

Marine protected areas for the conservation of Mediterranean Procellariiformes

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INTRODUCTION

Increasingly, marine conservation initiatives are embracing the need to address biotic communities and their broader ecosystems, instead of focusing on single species. Marine protected areas (MPAs) could facilitate this holistic approach by providing protection both to species of concern and to their habitats (Salomon et al. 2006).

Seabirds, particularly those species of the order Procellariiformes (albatrosses and petrels), are of high conservation concern due to anthropogenic threats at-sea (e.g., fisheries bycatch) and on land (e.g., predation by introduced mammals and habitat destruction) (BirdLife International 2004). Moreover, by virtue of their high trophic position and far-ranging habits, seabirds are ideal bioindicators of the ocean productivity and ecosystem structure since they play an important role in the ecosystem functioning (Furness & Camphuysen 1997).

As a first step towards the identification of MPAs regarding seabirds in the Mediterranean, we assessed the spring-time oceanographic habitat of three species of Procellariiformes within the continental shelf of the eastern Iberian Peninsula: the critically endangered Balearic shearwater *Puffinus mauretanicus*, the vulnerable Cory's shearwater *Calonectris diomedea*, and the vulnerable European storm-petrel *Hydrobates pelagicus*.

STUDY AREA AND METHODS

The study area comprised the continental shelf and slope of the eastern Iberian Peninsula during 1999, 2000, and 2002 (May–June). Seabird surveys were conducted onboard R/V “Cornide de Saavedra,” during the annual Spanish Mediterranean International Trawl Survey (MEDITS), from the Strait of Gibraltar to Cape Creus, using a standardized 300-m strip-width transect band (Louzao et al. 2006). During this period, the breeding stage of each species differs slightly: it represents the chick-rearing period for the Balearic shearwater and the incubation for both the Cory's shearwater and the European storm-petrel.

We applied a hierarchical modelling approach to identify those explanatory variables that most accurately delineated the foraging range and important foraging grounds of the

species, using occurrence and density data respectively (Louzao et al. 2006). Explanatory variables included spatial information (distance to shoreline and to the closest colony), physiographic data (water depth), and oceanographic variables (sea surface temperature and chlorophyll *a*). To account for possible seabird attraction to fishing vessels, we also included the occurrence and density of trawlers, as well as the effect of “year” to assess interannual variability on distribution and abundance patterns not captured by the habitat variables addressed in this study (see Table 1).

Table 1. Explanatory variables used in the hierarchical modelling approach, and associated processes influencing seabird distribution and abundance patterns.

<i>Explanatory Variables</i>	<i>Ecological process</i>
Distance to shoreline	Potential onshore-offshore gradients
Distance to colony	Breeding colony influence on central-place-foragers
Sea Surface Temperature (SST)	Water mass distribution and frontal systems
Chlorophyll <i>a</i> (Chl <i>a</i>)	Ocean productivity domains and frontal systems
Depth	Coastal vs. pelagic domains
Trawler distribution	Potential influence on seabird distribution
Year	Inter-annual changes not quantified with the other environmental variables

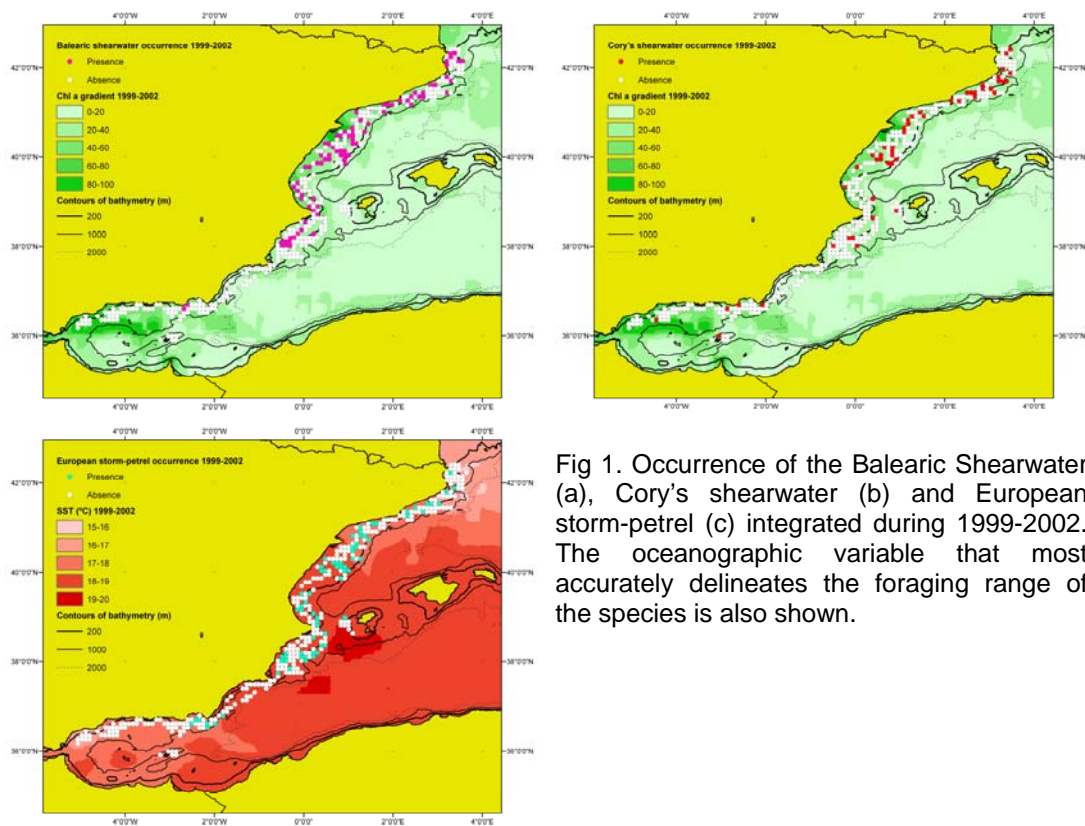


Fig 1. Occurrence of the Balearic Shearwater (a), Cory's shearwater (b) and European storm-petrel (c) integrated during 1999-2002. The oceanographic variable that most accurately delineates the foraging range of the species is also shown.

RESULTS & DISCUSSION

The oceanographic habitat of the three target species during spring mainly comprised the Iberian continental shelf between 38° N and 42° N (see occurrence maps, Fig. 1). Within this larger foraging range, birds aggregated in the highly productive waters around the Ebro Delta and the area extending to the south of Cape La Nao (see density maps, Fig. 2). These results suggest that seabird species respond to dynamic oceanographic processes, such as river plumes and mesoscale oceanographic features, which are liable to interannual variation.

There were differences in habitat association between the three study species:

- Balearic shearwaters: the foraging range encompassed the frontal systems along the eastern Iberian continental shelf, and was also influenced by breeding colonies at the Balearic Islands. The species aggregated in coastal productive shelf areas with elevated Chl a concentrations.
- Cory's shearwaters: this species was mainly present over the continental shelf, as well as associated to the shelf-break. They aggregated in areas of high trawler densities along frontal systems.
- European storm-petrels: the foraging range included warm waters in the pelagic domain (offshore, depth > 200 m). No specific environmental variables predicted areas of high density.

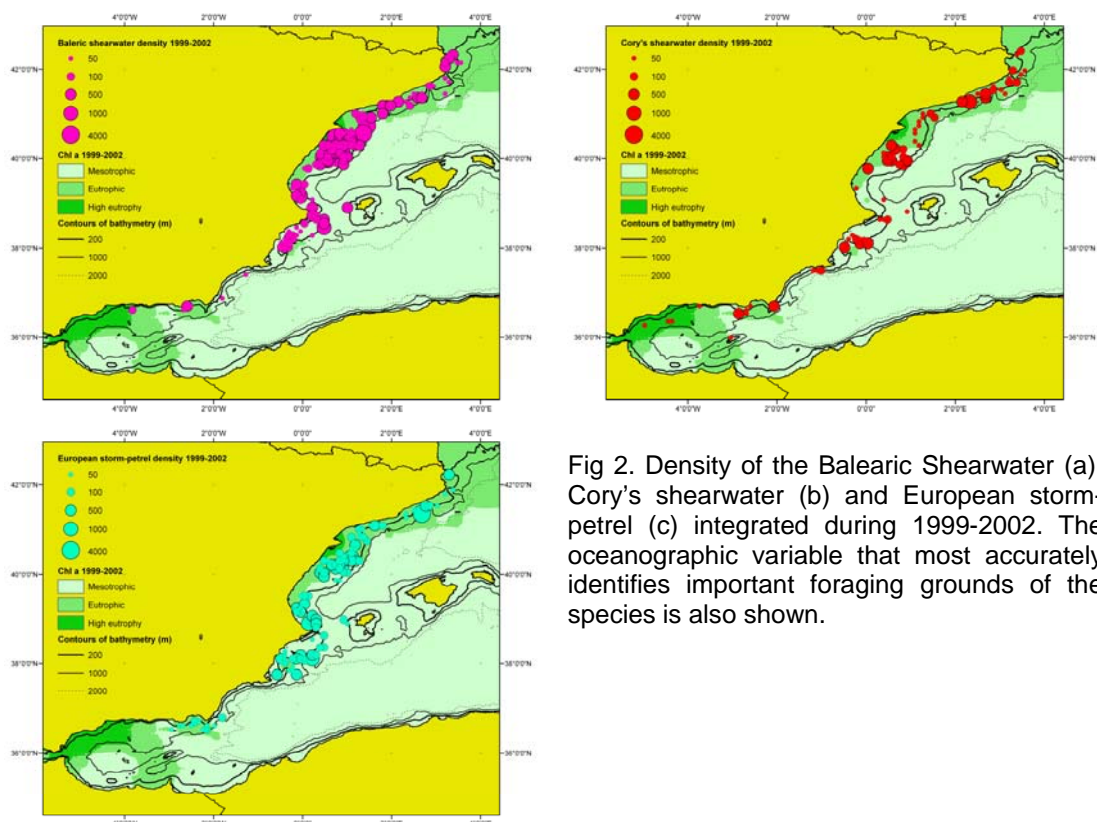


Fig 2. Density of the Balearic Shearwater (a), Cory's shearwater (b) and European storm-petrel (c) integrated during 1999-2002. The oceanographic variable that most accurately identifies important foraging grounds of the species is also shown.

Overall, the habitat modelling performed well for the Balearic shearwater and identified suitable habitats of aggregation accurately (i.e., prospective MPAs). However, the predictive power of the Cory's shearwater and the European storm-petrel models was low, even though > 65% of presences/absences were predicted correctly for both species. This study illustrates the complexity of applying a holistic approach to the design of MPAs, which is however essential to ensure biodiversity conservation in the western Mediterranean, a highly threatened marine ecosystem.

In conclusion, life history factors (e.g., foraging range, degree of aggregation) and habitat associations (e.g., with static / dynamic oceanographic variables) need to be considered when applying a multi-species approach to identify and design MPAs.

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