The functional-biogeography of the reef fishes in the Gulf of California: over-importance of a handful of sites

Damien Olivier[1,2] and Hector Reyes Bonilla[1]

[1] Departamento Académico de Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, BCS, Mexico

[2] Université de LIEGE

Introduction:

Functional biogeography is a new discipline allowing to link biogeographical patterns of trait and species diversity. This new area of research has a role in conservation policy because it permits to create functional maps to highlight hotspots of biodiversity. In this study, we evaluated the taxonomic and functional diversity of the reef-fishes in 30 "archipelagoes" widespread along the Gulf of California (GOC). The question before us is to highlight areas requiring a particular intention in conservation policy because they represent a large part of the legacy of reef-fish diversity in the GOC.

Materials & Methods:

From the literature, the most exhaustive list of fish diversity among main islands of the GOC has been used. Species were classified in functional entities (FEs) which are based on unique combinations of six categorical traits known to influence the functional role of fishes (e.g. size, diet… Table 1). For example the trait "mobility" is classified in "sedentary" (=1), "relatively mobile" (=2) and "highly mobile (=3). The number of FEs represent the level of functional diversity of the community.

Table 1. Example of a combination of six functional traits representing one FE.

	Size	Mobility	Period of Activity	Schooling	Vertical position	Diet
Sp 1	2	2	1	3	2	5

The functional space of the community is the volume that includes all the FEs. This volume is calculated according the principal axes of a Principal Coordinate Analysis (PCoA). The Fig. 1 illustrates the volume of two communities with the same number of FEs according three dimensions. In our study, we measured a volume in ten dimensions (10 PCs). Bigger is the volume, higher is the functional space of the community.

Figure 1. Ilustration of functional spaces in 3D of two communities with the same number of FEs.
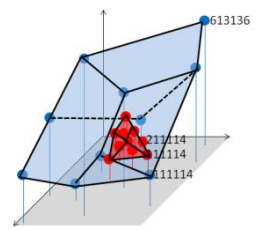
Results & Discussion:

Baja California Sur has the most diversified reef-fishes community, both taxonomically and functionally (> 90% of the species and of the functional diversity, Fig. 2A). However, a great part of the legacy of the reef-fishes diversity in the GOC is represented by a handful of sites: four archipelagoes present a dazzling diversity, i.e. Carmen, San José, Espiritu Santo and Cerralvo (≥ 60% of the taxonomic and functional diversity of the GOC, nbs 12, 15, 17 and 19 on Fig. 2B). Only Loreto and Espiritu Santo benefit of a protection level. Unfortunately, the former is poorly functioning and the latter is under evaluation.

30% of the species are represented by only 6 FEs (Fig. 2C). The FE « 111114 » includes 14% of all the species. That means that some FEs are over-represented and very robust while a lot of them are only represented by a few species and so vulnerable. About 80% of the FEs includes only one species, these FEs representing about 50% of the species.
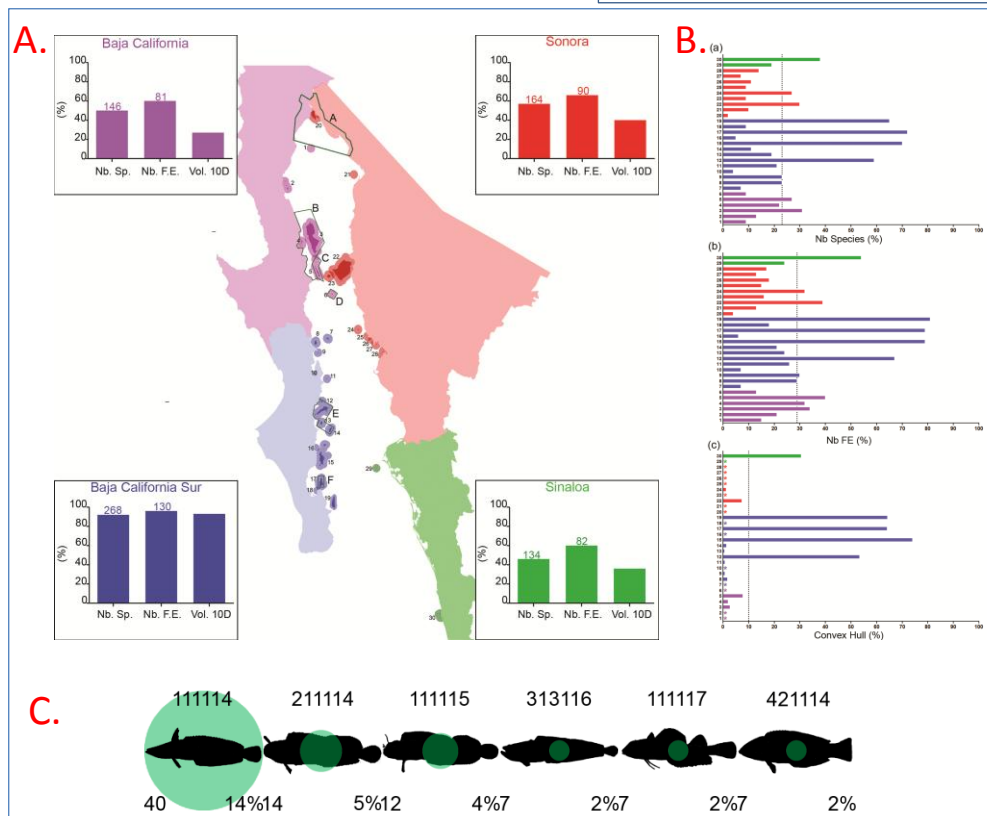

Figure 2. **A**. Representation of the 30 archipelagoes widespread (numbered) in the four states surrounding the GOC. The letters indicate the protected area. Four each states the nbs of species, FEs and the functional volume (in 10D) are indicated. **B**. Data for each archipelago, the dash line is the mean value. **C**. The six more represented FEs (including 30% of the species). The combination of the FE are written on the upper part of each square, the nb of species and their relative importance in the lower left and lower right sides respectively. The green circles are proportional to the relative importance, in term of species diversity, of the FE.

Conclusion:

The outcomes of the present study provide a global map of the reef-fishes diversity through the GOC, in term of species number and functional diversity. These results allow the identification of four major hotspots of diversity that should require a particular attention to preserve the legacy of reef-fishes diversity in the GOC.