Fish assemblages of the Prado bay reefs: high volumes and complexity are keys of efficiency

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INTRODUCTION

A 7 years fish survey has been conducted on the artificial reefs (AR) of the Prado bay (27 300 m^3, 400 reefs, 25-30 m depth, Marseilles, France) to assess the colonization dynamic of the 6 different types of reefs. The evolution of the population parameters has been analyzed to compare the fish assemblage per reef type, per reef group, and per location within the ARs concession.

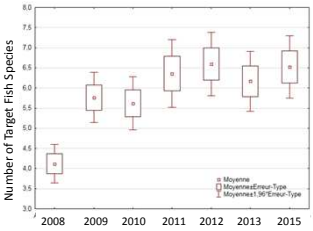
SAMPLING PROTOCOL

A seasonal monitoring of the fish has been conducted by visual census of abundance and size from 2009 to 2015 on the 6 reef types. Among results those from the autumn period are the most demonstrative when the fish population is the most stable and diverse. At least 6 census have been performed and analyzed per reef and per year (except 2014) totalizing 334 replicates.

RESULTS

Increasing of specific richness

The total number of the observed fish species since 2008 has now reached 76. The total fish species (PERMANOVA F=4.5; p=0.001) and the fishing targets' number (F=7.2; p=0.001) as well, are still increasing but less steeply than during the first year.

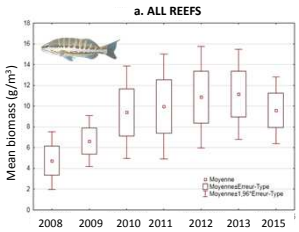


Increasing of biomass X 4 (total fish) to 8 (fishing targets) in 7 years

Fish Biomass (kg)			Min-Max biomass	Mean automnal biomass	Autumn 2015		Evolution 2008-2015
Reef type	Volume (m^3)	Fish Species			Mean	*Std error*	
ACI	187	Total	10.3-23.3	15.9	23.3	*12.6*	x 1.2
		Targets	5.8-13.8	8.8	13.8	*5.9*	x 2.4
ENR	100	Total	9.1-22	14.3	17.9	*14.7*	x 1.3
		Targets	6.6-12.7	8.6	12.7	*9.9*	x 1.9
FAK	75	Total	4.0-32.5	13.6	32.5	*17.6*	x 8.1
		Targets	3.0-30.0	11.2	30	*17.8*	x 10.0
CHI	19	Total	0.5-4.6	2.1	4.6	*3.8*	x 8.4
		Targets	0.3-4.2	1.2	4.2	*3.2*	x 14.8
AMA	10	Total	2.0-7.7	4.4	6.1	*6.8*	x 1.6
		Targets	0.7-4.6	2.5	4.6	*5.9*	x 1.9
FIL	21	Total	1.4-14.9	6.1	1.4	*0.6*	x0.1
		Targets	0.4-2.5	1.3	0.9	*0.7*	x2.0

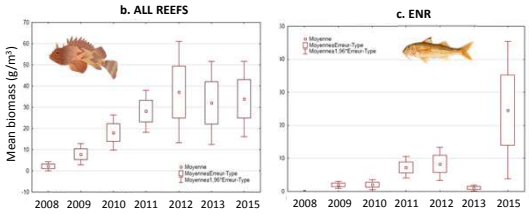
The mean fish biomass (kg) has been x1.2 to x8.4 and the fishing targets' biomass increased 1.9 to 14.8 according to the reef type. The FIL reef acting as a Fish Attractive Device (FAD) has a high empty volume (252 m^3) and shelters more often seasonal pelagic species as thunnids which are not easy to census.

The **trophic structure** of the fish population has significantly changed among years (F=6.02, p=0.0001).
Macrocarnivorous fish have increased between 2008 and 2015 (a.).



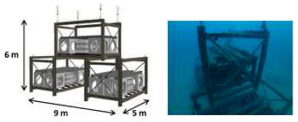
The **behavioural structure** and **spatial distribution** of the fish population has also changed (F=8.5, p=0.001). **Sedentary benthic species** = species with a reduced home range a**re favoured** (b.).

Other fish like *Mullus surmuletus* with a **high horizontal mobility** have found a suitable habitat as **quarry rocks** (ENR) had a biomass X by 100 (c.).

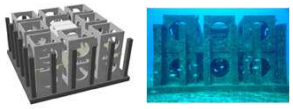


High volumes and more complex reefs (FAK, ACI, ENR) *vs.* smaller and single reefs (CHI, AMA)

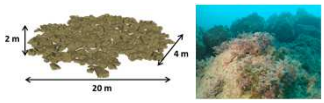
High volumes and more complex reefs (ACI, FAK, ENR) reach higher specific richness and mean biomass especially of fishing targets, carnivorous and piscivorous fish than the smaller reefs (CHI, AMA). The dynamics and trophic composition of their fish population are homogeneous in each group.



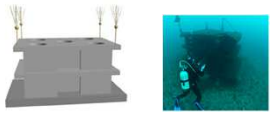
Steel basket (ACI)



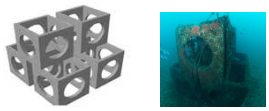
Fakir basket (FAK)



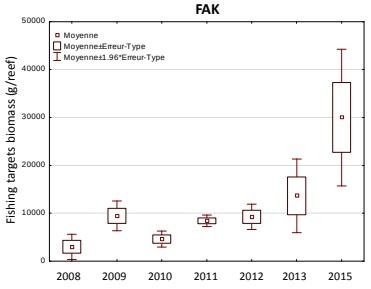
Quarry rocks (ENR)

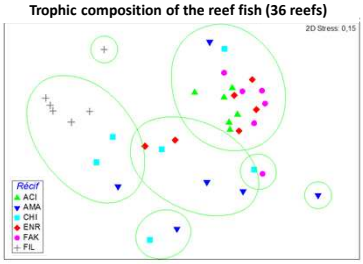


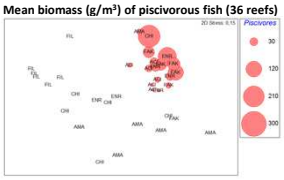
Maze (CHI)

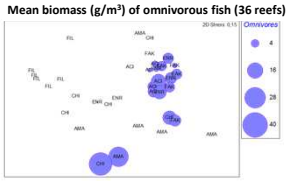


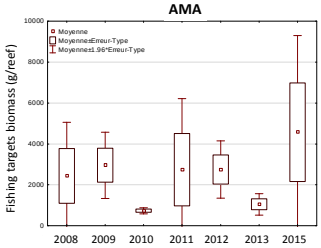
Cubes piles (AMA)











CONCLUSION

- **The biomass increasing is mainly due to the individual size increasing and a reserve effect (fish is banned) especially for fishing targets;**
- **the increasing of the carnivorous species assesses that the assemblages are more stable and mature after 7 years;**
- **mobile demersal species as sea breams are also using the Prado reefs more seasonally and their population does not increase in time;**
- **the type of reef has more influence on the fish assemblages' characteristics than their location within 'villages' or 'functional connections'**
- **the fish population is quite homogenous at the scale of the ARs concession (no significant differences between villages).**

The Prado reefs fish monitoring shows that the landscaping, the number, the volume and the diversification of the reefs type and their arrangement close to the *Posidonia* meadows and rocky areas are efficient to support the local coastal fish resources after 7 years.

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