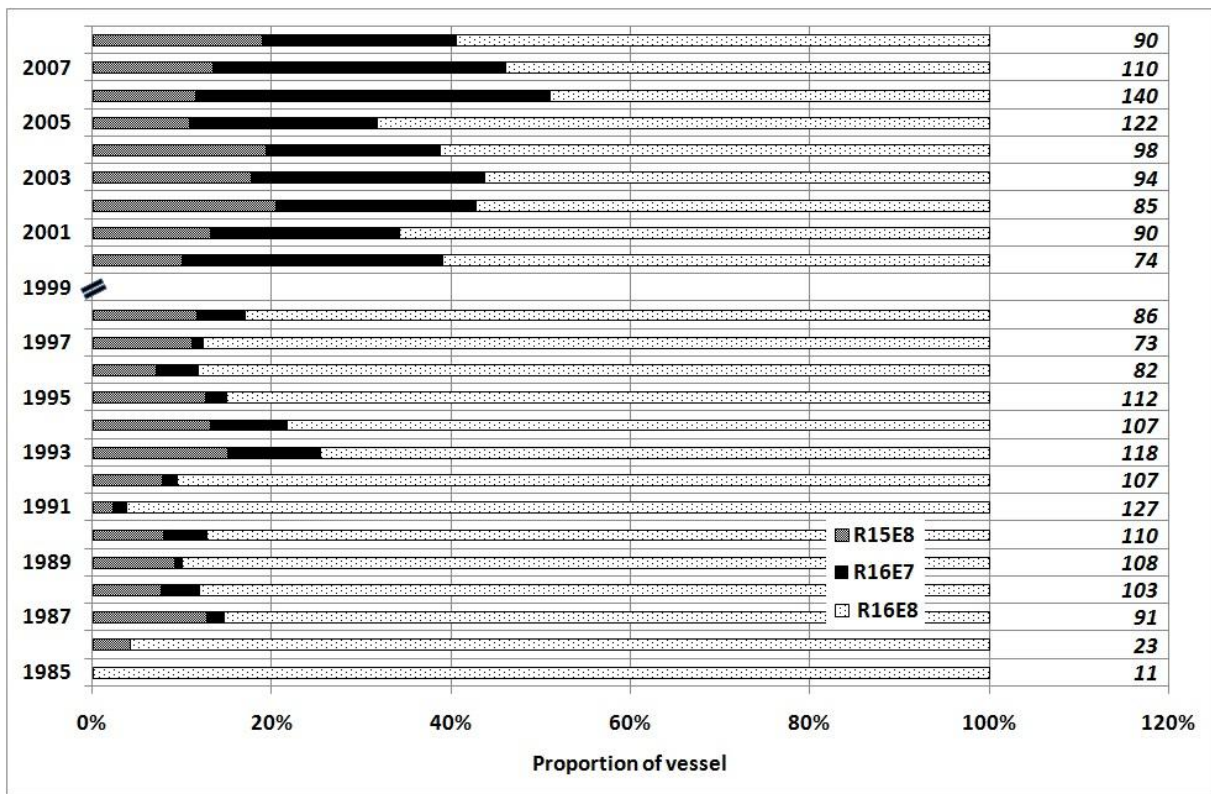
614 Fig.1 b



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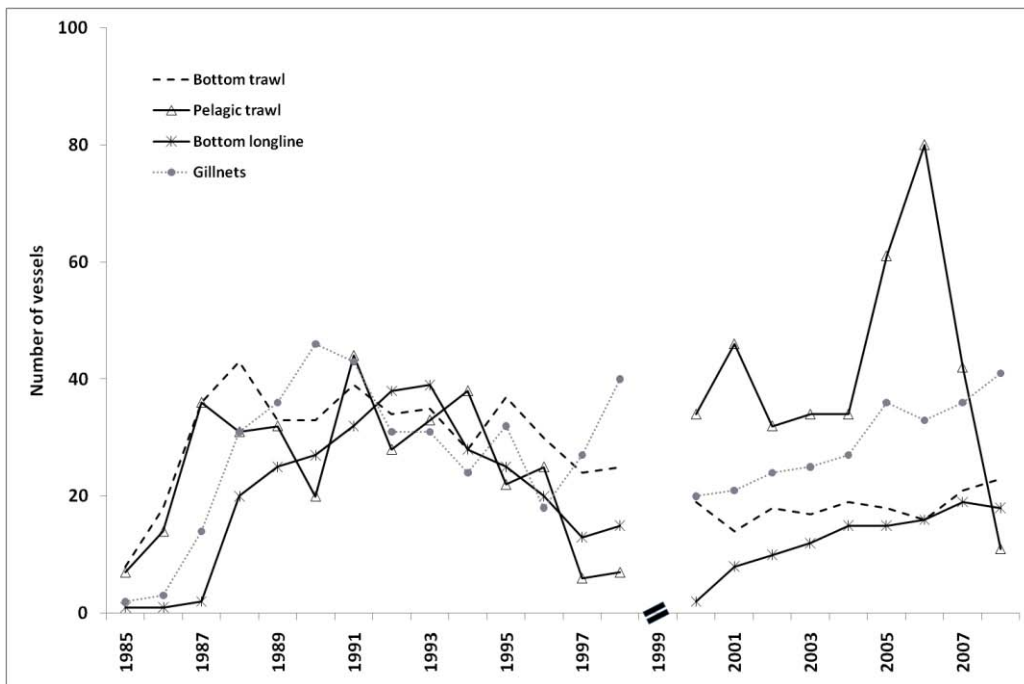
617 Fig. 2



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620 Fig. 3



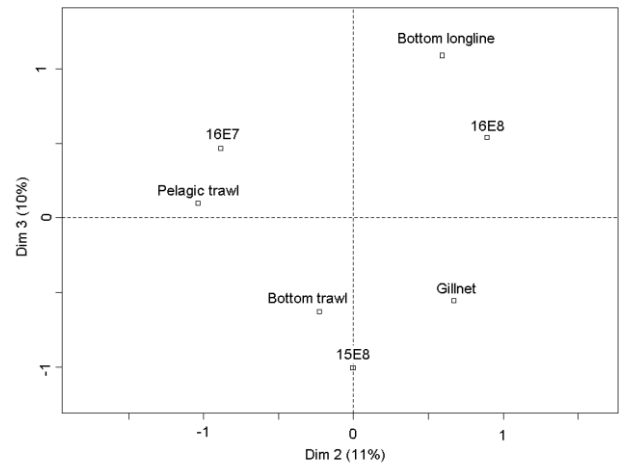
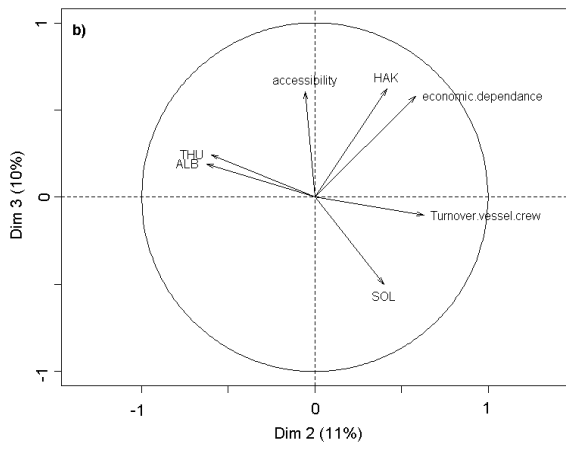
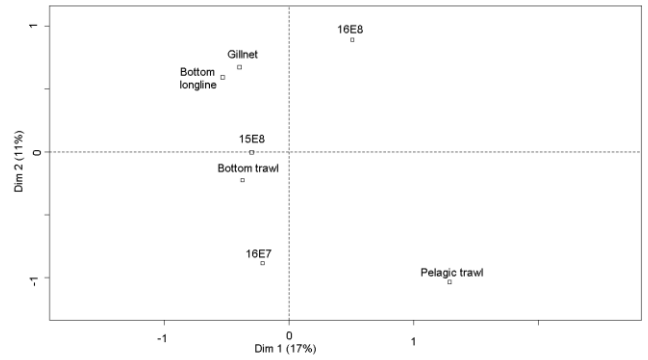
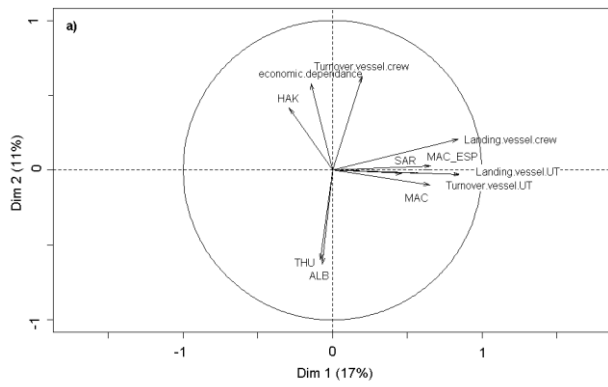
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625 Fig. 4



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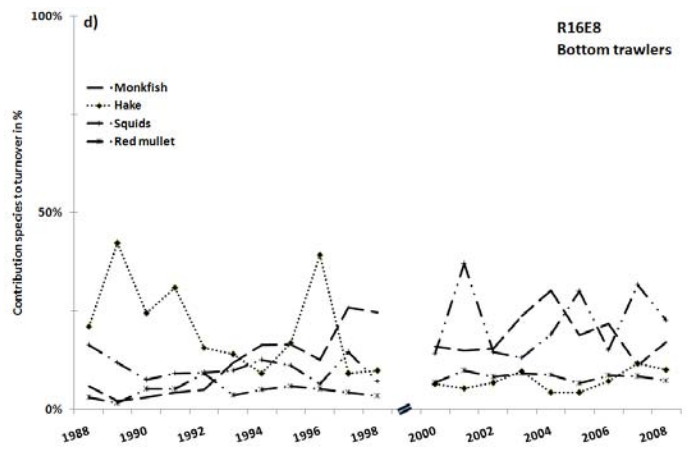
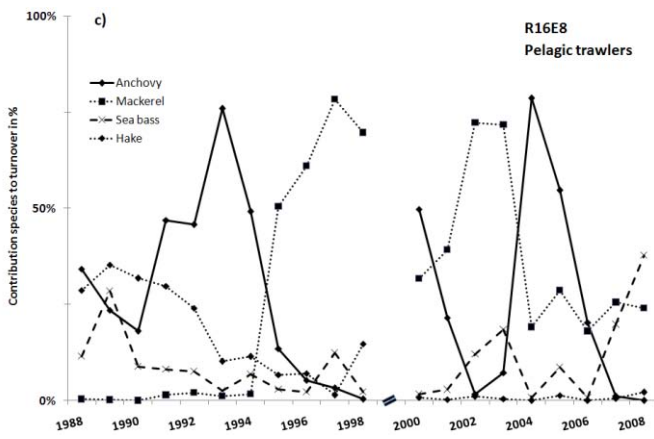
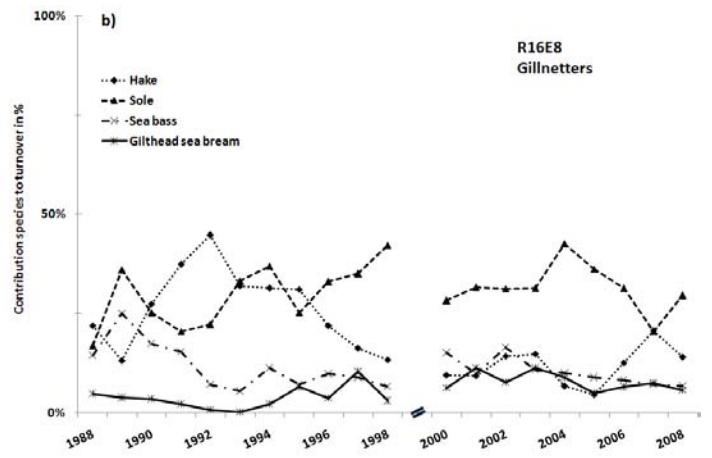
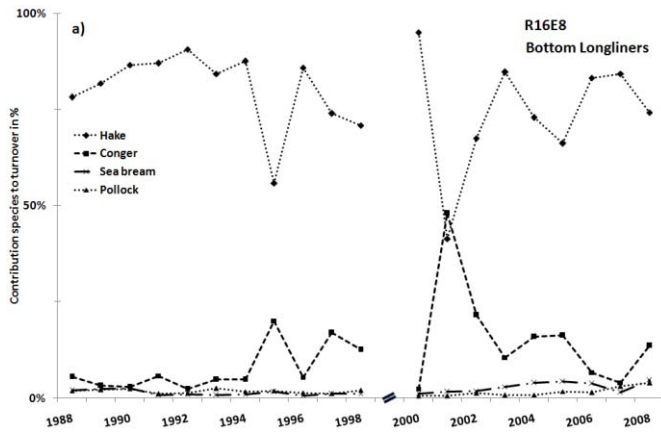
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630 Fig. 5

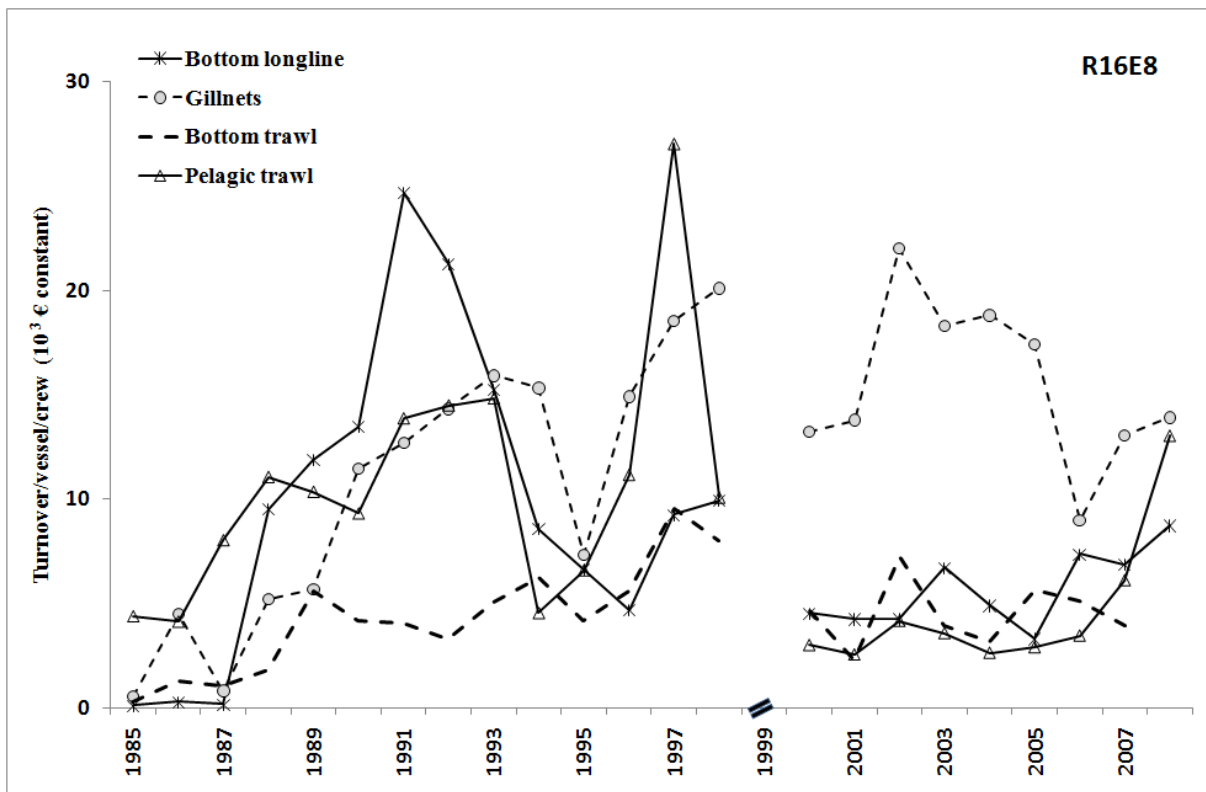
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634 Fig. 6



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637 **Tables**638 **Table 1.** Characteristics of métiers operating in the southern part of the Bay of Biscay.

| Métier | Gear dimension | Lenght vessel (m) | Trip duration | Main location | Season | Annual yields (T/vessel) | Target species (Common name) |
|-----------------|-----------------------------|-------------------|--------------------------|------------------------------------|---------------------------|--------------------------|---|
| Bottom longline | 1200 – 1800 hooks | 11 | 10 – 12 hrs | Edge of the canyon | Spring - Summer | 7 | Hake (80% of tonnage) Red Sea bream, Conger |
| Gillnet | | | | | | | Hake, Sea bream and Sea bass |
| Trammel net | 10 km/day | 12 | < 12 hrs | Coastal zone | All year | 8 | Sole, Monkfish |
| Pelagic trawl | Depends on targeted species | 21 | < 24 hrs Several days | Coastal zone | Winter – Spring Summer | 81 | Mackerel Tuna |
| Bottom trawl | Depends on targeted species | 19 | Few days | Shelf break North of the canyon | All year | 14 | Cephalopods, Red mullet, Monkfish, Hake |

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640

642 **Table 2.** Regulatory framework in the southern part of the Bay of Biscay [29].

| | Subject | Area | Origin | Date | Type of regulation | Gear, Fleets concerned | Exemption |
|--------------------|---|------------------------------|--------------------------------------|--------------|--|--|--|
| Surface | Prohibition Inside 3 miles | VIII ab | Fisheries Depart. (DPMA) | 3 Mar. 1977 | Ord. n° 1248 | Pelagic trawl | |
| | Prohibition Inside 6 miles & South 43°42' 5 N | 16E8 15E8 | Director of Maritime Affairs Bayonne | 27 Apr. 1981 | Ord. n° 88 | Pelagic trawl Bottom trawl Pelagic net | Engine power < 150 CV |
| | Maritime border | EEZ Bay of Biscay. | Government | 10 Dec. 1982 | Convention | All fleets | |
| | Restricted area 1 305 km ² | 16E8 16E7 17E7 17E8 | Prefecture | 5 Mar. 1985 | Ord.n°40 | Nets | |
| | Restricted area around landing buoy 0.8 km ² | 16E8 | Prefecture | 31 Jul. 1989 | Ord. n° 68/89 | Passive gears | Other gears |
| | Prohibition Inside 6 miles & South 43°42' 5 N | 16E815E8 | Secretariat of State | 8 Feb. 1993 | Ord. n° 21 | Bottom trawl | No more |
| | Restricted area 332 km ² | 16E8 | Prefecture | 23 Jun. 1999 | Ord n°156/99 | Nets | Except foreign vessels outside French territorial waters – area of 115 km ² |
| Fishery statistics | Logbook | EEZ | EEC | 29 Jun. 1982 | Reg. EC n°2057 | All European vessels | Vessel size >10m & < 17 m & trip duration < 24h |
| | Obligation to report catches | EEZ | Ministry | 26 Apr. 1989 | Dec. n°89/2773 | All French vessels | |
| | Catch reports | EEZ | Ministry | 18 Jul. 1990 | Ord. n°2091 | All French vessels < 10m | |
| | Logbook | EEZ | EEC | 12 Oct. 1993 | Reg. EEC n° 2847 | All European vessels | Vessel size < 10 m |
| Fishing effort | Operation Permit Implementation | | Ministry | 8 Jan. 1993 | Dec. n°99/33 | All French vessels | |
| | Driftnet prohibiting | EEZ | EEC | 8 Jun. 1998 | Reg EC n° 894/97 | All European vessels | |
| Species | Protection plan hake | VIII abcd | EEC | 14 Jun. 2001 | Reg. EC 1162/2001 2602/2001 & 494/2002 | All European vessels | |
| | Protection plan anchovy | VIII | EEC | 1 Jul. 2005 | Reg. EC 1037 | All European vessels | Duration 3 months |
| | Sole fishing license | VIII ab | EEC | 23 Jun. 2006 | Reg. EC 388/2008 | All French vessels | Landings < 2 t.year ⁻¹ or < 100kg.day ⁻¹ |
| | Anchovy fishery closure | VIIIabc | EEC | 11 Jun. 2006 | Reg. EC 1116 | All European vessels | |

644 **Table 3.** Maritime surface of rectangle and Spanish territorial waters (in km²). Prohibited
 645 maritime surface by gear concerned for the French vessels are mentioned (in km² and in
 646 percentage of total area).

| | | 15E8 | 16E7 | 16E8 | Total |
|--|---------------|---|-------------|-------------|--------------------|
| Maritime surface km ² | | 463.3 | 4 473.4 | 2 535.3 | 7 474.1 |
| Spanish territorial waters km ² | | 295 | - | 115 | 410 (5.5%) |
| Period | Gears | Prohibited surface in km² | | | |
| 1977 | Pelagic trawl | 402.9 | | 434.5 | 837.4 (11.2%) |
| 1981 | Pelagic trawl | 460.8 | | 580 | 1 040.8 (13.9%) |
| 1981 | Bottom trawl | 460.8 | | 580 | 1 040.8 |
| 1993 | All trawls | 463.5 | | 831.7 | 1 295.2 (17.4%) |
| 1982 | Longlines | 295 | | 115 | 410 (5.5%) |
| 1989 | Longlines | 295 | | 115.8 | 410.8 |
| 1985 | Gillnets | 295 | 238.6 | 950 | 1 483.6 (19.8%) |
| 1999 | Gillnets | 295 | | 332.8 | 627.8 (8.4%) |

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