Marine Policy 74 (2016) 120–127

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Exporting the problem: Issues with fishing closures in seabird conservation

Sofía Copello [a,*], Gabriela S. Blanco [b], Juan Pablo Seco Pon [a], Flavio Quintana [b,c], Marco Favero [a]

[a] Instituto de Investigaciones Marinas y Costeras (IIMyC, CONICET-UNMdP), Funes 3250, Mar del Plata 7600, Argentina
[b] Instituto de Biología de Organismos Marinos (IBIOMAR) CCT CONICET-CENPAT, Boulevard Brown 3500, Puerto Madryn, U9120ACF Argentina
[c] Wildlife Conservation Society, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina

ARTICLE INFO

Article history:
Received 1 March 2016
Received in revised form
29 August 2016
Accepted 2 September 2016

Keywords:
Thalassarche melanophris
Macronectes giganteus
VMS
Bycatch
Satellite tracking
Boundary effect

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.

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^2) 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

* Corresponding author.
E-mail addresses: scopello@mdp.edu.ar, soficopello@hotmail.com (S. Copello).

http://dx.doi.org/10.1016/j.marpol.2016.09.008
0308-597X/

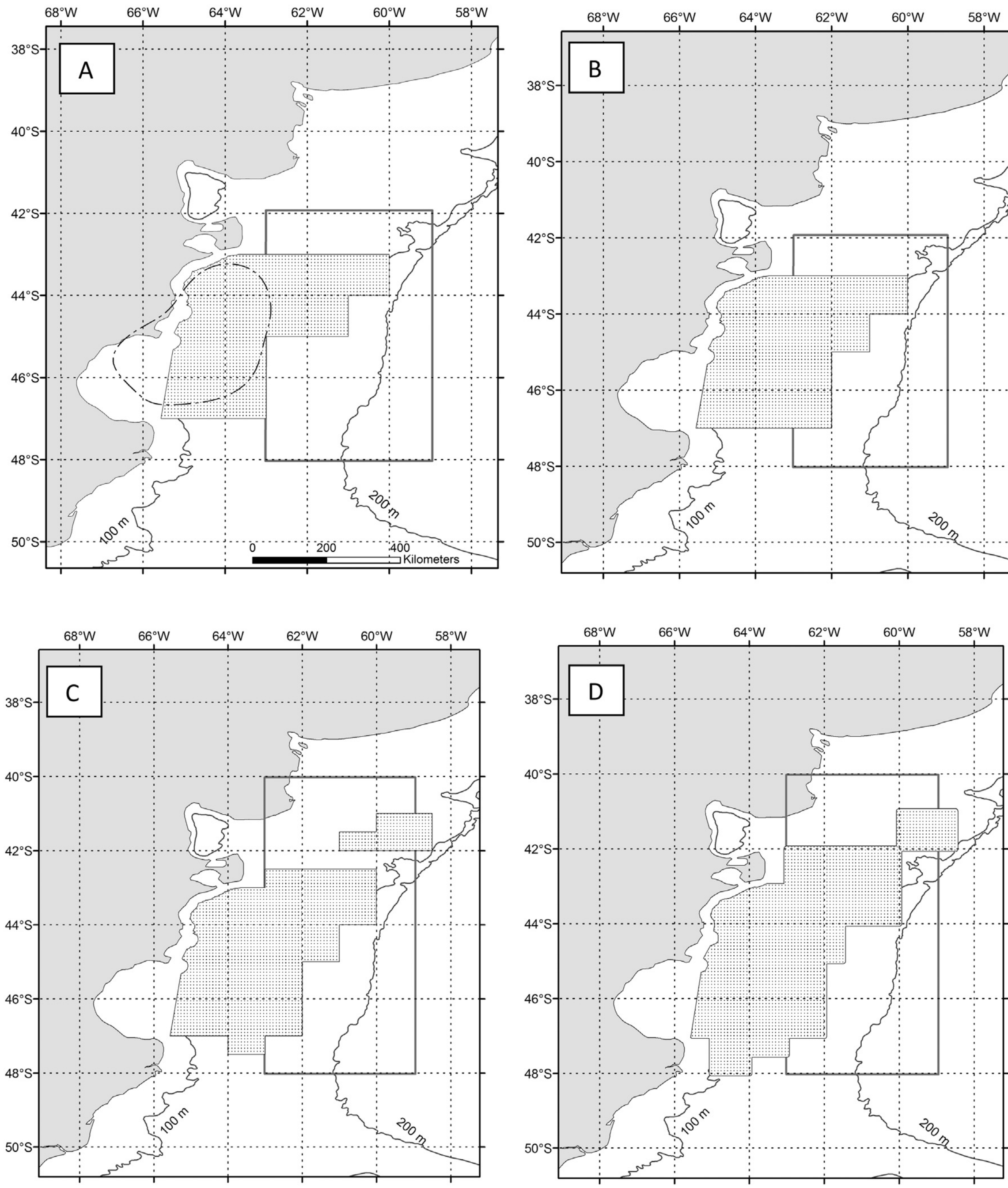

Fig. 1. Spatial pattern of the hake fishing closure (shaded) during 1999–2013 on the Argentine Continental Shelf (A: 1999–2002, B: 2005–2007, C: 2008, D: 2009–2013) superimposed to the area selected to perform spatial analysis of tracked albatrosses and petrels (grey outline). Dashed line in A corresponded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

From the seabird (and other top predator taxa) perspective there is no question that a very large offshore fishing closure implemented in Argentina have resulted in benefits by excluding large trawl fisheries from a rich oceanic area, and the consequent reduction of mortality for threatened albatrosses and petrels. However, it might be suggested that the concentration of fishing effort along the edge of the fishing closure may have exported this conservation problem to adjacent waters generating a boundary effect. Here, the distribution of seabirds attending vessels and their bycatch rates was explored in waters adjacent to the hake fishing closure, as well as the foraging behavior of BBAs and SGPs inside and outside this fishing closure.

2. Methods

2.1. Study site

The study area covers the Exclusive Economic Zone of Argentina (where the HFC is located, roughly from 41°S to 49°S). Fishing by trawlers was permanently banned inside the HFC since it legally came into force in December 1997 (SAGyP Res. N°930/97). Although the core area of the HFC has remained closed to fishing since its establishment, its shape and extent varied from time to time following the updated recommendations by the National Institute for Fisheries Research and Development (INIDEP) and adopted by the Federal Fisheries Council in Argentina (Fig. 1). To date, only double-beam trawlers targeting red shrimp (*Pleoticus mulleri*) are allowed to operate within the HFC on its western edge [19]. In order to avoid any effect of this fishery on the at-sea distribution of BBAs and SGPs, this research was conducted in the eastern portion of the HFC towards the external continental shelf where the shrimp fishery does not range (Fig. 1).

2.2. Data sources

Databases from different sources were used: (1) satellite vessel monitoring system database (VMS, Ministerio de Agricultura, Ganadería y Pesca), (2) National Observer Program seabird database (INIDEP, Argentina), and (3) BBA and SGP tracking databases (IIMyC and CENPAT-CONICET). Given the high spatial dynamic of the HFC since its implementation, the used databases were split or merge considering these changes. Distribution of trawl vessels in the Continental Shelf was obtained from the Argentinean VMS system for 2011 and 2012; this system records the position and speed of vessels every hour. Information about interactions between seabirds and high-seas ice-chilling and freezer trawlers (i.e. a total of 76 fishing trips and 988 sets were analyzed, both fleets combined; see fleet classification in [19]) was collected between 2007 and 2012 by on-board observers following protocols described in Favero et al. [24]. The later database included information on seabird contacts with vessel and fishing gear including bycatch rates by avian species. Since recent studies highlighted the occurrence of hidden mortality in trawlers [23,43,51], total contacts with fishing gear (irrespective of its final outcome) were used as a proxy of risk of bycatch to model the spatial patterns. A subsample of 269 ice-chilling trawls between 2009 and 2011 was used to analyze the abundance of BBA and SGP attending fishing operations. The bird-tracking database came from two long-term tracking programs in Argentina. SGPs have been tracked year round since 1999 in Patagonian colonies ([39] and references henceforth) and BBAs since 2011 only during their non-breeding period [18]. Details on the electronic tags models, attachment procedures and release locations can be found in Quintana et al. [40], Copello et al. [18] and Blanco and Quintana [9]. The tracking database for the SGP included a total of 24,808 fixes from 12 breeding and non-breeding adults and nine juveniles between 1999 and 2013. Only those trips that were not in coastal areas were selected for the SGP analysis given that the species is also known for scavenging in coastal areas in association to avian and/or marine mammals breeding colonies [40]. For the BBA, tracking data (a total of 12,317 fixes) included the distribution of five non-breeding adults during 2011–2013 (Supplementary material).

2.3. Data analysis

In order to determine the distribution of trawl fishing effort, the VMS data were filtered by speed and time of day including only positions of fishing (i.e. between 2 and 5 knt, 0700–2200 h local time–3GMT). To determine the core fishing areas, seabird bycatch and abundances of BBA and SGP associated with ice-chilling vessels, a kernel density method [52] was applied. In the last two cases the kernel was weighted for the total number of contacts and abundances, respectively. In the case of the fishing effort the core areas for both years were similar so the data were merged. Given that there was not autocorrelation between abundance census ($R_{Pearson}$: 0.33–0.73, $P > 0.05$), these data were considered independent. Generalized additive models (GAM) were employed to explore the relationship of seabird bycatch and birds associated with vessels with distance to the HFC boundary [53]. GAM was fit using *mgcv* package in R software and the negative binomial function was used to model the refereed relationships.

First difference correlated random walk switching state-space models (DCRWS SSM) were fit to the raw location data of BBA and SGP using *bsam* package in R software to infer two behavioral states [28]. The state-space models have been used in many tracking marine studies to estimate the animal's state [27,36,42]. The models identified low and contorted movement considered indicative of area restricted search (ARS) behavior [33], and in this study it was used as a proxy for foraging behavior [48]. To fit the SSM to each individual bird location dataset, 2 Markov Chain Monte Carlo (MCMC) chains of 10 000 iterations were run with a burn-in of 10 000. Each chain was thinned so that 1 in every 10 samples was retained, for a final MCMC sample size of 5000. The model fit provided location points at 3 h intervals along the movement path. Following O'Toole et al. [35], frequency plots of *b* parameter (state) of the SSM were used to assign behavioral state to each location. A visual threshold of the frequency plot was analyzed for each individual and values above the threshold are classified as search behavior. Then a kernel density method [47] was used to identify core foraging areas for BBA and SGP in relation to the HFC in each of the study areas (Fig. 1). Besides, in order to analyze the foraging activity in and out of the HFC, the time spent foraging in those areas (buffer areas at 30, 60 and 90 km at both sides of the boundary) were compared using Kruskal-Wallis and Wilcox tests.

3. Results

The trawl fishing effort was distributed along the Argentine Continental Shelf, showing core areas to the North of 49°S, in particular from South of the Río de la Plata estuary up to the shelf break and surrounding the boundaries towards the East of the HFC, covering a total area of 147,000 km^2 (Fig. 2A). The analysis of 1,634 seabird interactions (contacts with the vessel or the fishing gear as a proxy of risk of mortality) observed in 2007 revealed a rate of 54.5 ± 40.0 contacts per set ($n = 30$). The spatial distribution of these interactions was concentrated (50% kernel) in the SE boundary of the fishing closure between 45°–47°S covering an area of 9,689 km^2 (Fig. 2B). During 2008, 605 seabird contacts were

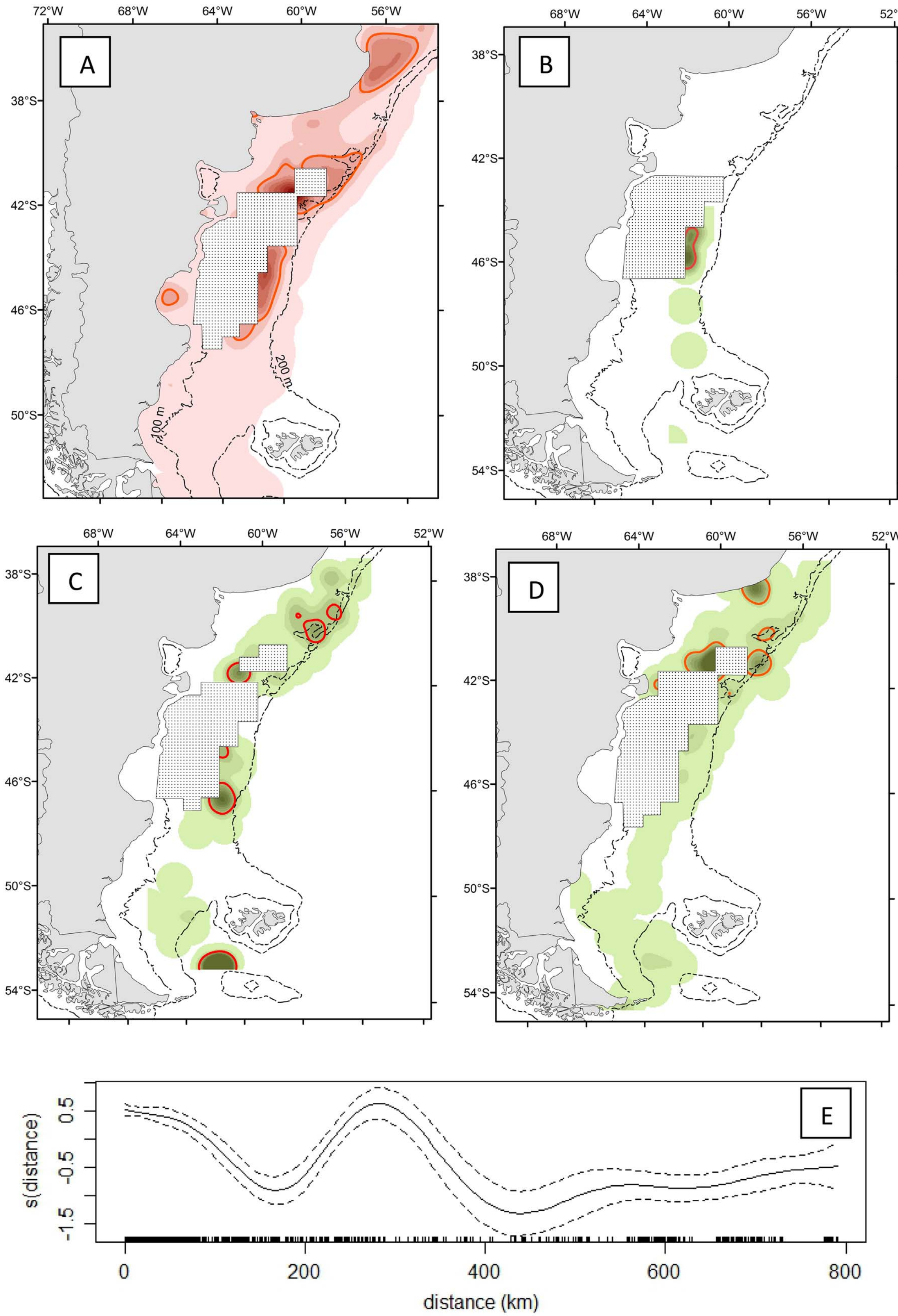

Fig. 2. Distribution of fishing effort (A), total seabird contacts (B: 2007, C2008, D: 2009–13) in the Argentinean Continental Shelf (see methods for details about changes in areal extent of fishing closure) and GAM-predicted non-linear spline of contacts (as proxy of risk of bycatch) as a function of the distance to the HFC (E). Red contours show 50% kernel boundaries.

observed with a contact rate of 4.2 ± 4.4 birds per set (n = 144) and there were seven core interaction areas. Three of them bordering the HFC and the others in northern areas over the shelfbreak and in the South of the Argentine Continental Shelf, with a total area of 31,466 km^2 (Fig. 2C). During 2009–2012 a total of 6,721 interactions with the vessel were observed, with a contact rate of 8.2 ± 22.3 contacts per set (n = 794). In this case, core areas were located in five clusters, three of them located in waters adjacent to the North of the fishing closure in an area of c. 30,000 km^2 and the remaining in coastal waters off Buenos Aires province and near the shelf break at 40°S (Fig. 2D). The distance to the boundary of the HFC had an effect on the interaction showing more contacts in nearby areas and at ca. 300 km from the HFC (estimated degrees of freedom, edf = 8.7, χ^2 = 280.9, P < 0.0001, deviance explained = 10%, Fig. 2E).

A total of 305,940 birds were recorded attending trawlers in 269 observed sets. BBAs were present in all censuses and accounted for 51% of the total abundance (average abundance = 574.0 ± 633.8 birds set^{-1}), while the SGPs were present in 82% of the surveys, although represented 1% of the total assemblage (average abundance = 10.5 ± 20.5 birds set^{-1}). The spatial modeling of seabird abundances revealed a pattern similar to that described for seabird contacts with fishing gear, with core areas in the boundaries of the HFC. For the BBA, four core areas of abundance were identified, two of them in waters adjacent to the HFC which represent the 80% of the total kernel area and the other two over the shelf-break (Fig. 3A). There was non-significant effect of distance on the BBA attending trawlers (edf = 6.7, χ^2 = 9.0, P = 0.3). For SGP, three core areas were identified; two of them in waters adjacent to the HFC (that overlapped with BBA) and a third one in the SE of the HFC (Fig. 3B). The SGP abundances attending trawlers were greatest near the HFC boundary and declining with distance (edf = 3.0, χ^2 = 86.1, P < 0.0001, deviance explained = 12.5%, Fig. 3C).

The bulk of the core foraging areas of satellite tracked BBAs and SGPs were concentrated in waters adjacent to the HFC. Core foraging areas for BBA were located in two areas bounding the HFC. A large area of 17,000 km^2 which expands from the North of the study area to the HFC northern edge and a smaller area of 1,500 km^2 bordering the southeast of the HFC (Fig. 4A). For adult SGPs, core foraging areas were located in the South-southeast boundaries of the HFC in average areas of about 11,600 km^2. Petrels also showed important core areas along the shelf-break between 45°S to 47°S (Fig. 4B, C and D). Tracked juvenile SGPs showed a different foraging behavior, core areas were located in the shelf-break and two individuals used a core foraging area inside the HFC (Fig. 4E and F). For both species the time spent foraging in the outside boundaries of the HFC was greater than inside the HFC (79.2 ± 8.0 vs. 20.8 ± 8.0%, W = 1.5, P < 0.05, Fig. 5). In general terms, foraging was more intense near the boundary of

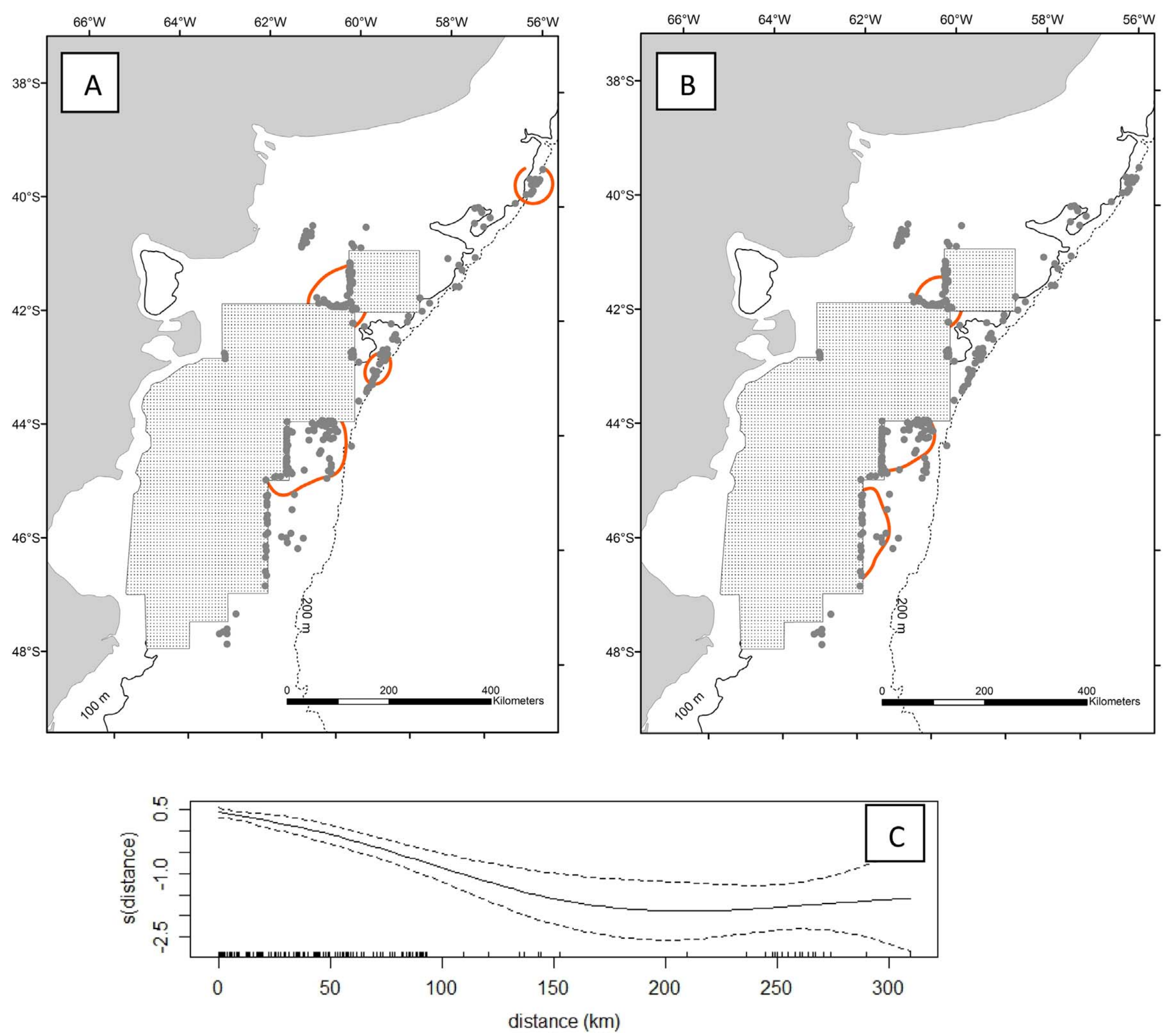

Fig. 3. Abundances of Black-browed albatrosses (A) and Southern Giant Petrels (B) attending ice-chilling vessels. GAM-predicted non-linear spline of the Southern Giant Petrel abundances as a function of the distance to the HFC (C). Red outline: kernel 50%, grey dots: observed sets.

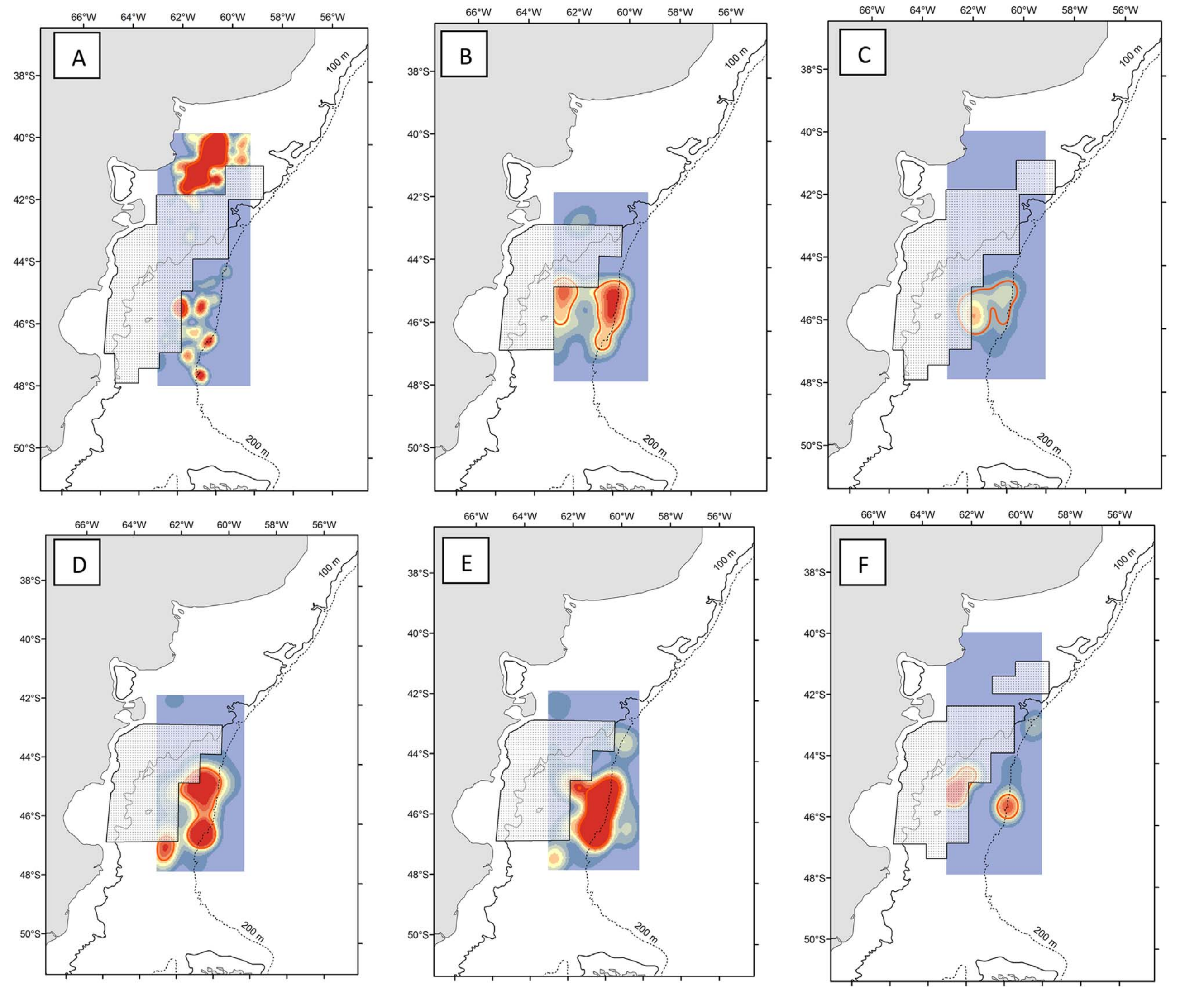

Fig. 4. Core foraging areas for adult Black-browed albatrosses (A), adult Southern Giant Petrels (B, C, D), and juvenile Southern Giant Petrels (E, F) in relation to changing fishing closures (A: 2011–2013; B: 1999–2002; C: 2013; D: 2005–2006; E: 2005–2007 and F: 2008). Red contour: core foraging areas (kernel 50%).

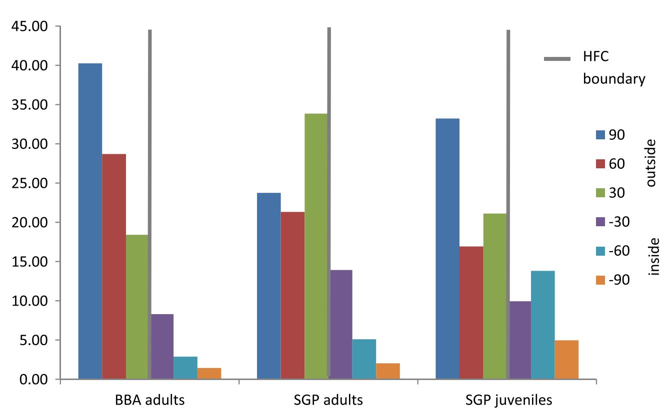

Fig. 5. Time spent foraging (%) by tracked Southern Giant Petrels and Black-browed albatrosses inside and outside the hake fishing closure (i.e. buffer areas) scaled every 30 km distance from the boundary.

the HFC (buffer $\pm$ 30 km) than away (Fig. 5). The time spent foraging in the boundaries was similar between species (87.4%, 78.9% and 71.3% for BBA, adults SGP and juveniles SGP, respectively, KW = 1.7, P = 0.43).

4. Discussion

This study provides novel information about the effect of a fishing closure (specifically designed for fishery management), on the foraging behavior and bycatch of albatrosses and petrels. Although the effect of fishing closures or marine reserves on the total bycatch rate of some top predators had been previously studied [46], the particularly approach used in our study in relation to the spatial component of bycatch was, up to our knowledge, never considered. Results of this study are key for the development and implementation of spatial conservation measures in the framework of an ecosystem-based management.

As reported by Alemany et al. [4] for previous years (from 2000 to 2008), the present study showed that the spatial pattern of the trawl fishing effort during 2011-12 was concentrated mainly in the boundaries of the HFC. This fishing tactic had consequences on the bycatch of seabirds showing greater rate of avian bycatch in the vicinity of the HFC boundary compared to other areas of the Continental Shelf. As was abovementioned there is still no a mitigation measure in place to reduce the seabird bycatch on trawlers in Argentina. During the period 2009-13, there was also a small hotspot of bycatch in the North of the HFC (coastal waters off Buenos Aires province, Fig. 2D). The bycatch of seabirds in this area could be attributed to the operation of a pelagic trawl fishery targeting-the northern stock of-anchovy (*Engraulis anchoita*), where high rates of incidental capture of shearwaters and other procellariforms birds were observed (Paz et al. unpublished data). Our analysis of seabird bycatch showed that the HFC produced a re-distribution of the bycatch creating a "boundary effect" due to the concentration of the fishing effort. This high fishing effort most likely brings forth an increase of discard availability (and fish facilitated during hauling) and the consequent attractiveness of fishing vessels for birds. This last point is more relevant if we take into account that there are no marine fronts (considered areas of high productivity) in the boundaries of the HFC. The abundance of BBAs and SGPs associated with fishing vessels was also greater in the HFC boundaries compared with other areas along Continental Shelf, clearly taking advantage of this predictable source of food. Although there is not yet available information on fishing captures around the HFC, the literature shows that capture increase around no-take (closure) fishing areas [34]. There was also an association of BBAs with the vessels in the shelf-break area. This area also showed a high fishing effort [4] and has also been described as a high productivity area [3] with a vast fishing effort of squid jiggers [11].

Previous studies in other marine areas of the world had showed that the fishing closures have an effect on population trends, foraging behavior, and breeding biology of non-procellariform seabirds [37,41]. Our results showed that the HFC produces an effect on the foraging behavior of albatrosses and petrels. The time spent foraging by adult BBAs and SGPs in the boundaries of the HFC was considerably greater than inside this area. The concentration of bird foraging effort in the HFC boundaries was not associated with the capture of "natural" prey as there is not any particular oceanographic feature in this area (e.g. marine front). However the high fishing effort in the area produces a high availability of fishes as supplementary food for the birds. In line with these results, studies on shearwaters and gannets had showed that the behavior of vessels (i.e. absence and presence of fishing activity and distance to the vessel) has an effect on the foraging movements of those species [6,10]. In the case of juvenile SGP, the majority of the birds foraged mainly along the shelf-break, fact that could be attributed to intra-specific competition between juveniles and adults. Juvenile individuals could be displaced by adults when competing for fishery discards given their smaller corporal size [16] and less aggressive behavior. In fact, the wintering foraging areas of adults and juveniles SGP from Patagonian colonies were not overlapped [9]. In addition, due to the SGP sexual segregation during the breeding period, SGP females may be more affected by the effect of the fishing closure than males, as females forage mainly in the Continental Shelf when males also feed in coastal areas [25,40].

5. Conclusion

In conclusion, although the HFC has an important relevance for the sustainability of hake and other non-target fish species [4], as well as top predators as seabirds and marine mammals, trawl fishery and top predator behavior deserve special attention in border areas due to the increased bycatch comprehensively described in the present study. These areas must be considered a priority in terms of urgencies for the implementation of conservation measures and even the development of specific regulations to mitigate the above referred side effects. The focus in those areas must be further considered in the framework of the National Plan of Action –Seabirds [14](PAN-AVES) and the Agreement for the Conservation of Albatrosses and Petrels [2]. Moreover, the boundary effect reported in this study should be taking into account in the development and implementation of spatial conservation measures such as the National System of Marine Protected Areas in Argentina and other marine areas around the world.

Acknowledgments

This project was mainly funded by the National Agency for the Promotion of Science and Technology (Agencia Nacional de Promoción Científica y Técnica, Argentina PICT 2008–0590, PICT 2012-295, PICT 1/6372), the National Research Council (Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina PIP CONICET 00070) and the National University of Mar del Plata (Argentina). The authors thank ACAP, Seaworld & Bush Gardens Conservation Fund, Quark Fund and Mohamed Ben Zayed for additional funds provided. All sampling was performed under permission and complies with current national legislation. We also wish to especially thank the Captain and crew of the fishing vessel Ur-Ertza and Raptor and Stuka and the Head of the National Observer programme Gabriel Blanco (INIDEP) for logistic support. We are grateful to Dr. Germán García, Dr. Rocío Mariano-Jelicich, Lic. Jesica Paz, Teresa Ravasi, Dra. Carolina Block, Julián Bastida for their assistance during fieldwork. We like to thank Gabriela Navarro, Laura Prodoscimi and Gustavo Martínez (Secretariat of Fisheries, Argentina) who kindly facilitated the access to VMS data and the On-board Observed Program of INIDEP who facilitated the bycatch data. Thanks also to seaturtle.org Satellite Tracking and Analysis Tool for the service provided to obtain the Argos data and Aquarium Foundation. Finally, thanks to the editor and an anonymous reviewer for their valuable input that greatly improved the manuscript.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.marpol.2016.09.008.

References

[1] ACAP. Report of Seabird Bycatch Working Group. In: Seabird Bycatch Working Group, p. 122. Seventh Meeting of the Advisory Committee ACAP. 2013.
[2] ACAP. Agreement on the Conservation of Albatrosses and Petrels. In, p. 25, 2015.
[3] E.M. Acha, A. Piola, O. Iribarne, H. Mianzan, Ecological processes at Marine Fronts: Oases in the Ocean, Springer, 2015.
[4] D. Alemany, O. Iribarne, E.M. Acha, Effects of a large-scale and offshore marine protected area on the demersal fish assemblage in the Southwest Atlantic, ICES J. Mar. Sci. 70 (2013) 123–134.
[5] O.R.J. Anderson, C.J. Small, J.P. Croxall, E.K. Dunn, B.J. Sullivan, O. Yates, A. Black, Global seabird bycatch in longline fisheries, Endanger. Species Res. 14 (2011) 91–106.
[6] F. Bartumeus, L. Giuggioli, M. Louzao, V. Bretagnolle, D. Oro, S.A. Levin, Fishery Discards Impact on Seabird Movement Patterns at Regional Scales, Curr. Biol. 20 (2010) 215–222.
[7] BirdLife International. Species factsheet: Thalassarche melanophris. 2016. Available at: 〈http://www.birdlife.org〉 (accessed 29/02 2016).
[8] G.A. Bisbal, The Southeast South American shelf large marine ecosystem: evolution and components, Mar. Policy 19 (1995) 21–38.
[9] G.S. Blanco, F. Quintana, Differential use of the Argentine shelf by wintering adults and juveniles southern giant petrels, *Macronectes giganteus*, from Patagonia, Estuar., Coast. Shelf Sci. Estuar. Coast Shelf Sci. 149 (2014) 151–159.
[10] T.W. Bodey, M.J. Jessopp, S.C. Votier, H.D. Gerritsen, I.R. Cleasby, K.C. Hamer, S. C. Patrick, E.D. Wakefield, S. Bearhop, Seabird movement reveals the ecological footprint of fishing vessels, Curr. Biol. 24 (2014) R514–R515.
[11] N.E. Brunetti, M.L. Ivanovic, G.R. Rossi, B. Elena, S. Pineda. Fishery biology and life history of Illex argentinus. International Symposium On Large Pelagic Squids (ed by T. Okuytani), 1998, pp. 217-231.
[12] A. Cama, J. Bort, I. Christel, D.R. Vieites, X. Ferrer, Fishery management has a strong effect on the distribution of Audouin's gull, Mar. Ecol. Prog. Ser. [Mar. Ecol. Prog. Ser.] 484 (2013) 279–286.

[13] Consejo Federal de Medio Ambiente (2013) Programa Nacional Para LA conservación del Petrel Gigante del Sur o del Petrel Gigante Común (Macronectes giganteus). In:.
[14] Consejo Federal Pesquero (2010) *Plan de acción nacional para reducir la interacción de aves con pesquerías en la República Argentina*. Available at: 〈http://www.ambiente.gov.ar/archivos/web/GTRA/file/Aves%20marinas/2010-%20PAN%20AVES_Res%20CFP%2015-10.pdf〉 (accessed 11 June 2013).
[15] S. Copello, F. Quintana, Spatio-temporal overlap between Southern Giant Petrels and fisheries at the Patagonian Shelf, Polar Biol. 32 (2009) 1211–1220.
[16] S. Copello, F. Quintana, G. Somoza, Sex determination and sexual size-dimorphism in Southern Giant-Petrels (*Macronectes giganteus*) from Patagonia, Argentina, Emu 106 (2006) 141–146.
[17] S. Copello, F. Quintana, F. Perez, The diet of the Southern Giant Petrel in Patagonia: fishery-related items and natural prey, Endanger. Species Res. 6 (2008) 15–23.
[18] S. Copello, J. Seco Pon, M. Favero, Use of marine space by Black-browed albatrosses during the non-breeding season in the Southwest Atlantic Ocean, Estuar. Coast. Shelf Sci. 123 (2013) 34–38.
[19] S. Copello, J. Seco Pon, M. Favero, Spatial overlap of Black-browed albatrosses with longline and trawl fisheries in the Patagonian Shelf during the non-breeding season, J. SEA Res. 89 (2014) 44–51.
[20] M.B., Cousseau, R.G., Perrotta (2003) Peces marinos de Argentina: Biología, distribución, pesca. INIDEP, Mar del Plata, Argentina.
[21] J.P. Croxall, S.H.M. Butchart, B. Lascelles, A.J. Stattersfield, B. Sullivan, A. Symes, P. Taylor, Seabird conservation status, threats and priority actions: a global assessment, Bird. Conserv. Int. 22 (2012) 1–34.
[22] FAO 2014 Global Capture Production Statistics 2012. In. Fisheries and Aquaculture Department.
[23] M. Favero, J. Seco Pon, Challenges in seabird by-catch mitigation, Anim. Conserv. 17 (2014) 532–533.
[24] M. Favero, G. Blanco, G. García, S. Copello, J. Seco Pon, E. Frere, F. Quintana, P. Yorio, F. Rabuffetti, G. Cañete, P. Gandini, Seabird mortality associated with ice trawlers in the Patagonian Shelf: effect of discards on the occurrence of interactions with fishing gear, Anim. Conserv. 14 (2011) 131–139.
[25] J. Gonzaléz-Solís, J.P. Croxall, V. Afanasyev, Offshore spatial segregation in giant petrels *Macronectes* spp.: Differences between Species, sexes and Seasons, Aquat. Conserv.: Mar. Freshw. Ecosyst. 17 (2008) 22–36.
[26] D. González Zevallos, P. Yorio, Seabird use of discards and incidental captures at the Argentine hake trawl fishery in Golfo San Jorge, Argentina, Mar. Ecol. Prog. Ser. 316 (2006) 175–183.
[27] I.D. Jonsen, R.A. Myers, M.C. James, Identifying leatherback turtle foraging behaviour from satellite telemetry using a switching state-space model, Mar. Ecol. Prog. Ser. [Mar. Ecol. Prog. Ser.] 337 (2007) 255–264.
[28] I.D. Jonsen, M. Basson, S. Bestley, M.V. Bravington, T.A. Patterson, M. W. Pedersen, R. Thomson, U.H. Thygesend, S.J. Wotherspoon, State-space models for bio-loggers: A methodological road map, Deep SEA Res. Part II: Top. Stud. Oceanogr. 88–89 (2013) 34–46.
[29] J.B. Kellner, I. Tetreault, S.D. Gaines, R.M. Nisbet, Fishing the line near marine reserves in single and multispecies fisheries, Ecol. Appl. 17 (2007) 1039–1054.
[30] B. Lopéz-Lanus, P. Grilli, A.S. Di Giacomo, E.G. Coconier, R. Banchs, Categorización de las aves de la Argentina según su estado de conservación, Aves Argentinas AOP, Secretaría DE Ambiente y Desarrollo Sustentable, Buenos Aires, Argentina, 2008.
[31] R. Mariano-Jelicich, S. Copello, J. Seco Pon, M. Favero, Contribution of fishery discards to the diet of the Black-browed albatross (*Thalassarche melanophris*) during the non-breeding season: an assessment through stable isotope analysis, Mar. Biol. 161 (2014) 119–129.
[32] W.A. Montevecchi, Interactions between Fisheries and Seabirds. Biology of Marine Birds, in: E.A. Schreiber, J. Burger (Eds.), CRC Press, Boca Ratón, Florida, 2002, pp. 527–557.
[33] J.M. Morales, D.T. Haydon, J. Frair, K.E. Holsinger, J.M. Fryxell, Extracting more out of relocation data: building movement models as mixtures of random walks, Ecology 85 (2004) 2436–2445.
[34] S.A. Murawski, S.E. Wigley, M.J. Fogarty, P.J. Rago, D.G. Mountain, Effort distribution and catch patterns adjacent to temperate MPAs, ICES J. Mar. Sci. 62 (2005) 1150–1167.
[35] M. O'Toole, M.A. Hindell, J.B. Charrassin, C. Guinet. Foraging behaviour of southern elephant seals over the Kerguelen Plateau. 502, 2014, 281-294.
[36] C. Péron, D. Grémillet, A. Prudor, E. Pettex, C. Saraux, A. Soriano-Redondo, M. Authier, J. Fort, Importance of coastal Marine Protected Areas for the conservation of pelagic seabirds: The case of Vulnerable yelkouan shearwaters in the Mediterranean Sea, Biol. Conserv. 168 (2013) 210–221.
[37] L. Pichegru, P.G. Ryan, R. van Eeden, T. Reid, D. Grémillet, R. Wanless, Industrial fishing, no-take zones and endangered penguins, Biol. Conserv. 156 (2012) 117–125.
[38] E.K. Pikitch, C. Santora, E.A. Babcock, A. Bakun, R. Bonfil, D.O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heneman, E.D. Houde, J. Link, P. A. Livingston, M. Mangel, M.K. McAllister, J.G. Pope, K.J. Sainsbury, Ecosystem-Based Fishery Management, Science 305 (2004) 346–347.
[39] F. Quintana, P. Dell' Arciprete, Foraging grounds of southern giant petrels (*Macronectes giganteus*) on the Patagonian shelf, Polar Biol. 25 (2002) 159–161.
[40] F. Quintana, P. Dell' Arciprete, S. Copello, Foraging behavior and habitat use by the Southern Giant Petrel on the Patagonian Shelf, Mar. Biol. 157 (2010) 515–525.
[41] P. Regular, W. Montevecchi, A. Hedd, G. Robertson, S. Wilhelm, Canadian fishery closures provide a large-scale test of the impact of gillnet bycatch on seabird populations, Biol. Lett. 9 (2013), 20130088.
[42] T. Reid, R.A. Ronconi, R.J. Cuthbert, P.G. Ryan, The summer foraging ranges of adult spectacled petrels *Procellaria conspicillata*, Antarct. Sci. (2013) 1–10.
[43] Y Richard, ER Abraham. Risk of commercial fisheries to New Zealand seabird populations. In: New Zealand Aquatic Environment and Biodiversity Report p. 58. Ministry for Primary Industries, New Zealand. 2013.
[44] J. Seco Pon, Asociación de aves marinas pelágicas a la flota argentina de arrastre de altura: caracterización integral de las interacciones y desarrollo de una estrategia de conservación para especies con estado de conservación amenazado, Universidad Nacional DE Mar del Plata, 2014.
[45] J. Seco Pon, S. Copello, L.L. Tamini, R. Mariano-Jelicich, J. Paz, G. Blanco, M. Favero, Seabird Conservation in Fisheries: Current State of Knowledge and Conservation Needs for Argentine High-Seas Fleets, in: G. Mahala (Ed.), Seabirds and Songbirds: Habitat Preferences, Conservation and Migratory Behavior, Nova Publishers, 2015, pp. 45–87.
[46] J. Senko, E.R. White, S.S. Heppell, L.R. Gerber, Comparing bycatch mitigation strategies for vulnerable marine megafauna, Anim. Conserv. 17 (2014) 5–18.
[47] B.W. Silverman, Density Estimation for Statistics and Data Analysis, Chapman and Hall, New York, 1986.
[48] J. Sommerfeld, A. Kato, Y. Ropert-Coudert, S. Garthe, M.A. Hindell, Foraging Parameters Influencing the Detection and Interpretation of Area-Restricted Search Behaviour in Marine Predators: A Case Study with the Masked Booby, PLoS One 8 (2013) e63742.
[49] L. Torres, D.R. Thompson, S. Bearhop, S. Votier, G.A. Taylor, P.M. Sagar, B. C. Robertson, White-capped albatrosses alter fine-scale foraging behavior patterns when associated with fishing vessels, Mar. Ecol. Prog. Ser. 428 (2011) 289–301.
[50] L.S. Tringali, Biología y pesca de la merluza del Mar Argentino, Instituto Nacional de Investigación y Desarrollo Pesquero INIDEP, Mar del Plata, 2012.
[51] B.P. Watkins, S.L. Petersen, P.G. Ryan, Interactions between seabirds and deep-water hake trawl gear: an assessment of impacts in South African waters, Anim. Conserv. 11 (2008) 247–254.
[52] B.J. Worton, Kernel methods for estimating the utilization distribution in home-range studies, Ecology 70 (1989) 164–168.
[53] A.F. Zuur, E.N. Ieno, N.J. Walker, A.A. Saveliev, G.M. Smith, Mixed Effects Models and Extensions in Ecology with R, Springer, New York, 2009.
[54] R. Zydelis, C. Small, G. French, The incidental catch of seabirds in gillnet fisheries: A global review, Biol. Conserv. 162 (2013) 76–88.