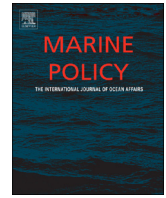




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## Exporting the problem: Issues with fishing closures in seabird conservation



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### ABSTRACT

Fisheries management may impact on a range of seabirds' traits such as foraging behavior. There is an extensive hake fishing closure in Argentine waters (HFC) where trawling is banned. The concentration of fishing effort in the boundary of this area triggered the question of a potential negative effect of seabird bycatch in such area. The distribution of seabirds attending vessels and their bycatch rates was explored as well as the foraging behavior of Black-browed albatrosses (BBA, *Thalassarche melanophris*) and Southern Giant Petrels (SGP, *Macronectes giganteus*) in relation to the HFC. For this, 55 satellite transmitters were deployed on the birds and discrete behavioral mode was inferred using state-space models. Seabird attendance at trawlers and bycatch data were obtained from on-board observers. The spatial distribution of the birds' bycatch was concentrated in the boundary of the HFC and the distance to the boundary had a significant effect on the interactions. The spatial modeling of seabird attendance revealed a similar pattern with core areas in the margins of the HFC. The bulk of the core foraging areas of BBAs and SGPs were concentrated in waters adjacent to the HFC. Besides, the time spent foraging in the boundaries of the HFC was greater than inside the HFC. The study highlights that the "exporting effect" due to the concentration of fishing effort and seabird foraging in bordering areas may increase seabird bycatch in the neighboring waters. Hence, the design of management measures for seabird bycatch should contemplate regulations to address these negative side effects.

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### 1. Introduction

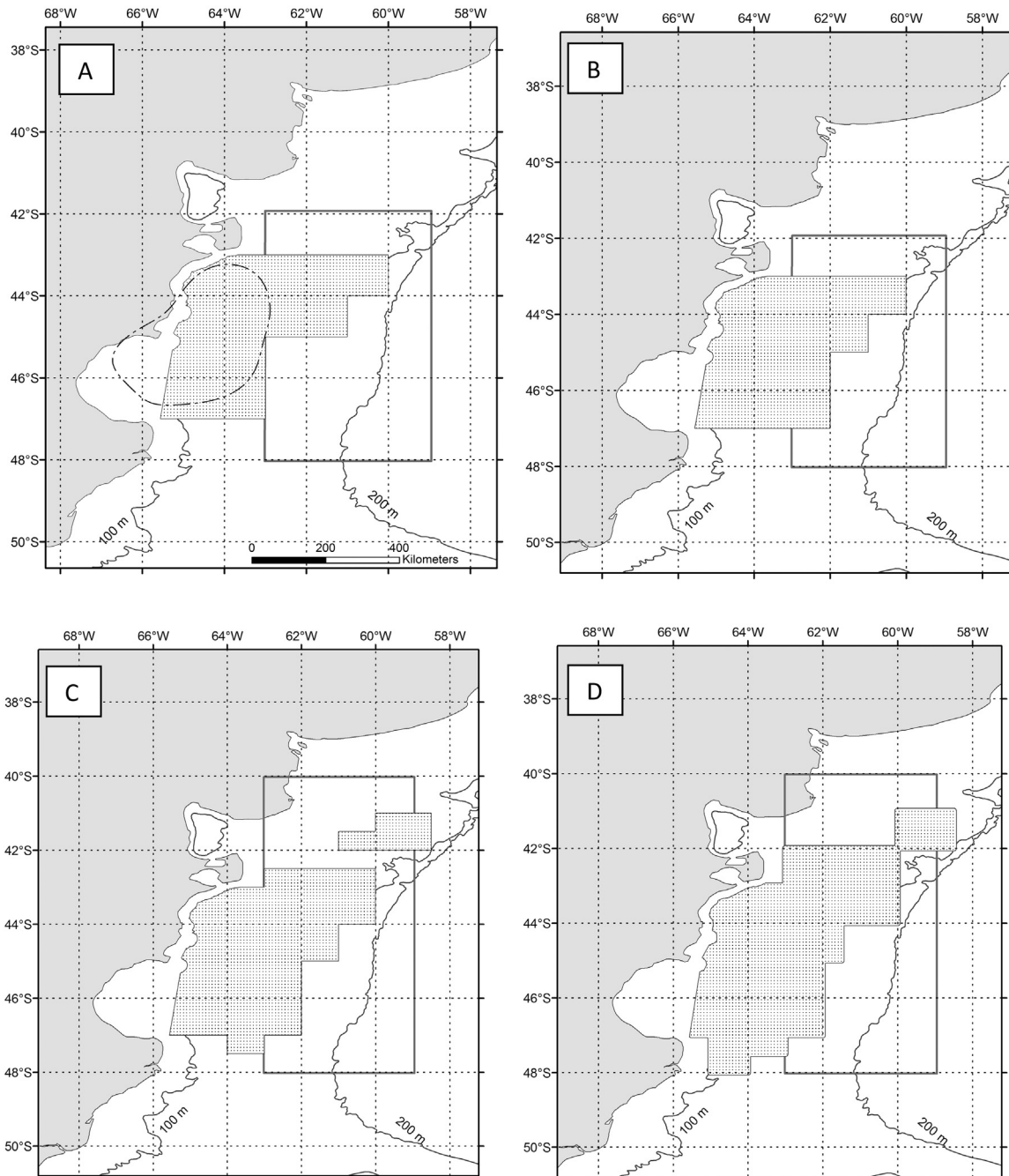
Fishing activities may have profound consequences in the ecology and demography of seabirds [32]. Vessel and fleet behavior may for instance influence seabird foraging movements [49], at-sea distribution [12] and/or survival through the incidental mortality [5,54]. Seabird bycatch has been considered one of the main at-sea threats for albatrosses and petrels, certainly affecting the conservation status of many species [21]. The impact of fisheries can not only be affected by the onboard fishing activities, but also by commercial scenarios, management strategies and decisions, among others. Several measures have been developed during the last decades to mitigate the incidental mortality of seabirds in fisheries. These include from the deployment of mitigation gear (e.g. bird scaring lines or bird curtains) to deter birds from attacking hooks or getting in contact with the fishing gear, to the

management of discards and offal, and even the establishment of fishing closures (whether temporary, seasonal or permanent) in areas of high seabird activity and susceptibility [1].

The Argentinean Continental Shelf is one of the largest and richest marine ecosystems in the world [8], with a productivity listed within the top 25 major worldwide fisheries [22]. In the Argentinean Exclusive Economic Zone, one of the most relevant fisheries management measures adopted in the mid 1990's was (still is) an extensive fishing closure covering almost one-third (c.120,000 km<sup>2</sup>) of the Patagonian Shelf area (Fig. 1) aimed at protecting the Argentine hake *Merluccius hubssi* (HFC hereafter) the main target species in the area [20,50]. In this closed area trawling operations have been banned since 1997 and, as a consequence, the trawl fishing effort has increasingly concentrated in waters adjacent to the boundary [4], thus producing a fishing described as "fishing in the line" [29]. The HFC has yielded a positive impact on the hake and other target and non-target fish stocks, substantially increasing their abundances [4]. However, there is no reference about the effects of this management

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**Fig. 1.** Spatial pattern of the hake fishing closure (shaded) during 1999–2013 on the Argentine Continental Shelf (A: 1999–2002, B: 2005–2007, C: 2008, D: 2009–2013) superimposed to the area selected to perform spatial analysis of tracked albatrosses and petrels (grey outline). Dashed line in A corresponded to the fishing area of double-beam trawlers (adapted from [19]).

measure on other taxa or conducted under an ecosystem-based management framework [38].

A number of studies have shown the existence and magnitude of seabird incidental mortality in trawlers operating along the Argentinean Continental Shelf [24,26,44]. However, there is still not a mitigation measure to reduce the seabird bycatch in the area. The Black-browed albatross (BBA, *Thalassarche melanophris*) and the Southern Giant Petrel (SGP, *Macronectes giganteus*) are within the most abundant, frequent and by-caught species in commercial trawlers in the area [24,45]. The at-sea distribution of both species highly overlap with the fishing grounds of several fisheries including trawlers [15,19] and their diets also include fishery discards [17,31]. Both seabird species are listed under Annex 1 of the

Agreement on the Conservation of Albatrosses and Petrels [2] and are threatened at regional or global scale [7,30].

In recent years Argentina has made significant progress including regulations and conservation actions addressing threatened seabirds, in particular after the ratification of the Agreement on the Conservation of Albatrosses and Petrels in 2006. Further, in 2010 the Federal Fisheries Council of Argentina adopted a National Plan of Action - Seabirds (NPOA-S)[14] comprising a range of concrete and targeted actions to minimize at-sea threats pose to seabirds and improve their conservation status. More recently, a conservation program to specifically protect coastal populations of SGP in Argentina was approved by the Federal Council of Environment [13].

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