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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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A B S T R A C T

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