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Spatial overlap of Black-browed albatrosses with longline and trawl fisheries in the Patagonian Shelf during the non-breeding season

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ABSTRACT

Incidental mortality in fisheries is the main at-sea threat albatrosses are facing nowadays. In this study we used remote sensing techniques to model the degree of spatial overlapping between the Black-browed albatross (*Thalassarche melanophris*) and Argentine fisheries, assuming this as a proxy of risk for albatrosses. Eleven tags were deployed on albatrosses during the non-breeding seasons 2011 and 2012 in the Patagonian Shelf. Their distribution overlapped to different extents with the two coastal trawl, three offshore trawl and one demersal longline fisheries. The overlap index showed highest values with both coastal fleets, followed by the ice-chilling trawl fleet. These intersections were located in the Argentinean–Uruguayan Common Fishing Zone, in coastal areas of the SE of Buenos Aires province, El Rincón estuary and over the shelf break. The analysis of intersections of focal areas from albatrosses and all fisheries allowed the identification of thirty-four fishing management units (1° by 1° grid within the Argentine EEZ) classified as of medium, high or very high conservation priority. Very high priority units were placed between 35 and 38°S in the external mouth of Rio de la Plata, and between 45 and 47°S in neighboring waters East to the hake fishing closure. Although there were possible biases due to the limited number of tracked birds and the locations where albatrosses were captured and instrumented, the information presented in this study provides a comprehensive picture of important areas of overlapping during winter that could be used by the fishery administration to prioritize conservation actions under limited resource scenarios.

1. Introduction

Most of the albatross species are currently threatened with extinction (BirdLife International, 2012) and one of their main threats is the incidental mortality in association with commercial fisheries (Croxall et al., 2012). Literature shows that seabird bycatch occurs in vessels using different fishing gears such as pelagic and bottom longlines, trawl and gillnets, among others (Anderson et al., 2011; Baker et al., 2007; Zydelis et al., 2013). Hence, a multi-gear approach is essential to understand and deal with this conservation issue threatening a large number of very fragile species. In the South Atlantic, waters within the Argentine economic exclusive zone present a clear example of an area where large fisheries comprising some 800 vessels operate throughout the year using a wide range of fishing gears (Consejo Federal Pesquero, 2010), and overlap with the distribution of seabirds such as albatrosses and petrels. The dynamics of these fisheries are highly complex, not just because of the multiplicity of fishing gear (e.g. coastal and offshore ice trawlers and freezer trawlers, bottom longliners) but also because the existence of changing fishery regulations over time (regarding use of particular fishing gears, management jurisdictions, and spatial and temporal fishing closures). Moreover, the high biodiversity and biomass of marine top predators, including albatrosses and petrels, create an environment where the interaction with fishing activities is at least not negligible and in most cases important.

More than half of the 22 albatross species make use of this marine space as a foraging area during the breeding and/or the non-breeding period (Falabella et al., 2009; Favero and Silva Rodriguez, 2005; Nicholls et al., 2002; Seco Pon et al., 2007). Some of these species have been previously reported in the bycatch of longline (Favero et al., 2013) and trawl fleets, including coastal vessels and those operating in the high seas (Favero et al., 2011; González-Zevallos and Yorio, 2006; Sullivan et al., 2006). Incidental mortality is a result of seabirds converging with fisheries in the same areas and consequently attending vessels due to the attraction generated by the availability of food in the form of bait, offal and/or discards (Tasker et al., 2000). This predictable and abundant source of food can certainly affect the distribution of seabirds (Bartumeus et al., 2010). Although this food subsidy could be understood as beneficial for some seabirds, it is clear that for low productive seabird species such as albatrosses and petrels, the negative effect of incidental mortality on albatross populations is by far more important than any positive effect (Finkelstein et al., 2008).

The accession of Argentina to the Agreement on the Conservation of Albatrosses and Petrels in 2006 triggered a number of domestic

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conservation actions, including the adoption in 2008 of a binding measure for the use of mitigation (bird scaring lines, night setting and line weighting) in longliners (Federal Fisheries Council Resolution CFP 8/2008, entering into force in 2010), and the formal adoption in 2010 of the National Plan of Action-Seabirds (Resolution CFP 15/2010) addressing all fisheries known or suspected to interact with seabirds in Argentine waters. Despite the progress achieved, issues dealing with the full implementation of the conservation measures in longliners and the bycatch reduction in the large and complex trawl fishery remain partially addressed and need urgent attention.

Similar to other fisheries in the South Atlantic (Anderson et al., 2011; Bugoni et al., 2008; Jiménez et al., 2009; Watkins et al., 2008), the Black-browed albatross (*Thalassarche melanophris*, herein BBA[1]) is among the most common Procellariiform species in the bycatch in Argentina (Favero et al., 2011, 2013). This species is the most abundant of the southern hemisphere albatrosses with a current global population estimated at 600,000 breeding pairs, of which c. 70% breed in Malvinas (Falkland) islands and chiefly forage in Argentinean, Uruguayan and Brazilian waters on the continental shelf (Catry et al., 2013; Copello et al., 2013; Grémillet et al., 2000; Huin, 2002). Although present along the Patagonian shelf throughout the year, BBAs migrating northwards during the winter concentrate in two large marine areas, one from the mouth of Rio de la Plata towards the E–SE reaching the shelfbreak, and another at El Rincón estuary and waters to the South (Copello et al., 2013). The unsustainable levels of incidental mortality of this species in longline and trawl fisheries has caused steep population declines (Arnold et al., 2006; Huin and Reid, 2007; Tuck et al., 2011) and the deterioration of its conservation status. However, increases recently reported for the population breeding in Malvinas, likely as a result of reduced seabird bycatch and favorable feeding conditions (Catry et al., 2011; Wolfaardt, 2012) triggered the recent downlisting of the species from Endangered to Near Threatened (BirdLife International, 2014).

In order to better understand the interactions between seabirds and fisheries and to implement an ecosystem-based management in the area, it is crucial to take into account the spatial dynamics of such interactions (Crowder and Norse, 2008). The miniaturized bio-logging devices deployed on live animals, broadly used nowadays, have enabled the detailed study of individual distribution patterns, particularly of seabirds at sea (Ropert-Coudert and Wilson, 2005). When combined with fisheries data, such information can allow a better understanding of the spatial overlap between seabirds and fisheries (see for example Granadeiro et al., 2011). This spatial overlap is a necessary precondition for interactions and/or bycatch, thus it can be used as a proxy of risk faced by the birds interacting with fisheries (Delord et al., 2010; Tuck et al., 2011; Yorio et al., 2010).

Most of the available fishery datasets are provided at a spatial resolution of 5° × 5° (e.g. Regional Fisheries Management Organizations), and some studies highlighted the need for data at a finer scale for overlapping modeling studies (Granadeiro et al., 2011; Votier et al., 2013). In recent years Argentina converted its system for the obtainment of data on fisheries distribution from the traditional logbooks with a spatial resolution of 1° × 1° grid to a satellite vessel monitoring system with even higher resolution and enhanced capabilities for monitoring and surveillance. This largely improved the context in which detailed studies on the interaction between albatrosses and a range of fisheries can be conducted. In the present study, we used remote sensing techniques (satellite telemetry devices installed on albatrosses and vessel monitoring system, VMS) to model the degree of spatial overlapping between BBAs and Argentine fisheries known to pose a threat to albatrosses.

[1] BBA — Black-browed albatross

2. Material and methods

2.1. Black-browed albatross tracking data

We deployed 11 satellite transmitters (battery-powered Platform Terminal Transmitters PTTs, K3H 179A KiwiSat303, Sirtrack® and TAV-2656 Telonics Inc.) on adult Black-browed albatrosses during the austral winters (June–September) 2011 and 2012 (see Copello et al., 2013 for more details about tracking procedure). The distribution of this species was recently analyzed to characterize the use of marine space and oceanographic areas during the nonbreeding season (Copello et al., 2013). Tags weighed 63 and 55 g respectively, representing less than 1.6% of the adult body mass (mean = 4 kg, n = 31, Seco Pon unpub. data), and well under the maximum of 3% recommended to avoid adverse effects on bird behavior (Phillips et al., 2003). Birds were captured at sea from fishing vessels (sport and commercial) using hoop nets. Tags were attached to the back feathers with Tesa® tape and zip ties. The devices were programmed to transmit with a duty cycle of 8 h on (0900–1700 h local time) and 16 h off, and 12 h on (0600–1800 h local time) and 12 h off for 2011 and 2012, respectively. On average, 7.1 (range: 3–18) and 12.5 locations (range: 3–16) were obtained per duty cycle for the tags deployed in 2011 and 2012, respectively. This setting was decided considering that (1) BBAs are essentially diurnal feeders and (2) fishing operations in the large trawl fleets occur during daytime. Position fixes for satellite-tagged albatrosses were received from Argos System (CLS America, Inc., Largo, Maryland, USA) using the Satellite Tracking and Analysis Tool to download the data (Coyne and Godley, 2005). All Argos locations (accuracy classes A, B, Z, 0, 1 to 3) were used after filtering positions according flight speed (maximum velocity was set at 100 km h^{-1}) (BirdLife International, 2004). Standard locations (classes 3 to 0) accounted for most of the gathered locations (82%) and the speed filter removed 9% of received positions. Tracks were re-sampled at 30 min intervals, assuming that birds moved in a straight line between positions (no assumptions were made about the bird's locations along the track during the “off” cycle for PTTs).

2.2. Fishery data

Black-browed albatrosses have been reported to interact with a range of fisheries in Argentine waters (Favero et al., 2011, 2013; Gandini et al., 1999; González-Zevallos and Yorio, 2006; González-Zevallos et al., 2011; Seco Pon et al., 2012, 2013; Yorio and Caille, 1999). Accordingly, in this study two coastal fisheries (close and distant coastal trawl), three offshore demersal trawl fisheries (ice-chilling, freezer and double-beam trawl), and the bottom-demersal longline fishery were included in the analysis (see Table 1). Information on the distribution of these fleets for the winter 2011 was obtained from the Argentinean Vessel Monitoring System (VMS, Ministerio de Agricultura, Ganadería y Pesca), providing the GPS position of each vessel every hour. Vessel positions were filtered by speed and time of day in order to represent the distribution of the actual fishing effort (i.e. including only vessels actively fishing, for trawlers between 2 and 5 knt, 0700–2200 h local time −3 GMT; for longliners speeds lower than 6 knt, 24 h).

2.3. Data analysis

The geographic mean center was estimated for each fishery (Fotheringham et al., 2000). At-sea distribution of the BBAs and main fishing fleets were analyzed with kernel home-range utilization distributions (UD, based on Worton, 1989). Kernel density analyses have been successfully used in modeling the habitat of albatrosses and petrels (BirdLife International, 2004; Tancell et al., 2013) as well as fisheries (Favero et al., 2013; Louzao et al., 2011). The smoothing parameter (h) was 50 km, and contour levels were estimated for 50% (core area), 75% (focal area) and 95% (range area) of the locations

Table 1
Characterization of the study fisheries.

Name	Fleet strata	Catch condition	Length (m)	Fishing gear[a]	Target species[a]	Number of vessels	Maximum operational distance	Landings (ton)[b]
Close coastal fleets	Semi-industrial close coastal	Preserved fresh in ice (within plastic cubes *ca.* 0.05 m^3)	9–15 m	Multi-gear and multi-strata depending on the target species, season and market demand	Non-selective fishery (Prawn *Artemesia longinaris*, Shrimp *Pleoticus muelleri*, Whitemouth croaker *Micropogonias furnieri*, Argentine hake *Merluccius hubbsi*, Argentine anchovy *Engraulis anchoita*, Striped weakfish *Cynoscion guatucupa*, Rays *Dipturus flavirostris*, among others)	23	40 nmi	29,845
Distant coastal trawlers	Industrial distant coastal	Preserved fresh in ice (within plastic cubes *ca.* 0.05 m^3)	15–27 m	Demersal trawl net	Argentine hake *M. hubbsi* (among others)	92	100–180 nmi	113,282
Ice-chilling trawlers	Industrial ice-chilling	Preserved fresh in ice (within plastic cubes ca. 0.05 m^3)	20–72 m	Demersal trawl net	Argentine hake *M. hubbsi*, Chub mackerel *Scomber japonicus*, and Skates *D. flavirostris* and *Bathyraja spp.*	138	AEEZ[c]	253,201
Freezer trawlers	Industrial freezer	Deep frozen	30–113 m	Demersal trawl net	Argentine hake *M. hubbsi*	58	AEEZ[c]	212,351
Double-beam trawlers	Industrial freezer	Deep frozen	26–54 m	Double beam trawl net	Patagonian shrimp *P. muelleri*	77	AEEZ[c]	60,038
Bottom-demersal longliners	Industrial freezer	Deep frozen	45–56 m	Bottom-demersal longline	Patagonian toothfish *Dissostichus eleginoides*	6	AEEZ[c]	2029

[a] Fishing gear and target species were defined for each fleet stratum on the basis of species or groups of species whose landings were ≥70% of the total national catch in 2011.
[b] Total landings for 2011. http://www.minagri.gob.ar/site/pesca/pesca_maritima/02-desembarques/lectura.php?imp=1&tabla=especie_flota_2011.
[c] Covering *Argentina's exclusive economic zone.*

(Favero et al., 2013; Hyrenbach et al., 2006). We used the overlap index developed by Fieberg and Kochanny (2005) and applied in previous studies analyzing the overlapping between seabirds and fisheries (Delord et al., 2010; Granadeiro et al., 2011). This index (utilization distribution overlap index, UDOI) is equal to 0 if the two home ranges do not overlap at all, and is 1 if both UDs are uniformly distributed and show 100% overlap. Differences between UDOI were analyzed with Kruskal–Wallis test and post-hoc Tukey's test. The intersections (i.e. overlapped areas) between albatrosses and fisheries UDs (50, 75 and 95%) were defined and used as a proxy of risk of incidental mortality. In order to make the results practical for decision makers and the local fisheries administration, the overlapping between albatrosses and all fisheries (75% focal areas) was arranged in a 1° × 1° grid following the current setting of Argentine fishery management units. For such analyses, all BBA–fishery intersections were merged and the risk within each grid was defined by weighting the extent of coverage of kernel areas as follows: medium (<25% grid surface), high (25–75%) or very high (>75%) risk.

Values were reported as means ± s.d. spatial analysis, estimations of overlap indices and kernel estimations (package *adehabitat*) (Calenge et al., 2009) and statistical analysis were performed using R 2.15 and ArcGIS 10.0.

3. Results

3.1. Spatial distribution of the BBA and fisheries

A total of 4863 BBA fixes were obtained, and birds were tracked for a maximum of 107 days (mean = 39.9 ± 46.2 days). Black-browed albatrosses were widely distributed over the continental shelves of Argentina, Uruguay and southern Brazil, exceptionally exploring waters beyond the shelf break. Birds ranged from 29° to 51°S and from the high seas to neritic waters (Fig. 1A). Over 2,195,000 vessel fixes were obtained, from which c. 9% corresponded to operating vessels (i.e. vessels actually fishing, transit excluded). Four fisheries (close and distant coastal, ice-chilling and freezer trawlers) accounted for the bulk of the national fleet in terms of number of vessels, and significantly contributed to the annual catch (Table 1). Fishing operations during the study period (all fisheries combined) were roughly distributed from 34° to 57°S and from coastal waters to the shelf break, with demersal longliners and freezer trawlers reaching waters beyond the shelf break. The six fisheries analyzed showed distinctive distributions, with different geographic mean centers. Longliners and distant coastal trawl fisheries showed more dispersed distributions in comparison to other fisheries (Fig. 1B).

Although the fishing fleets were broadly distributed all over the Patagonian Shelf, the analysis of core areas (50% UD) showed a distinctive concentration of fishing effort in different marine domains (Fig. 2). Close coastal multi-target fleets were concentrated in northern Patagonian Shelf, off SE Buenos Aires province and the Argentinean–Uruguayan Common Fishing Zone (AUCFZ), while distant coastal trawlers targeting the Argentine hake (*Merluccius hubbsi*) were mainly distributed along coastal waters of San Jorge Gulf and AUCFZ (between 35 and 38°S). Fishing activity of ice-chilling trawlers was concentrated in two main areas of the Patagonian Shelf between 39 and 46°S, in the vicinity of the shelf break and a small area south to El Rincón estuary. Freezer trawlers' main fishing grounds were located south of 44°S, near the shelf break between 44° and 50°S. Both ice-chilling and freezer trawlers showed core areas adjacent to the trawl fishing closure area, while double-beam trawlers targeting Patagonian shrimp (*Pleoticus muelleri*) were concentrated in the medium shelf from 46°S to the north reaching 43°S. Longliners fishing grounds were concentrated in the southern Patagonian Shelf over the shelf break and in the vicinity of Namuncurá (Burdwood) Bank (Fig. 2). The average size (±SD) of core areas (50% UD) for all fleets was 75,412 ± 27,587 km^2, with ice-chilling and freezer trawlers showing the largest fishing grounds (50% UD areas: 110,943 and 100,182 km^2, respectively).

3.2. Spatial overlap between albatrosses and fisheries

The spatial overlap of BBAs wintering distribution with fisheries was wide, although varying according to each fleet. The core areas (50% UD) of close and distant coastal trawl fleets and ice-chilling trawlers were largely overlapped with albatrosses. Intersections were located in the AUCFZ, in coastal waters of SE Buenos Aires province, El Rincón and over the shelf break. The overlap of focal areas between albatrosses and ice-chilling trawlers showed, in addition to core areas, waters to the East of the Argentine hake fishing closure between 45° and 47°S. Albatrosses also shared two pelagic focal areas with freezer trawlers between the shelf break and the fishing closure at 45°–47°S

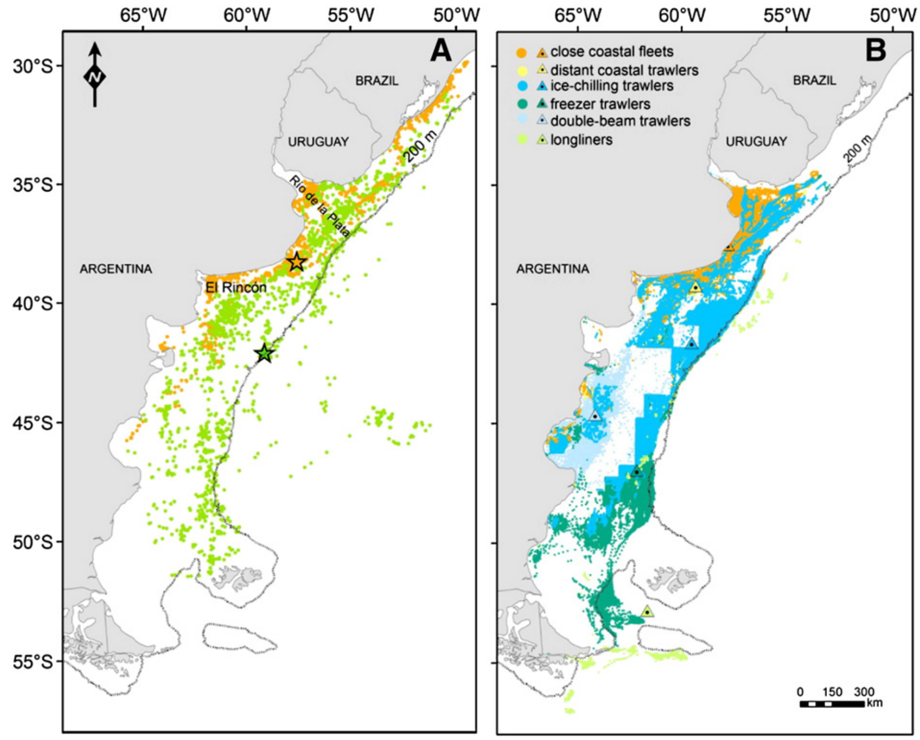

Fig. 1. A) Spatial distribution of tracked Black-browed albatrosses during the non breeding period 2011 (green points)–2012 (orange points) (adapted from Copello et al. 2013); B) spatial distribution (points) and geographic mean center (triangles) of Argentine fishing fleets defined by the national Vessel Monitoring System (VMS) from June to September 2011. Stars show locations of capture and release of BBA in 2011 (green star) and 2012 (orange star).

and 48°–49°S. Smaller overlapping areas were identified with double-beam trawlers in the mid shelf between 44° and 45°S, and with longliners near the shelf break between 39° and 40°S (Fig. 3).

The overlap index between albatrosses and fisheries showed the highest values with both coastal fleets (UDOI 50% $= 0.012 \pm 0.021$ and 0.013 ± 0.026 for close coastal and distant coastal fleets, respectively), followed by ice-chilling trawlers (UDOI 50% $= 0.010 \pm 0.025$), and freezer and double-beam trawlers (UDOI 50% $= 0.001 \pm 0.003$ and 0.001 ± 0.002, respectively). There was no overlap with longliners in both core and focal areas (UDOI 50 and 75% = 0). The above mentioned differences were only statistically significant between longliners and both coastal trawlers (Tukey test $P < 0.05$).

Merging all intersections from analyzed fleets, a total of thirty-four $1° \times 1°$ fishing management units (17% of the total in the Argentinean EEZ), were classified as of medium, high or very high overlap with BBAs during winter (Fig. 4). One fourth of total management units, located between 35 and 38°S in the AUCFZ at the external mouth of Rio de la Plata, and between 45 and 47°S in neighboring waters East to the hake fishing closure, were classified as of very high risk. High overlapping units were also identified East to AUCFZ along the shelfbreak, in the vicinity of the Argentine hake fishing closure, as well as in waters off El Rincón estuary (Fig. 4).

4. Discussion

Black-browed albatrosses showed a widespread distribution from breeding sites in Malvinas towards waters off southern Brazil, although chiefly concentrated in central Patagonia, in particular the external mouth of La Plata River and El Rincón estuary (see Copello et al. 2013). Two shortcomings in the tracking procedure are worth noting, (1) the limited sample size, and (2) capturing of birds for the deployment of PTTs occurred in two locations in central-north Patagonia (38° and 42°S), facts that may have caused an underestimation (or no identification) of risk areas in southern waters, in particular to the South of breeding sites. Despite these limitations, this is the first study published to date showing high spatial resolution data of BBAs during the non-breeding season in association with a range of Argentine fisheries operating in the Patagonian Shelf.

Most of the studies analyzing the spatio-temporal relationships between seabirds and fisheries focused on just one type of fishery (but see Louzao et al., 2011). However, our analysis took into account a substantial proportion of the fishing effort in Argentina, using the Black-browed albatross as a keystone species, given its importance in seabird assemblages attending fishing vessels and the bycatch reported in some fisheries in the region (Favero et al., 2011, 2013; Seco Pon et al., 2012, 2013). In terms of conservation and management, this multi-gear/fishery approach can be advantageous, providing decision makers with a comprehensive picture to be used to prioritize actions in particular fisheries under limited resource and capacity scenarios.

Argentine fisheries showed a wide distribution during winter, operating in different areas of the Argentine Economic Exclusive Zone, with a marked spatial segregation. BBAs showed a higher spatio-temporal overlapping with trawl fleets in comparison with longliners. There is ample literature reporting the use of baits, discards and offal by this species (Bugoni et al., 2010; Cherel et al., 2000) and recent findings based on the analysis of C/N stable isotopes indicate that BBA distributed in Argentinean waters showed blood signatures closer to demersal fish (such as the Argentine hake *Merluccius hubbsi*) dominant in the bycatch of trawlers, compared to byproducts originated by longliners, both pelagic and demersal (Mariano-Jelicich et al., 2013). Similarly, in the Benguela Upwelling System, foraging areas of BBAs were strongly correlated with the presence of trawlers and the relationship with longliners was null or negligible during the non-breeding period (Petersen et al., 2008). Studies conducted during the breeding period in Malvinas (Falklands) indicate that BBAs show lower interaction and spatial overlap with trawlers (Catry et al., 2013; Granadeiro et al., 2011, 2013),

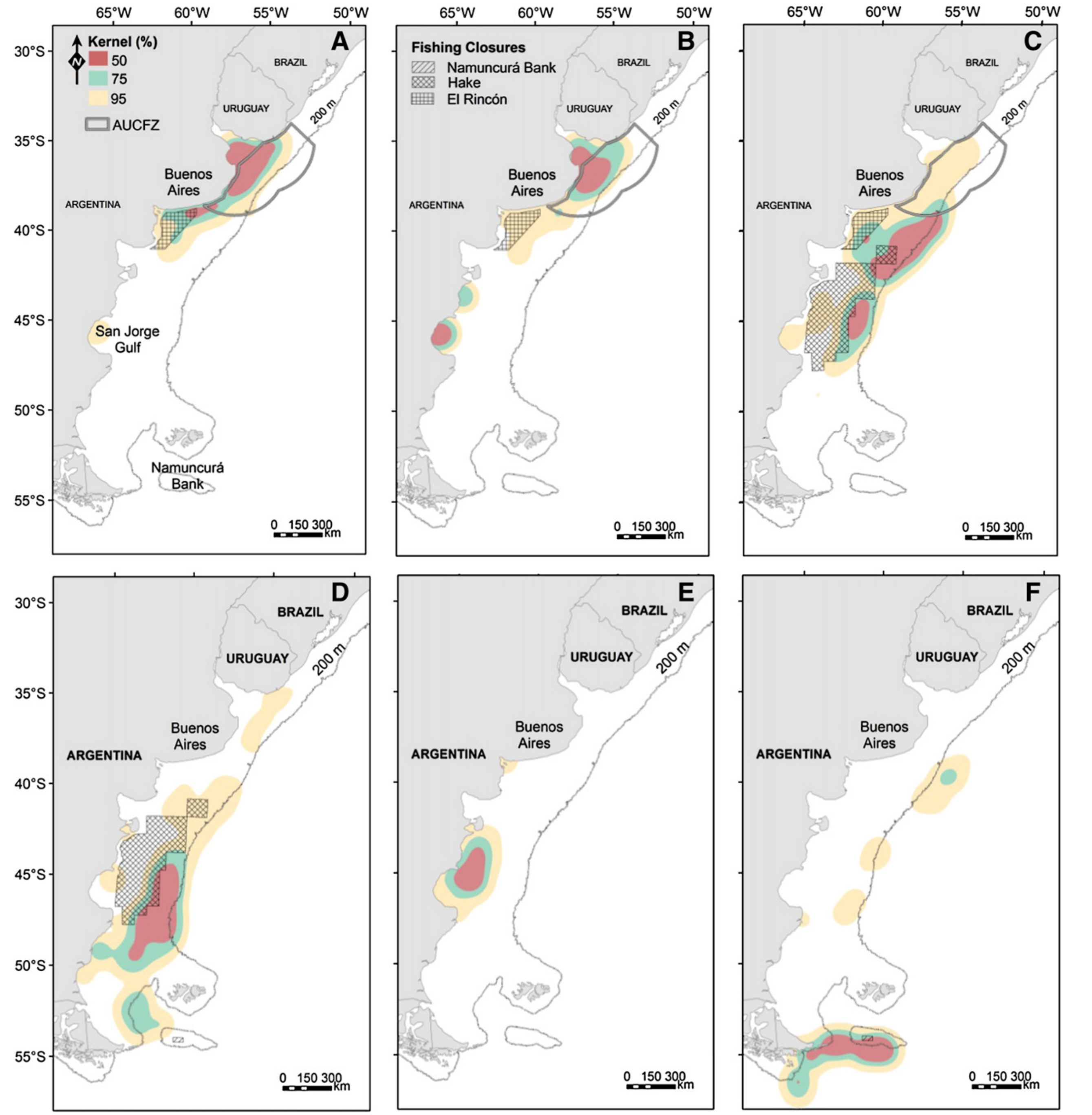

Fig. 2. Distribution of the fishing effort (UDs) and location of fishing closures for A) close coastal trawl fleet, B) distant coastal trawlers, C) ice-chilling trawlers, D) freezer trawlers, E) double beam trawlers, and F) demersal longliners.

although these studies considered a small fraction of the fishing effort in the vicinity of breeding sites. The overlap index between BBA and fisheries core and focal areas was greater for both coastal trawl fleets and ice-chilling trawlers compared with freezer, double beam trawlers and longliners. This greater overlap with trawlers in comparison with longliners could be the result of the attraction generated by the larger volumes of discards and offal generated by trawl fisheries. Lower overlap with freezer trawlers in winter could be the result of a stronger use of the northern Patagonian shelf by BBA during winter, although it wouldn't be unexpected to find stronger overlap with freezers in spring–summer when the distribution of breeding albatrosses is more concentrated around breeding sites (Catry et al., 2013; Granadeiro et al., 2011).

The incidental mortality of BBAs in Argentina has been confirmed in demersal longliners (Favero et al., 2013), ice-chilling trawlers (Favero et al., 2011), distant coastal trawlers (González-Zevallos et al., 2007) and freezer trawlers (Consejo Federal Pesquero, 2012). There was no BBA bycatch reported neither in close coastal trawl fleets, including purse seiners (Seco Pon et al., 2012) and trawlers (Marinao and Yorio, 2011; Seco Pon et al., 2013) or double-beam trawlers (González-Zevallos et al., 2011), although attendance has been reported. Consequently, ice-chilling and distant coastal trawlers should be considered as the fleets with greater risk for BBA in winter, and a priority for the fishery administration. Recognizing the existence of hidden bycatch in trawlers and the consequent complexity of identifying and quantifying incidental mortality in these fisheries (Watkins et al., 2008), special

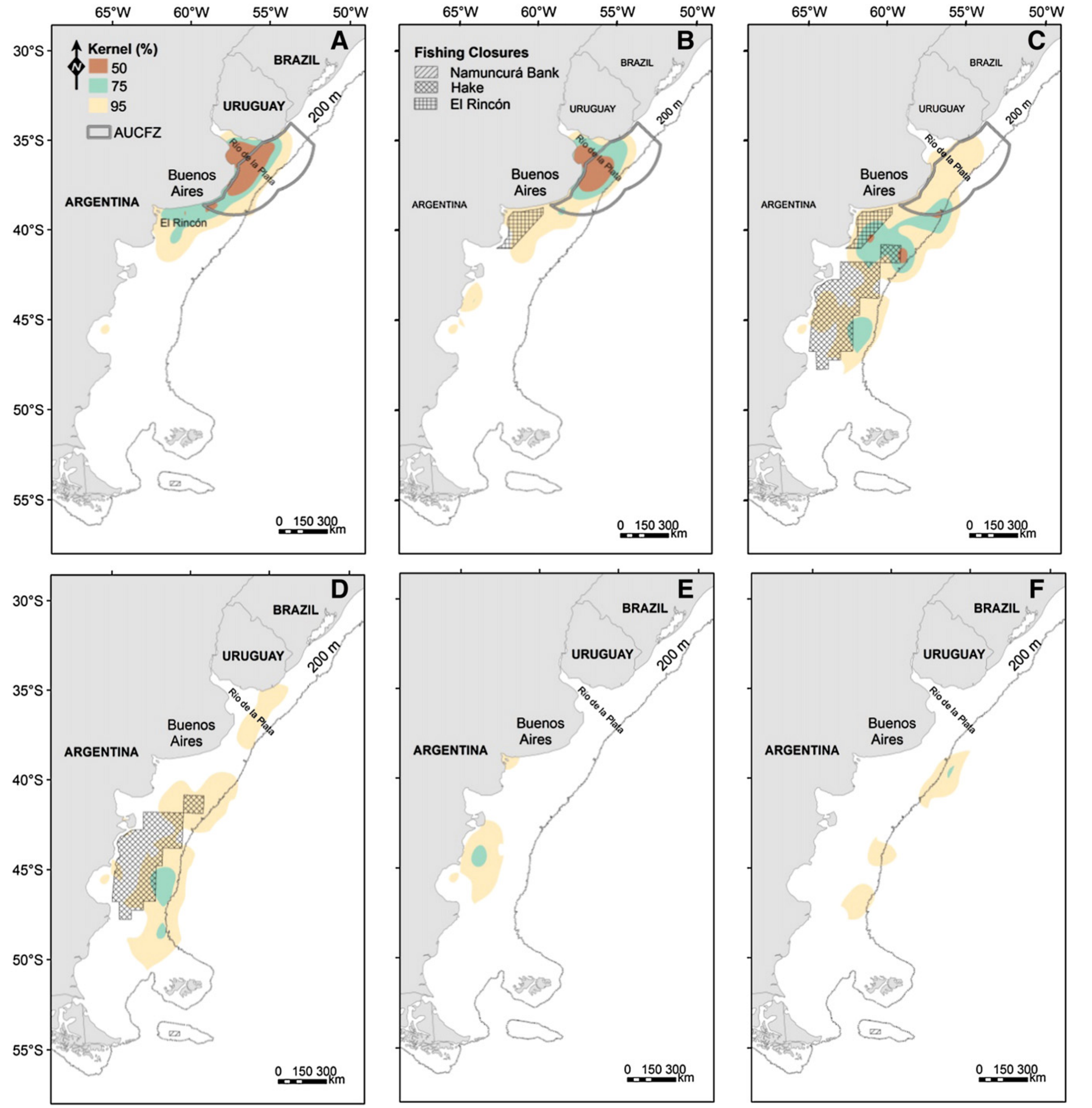

Fig. 3. Modeling of overlapping between Black-browed albatrosses and fisheries for core, focal and range areas (i.e. intersections of 50, 75 and 95% UDs). A) close coastal trawl fleets, B) distant coastal trawlers, C) ice-chilling trawlers, D) freezer trawlers, E) double beam trawlers, and F) demersal longliners.

attention should be paid to those fleets where attendance but no bycatch has been recorded. In this regard, the information provided by onboard observer programs (both observing vessels operating in national and provincial jurisdictions) is crucial. Ongoing trainings to increase capacities within observer programs should improve the quality of data obtained and allow a better understanding of the impact of the trawl fisheries on seabirds. In recent years, two fisheries (freezer trawlers targeting the Patagonian grenadier *Macruronus magellanicus* and coastal trawlers targeting the Argentine anchovy *Engraulis anchoita*) have been certified under the MSC scheme (http://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/south-atlantic-indian-ocean) and a third one (targeting the Patagonian toothfish *Dysostichus eleginoides*) is currently under evaluation. These initiatives had, to a certain extent, improved the context in which data on the ecosystem effect of fisheries is gathered.

Increases of BBA breeding population in Malvinas (Catry et al., 2011; Wolfaardt, 2012) have been at least partially attributed to reduced bycatch. In Argentina, incidental mortality of seabirds in the demersal longline fishery decreased due to the significant reduction of fishing effort (both lower number of vessels and replacement of longlines by pots) and the (partial) implementation of conservation measures (see Favero et al., 2013). However, neither regulations have been developed nor mitigation implemented in trawlers with the exception of trials conducted in the distant coastal and freezer trawl fleets (Consejo

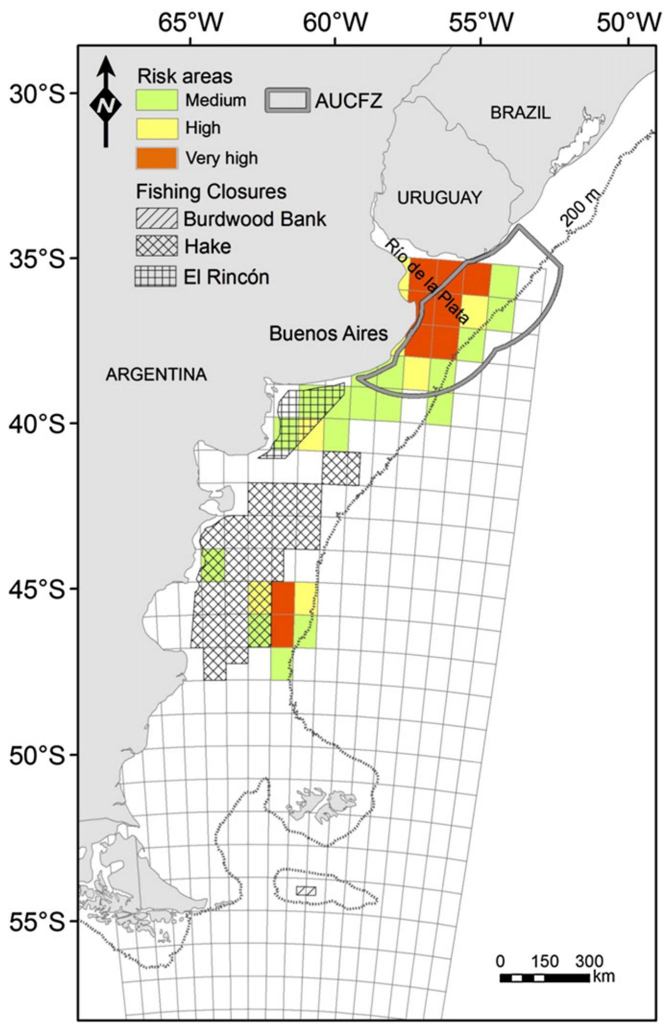

Fig. 4. Risk analysis for Black-browed albatrosses in Argentina arranged by fishery management unit and superimposed with fishing closures and the Argentinean–Uruguayan Common Fishing Zone.

Federal Pesquero, 2012). The national government of Argentina adheres to the ecosystem approach in fisheries and has instruments, such as the National Plan of Action-Seabirds, aimed to minimize the detrimental effects of fishing operations to seabirds. By identifying fishing management units and fisheries of higher risk for albatrosses in the AUCFZ, El Rincón and SE of the Argentine hake fishing closure, this study may help decision makers in prioritizing actions and designing conservation strategies to reduce seabird bycatch, with particular emphasis in trawlers. Some of these high risk areas for albatrosses are relevant for other top predators such as Southern sea lions *Otaria flavescens* (Riet-Sapriza et al., 2013; Rodríguez et al., 2012), sea turtles (González Carman et al., 2012; Wallace et al., 2010, 2011), sharks (Lucifora et al., 2011) and other seabird species (González-Solís et al., 2007; Nicholls et al., 2002, http://seamap.env.duke.edu/dataset/550; Phillips et al., 2006). Further multi-taxa studies should be encouraged in this area for a better understanding of the use of the marine space by top predators and the efficient development of management strategies. Moreover, considering that tracked albatrosses spent significant time at sea in Uruguayan and Brazilian EEZs, and shared fishery administrations (i.e. AUCFZ), information on fishing effort and levels of interaction in unexplored fleets from neighboring waters should be considered in future studies in order to have a comprehensive understanding of threats that Black-browed albatrosses (among other albatrosses and petrels) are facing in the SW Atlantic Ocean.

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