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Disturbance to a foraging seabird by sea-based tourism: Implications for reserve management in marine protected areas

Alberto Velando [a,*], Ignacio Munilla [b]

[a] Departamento de Ecoloxía e Bioloxía Animal, Campus As Lagoas-Marcosende, Edificio Ciencias, Universidade de Vigo, 36310 Vigo, Spain
[b] Departamento de Botánica, Facultade de Bioloxía, Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain

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ABSTRACT

The provision of recreational opportunities is one of the important human goals of marine protected areas. However, as levels of recreational use increase, human disturbance is likely to cause significant detrimental effects upon wildlife. Here we evaluate the best managing options to mitigate the impact of sea-based tourism on the foraging activity of an endangered population of European shags, *Phalacrocorax aristotelis*, in a coastal marine protected area (Cíes islands, north-western Iberia). Boat disturbance elicited a characteristic avoidance behavior that resulted in a substantial reduction in foraging activity as levels of boat use increased. Moreover, boats excluded shags from the best feeding areas, resulting in higher densities of foragers in areas of little boat traffic. We used a behavioral model to explore the effects of managing strategies aimed at reducing the impact of boats on the foraging activity of shags. Our model suggested that in low boat disturbance scenarios limiting the number of boats using the reserve would be a better management option than habitat protection (i.e. the establishment of set-aside areas free of boat traffic). On the contrary, when boat disturbance levels are high the protection of habitat is recommendable, even if spatial variation in habitat quality is unknown or poorly assessed. Our study stresses the point that management strategies to minimize disturbance to foraging seabirds may depend on the spatial overlap between sea-based recreational activities and foraging seabirds and the spatial variation in marine habitat quality for seabirds.

1. Introduction

Marine protected areas (MPAs) are expected to be efficient tools to ensure the provision of long-term ecosystem services, especially with regard to conserving biodiversity and securing a sustainable human use of the marine environment (e.g. Palumbi et al., 2009). In recent years, the number of marine reserves has been growing rapidly worldwide and is now a global phenomenon with complex ecologic, scientific, and socio-economic dimensions (McClanahan et al., 2006; McCook et al., 2010). Consequently, research on marine reserves has increased swiftly in the past 15 years (Selig and Bruno, 2010; Halpern et al., 2010).

Human goals for MPAs include replenishing stocks of commercial fisheries, and maintaining areas for recreation, education, science, and aesthetic needs (Lubchenco et al., 2003; Roberts et al., 2003). In fact, MPAs have been relatively successful in restoring over-harvested populations of fish and invertebrates (e.g. Selig and Bruno, 2010; McCook et al., 2010). On the other hand, sea-based tourism may be responsible for the majority of the economic and social benefits provided by MPAs (e.g. Kelleher, 1999; Russ et al., 2004). For example, in the Great Barrier Reef Marine Reserve, tourism accounts for the majority of the income and employment generated by the reserve (estimated to be about 36 times the amount attributable to commercial fishing; McCook et al., 2010). However, as levels of recreational use increase in marine reserves, human disturbance is likely to cause significant detrimental effects upon wildlife (Nisbet, 2000; Gill, 2007).

Around the world, tourism to the coast is growing and the proportion of the marine environment accessible to the tourist, including multiple use MPAs, is thus spreading (Kelleher, 1999; Badalamenti et al., 2000). Outdoor recreation has the potential to disturb wildlife behavior and may result in animals avoiding parts of their normal range, with likely energetic costs and negative impacts on fitness (e.g. Taylor and Knight, 2003; Beale and Monaghan, 2004). Reduction of natural conservation values in the marine environment due to nature-based tourism and recreation, has been reported for sea-based activities (McCrone, 2001; Williams et al., 2002). Thus, paradoxically, marine reserves may have indirect adverse effects on some species, especially in highly mobile animals (e.g. marine mammals, birds, and turtles).

Seabirds are conspicuous components of marine ecosystems that may attract considerable public interest by themselves as they usually breed colonially in coastal and insular areas of outstanding

* Corresponding author. Tel.: +34 986812590; fax: +34 986812556.
E-mail address: avelando@uvigo.es (A. Velando).

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conservation value. Many seabird species spend the larger part of their lives at sea where they widely interact with human activities with either negative (e.g. oiling or mortality in fishing gears: e.g. Munilla et al., 2007) or beneficial (e.g. fishing discards as a food source) outcomes (Tasker et al., 2000). In general, reserves can benefit seabirds through habitat restoration and by limiting or preventing overfishing (Hooker and Gerber, 2004). In the last decade there has been an increasing interest to extend MPAs to encompass seabird conservation (e.g. Louzao et al., 2006). Nevertheless, expected increases on the demand of recreational uses at seabird colonies, as well as mounting awareness for seabird and nature conservation, has recently led to studies that intend to measure and model the impact of visitors upon breeding seabirds (Beale, 2007; Beale and Monaghan, 2007). However, very little is known on the effect of nature-based tourism upon seabirds at sea (but see Burger, 1998; Ronconi et al., 2002; Rojek et al., 2007).

In this study, we analyzed the interaction between recreational boating and a near shore marine bird, the European Shag (*Phalacrocorax aristotelis*), in the MPA around the Cíes archipelago, which is part of the National Park of the Atlantic islands of Galicia (north-western Spain). This protected area holds about two thirds of the European shags breeding in Atlantic Iberia, a population that is under the risk of extinction (Velando and Alvarez, 2004). This threatened population has been declining at a rate of about −12% a year in the last 10–15 years, due to the 2002 *Prestige* oil spill and to continued low survival and reproductive success (Velando and Freire, 2002; Velando and Munilla, 2008). European shags feed extensively on sandeel, a semipelagic shoaling fish, in the vicinity of the islands where the breeding colonies are located (Velando and Freire, 1999). Though these conspicuous feeding groups are one of the outstanding natural features of this MPA, disturbance by recreational boats is widespread, especially in summer when juveniles become independent from their parents (Velando, 1998). In this species reduced foraging time after independence results in high juvenile mortality (Daunt et al., 2007). A recent demography study showed that, combined with other management measures, reducing foraging disturbance is one of the best strategies to promote population recovery through effects on reproductive success and juvenile survival (Velando and Munilla, 2008).

In this study, we used two complementary approaches (field work and modeling) to evaluate the potential effects of sea-based tourism management on the foraging activity of shags in the MPA around Cíes islands. We first assessed marine habitat use by shags, identifying those environmental variables that most accurately reflected the distribution of shags in the MPA. Afterwards, we measured the effect of the number of boats that were using the reserve on: (1) the abundance and distribution of foraging shags; (2) the probability of disturbance to foraging groups; and, (3) foraging activity. Lastly, we modeled boat disturbance to foraging shags by means of an ideal free distribution framework (Fretwell and Lucas, 1970) that assumes depletion of resources with continuous input conditions, assumptions that fit well with our observations of foraging groups of shags around Cíes (see Section 3). Thus, we modeled the consequences, on shag foraging efficiency, of different management options aimed at reducing the impact of recreational boating.

2. Materials and methods

2.1. Study area and species

The terrestrial and marine National Park of the Atlantic islands of Galicia, located on the north-western coast of the Iberian Peninsula, comprises three main archipelagos (11.9 km^2) and the marine area that surrounds them (72.6 km^2). Cíes islands are the southermost archipelago and are located at the entrance of Ría de Vigo (Fig. 1) a heavily populated estuary (400,000 inhabitants) that receives a build-up of tourists in the summer months (July and August). Boating is one of the main recreational sea-based uses at Cíes. Typically, boats stay at anchor in one of the three main sites where anchorage is allowed, off the major sandy beaches, which are located in the eastern part of the islands (Fig. 1). Thus, most recreational boat traffic occurs as boats move between anchorage areas and between these and the mainland ports. The number of boats at anchor is recorded daily by the staff of the National Park.

The European Shag is a pursuit-diving seabird, distributed in the Atlantic coasts of the western Palearctic and the Mediterranean.

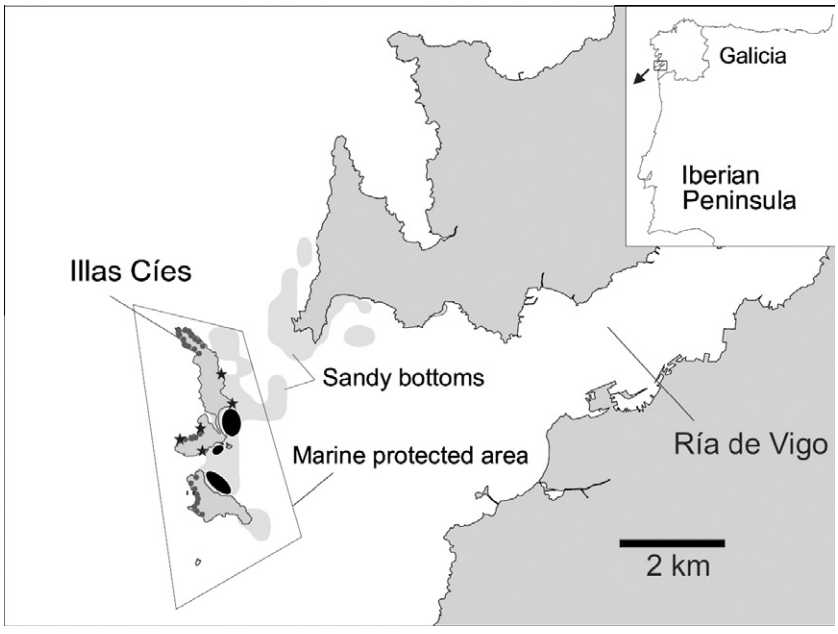

Fig. 1. Map of the study area showing the Cíes marine protected area in the National Park of the Atlantic islands of Galicia (north-western Iberia). The black dots indicate the sites where anchorage is permitted. The shaded areas show the distribution of sandy bottoms (i.e. sandeel habitat) at the mouth of the Vigo estuary (Ría de Vigo). Land grey points indicate main breeding areas and stars indicate observational stations (vantage-points).