Patch reef: a functional hotspot of tropical fishes

Jac Cyrielle[1], Dupont Priscilla[1,2], Gaboriau Matthias[3], Mercky Yann[1,2], Pelletier Dominique[4], Roos David[3], Sucré Elliott[1,2], **Claverie Thomas**[1,2]

[1] Marine Biodiversity Exploitation and Conservation (MARBEC) – Montpellier, France; [2] Centre Universitaire de Mayotte (CUFR) – Mayotte; [3] Ifremer, Délégation Océan Indien (DOI) – La Réunion, France; [4] Ifremer, Laboratoire Ecologie et Modèles pour l'Halieutique (EMH) – Nantes, France

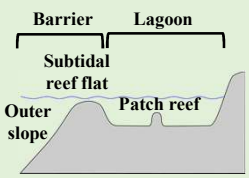
Abstract : In days of increasingly threatened marine tropical ecosystems, it is important to improve knowledge on understudied but taxonomically rich habitats. If fish assemblages from barrier and fringing reefs are generally well studied, patch reefs are much less known. **The objective of the present study (part of the EPICURE project) was to better understand taxonomic and functional specificity of patch reefs fish assemblages compared to the well-studied subtidal reef flat and outer slope habitats.** Unbaited rotating video systems (STAVIRO) were used to quantify fish abundance on two sites from the northern Mozambic channel (Mayotte Iris bank and Geyser bank). Taxonomic and functional diversity metrics were used to compare assemblages among habitats. Although total abundance was greater in patch reefs than other habitats, the species diversity indices considered (Species richness, Shannon, Simpson and Pielou) showed little variation among habitats, while most of functional richness indices did (richness, specialization and originality). Overall, assemblages from patch reefs appear to be taxonomically different than other reef habitat principally by having more specialist and functionally original species than subtidal reef flat and outer slope. This work showed original assemblages on patch reefs and suggest that these habitats could be of particular interest for further investigation.

Patch reef

Patch reefs are isolated coral formations in the form of pinnacles or patches on a sandy lagoon bottom

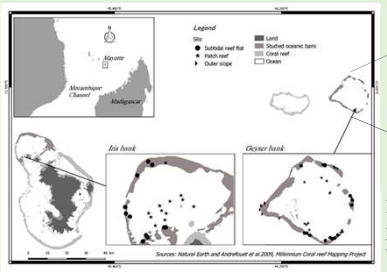
Objective

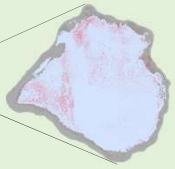
To compare fish assemblages structure among three habitats : Patch reef, Barrer reef, external slope reef



Where

Geyser and Iris bancs. Northern Mozambique Channel





Red colors represent patch reefs (estimated to more than 25000)

Fish assemblage quantification

Rotating video system (STAVIRO). The system provide a 360° view divided in 6 frames of 30s (3 min per full rotation) replicated 3 times. In each frame of 30s, every species was counted within a 10m radius (5m radius for species known to be smaller than 20cm). These fish count were used to calculate taxonomic diversity indexes such as total abundance, species richness, Shannon diversity index, Simpson diversity index and Pielou equitability index.

Functional fish metrics

Six biological traits were qualified for each of the species present in the assemblages :

- Average size
- Diet
- Position in the water column
- Gregarious behavior
- Mobility
- Nictemeral activity

Subsequently each species was placed in a functional space using these metrics (Fig. 1). A functional space is like a map of ecological function that each species play in an ecosystem. This tool was then used to calculate functional metrics such as functional richness, functional originality or functional specialization.

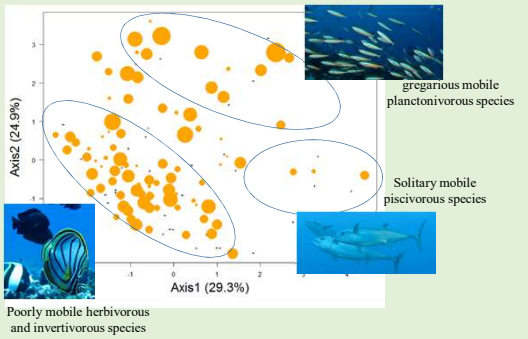


Figure 1 : Principal Component Analysis (PCA) of species traits is a representation of the functional space here with abundances of species from Iris bank (orange circle with diameter proportional to log density)

General taxonomic variation

Multivariate analyses based on Jaccard dissimilarity showed significant differences between bank (PERMANOVA, $F_{2,60}$=4.8, p<0.001) and among habitat (PERMANOVA, $F_{1,60}$=12.1, p<0.001). Such variation represented by a PCoA analysis showed that patch reefs have different assemblages composition than outer slope or subtidal reef flat (Fig. 2).

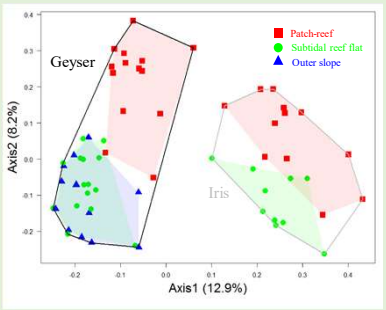


Figure 2 : Principal Coordinate Analysis (PCoA) performed on Jaccard based dissimilarity matrix of assemblages densities among sites and habitats

Detailed assemblages variations

Table 1: Mean ± Standard error of various diversity metrics with ANOVA (type 2) or Kruskall Wallis statistics. Significant results are in Black bold.

	Variable	Patch reef	Outer slope	Subtidal reef flat	ANOVA or Kruskall Wallis
Iris	Sample size	12	0	11	
	Density	**175.1 ± 26.2**		**87.9 ± 9.5**	**$F_{1,21}$=10.8, p<0.01**
	Species richness	38.1 ± 2.9		32.8 ± 2.9	$F_{1,21}$=1.5, p=0.226
	Shannon	2.3 ± 0.1		2.3 ± 0.1	$F_{1,21}$=0.0, p=0.982
	Simpson	0.78 ± 0.03		0.81 ± 0.02	$F_{1,21}$=0.41, p=0.516
	Pielou eveness	0.64 ± 0.04		0.67 ± 0.02	$F_{1,21}$=0.4, p=0.549
	FRic	**0.33 ± 0.05**		**0.19 ± 0.03**	**$F_{1,21}$=5.69, p<0.05**
	FSpe	**0.62 ± 0.02**		**0.56 ± 0.01**	**$F_{1,21}$=9.12, p<0.01**
	FOri	0.32 ± 0.02		0.27 ± 0.02	$F_{1,21}$=2.45, p=0.132
Geyser	Sample size	14	13	15	
	Density	**225.8 ± 46.7**	**96.8 ± 14.5**	**80,1 ± 7.0**	**χ^2=8.9, df=2, p< 0.05**
	Species richness	32.5 ± 2.7	35.3 ± 2.3	35.1 ± 2.0	$F_{2,39}$=6.6, p=0.648
	Shannon	**2.2 ± 0.1**	**2.8 ± 0.1**	**2.8 ± 0.1**	**$F_{2,39}$=11.9, p<0.001**
	Simpson	**0.76 ± 0.04**	**0.88 ± 0.01**	**0.88 ± 0.02**	**χ^2=15.1, df=2, p<0.001**
	Pielou eveness	**0.63 ± 0.04**	**0.79 ± 0.03**	**0.80 ± 0.02**	**χ^2=15.4, df=2, p<0.001**
	FRic	**0.33 ± 0.04**	**0.28 ± 0.04**	**0.20 ± 0.02**	**$F_{2,39}$=5.3, p<0.01**
	FSpe	**0.64 ± 0.04**	**0.48 ± 0.02**	**0.44 ± 0.01**	**χ^2=15.8, df=2, p<0.001**
	FOri	0.33 ± 0.02	0.32 ± 0.01	0.34 ± 0.01	χ^2=1.5, df=2, p=0.456

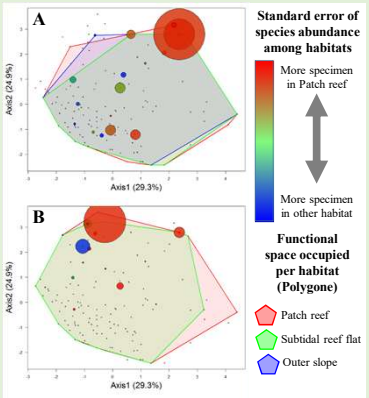


Figure 3: Distribution of species in functional space (Fig. 1, black crosses) with habitat specific species occupation (polygons) and variation of abundance among habitats (circles) for the site of Geyser (A) and Iris (B)

Diversity index based results shows that patch reefs are more densely populated but a little less rich and homogeneous that the two other habitat type (Table 1). Similarly they are more functionally rich and specialized but less redundant. It appear that patch reef are more densely populated with gregarious planctivorous fishes (Fig 3).

Conclusion

Patch reefs appear to be original habitats hosting their own fish assemblage structure: they are more abundant and functionally richer that barrier reef but have less functional redundancy. Such habitat might therefore be of key interest in lagoon ecology but more work is necessary to better understand how such habitat is connected to the others. Indeed such fragmented habitat disseminated all over lagoons could play a major role in connecting various habitats.

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