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The Use of Fish Assemblages as Reserve Effect Indicators for Small Mpas. A Case Study in Southern Spain (Strait of Gibraltar)

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Abstract

Marine protected areas (MPAs) are considered a useful tool for marine biodiversity and ecosystems conservation and management. Nevertheless, concern has arisen about the negative effects experienced on marine reserves with low levels of protection. In terms of fish conservation, small MPAs cannot provide effective protection for highly mobile species but can serve as reserve for low-mobility fishes. Therefore, these species could serve as indicators for small MPAs effectivity assessment. In this study, rapid surveys on fish assemblages were carried out in a small (1.8km long, 0.8km wide) no-take/no-entry zone of El Estrecho Natural Park (Alboran Sea, Spain) and a directly adjacent non-protected zone. Species of commercial interest and showing homing behaviour were used as indicators of reserve effect. Species with homing behaviour and of commercial interest could be good indicators of small coastal MPAs effectivity. Nevertheless, fish abundance and community structure did not vary in composition between protected and unprotected areas, which could suggest low to no protection for fish species in El Estrecho Natural Park. Additionally, insufficient resources for effective enforcement have been reported for this MPA. Therefore, management and effective surveillance of this marine protected area should be properly implemented to make protection effective in the studied area.

Keywords: Fish Indicators; Reserve Effect; Illegal Fishing; Paper Parks; MPAs Enforcement

Introduction

The establishment of marine protected areas (MPAs) is a universal conservation tool and an ever-increasing trend [1,2]. The main objectives when establishing an MPA are to obtain a series of benefits from areas in which extractive activities have been prohibited. These benefits are known as the reserve effect [3]. One of those benefits is to increase fish biomass and stock inside the MPA and enhance the migration of the stock from protected zones to nearby areas [4,5]. When this occurs, the reserve effect generates a transition border between protected and unprotected areas in which fish abundance diminishes progressively [6]. This transition border can be used to monitor and evaluate MPA effectiveness, especially for big MPAs, where the reserve effect can be tested a larger scale [7].

The current trend in coastal areas is to designate small-sized MPAs, as a consistent network of these is effective in terms of regional biodiversity conservation, especially for non-mobile species [8-10]. Nevertheless, very small MPAs have been criticized because of their low area/perimeter ratio, so larvae and biomass export to nearby areas will be high and it will be less effective in terms of highly mobile fish conservation [11]. In any case, the optimal size will depend on the specific objectives of each MPA and the environmental, ecological and socioeconomic context of the area in which it is implemented [12]. When establishing MPAs, the determination of proper management, enforcement and long-term monitoring are essential [13,14]. But for the monitoring of fishes and other mobile species on small MPAs (<10 km), the quick assessment of the reserve effect can be seriously hindered, especially in ways accessible to managers [15, 16].

In this matter, some families of benthic and nektobenthic fishes, which show homing behaviour (i.e. Blenniidae, Gobiidae or Labridae), have been proposed in order to detect the reserve effect at small scales, as they may be intendedly or unintendedly extracted by recreational and commercial fishing [17,18]. On the other hand, low-mobility species of commercial interest could be

also used to test protection effectiveness on small MPAs [19, 20]. Finally, fish species with schooling behaviour tend to approach to divers and come up several times during samplings and they are not indicated for rapid assessment methods carried out by divers or snorkelers, which are commonly used on citizen science [21,22].The present study aims to evaluate the effectiveness of a small MPA in terms of fish abundance. Secondarily, the effectiveness of the spatial patterns of fish assemblages at small spatial scales will be considered as a tool for the management of small MPAs, especially for families of benthic or nektobenthic fishes (species with homing behaviour) and for species of commercial interest.

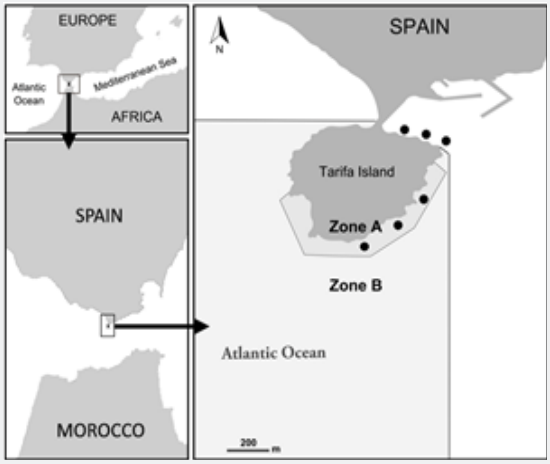

Figure 1: Location of the Marine Protected Area of El Estrecho Natural Park and location of the no-take/no-entry zone (Zone A) and medium protection zone (Zone B) in the proximities of Tarifa Island (36°00'10.8"N 5°36'35.8"W). Dots indicate the locations in which the visual surveys were carried out.

Material and Methods

Study location

Located between both the Atlantic Ocean and the Mediterranean Sea, the Strait of Gibraltar is an area of biogeographical interest and a biodiversity hotspot in Europe and the Mediterranean Sea [23]. Within the northern coast of the Strait of Gibraltar, El Estrecho Natural Park is a maritime-terrestrial protected area, created in 2003 and included in the Intercontinental Biosphere Reserve of the Mediterranean [24,25]. The marine segment of El Estrecho Natural Park includes a no-take/no-entry zone, which consists of a strip 0.8 km wide that extends 1.8 km along the southern coast of a small peninsula and a 1.8 km wide no-take zone with intermediate protection where non-invasive recreational activities are permitted (Figure 1).

Data Collection and Treatment

Surveys were conducted in September of year 2009 along the coast of the Island of Tarifa. Three sites were selected in the no-take/no-entry zone of El Estrecho Natural Park MPA and three sites in a nearby non-protected area (see Figure 1). On each site, three transects 10 m long and 8 m wide were surveyed by a taxonomic expert using underwater visual censuses [26]. Data was collected on natural rocky bottoms at 8 (±2) m depth within 9 and 11 h in the morning [27]. Fish species showing schooling behaviour were not considered. For the rest of species, all fishes present on the sea-bottom and water column were annotated. For highly abundant fishes, the number of encounters was estimated for each transect.

Data Analyses

Species abundance data was fourth root transformed and four resemblance matrixes were calculated in the basis of Bray-Curtis similarities, using (1) all species, (2) species with homing behaviour, (3) species of commercial interest and (4) species of commercial interest showing homing behaviour. Using these matrixes, nMDS ordinations and PERMANOVA and PERMDISP analyses were carried out, testing a nested design with factor Site (random, three levels) nested in Protection (fixed, two levels: protected and non-protected). Differences in fish abundances between protected and non-protected areas were tested using ANOVA and homogeneity of dispersions was tested using Levene's test. PRIMER-e v6 +PERMANOVA software was used for multivariate analyses and IBM SPSS Statistics 25 for univariate analyses [28].

Results

A total of 38 species belonging to 12 families were recorded (36 in the non-protected area and 28 in the no-take/no-entry area). Among them, Labridae and Sparidae were the most representative families in terms of species richness and abundance and *Symphodus* (Labridae) and *Diplodus* (Sparidae) the most abundant genera. Within the species recorded, species with homing behaviour (14) and of commercial interest were (29) the most abundant in terms of species richness and abundance on both protected and unprotected areas, although no differences in abundance were found between zones for any species group (Figure 2). Among species showing homing behaviour, ten species of commercial interest were found in the non-protected zone and seven in the protected zone. For those species, no differences in abun-

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dance were found between protected and non-protected zones (P (Levene) = 0.192; P (ANOVA) = 0.425). Seemingly, no differences in community composition were found for any of the studied groups of species (Figure 3).

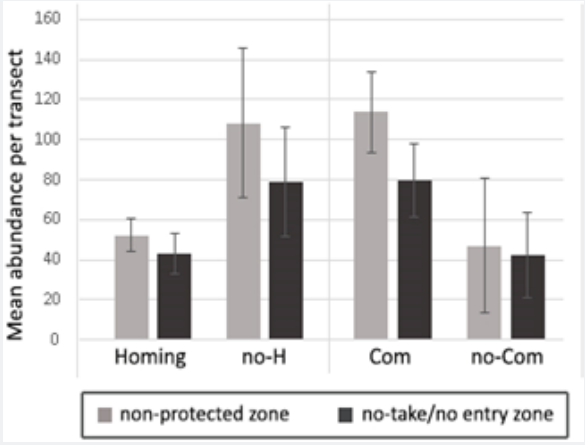

Figure 2: Mean abundance per transect and standard deviation error bars for the 38 fish species surveyed. Species were grouped attending to their homing behaviour and commercial interest. No differences in abundance were found between protected and unprotected zones for any of the species groups. Homing: species with homing behaviour (14); no-H: species without homing behaviour (25); Com: species of commercial interest (29); no-Com: species without commercial interest (9).

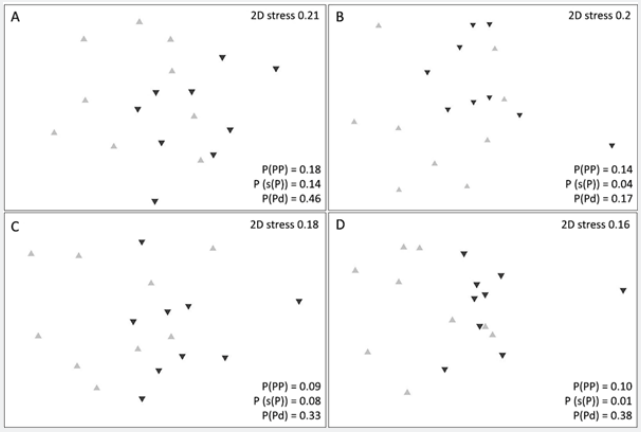

Figure 3: nMDS for (A) all species and the subsets: (B) species with homing behaviour, (C) species of commercial interest and (D) species with homing behaviour of commercial interest. Overall, no differences in community composition or multivariate dispersion were found between protected and non-protected zones, although differences occurred for some sites when using subsets B and D. P(PP) = P (PERMANOVA) for factor Protection; P(s(P)) = P (PERMANOVA) for factor site (nested in Protection); P(Pd) = P (PERMDISP) for factor Protection.

Figure 4: Observations on the no-take/no-entry zone of Tarifa Island in El Estrecho Natural Park. (A) illegal spear fishing activities, (B) illegal pole and line fishing, (C) invasive species *Caulerpa cylindracea* and (D) abandoned fishing equipment giving rise to ghost fishing.

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Discussion

Because of its size (less than 2 km^2), the no-take/no-entry zone of Tarifa Island in El Estrecho Natural Park may have little to nonpositive effects on the conservation of fish populations, even for those showing low mobility or homing behaviour [17,18, 29]. Nevertheless, the results of this study may not invalidate the use of fish behavioural and economic interest indicators as tools for the monitoring of the reserve effect on this small MPA, as differences among protected and unprotected sites were bigger for these groups. Nonetheless, the absence of differences between zones may be a result of the low levels of protection and reinforcement in El Estrecho Natural Park, as those may be largely constrained by its annual economic assignations. In this matter, the mean economic assignation per hectare for national parks in Andalusia amounts to 23.4 euros, being human resources insufficient for an adequate reinforcement [30]. Hereby, recreational fishing is commonly observed in the study area, being spear fishers and pole and line fishers present in the no-take/no-entry zone all year round (Figure 4).

Therefore, it seems that protection could be unsuccessful in terms of fish communities in El Estrecho Natural Park. On the other hand, there are impacts to which MPAs cannot bring protection (such as those derived from climate change, biological invasions, marine litter and pollution) that may contribute to the homogenization of fish communities among protected and non-protected areas [31,32]. In this regard, the invasive seagrasses *Caulerpa cylindracea* (C in Figure 4), *Asparagopsis armata*, *A. taxiformis* and *Rugulopteryx okamurae* have been reported as pernicious species that could drive important changes in the trophic structure of the ecosystems [33-38]. Seemingly, marine litter such as lost fishing lines and nets could drive to fish mortalities both inside and outside the MPA (see D in Figure 4). Despite the differences in shoreline orientation, fish abundance and community composition patterns did not differ between protected and unprotected zones.

This suggests that the methodology carried out may be non-sensitive to environmental differences at small scales. Hereby, these indicators could be adequate to test possible protection effects on fish communities at the small Island of Tarifa no-take/no-entry zone [39-42]. Nevertheless, differences among sites suggest that higher sampling effort may be needed for future studies carried out in this area, in order to properly represent the inherent variability of fish community in each zone [43]. It is concluded that the official establishment of the studied MPA should be further accompanied by genuine and effective protection measures, plus enough funding to ensure long-term protection. Considering the touristic attractive of Tarifa Island, an appropriate exploitation of touristic resources may be considered as a financial strategy that could increase reinforcement in El Estrecho Natural Park [44-50].

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