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Vessels' site fidelity and spatio-temporal distribution of artisanal fisheries before the implementation of a temperate multiple-use marine protected area

Bárbara Horta e Costa[a,b,1], Leonel Gonçalves[a,1], Emanuel J. Gonçalves[a,*]

[a] Eco-Ethology Research Unit, ISPA – Instituto Universitário, R. Jardim do Tabaco 34, 1149-041 Lisboa, Portugal
[b] Centre of Marine Sciences, CCMAR, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal

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ABSTRACT

Marine protected areas (MPAs) are increasingly proposed as a fisheries management tool besides their conservation purposes. When assessing the ecological, economic, and social-cultural impacts of protection, the dynamics of fisheries and fishers reallocation within and around multiple-use MPAs should be analyzed. Despite this, few studies incorporate the baseline information of fisheries distribution, therefore compromising an understanding of fishers' preferences, choices and constrains before losing fishing grounds through the establishment of zoning and protection measures. To fulfil this gap, here we assess the spatial and seasonal fishers' preferences from local artisanal fisheries (nets, traps, jigs and longlines) before the implementation of a MPA management plan (the Arrábida Marine Park, Portugal). Zero inflated modelling, hotspot analysis, vessels distribution range and site fidelity statistics showed that the main drivers of fishing effort allocation are the placement of preferred fishing grounds which are likely related to the distribution of target species and associated habitats. Proximity to port, weather conditions and distance to coast are also important factors influencing, in different ways, these artisanal fisheries. Our findings highlight the complex dynamics of the distribution of artisanal fisheries operating multiple-gears and targeting multiple-species and are likely transferable to many coastal multiple-use MPAs where no baseline data exist. Moreover, the variety of responses and preferences found between gears and fishers before the establishment of zoning are important to understand the dynamics of local fisheries, to contribute to an ecosystem-based management and to improve both conservation and fisheries management decisions. Our study is one of the few characterizing fisheries dynamics and fishers' preferences before protection measures are implemented providing important lessons to the management of coastal fisheries where artisanal fisheries prevail.

1. Introduction

Marine protected areas (MPAs) have been identified as being an important conservation and fisheries management tool (Claudet et al., 2011; Gell and Roberts, 2003) with the potential to function as an ecosystem based management approach (Fraschetti et al., 2011). Multiple-use MPAs have been widely implemented due to their potential to accomplish conservation objectives while allowing human uses and minimizing conflicts by including some degree of protection for commercial species and important habitats as well as promoting the use of local fisheries and a range of recreational activities (Claudet et al., 2010a, 2006; Lester and Halpern, 2008; Rocklin et al., 2011). Several studies and reviews indicate the potential of no-take areas (marine reserves), either isolated or embedded inside multiple-use MPAs, to increase density, size, biomass and diversity of species, especially those most targeted by fisheries (Micheli et al., 2004; Russ, 2002). Currently, there is strong evidence showing that in several appropriately designed and well enforced marine reserves there is an export of adults to nearby areas (Goñi et al., 2008; Stelzenmüller et al., 2007; Stobart et al., 2009). However, the strength of this 'reserve effect' depends both on species characteristics and behaviour, such as mobility, commercial value and association to particular habitats (Claudet et al., 2010b), and also on socio-economic factors such as enforcement, compliance and fishers' preferred fishing grounds (Abesamis et al., 2006; Samoilys et al., 2007).

Small-scale artisanal fisheries comprise the greatest percentage of fishing communities of coastal multiple-use MPAs (the vast majority of MPAs around the world, UNEP-WCMC, 2008) and the factors influencing fishers' preferences are of major importance to management decisions and to implement ecosystem-based

* Corresponding author. Tel.: +351 218811758; fax: +351 218860954.
E-mail address: emanuel@ispa.pt (E.J. Gonçalves).
[1] Both authors contributed equally to this work.

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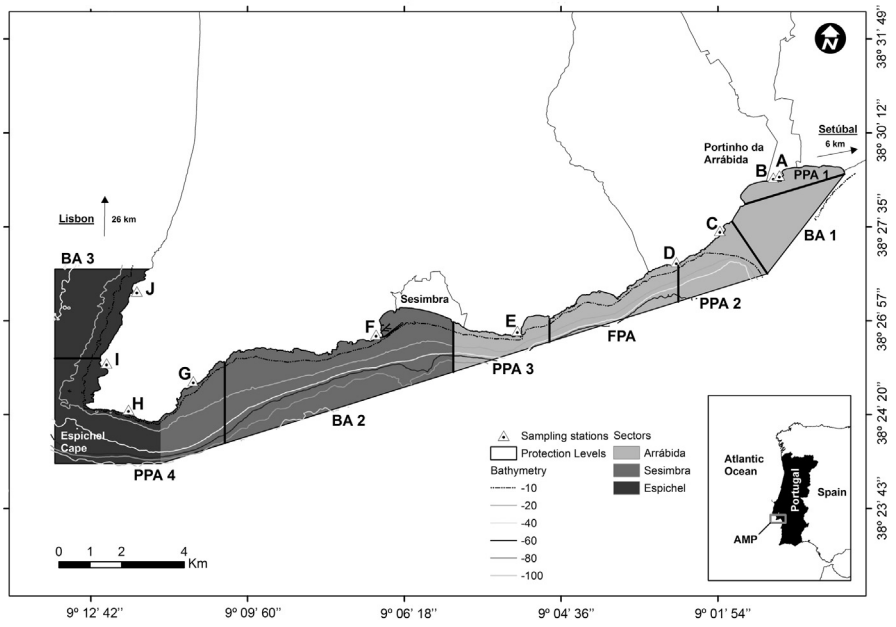

Fig. 1. Map of the location of the Arrábida Marine Park (Portugal). The zoning of the different protection levels (fully protected area – FPA; partially protected areas – PPA; buffer areas – BA) implemented in the management plan (2005) is shown. Sampling stations (A–J), depth contours and park sectors from the observation network along the marine park are also shown.

management approaches. Fishing effort allocation may depend on target species distribution (Murawski et al., 2005) and on fishers' traditional routines and ecological knowledge (Davis et al., 2004). The loss of fishing grounds with the designation of a MPA may affect those fishers' choices as well as the profitability of some fisheries. Moreover, if a high density of fishing effort aggregate near the boundary of a no-take area (a.k.a. "fishing the line", Kellner et al., 2007) and if gear selectivity is high (Goñi et al., 2010), the effectiveness of protection on the spawning biomass of species targeted by fisheries may be compromised. Even if fishers do not aggregate in no-take borders but their effort concentrates and increases in adjacent buffer areas, the fisheries productivity of those areas will likely be affected (Goñi et al., 2008). Therefore, knowledge on fisheries' dynamics, preferences and constrains before the implementation of a MPA allows a better understanding of the benefits and impacts of conservation policies on small-scale coastal communities.

Some studies have been conducted in MPAs to investigate how the distance to their borders, depth, and particular habitats influence the spatial allocation of fishing effort (Abesamis et al., 2006; Forcada et al., 2010; Goñi et al., 2008; Stelzenmüller et al., 2008; Wilcox and Pomeroy, 2003). However, those studies lack baseline information on the spatial distribution of fishing effort before the implementation of protection, thus potentially biasing the interpretation of the observed patterns. Recent studies compared fisheries allocation before and after the implementation of protection measures both in temperate large-scale fisheries (Abbott and Hayne, 2012; Murawski et al., 2005) and in tropical artisanal fisheries (Campbell et al., 2012; Lédée et al., 2012), but there is a lack of empirical studies assessing fishery displacement through direct observations in temperate MPAs where artisanal fisheries predominate (but see Horta e Costa et al., 2013).

We use a set of observational and statistical methods to explore spatial data on fisheries allocation before the implementation of a multiple-use MPA (the Arrábida Marine Park, Portugal). This case study fills the existing gap, by addressing the spatial distribution and dynamics of fishing effort and site fidelity of individual vessels before the MPA implementation, i.e. when fishing is not constraint by additional zoning and regulation schemes. This type of information is potentially usefull to managers of coastal fisheries and to a large majority of MPAs where artisanal fisheries are the norm and where only 'after data' exists.

2. Materials and methods

2.1. Study area

The Arrábida Marine Park is a 38 km stretch of coastline (53 km^2) on the west coast of Portugal, adjacent to a terrestrial nature park created in 1976 – the Arrábida Nature Park. This marine park includes the rocky shores and adjacent mixed sandy substrata between north of the Espichel Cape (38°27′ N, 9°12′ W) and Portinho da Arrábida (38°29′ N, 8°57′ W) (Fig. 1). The shore is steep and bordered by high calcareous cliffs in most of the park. Excluding beach areas, throughout the park the shallow rocky reefs and rocky outcrops are confined to the first 100–150 m from shore except near the Espichel Cape where they extend to deeper waters. Extensive sand banks prevail, especially in front and to the west of Sesimbra port and in the Portinho da Arrábida bay, where seagrass meadows used to occur. In fact, sand is the primary habitat covering the majority of the park from shallow (adjacent to rocky reefs and rocky outcrops) to deeper areas where it is replaced by mud near the Park limits. This marine park is utilized year-round for commercial and recreational activities as it faces south and is protected from the prevailing north and northwest winds and waves. Nearby are the cities of Lisbon and Setúbal, the latter being an important fishing and commercial port located to the east of the park in the Sado estuary. In the middle of the park there is a small fishing town, Sesimbra, which has a long fishing tradition and is nowadays an important touristic area.

The marine park was designated in 1998 but the management plan was only approved in 2005 (Portuguese legislation, Council of Ministers Resolution 141/2005). It includes: a fully protected area (FPA) which is a no-take, no-go area (with the exception of research, monitoring and education purposes); four partially protected areas (PPAs) (two surrounding the no-take area) in which non-extractive recreational activities and licensed commercial fishing with traps and jigs are allowed beyond 200 m from coast; and three buffer areas (BA) where recreational activities (including fishing) and