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First results of fauna community structure and dynamics on two artificial reefs in the south of the Bay of Biscay (France)

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ABSTRACT

The French experiments of artificial reefs started in the 60's, mainly on the Mediterranean coast. This study focused on two main sites along the Atlantic coast (Aquitaine): the Porto artificial reef, located at Mimizan (1989) and the artificial reefs of Capbreton (1999). Both have been placed off the sandy coast at depths of 12–25 m.

A standardized monitoring by visual censuses has been performed since 2009–2010 with 4 sampling points placed on different substrates (barge and concrete pipes) to cover the whole Porto site and 2 sampling points on concrete pipes and Typi unit at Capbreton.

Twenty-two taxa were recorded on the Porto artificial reef, dominated by benthic fishes. First results indicated differences in taxa richness between the sampling points: the barge had a more important diversity than the assemblage of concrete modules. Hence, a gradient of habitat complexity is discussed in light of results on taxa richness and biomass assessments.

Visual censuses revealed a specific richness of 36 taxa on artificial reefs of Capbreton with a significant difference between concrete pipes and Typi unit. Five taxa were counted every year on both sites and could be considered as more representative of these artificial reefs: *Trachurus trachurus, Umbrina* sp., *Trisopterus luscus, Conger conger,* Blenniidae. Despite sharing common species, each site had its own species showing their complementarity.

Different temporal variations were found on both sites, in particular at Capbreton where pelagic fishes in 2010 have been replaced in 2013 by benthic fauna.

These pioneering analyses on the Aquitaine coast require further research, particularly on the temporal evolution of abundances and biomass.

1. Introduction

Artificial reefs (ARs) have been used for a variety of purposes: ecosystems conservation and restoration, fish stock enhancement, fishery management and improvement, aquaculture, research and recreation (Jensen, 2002). Recently, the use of ARs is also encouraged as part of Marine Protected Areas (MPA), for instance to sustain artisanal coastal fisheries, or prevent illegal trawling, so protecting seagrass beds (Barnabé et al., 2000; Claudet and Pelletier, 2004).

Many studies showed an increase of the diversity and/or the abundance of fish after the deployment of ARs (Bohnsack and Sutherland, 1985; Alevizon and Gorham, 1989; Walker et al., 2002) especially when sites are located far from natural hard substrates (Bombace et al., 1994) or surrounded by barren expanses of sand (Walsh, 1985). Deployment of ARs can also lead to several effects such as increasing the number of local resident reef fishes (Alevizon and Gorham, 1989), altering the composition of meiofaunal assemblages (Danovaro et al., 2002), affecting the soft-bottom community (Davis et al., 1982; Fabi et al., 2002), increasing secondary biomass production (Cresson et al., 2014b).

France was the first European country to carry out experiments on artificial reefs, starting in 1968 with some pilot reefs made of waste materials on the Mediterranean coast. Most of the French ARs are now located along the Mediterranean coast, 19 sites versus 8 along the Atlantic coast (Tessier et al., 2015). This difference in the

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amount of constructions between the two coasts reflects the relatively instable benthic condition of the Atlantic coast (Barnabé et al., 2000). Tessier et al. (2015) also assumed a lesser demand among Atlantic stakeholders or differences of local artisanal fishing practices.

The French Mediterranean ARs received much more attention (e.g. Ody and Harmelin, 1994; Barnabé et al., 2000; Charbonnel et al., 2002; Cresson et al., 2014a) than the French Atlantic ARs, which might be explained by their lower number, the action of swell and the difficulties associated with observation by SCUBA divers in the Atlantic.

The recreational divers' association ADREMCA (Mimizan, Aquitaine coast in the southern part of the Bay of Biscay) deployed the Porto artificial reef in 1989. Several materials were used over time: tyres, concrete modules, barge … Ten years later, another association (ALR) placed 800 m^3 of concrete pipes at Capbreton (60 km south of Mimizan). In 2010 it deployed its new concrete module called "Typi".

All these ARs were placed to restore and enhance the marine fauna of this sandy area. Anchoring, diving and all types of fishing are prohibited by a prefectural decree from juridical authority.

The main purpose of this work is to study the composition of the fish community associated to these ARs. We present here the first results of our 4-years survey related to 1/community structure, 2/spatial variations and 3/temporal variations.

2. Materials and methods

2.1. Study area and artificial reefs

The study was conducted along the Landes coast, in the south of the Bay of Biscay (Fig. 1). This area is a subtropical/boreal transition subprovince. The fauna in this area is mixed with groups of boreal and subtropical origin and many fish species reach the southern or northern limit of their distribution in the Bay of Biscay (OSPAR Commission, 2000).

The first site (Porto AR), managed by the association ADREMCA, is located ~ 18 km off Mimizan at of 12–25 m water depth on a sandy substrate. A barge (18 × 3.5 m) has been placed in 1994, then a central chaotic structure of concrete modules in 2003 (with modules added each year) and an isolated cluster in 2003 and 2004 formed by 100 t of concrete modules. The nearest rocky shore is 84 km away to the south and extends to the Spanish border.

The second site (Capbreton AR) is established on a sandy bottom, at 18 m depth near the Capbreton Canyon, a unique feature in Europe where the shelf break (isobaths 200 m) is only 2 km from the coast. We focused on two structures: a single module "Typi" of 70 m^3 (13 t, diameter 4.64 m, height 2.60 m) deployed in 2010, and 800 m^3 of concrete pipes (diameter 0.9 m, length 1 m) deployed individually and randomly in 1999. The site is 20 km away of the rocky shore.

2.2. Sampling design

According to Bortone (2006), researchers were often tempted to answer many reef fish assemblage questions in a single study. Thereby we focused our survey on the development of a consistent sampling method which will track relative changes in fish abundance.

The census technique was elaborated taking into account some difficulties: oceanic conditions (low visibility, high swell, low temperatures), materials and time constraint. We chose a stationary visual census adapted from Bohnsack and Bannerot (1986) rather than a linear transect method because this technique does not require materials or preplacement of reference line and it can also be conducted in a limited area (Bortone et al., 1989). The stationary method is logistically simple to implement and also allows an extended period of observation of given individuals (Colvocoresses and Acosta, 2007).

Two divers counted fishes in a cylindrical space of 2 m radius during 3 min. The size of the radius was adapted to the poor visibility in the area. As recommended by Bohnsack and Bannerot (1986), sampling radius can be small if all stations are sampled in the same condition. The duration (3 min) was determined by the SCUBA divers, considering all stations to monitor and their time limitation underwater. Data on species composition, abundance and size (only on the Porto AR) were collected simultaneously.

Four stations have been chosen for the Porto AR to cover the whole site and its different substrates (Fig. 1): the barge (station 1), the central chaotic structures of concrete modules (stations 2 and 3) and the isolate cluster of concrete modules (station 4). The survey was conducted from 2009 to 2012, during the months of July, August and September. A total of 15 underwater visual censuses were carried out under standardized conditions (meaning with >2 m visibility), involving 3 to 5 replicates on all stations each year (Table 1).

Two stations were sampled on the Capbreton AR: the Typi, which data have been collected since its deployment in 2010, and the concrete pipes, already deployed since 1999. The survey was conducted from 2010 to 2013, mostly between June and September. A total of 14 underwater visual censuses were carried out, meaning 2 to 5 replicates on both stations each year (Table 1).

Intra-annual variations, mostly due to seasonality and reported in many studies (Bohnsack and Sutherland, 1985; Relini et al., 1994; Santos et al., 2005), were not included since all dives were conducted each year at the same period for both sites (*i.e.* between June and September).

2.3. Data treatment

ARs on both sites were deployed in different years, they also differed in terms of substrates and number of modules. Hence some data could not be compared.

Community structure parameters, including mean abundance (mean number of individuals/dive/m^3), mean taxa richness (mean number of taxa/dive) and mean biomass (mean weight (g)/dive/m^3), were calculated for each stationary point and then compared among stations using non-parametric test (Wilcoxon–Mann––Mann–Whitney test) and through years (Kendall test). A frequency of appearance (FA) was assessed according to Rilov and Benayahu (2000): FA = (number of censuses in which the species *i* was counted/total number of censuses) X 100. The frequency of appearance of each species was then transformed into four categories: $0 < FA \leq 25$, $25 < FA \leq 50$, $50 < FA \leq 75$, $75 < FA \leq 100$.

Fish size was only recorded on the Porto AR (not on the Capbreton AR), allowing biomass assessment. The fish weight was calculated using the power function $W = aL^b$, where W is the weight (g), L is the estimate length (cm), and a and b are parameters estimated by linear regression of logarithmically transformed length–weight data. We used the parameters a and b reported previously in the literature (Bauchot and Bauchot, 1978; Latrouite et al., 1981; Dorel, 1986; Coull et al., 1989; Morato et al., 2001; Santos et al., 2002; Borges et al., 2003; Mahé et al., 2006; Robinson et al., 2010; Torres et al., 2012).

We also performed a multivariate analysis for comparing the community structure of the two sites through time, using a correspondence analysis based on the presence/absence of taxa with the Statbox software (6.4 version). Species were assigned to three functional groups adapted from Bombace et al. (1994) and

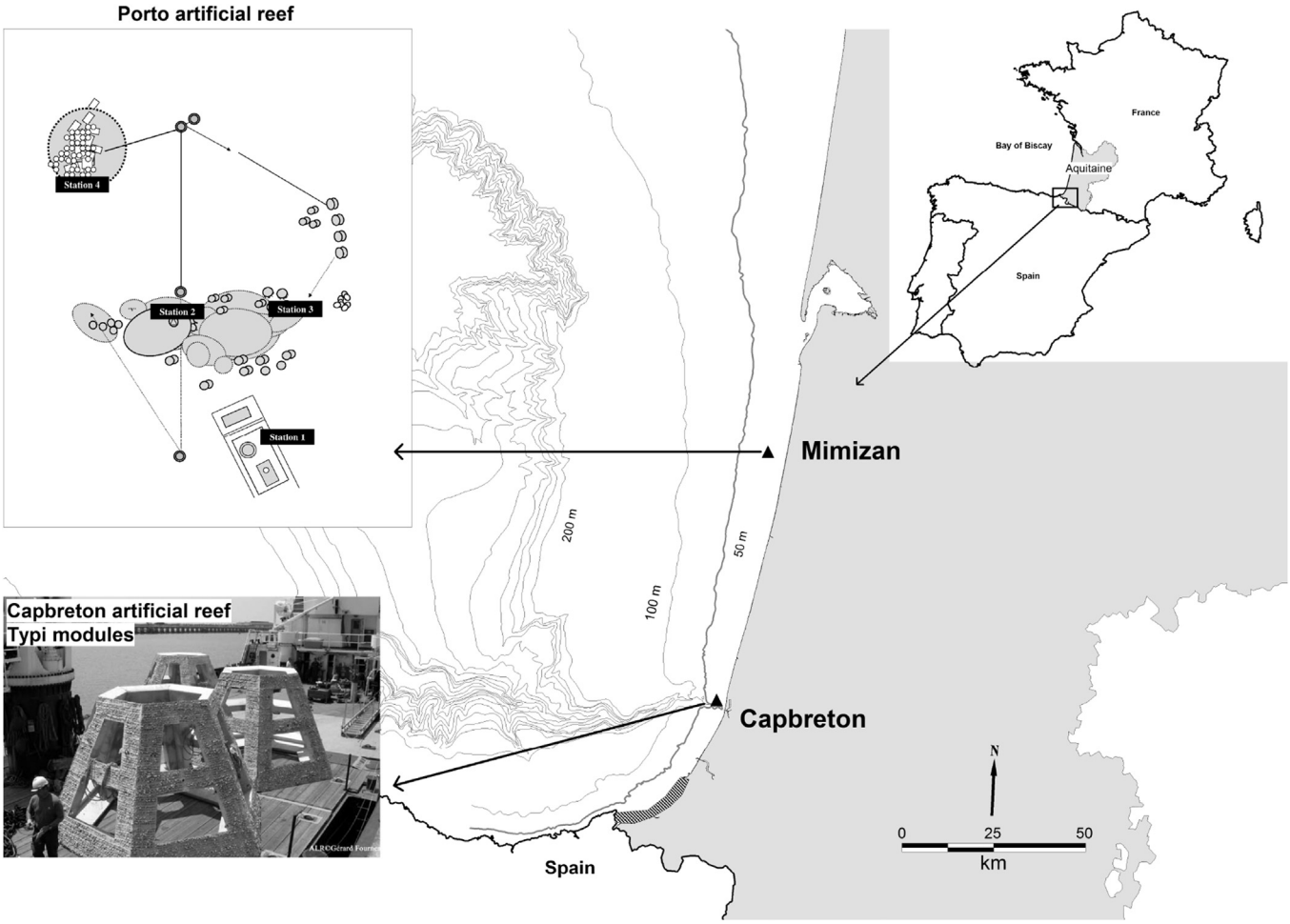

Fig. 1. Map of the study area. Reef organization on the Porto artificial reef (at Mimizan) is detailed with location of the 4 visual censuses stations. The photography illustrates Typi modules before their deployment at Capbreton. Hatching area represents the natural rocky shore that extends to the Spanish border.

Table 1
Number of dives performed each year on the two artificial reefs: Porto and Capbreton. All stations were sampled during each dive. (NA: no data available).

Artificial reef	Station	Year				
		2009	2010	2011	2012	2013
Porto	Station 1	3 dives	5 dives	4 dives	3 dives	NA
	Station 2					
	Station 3					
	Station 4					
Capbreton	Concrete pipes Typi	NA	4 dives	2 dives	3 dives	5 dives

according to their habitat: Pelagic (P), Bentho-demersal (BD) and Benthic (B).

All analyses were conducted after homogenizing data to a mixed taxonomic level (see Table 2).

3. Results

3.1. Fish assemblage

Marine fauna monitored in the two study sites was listed in Table 2 according to the frequency of appearance (FA). A total of 22 taxa (50% benthic) was counted on the Porto AR.

Most common species ($75 < FA \leq 100$) were combtooth blennies, European conger (*Conger conger*), pouting (*Trisopterus luscus*), velvet crab (*Necora puber*), striped red mullet (*Mullus surmuletus*), Atlantic horse mackerel (*Trachurus trachurus*), edible crab (*Cancer pagurus*) and drums (*Umbrina* sp.). Among them, Atlantic horse mackerel and pouting represented more than 80% of total abundance.

Thirty-six taxa were recorded on the Capbreton AR. Sparidae was the most representative family with 5 species. Most common species ($75 < FA \leq 100$) were combtooth blennies, European conger, pouting, Atlantic horse mackerel, octopus (*Octopus vulgaris*) and drums. The most abundant species were: Atlantic horse mackerel, pouting, drums and striped red mullet.

Some species were specific to one or the other AR. For instance, 5 species were counted only on the Porto AR, e.g. bogue (*Boops boops*) or meagre (*Argyrosomus regius*). In the same way, 19 taxa have been seen only on the Capbreton AR, especially Sparidae (such as *Diplodus vulgaris* or *Spondyliosoma cantharus*).

Table 2
Frequency of appearance (FA) of all taxa that occurred in the censuses on the two study sites. [The number of asterisks represents the taxa frequency as follows: * = 0 < FA ≤ 25, ** = 25 < FA ≤ 50, *** = 50 < FA ≤ 75, **** = 75 < FA ≤ 100]. Species were assigned to three functional groups adapted from Bombace et al. (1994) and according to their habitat: Pelagic (P), Bentho-demersal (BD) and Benthic (B).

Family	Species	Common name	Habitat	Porto AR	Capbreton AR
				FA	FA
Balistidae	*Balistes capriscus*	Grey triggerfish	BD	*	***
Blenniidae	Blenniidae	Combtooth blennies	B	****	****
Cancridae	*Cancer pagurus*	Edible crab	B	****	*
Carangidae	*Trachurus trachurus*	Atlantic horse mackerel	P	****	****
Clupeidae	*Sardina pilchardus*	European sardines	P	*	*
Congridae	*Conger conger*	European conger	B	****	****
Engraulidae	*Engraulis encrasicolus*	Anchovy	P		*
Gadidae	*Pollachius pollachius*	Atlantic pollock	BD		*
	Trisopterus luscus	Pouting	BD	****	****
Gobiidae	*Gobius nig er*	Black goby	B		*
Labridae	*Ctenolabrus rupestris*	Goldsinny wrasse	BD	*	
	Labrus bergylta	Ballan wrasse	BD	*	*
	Symphodus sp.	Wrasse	BD		***
Majidae	*Maja brachydactyla*	European spider crab	B	*	*
Molidae	*Mola mola*	Ocean sunfish	P	*	*
Moronidae	*Dicentrarchus labrax*	European seabass	BD		*
Mullidae	*Mullus surmuletus*	Striped red mullet	B	****	***
Nephropidae	*Homarus gammarus*	Common lobster	B	**	
Octopodidae	*Octopus vulgaris*	Octopus	B	**	****
Osmeridae	*Mallotus villosus*	Capelin	P		**
Paguridae	*Pagurus bernhardus*	Hermit crab	B		**
Palaemonidae	*Palaemon serratus*	Common prawn	B		***
Polybiidae	*Necora puber*	Velvet crab	B	****	***
Sciaenidae	*Argyrosomus regius*	Meagre	BD	*	
	Umbrina sp.	Drums	BD	****	****
Scombridae	*Sarda* sp.	Bonito	P		*
Scophthalmidae	*Scophthalmus rhombus*	Brill	B		*
	Zeugopterus punctatus	Topknot	B	**	
Scorpaenidae	*Scorpaena* sp.	Scorpionfish	B	*	***
Sepiidae	*Sepia officinalis*	Common cuttlefish	B		*
Serranidae	*Serranus cabrilla*	Comber	BD		**
Soleidae	*Solea solea*	Common sole	B		*
Sparidae	*Boops boops*	Bogue	BD	*	
	Diplodus puntazzo	Sharpsnout seabream	BD		*
	Diplodus sargus	White seabream	BD		****
	Diplodus vulgaris	Common two-banded seabream	BD		***
	Sparus aurata	Gilthead seabream	BD		**
	Spondyliosoma cantharus	Black Seabream	BD		**
Trachinidae	Trachinidae	Weevers	B	**	**
Triglidae	Triglidae	Gurnards	B		*
Zeidae	*Zeus faber*	John Dory	BD	**	**

Both sites had 17 taxa in common, including 5 taxa that were counted every year: combtooth blennies, Atlantic horse mackerel, European conger, drums and pouting. Almost all these taxa were among the 10 most abundant at both sites (Table 3).

Table 3
Ranking of the ten most abundant taxa at each study site [*: species present, but with lower abundances (i.e. rank >10)].

Species	Porto AR	Capbreton AR
Trisopterus luscus	1	2
Trachurus trachurus	2	1
Sardina pilchardus	3	6
Mullus surmuletus	4	4
Umbrina sp.	5	3
Necora puber	6	*
Boops boops	7	
Conger conger	8	*
Blenniidae	9	9
Cancer pagurus	10	*
Mallotus villosus		5
Diplodus sargus		7
Engraulis encrasicolus		8
Diplodus vulgaris		10

3.2. Spatial variations

3.2.1. Taxa richness

Station 1 (barge) of the Porto AR (Fig. 2) showed a higher mean taxa richness than stations 3 ($p = 0.02$) and 4 ($p = 0.02$), as well as station 2 compared to station 4 ($p = 0.03$). Taxa richness of the other stations was similar. A decreasing richness gradient can be observed from station 2 to station 4.

At the scale of the two sites, the mean taxa richness is higher on the Capbreton AR, especially around the concrete pipes (see Table 4 for all p-values).

3.2.2. Abundances and biomass of marine fauna

The mean biomass (mean weight (g)/dive/m^3) was assessed on the Porto AR where fish sizes were reported (Fig. 3a). Station 4 had a higher biomass than the other stations ($p < 0.01$). Station 1 had a mean biomass higher than station 2 ($p = 0.02$) and station 3 ($p = 0.02$). Most of the biomass differences between the stations on the Porto AR were explained by the reef-dwelled congers.

Abundances were the same on all stations on the Porto AR (Fig. 3b; $p > 0.05$ for all of them) and did not differ with the Typi. The highest abundance (mean number of individuals/dive/m^3) was

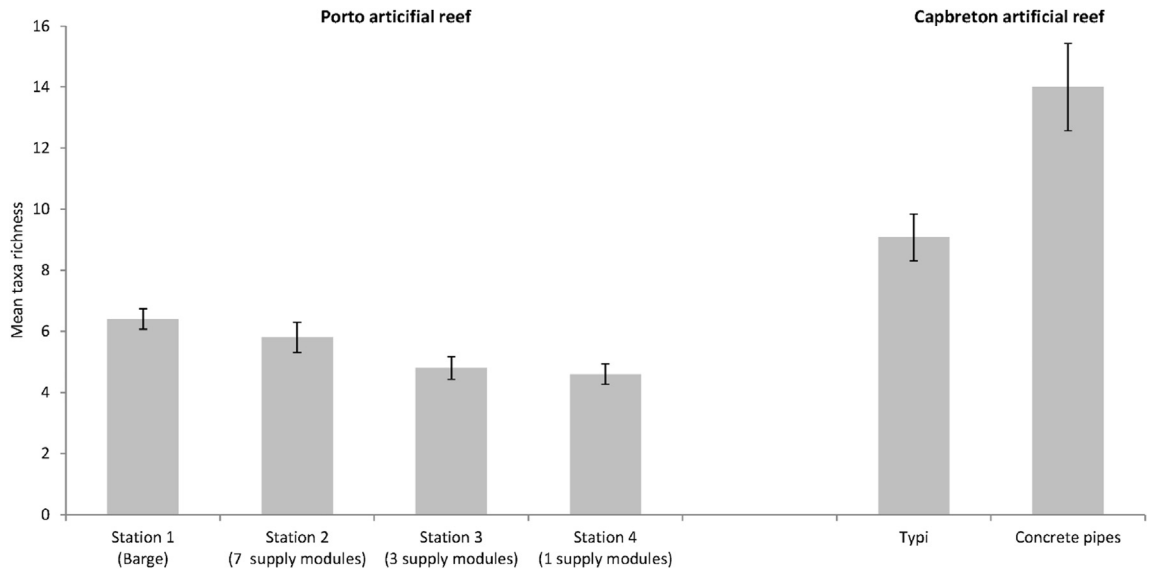

Fig. 2. Mean taxa richness (mean number of taxa/dive ± S.D) on the Porto AR (2009–2012) and on the Capbreton AR (2010–2013). Number of added modules on the Porto AR is also indicated.

Table 4
Comparison of taxa richness between stations. Analyses were performed using a Wilcoxon–Mann–Whitney test. Significant values are in bold type.

Porto artificial reef				Capbreton artificial reef	
	Station 2	Station 3	Station 4	Typi	Concrete pipes
Station 1	0.90	**0.02**	**0.02**	0.16	**0.01**
Station 2		0.06	**0.03**	0.2	**0.01**
Station 3			0.33	**<0.01**	**<0.01**
Station 4				**<0.01**	**<0.01**
Typi					**0.03**

found around concrete pipes (Fig. 3c). These latter dominated all the stations ($p \leq 0.01$) because of the greater abundances of Atlantic horse mackerel, pouting and drums. The seabreams, only recorded on the Capbreton AR, also were abundant and had a part in the differences between stations.

3.3. Temporal variations

The mean taxa richness did not show a temporal trend on both sites (Fig. 4; $p > 0.05$).

However a closer look to the temporal variations of the community structure on the Porto site (Fig. 5a) indicated a divide between the first year (2009) and the others. A pool of 8 taxa was common each year, in the middle of the correspondence analysis (combtooth blennies, *C. pagurus*, etc.).

A temporal pattern has been highlighted on the Capbreton AR (Fig. 5b) where pelagic species reported in 2010 (ocean sunfish *Mola mola*, sardines) were replaced by benthic species in 2013 (edible crab, gurnards or common sole *Solea solea*).

4. Discussion

4.1. Porto AR

The fish responses to reefs are often affected by site-specific factors related to the design, size and complexity of the reefs, features of the area, proximity to other reefs, and biological factors such as competition and density-dependent mortality (Chandler et al., 1985; Bohnsack et al., 1994; Charbonnel et al., 2002; Moreno, 2002; Strelcheck et al., 2005; Hunter and Sayer, 2009; Campbell et al., 2011).

The Porto AR fish assemblage showed a spatial pattern related to habitat complexity. The highest taxa richness was found on the barge, established in 1994. We assume that the barge may be more complex than the other modules, providing more available space resources for fishes, or a vertical relief (Chandler et al., 1985; Rilov and Benayahu, 2000). Baynes and Szmant (1989) also showed the importance of the current flow around a wreck AR for sessile benthic community. To our knowledge, no artificial reef study has yet compared the fish assemblage between a barge and concrete modules. However, papers had already showed the prominent role of habitat complexity in relation to artificial reef design on diversity and abundance of the fish assemblage (e.g. Charbonnel et al., 2002).

Every year since 2003, new modules were randomly sunk in the central part of the site, increasing reef size and complexity. These additions created a chaotic and heterogeneous arrangement that provided various sizes of shelters and benefits for many fish species (Charbonnel, 2005). Despite no significant results, the richness gradient observed between stations 2 and 3 could be linked to a difference in modules added: with seven additions of concrete modules through years, station 2 could have a more complex structure than station 3 (3 modules added). In the same way, the isolate cluster (station 4), where no module has been added since its deployment (2004–2005), could be considered as simple design.

Nevertheless, this complexity gradient was not reflected in the biomass analysis. Indeed, station 4 had the highest biomass due to the presence of big European congers (greater allometric growth parameter b among species). One explanation could be that the addition of modules each year on stations 2 and 3 could disturb resident species as conger. Therefore we could assume that a single deployment was better for this species than a successive deployment. A second hypothesis is that the random assemblage of modules at station 4 could also provide a more suitable shelter for congers.

Station 1 had the second highest mean biomass, still due to the congers. If this result reinforced our hypothesis of a more complex design of the barge and could be relevant with previous

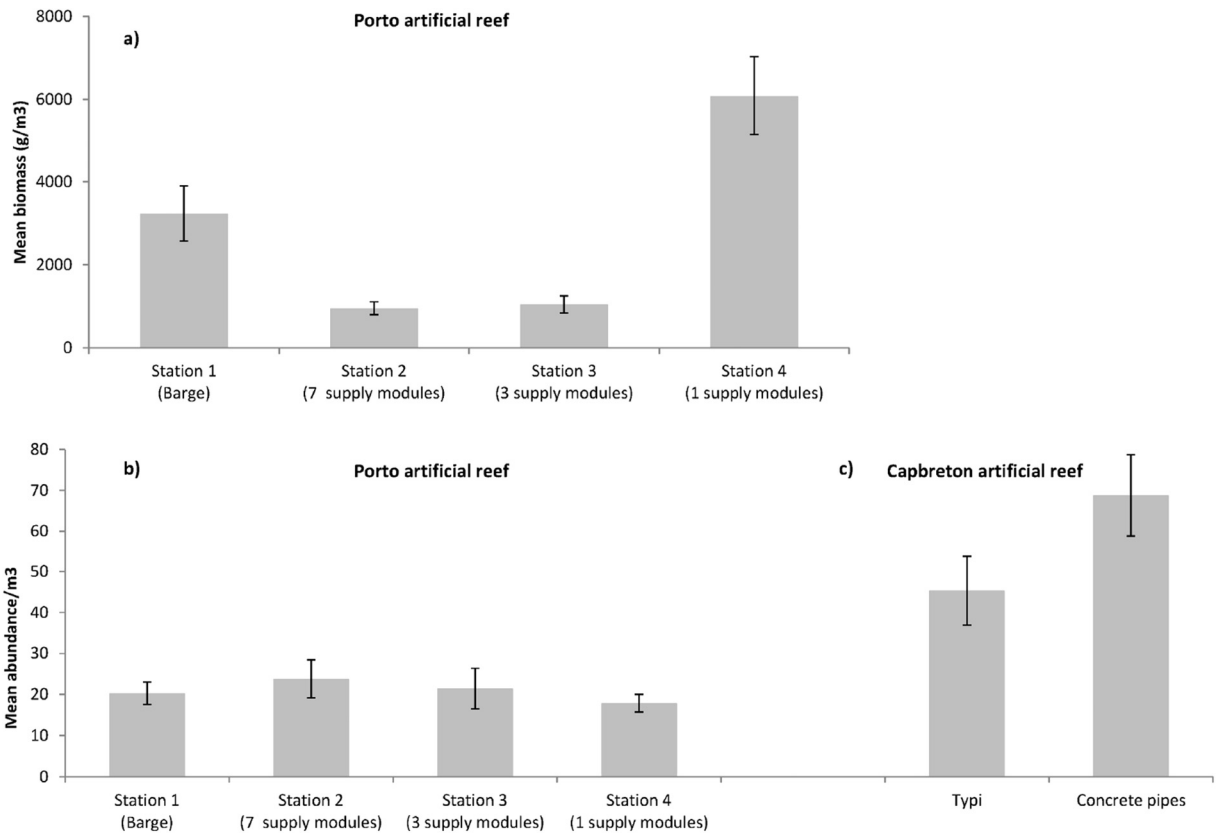

Fig. 3. Mean biomass (mean weight(g)/dive/m^3 ± S.D.) on the Porto AR (a), mean abundance (mean number of individuals/dive/m^3 ± S.D.) on the Porto AR (b) from 2009 to 2012 and on the Capbreton AR (c) from 2010 to 2013. Number of added modules on the Porto AR is also indicated.

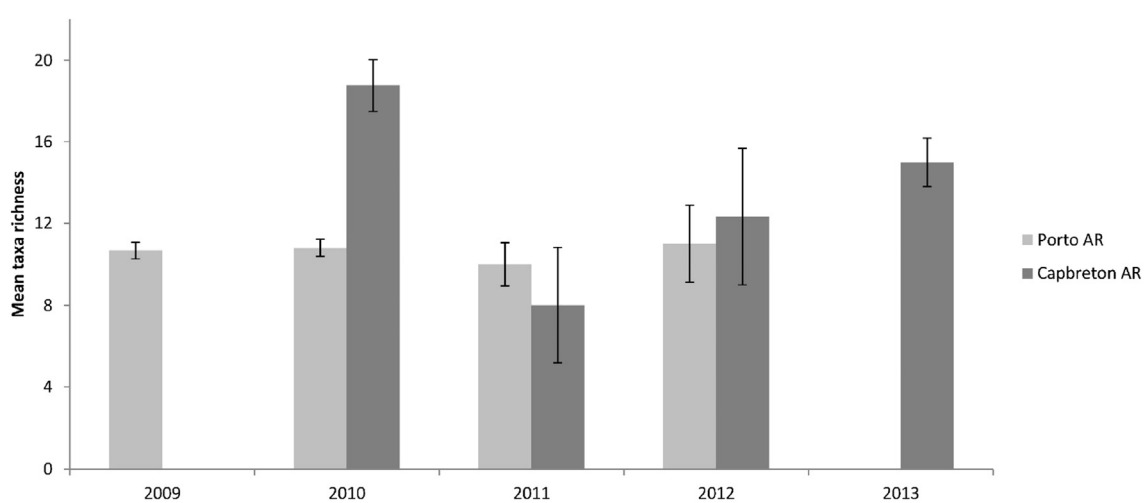

Fig. 4. Variation of the mean taxa richness on the Porto artificial reef from 2009 to 2012, and on the Capbreton artificial reefs from 2010 to 2013 (±S.D.).

studies (Charbonnel et al., 2002; Hunter and Sayer, 2009; Le Diréach et al., 2015), it did not match with our last assumption about the less complex design of station 4. This observation emphasizes the need to consider several factors to define the degree of complexity of an AR. More investigations *in situ* would be necessary to better determine the modules assemblage on the Porto AR and lead to further conclusions.

The Porto reef gathered resident taxa such as European conger, combtooth blennies and striped red mullet counted every year. Besides, pouting and Atlantic horse mackerel represent more than 80% of the total abundance. These two species are known to be attracted by artificial hard substrates (Fabi et al., 2004; Santos et al., 2005; Reubens et al., 2011, 2013a, 2013b). The Atlantic horse mackerel is one of the most important species caught off the south of the Bay of Biscay in the 22 km boundary (Augris et al., 2009). Recent studies evidenced the important role played by artificial reefs, directly or indirectly, for fish

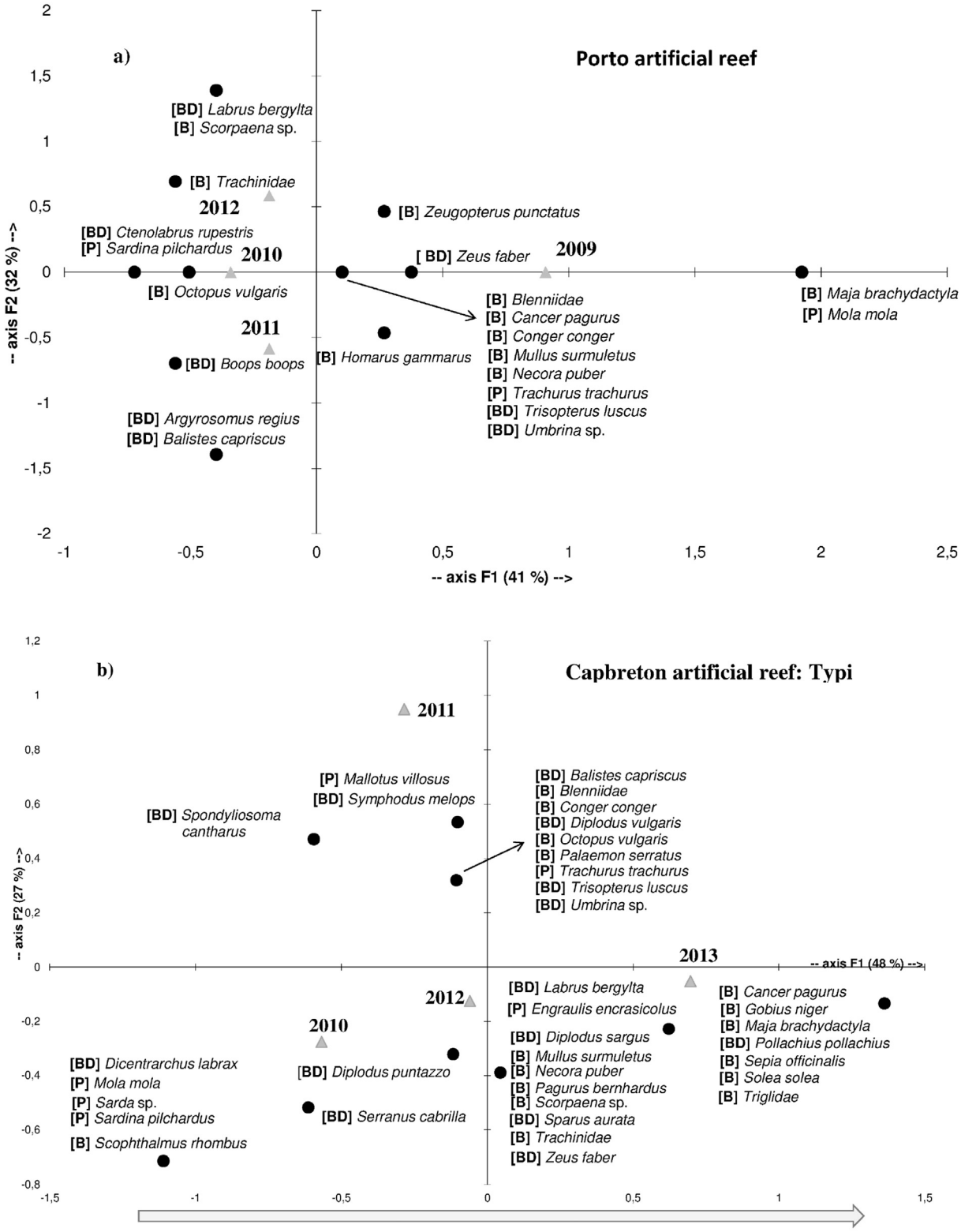

Fig. 5. a) Correspondence analysis, projection of the years (2009–2012) and taxa recorded on the Porto artificial reef in the principal plane (first and second axes plane). b) Correspondence analysis, projection of the years (2010–2013) and taxa recorded on the Capbreton artificial reef in the principal plane (first and second axes plane). Habitat of each taxa is showed [B = Benthic; BD = Bentho-demersal; P = Pelagic].

foraging (Relini et al., 2002; Fabi et al., 2006; Leitão, 2013 and references therein; Leitão et al., 2007; Claisse et al., 2014; Cresson et al., 2014a, 2014b), thus a new attention should be paid to better understand the use of Porto AR by these species.

4.2. Capbreton AR

The Typi module was monitored since its deployment, near concrete pipes sunk in 1999. One month after its settlement, only 7

taxa were counted among the 17 found on concrete pipes. Three years later, a total diversity of 28 taxa has been observed on the Typi and the species richness per dive had increased (sometimes doubled). We assumed the Typi would benefit of the population already established on the old concrete pipes (~10–15 m away) as demonstrated elsewhere (Leitão et al., 2008). This hypothesis was also reinforced by the abundances. According to the review of Bohnsack and Sutherland (1985), equilibrium community structure is usually achieved within one year to a maximum of 5 years, depending on seasonal variations. However, species richness can continue to increase even more than 10 years after deployment (Tessier et al., 2015 and references therein).

A temporal change in marine fauna community has been highlighted on the Typi since its deployment. Some of the species observed only the first year were not related to the Typi settlement because they usually are not attracted by artificial reefs (e.g. ocean sunfish). However a change in the community structure was revealed, especially in 2013 with a lot of new benthic species as gurnards.

The Typi had a more complex structure than concrete pipes through its architecture with voids, shelter, vertical relief and heterogeneity. Hence we suggest that Typi could have attracted new site-specific species, e.g. gurnards and sharpsnout seabream *Diplodus puntazzo*, only recorded on this reef. Habitat limitation is the primary factor determining the specific composition of the artificial reef fish assemblages through availability of food or shelter (Bohnsack, 1989). As old reefs are limited in extension, the provision of the Typi could bring new habitats for the population already established, and attract new species.

The Capbreton AR was created to enhance fish stock and to sustain artisanal coastal fisheries. Four pelagic and demersal species among the most important in the Bay of Biscay in terms of abundance and commercial interest were recorded on this AR: sardine, anchovy, Atlantic horse mackerel and pouting (OSPAR Commission, 2000). Ten bentho-demersal or benthic taxa with a more moderate commercial interest were also recorded on the Capbreton AR, such as seabreams, bogue or scorpionfish. Leitão et al. (2009) remind us the important role played by AR as a tool for the management of fish stocks in the case of artisanal fisheries. Coastal fisheries are very important along the Aquitaine coast since 80% of the local fleet operate within 22 km (Caill-Milly and Prouzet, 2013). Several ARs worldwide failed to contribute to fisheries enhancement, as usually no guidelines for artificial reef sustainable exploitation are enforced (Leitão et al., 2009). These authors recommended a fishery management based on knowledge of the reef fish assemblages.

4.3. Both sites

The study was not intended to compare the management or efficiency of each site, managed by different associations. Even if the monitoring was created for both sites, unfortunately its application differed in time and some comparisons were not possible, in particular regarding the biomass. Nevertheless, our results highlighted some valuables points.

First of all, we observed the effect of habitat complexity on taxa richness. Our preliminary work can sort the stations according to a decreasing effect of architectural complexity on diversity: concrete pipes > Typi = Barge = 7 supply >3 supply = 1 supply.

This relation was not so obvious for the abundances even if concrete pipes had the greatest abundances. The biomass, only recorded on the Porto AR, was largely dominated by congers and did not match with the previous relationship about complexity. As a result, we recommend investigating the size and the modules' assemblage to better define the complexity of these ARs. The study of the biomass is also needed on the Capbreton AR.

The location of the two sites could also explain some differences among the taxa recorded, particularly the distance between them (60 km away). Moreover, Capbreton AR is closer to the rocky shore (20 km) than the Porto AR (84 km). These coastal influences may have served as donor area and facilitated the colonization, or the adult emigration.

5. Conclusions

Artificial reefs of the French Atlantic coast have been rarely studied compared to the man-made structures located in Mediterranean. Hence the present study is the first to integrate a long-term standardized monitoring on two main ARs at Mimizan (Porto AR) and Capbreton. The preliminary results had described for the first time the fish assemblage of these French Atlantic ARs. The analyses showed a spatial distribution of taxa richness that could be linked to a gradient of architectural complexity. The monitoring of Capbreton site indicated that, three years after its deployment, colonization of the Typi is still ongoing with changes in the population structure (e.g. appearance of more benthic species).

Despite sharing common species, each site had its own species linked to its particularities. In any case, it is important to guarantee long-term monitoring of the ARs fish assemblage, especially because these sites are unique in the Bay of Biscay.

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