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Spatio-temporal overlap between the at-sea distribution of Southern Giant Petrels and fisheries at the Patagonian Shelf

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Abstract The interactions between seabirds and fisheries pose significant threats for the seabird species such as incidental capture. In contrast, several species of seabirds meet part of their energetic requirements through the use of fisheries discards. Knowledge about the relationship between at-sea distribution of Procellariiformes and fisheries is a key tool in marine ecosystem management. We analysed the spatio-temporal relationship between the areas used by 16 satellite-tracked breeding adults of the Southern Giant Petrel and fisheries distribution and catch at the Patagonian Shelf. We also determined the time spent by adults in different marine jurisdictions. Results indicated a marked spatio-temporal association between birds and fisheries, mainly trawlers. The Southern Giant Petrels concentrated their foraging effort over Argentinean waters. The use of an abundant and predictable food source provided by the fisheries discards may be one of the factors affecting the dynamics of the Southern Giant Petrel populations in Patagonia, Argentina.

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Introduction

The interaction between seabirds and fisheries results in significant threats for the seabird species such as: (1) incidental capture (Tasker et al. 2000; Furness 2003), (2) decrease in prey abundance (Furness and Ainley 1984; Becker and Beissinger 2006), and (3) contamination (Renzoni et al. 1986; Montevecchi 1991; Burger and Gochfeld 2000). Thirty percent of the world's seabird species are threatened and Procellariiformes represent 60% of this percentage (IUCN 2004). The expansion of fishing activities has been identified as one of the main reasons for such a high proportion of seabird species considered threatened compared to other bird groups (Butchart et al. 2004). Incidental capture seems to be the main cause of the decline of several albatross and petrel populations (Weimerskirch et al. 1997; Croxall et al. 1998; Lewison and Crowder 2003). At the same time, several seabird populations meet a large proportion of their energetic requirements through the use of waste provided by fishing operations (see revision in Tasker et al. 2000). Studies conducted in waters near the Falkland (Malvinas) Islands showed that, during the breeding period, Black-browed albatrosses obtained between 10 and 15% of their food requirements from *Loligo* spp. captured by trawlers (Thompson 1992). On the coast of Argentina, the Kelp Gull (*Larus dominicanus*) showed a population increase and expansion mainly as a result of its use of waste generated by fishing activities (Yorio et al. 2005). In addition, discard use may lead to changes in the at-sea distribution of seabirds and changes in foraging behaviour and feeding patterns (Abrams 1985; Ryan and Moloney 1988; Freeman 1997).

On the Patagonian Shelf, fishing activities have increased by 60% in the last decade (Bezzi et al. 2000; FAO 2005; SAGPyA 2005). The industrial fishing fleet consists of hundreds of ships comprising jiggers, trawlers and longliners. Estimates of incidental capture of albatrosses and petrels by longline fishing vessels on the Patagonian Shelf showed that at least between 2,000 and 4,000 seabirds are killed each year by this fishery (Schiavini et al. 1998; Favero et al. 2003; Gandini and Frere 2006). However, recent studies have shown that by-catch of seabirds by trawlers is of great magnitude and may end up having a greater impact than that generated by longliners (González Zevallos and Yorio 2006; Sullivan et al. 2006; González Zevallos et al. 2007). This acquires more importance when considering that the size of the trawl fishery on the Patagonian Shelf is considerably greater than the rest of the other fleets (~380 trawlers vs. 10 longliners) (Bezzi et al. 2000).

The Southern Giant Petrel is one of the species which has frequently been reported associated with fishing vessels (Yorio and Caille 1999; González Zevallos and Yorio 2006; Otley et al. 2006; Sullivan et al. 2006) and for which incidental captures by longliners have been recorded (Favero et al. 2003). The role of the Southern Giant Petrel as one of the main "ship followers" and scavengers on the Patagonian Shelf has been emphasised in recent studies on the diet of breeding birds from the Patagonian colonies (Copello and Quintana 2003; Copello et al. 2008) and tracking studies of birds from South Georgia (Georgias del Sur) colonies (González-Solís and Croxall 2005).

Understanding the relationship between the spatio-temporal at-sea distribution of the Southern Giant Petrel and fisheries is of paramount importance in determining higher risk areas, analysing incidental capture rates and the potential factors involved, and in contributing to the implementation of monitoring and mitigation measures for the species in the marine ecosystem of the Patagonian Shelf. In this sense, ecological aspects such as sexual segregation should also be considered given their direct implications in the interaction with fisheries (Catry et al. 2005). The Southern Giant Petrel showed differences between sexes in several aspects of its foraging ecology such as diet (Hunter and Brooke 1992; Forero et al. 2005) and at-sea distribution (Quintana and Dell' Arciprete 2002; González-Solís et al. 2008). In addition, it is important to determine how these animals travel and forage across different marine jurisdictions, so that countries know to what extent the conservation of the species depends on the use and management of their marine environment (Nicholls et al. 2000; Hyrenbach and Dotson 2003; Birdlife-International 2004).

In this study, we proposed: (1) to analyse the spatio-temporal relationship between the marine areas used by the Southern Giant Petrel during the breeding period and the distribution and total catch of the different fisheries that operate on the Patagonian Shelf, (2) to quantify the overlap between the Southern Giant Petrel's distribution and fisheries and to evaluate the differences amongst colonies and sexes, and (3) to determine the amount of time birds spent in different jurisdiction areas of the southwestern Atlantic.

Methods

At-sea distribution of Southern Giant Petrels

The at-sea movements of breeding Southern Giant Petrels were studied by means of satellite telemetry techniques. A total of 16 adult breeding Southern Giant Petrels from Isla Arce and Isla Gran Robredo (North colonies, 3 females and 6 males), and Isla Observatorio, Isla de los Estados (South colony, 1 male and 6 females) (see Table 1; Fig. 1) was equipped with satellite transmitters (PTTs-100, "Platform Terminal Transmitters", Microwave Telemetry, Columbia, MD, USA) during four breeding seasons (1999–2004). Birds were tracked during the start of the chick-rearing period or during the end of the incubation period (only two birds). Satellite transmitters weighed between 45 and 90 g representing less than 3.6% of the animal's body weight. Birds fitted with transmitters were sexed by morphometric measurements and/or by molecular techniques (Copello et al. 2006). PTTs were attached to the mid-dorsal mantle feathers using Tesa® Tape (Wilson et al. 1997) and were programmed to transmit data every 60 s. Data on the geographic position of the instrumented animals were obtained from the ARGOS service provider (CLS, Toulouse, France) (ARGOS 2006). Each position obtained was automatically classified according to its estimated error/quality as: Type 0, >1,000 m; Type 1, 350–1,000 m; Type 2, 150–350 m; Type 3, 0–150 m; Type A or B, without an estimated error (ARGOS 2006). All positions obtained by the ARGOS system were filtered following the iterative procedure used by the "Global Procellariiform Tracking Database" (Birdlife-International 2004; McConnell et al. 1992). This procedure takes into consideration the position quality (determined by ARGOS) and the horizontal flying speed between each location fix. Positions with a quality of 0, A or B and a flying speed higher than 100 km h^{-1} were eliminated. Validated positions were mapped using ArcView GIS 3.2. Filtered positions were then re-sampled every hour following the procedure of Birdlife-International (2004). The re-sampling method ensured that each trip was weighted by its duration when calculating kernel maps (see below).

Table 1 Summary of satellite telemetry data obtained from instrumented Southern Giant Petrels from Patagonian colonies during the breeding period

Individual	Sex	Colony	Time of breeding	Start tracking	End tracking	Total days recorded	Total hours of tracking
North colonies							
5609	M	Gran Robredo	Chick rearing	09/01/1999	31/01/1999	22	528
5819	F	Gran Robredo	Chick rearing	09/01/1999	22/02/1999	43	1054
25135	F	Gran Robredo	Late incubation/chick rearing	26/11/1999	23/01/2000	57	1393
25138	M	Gran Robredo	Late incubation/chick rearing	27/11/1999	20/01/2000	53	1299
10100	M	Arce	Chick rearing	03/01/2002	22/02/2002	49	1197
10101	F	Arce	Chick rearing	04/01/2002	24/02/2002	50	1247
10102	M	Arce	Chick rearing	03/01/2002	28/02/2002	55	1258
10103	M	Arce	Chick rearing	04/01/2002	06/01/2002	2	58
10104	M	Arce	Chick rearing	06/01/2002	16/01/2002	10	250
South colony							
44281	M	Observatorio	Chick rearing	06/01/2004	10/03/2004	64	1386
44282	F	Observatorio	Chick rearing	06/01/2004	11/01/2004	5	124
39792	F	Observatorio	Chick rearing	06/01/2004	12/01/2004	6	137
39791	F	Observatorio	Chick rearing	06/01/2004	09/01/2004	3	69
39793	F	Observatorio	Chick rearing	09/01/2004	08/03/2004	59	1399
39794	F	Observatorio	Chick rearing	12/01/2004	02/03/2004	50	1197
44283	F	Observatorio	Chick rearing	12/01/2004	04/02/2004	22	546

A Kernel analysis ("fixed kernel method", Worton 1989) was employed to analyse habitat use and the amount of time spent in different marine areas. Kernel density estimators have been successfully used in several tracking studies to quantify habitat use and identify home ranges (e.g. Wood et al. 2000; Birdlife-International 2004; Nicholls et al. 2005). We used the "Animal Movement Program" package of ArcView 2.0 (Hooge et al. 1999) with a smoothing parameter *h* of 40 km to determine the areas where animals spent 95, 75 and 50% of their foraging time (see above). Even though validated positions from the same trip are not independent, kernel density procedures do not require independence of data (De Solla et al. 1999).

Fishing data

The at-sea distribution and total catch of the main fishing fleets operating on the Patagonian Shelf (trawlers, jiggers and longliners) were analysed (FAO 2005). This fleet classification is based on the kind of fishing gear employed: trawlers use different types of trawling nets to capture their prey (e.g. double-beam trawlers, bottom trawl net, etc.), jiggers use powerful lights to facilitate the capture of squid which is carried out by means of jigs, and longliners employ hooks attached to a mainline (Cousseau and Perrotta 2003). Distribution and total catch data for the entire fleet operating on the Patagonian Shelf were obtained from National Fishing reports provided by the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP, National Institute of Fisheries Research and Development). Fishing effort is the variable traditionally used to analyse the interactions between fisheries and seabirds; however, these data were not available, instead we used total capture as a proxy of fishing effort. The spatial resolution of the data was $1° \times 1°$ and the monthly catch values for the summer months (January, February and March) of 1999, 2000, 2002 and 2004 were also obtained to coincide with the years for which the at-sea distribution data from seabirds fitted with satellite transmitters were available. Given that there is a great variability in the total capture between fisheries, the catch data were assigned into one of three categories, depending on each fleet. For trawlers, it was classified as follows: low (<60 ton), medium (between 60 and 200 ton) and high (>200 ton); for jiggers: low (<900 ton), medium (between 900 and 2,500 ton) and high (>2,500 ton), and for longliners: low (<4 ton), medium (between 4 and 9 ton) and high (>9 ton).

Eighty percent of the total catch on the Patagonian Shelf came from ice-trawlers, freezer-trawlers and jiggers (www.sagpya.mecon.gov.ar). A total of 135 ice-trawlers operate in the Patagonian shelf area (Blanco, pers. com.) using bottom nets to catch fish. The target species of these vessels are hake (*Merluccius hubbsi*), with a total annual catch of 323,000 ton in 2006 (Favero and Gandini 2007). The catch is not processed on board, and the by-catch is discarded unprocessed. The duration of each fishing trip is

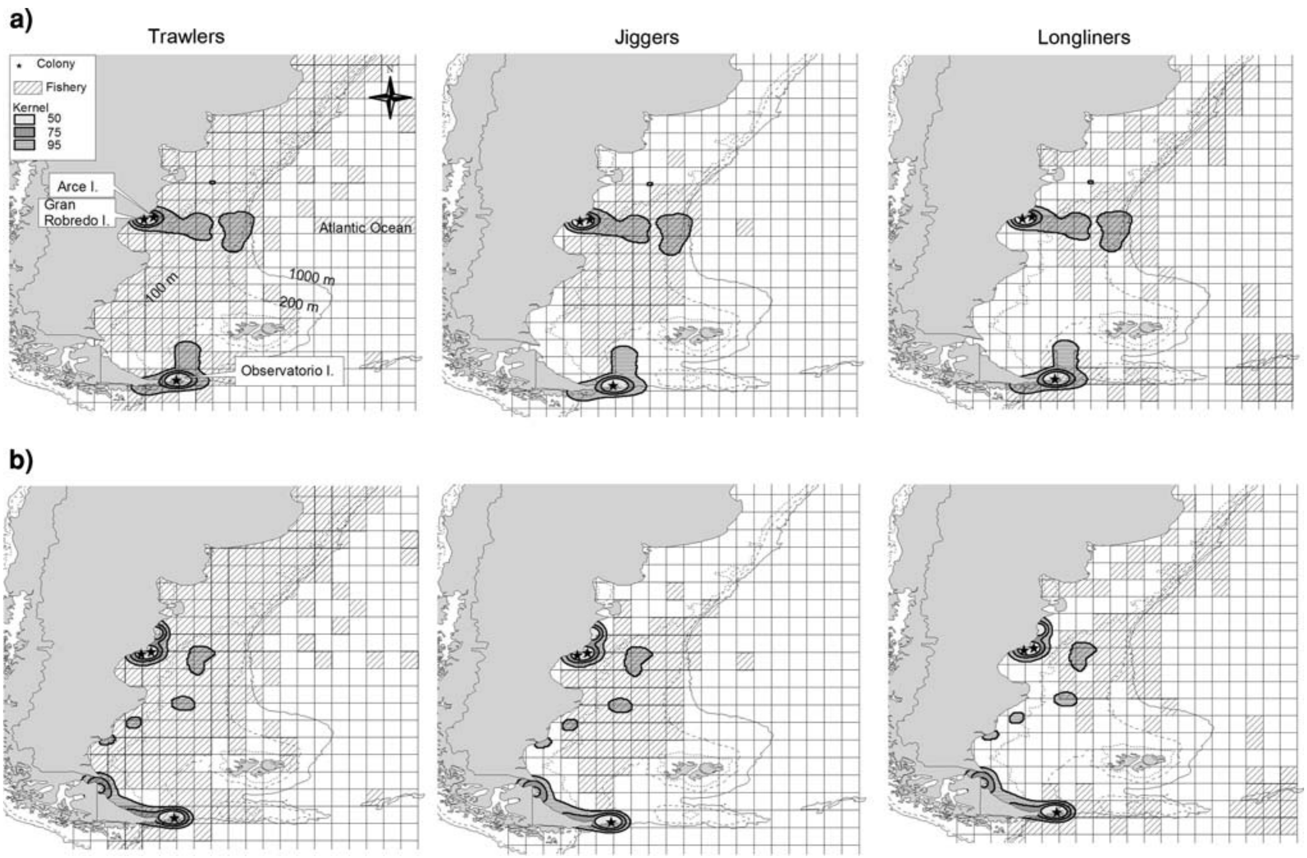

Fig. 1 Summer distribution of fisheries from the Argentinean Sea and main ranging areas (kernel contours) of Southern Giant Petrel (*Macronectes giganteus*) females (**a**) and males (**b**) during four breeding seasons (see text). Kernel contours shown as 50, 75 and 95% of at-sea locations

between 4 and 15 days. The freezer-trawlers comprise about the same number of vessels as ice-trawlers (~134). The target species are kingclip (*Genypterus blacodes*), Patagonian grenadier (*Macruronus magellanicus*) and Southern blue whiting (*Micromesistius australis*), with an annual catch of 290,000 ton in 2006 (Bezzi et al. 2000; Favero and Gandini 2007). These species are captured using bottom, pelagic or semi-pelagic nets (Cousseau and Perrotta 2003). The vessels process the catch on-board and discard the offal and by-catch. The fishing trips lasted more than 30 days.

The jigger fleet has a total of 150 vessels which catch mainly squid (*Illex argentinus*). This fleet follows the seasonal movements of the target species, fishing in the south in summer and moving north during winter (Bezzi et al. 2000). The total annual catch during 2006 was 261,000 ton (Favero and Gandini 2007). Traditionally, most vessels freeze the whole squid; however, decreasing prices have prompted vessels to process squid into tubes/mantle and discard the tentacles, head and offal.

Another fleet that uses selective fishing gear and that could present a serious threat for seabirds is the demersal longline fishery that used mainly the Spanish method. This fishery started in the 1990s with a fleet of 12 vessels; currently there are only three vessels operating with a fishing effort of less than 30 million hooks annually. This fishery targeted Patagonian toothfish (*Dissostichus eleginoides*) and kingclip (*G. blacodes*), although one vessel targeted Yellownose skate (*Dipturus chilensis*) on the northern Patagonian Shelf. The annual total catch was 3,000 ton (Favero and Gandini 2007).

Spatial analysis

Both the spatial and temporal association between the areas used by Southern Giant Petrels during the breeding period (kernel analysis), and the average distribution and catch of the fishing fleet during the summer months were determined for the years during which birds had been fitted with satellite transmitters. The data were integrated into the ArcView GIS 3.2 program and overlap maps were produced. The at-sea areas were classified as coastal (<100 m), middle shelf (between 100 and 200 m) and shelf break (>200 m). In addition, in order to quantify the relationship between petrels and fisheries, the at-sea distribution of petrels was analysed using the same spatial scale as the one used for the fishing data. In this way, both the proportion of $1° \times 1°$

areas used by birds in which fishing operations were observed (proportional overlap) and the percentage of time that the birds remained within areas in which the three types of fisheries operated were analysed (Hyrenbach and Dotson 2003).

Fishing information corresponding to the summer months of 1999, 2000, 2002 and 2004 was used to carry out these analyses. The years 1999, 2000 and 2002 coincided with the at-sea tracking of birds from Isla Arce and Gran Robredo, and the year 2004 corresponded with the tracking of instrumented individuals from Isla Observatorio. In addition, we calculated the amount of time that petrels spent in areas under different marine jurisdictions and the differences between sexes and colonies. In order to do this, we computed the amount of time that petrels spent within the Exclusive Economic Zones (EEZs) of Chile and Argentina (12–200 miles), the Argentinean Sea (0–12 miles) and in international waters (beyond 200 miles).

Results

Overlap between Southern Giant Petrels and catch distribution

The at-sea distribution of Southern Giant Petrels during the chick-rearing period overlapped with some of the areas used by the different fisheries operating on the Patagonian Shelf during the summer (Fig. 1a, b). Females from the North colonies were found to be spatio-temporally associated with all three types of fisheries (Fig. 1a). Whereas a high spatio-temporal overlap between the fishing grounds of the three types of fisheries and the females' foraging areas was observed at the middle shelf and shelf break, in coastal areas overlap was evident with trawlers and jiggers only (Fig. 1a). Females from Isla Arce and Gran Robredo (North colonies) were mainly associated with trawlers half of the time they spent at sea (kernel area 50%) and, to a lesser extent, with jiggers (Fig. 2a). The spatial overlap between the 95% use areas and areas with a "high" level of catch (see "Methods") was evident for all three types of fisheries (Fig. 2a). However, female petrels spent 75% of their time at sea within areas with "medium" trawler catch levels and "low" jigger catch levels, and did not overlap with the longline fishing grounds (Fig. 2a). The ranging areas of the males from Isla Arce and Gran Robredo overlapped with all three types of fisheries in the middle shelf area but only with trawlers and jiggers in coastal regions as for female petrels (Fig. 1b). Thus, within the 50 and 75% utilisation areas, the main fishery type observed was trawler operations, with jigger fisheries observed to a lesser extent, and no longline fishing operations present in those areas (Fig. 1b). The 95% utilisation areas were found to be associated with areas of "high" catch by the three types of fisheries in the middle shelf zone, and those of 75% utilisation were found to be associated with areas of principally "low" catch by trawlers and jiggers (Fig. 2b).

Female petrels from the South colony were spatially associated mainly with trawlers and longliners, and partially with jiggers (Fig. 1a). The areas of importance of 50 and 75% overlapped only with trawl and longline fisheries (Fig. 1a). The catch within these areas was rated as "medium" for trawlers and "high" for longliners (Fig. 2a). In addition, the only male petrel tracked from Isla Observatorio (South colony) ranged almost exclusively within the waters targeted by trawlers, and it showed low spatial overlap with longliners (Fig. 1b). The 50 and 75% utilisation areas overlapped mainly with trawlers and to a lesser extent with longliners, especially in waters just off the colony (Fig. 1b). The catch levels of the trawl fishery within the areas frequented by the male petrel from Isla Observatorio were "low". Catch levels by longliners in these areas were "high" and spatial overlap with areas with "medium" catch levels was observed in the proximity of Staten Island (Fig. 2b).

Quantification of the relationship between Southern Giant Petrels and fisheries

As has already been mentioned, during the chick-rearing period, petrels overlapped spatially and temporally with different types of fisheries that operated on the Patagonian Shelf. These results were confirmed by the analysis carried out using the $1° \times 1°$ fishing data (see "Methods"). In most of the $1° \times 1°$ cells occupied by petrels, fishing operations were also recorded. Except for the only male petrel from the South colony, which spent most of its time within coastal areas, for the rest of the individuals the presence of fisheries was null in less than 13% of the cells occupied by petrels (Fig. 3a). The spatio-temporal association occurred mainly with trawlers, since this fishery operated in more than half (range: 50–91%) of the cells occupied by petrels (Fig. 3a). Jiggers and longliners operated in less than 43% of the cells used by petrels (0–43% for jiggers and 6–32% for longliners) (Fig. 3a). For birds from the North colonies, no differences were observed in terms of the percentage of cells used by both sexes and the presence of trawlers, jiggers or longliners (Fig. 3a). For individuals from the South colony, both the females and the only male petrel were associated with trawlers and longliners, but there was no overlap with fishing grounds used by jiggers (Fig. 3a). However, greater activity by longliners and trawlers was observed in the cells used by females compared to cells used by the male (32 vs. 8% and 80 vs. 50% for longliners and trawlers, respectively) (Fig. 3a). The percentage of time petrels spent in cells where no fishing activity was

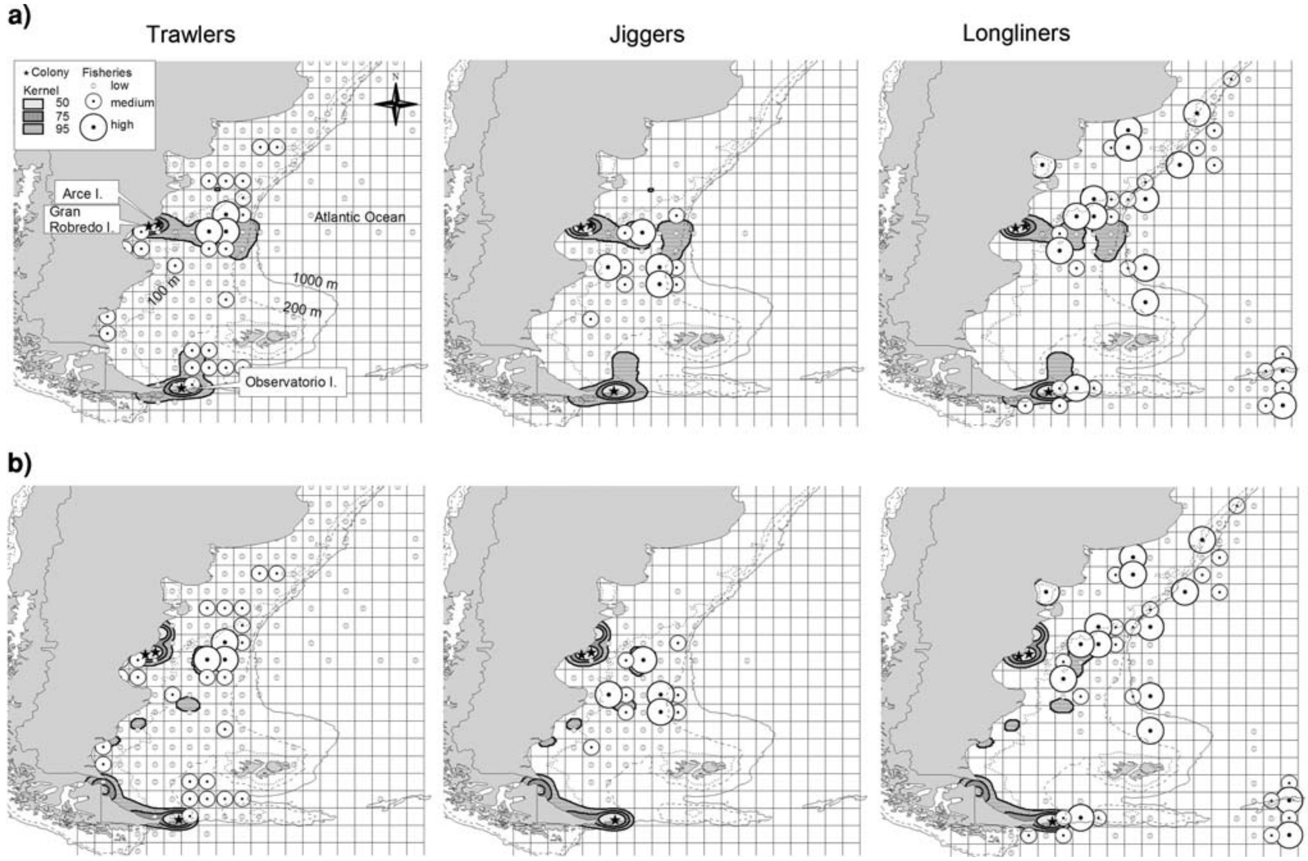

Fig. 2 Summer distribution and total fisheries catch from the Argentinean Sea, and main ranging areas (kernel contours) of Southern Giant Petrel (*Macronectes giganteus*) females (**a**) and males (**b**) during four breeding seasons (see text). Kernel contours shown as 50, 75 and 95% of at-sea locations

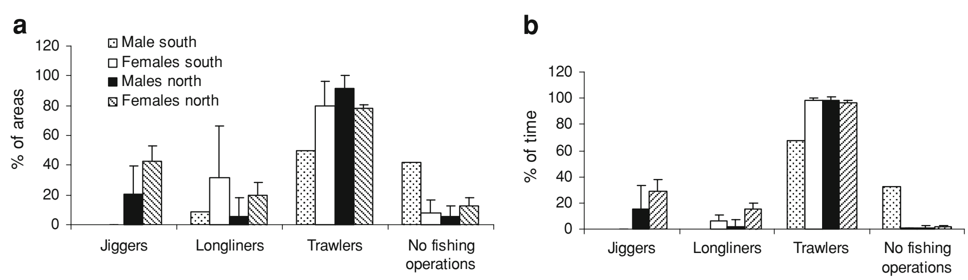

Fig. 3 **a** Percentage of 1° × 1° cells used by Southern Giant Petrels (*Macronectes giganteus*) in which fishing operations were or were not recorded and **b** percentages of time that Southern Giant Petrels spent at sea in cells where some kind of fishing operation was or was not recorded

recorded was extremely low (0.5–1.8%, with the exception of the male from Isla Observatorio) (Fig. 3b). Petrels spent most of their time at sea within 1° × 1° areas where trawlers operated (68–98%) and less than 28% of their time at sea (0–28.4%) within areas where jiggers and longliners operated (Fig. 3b). For petrels from the North colonies, females spent a greater percentage of their time at sea in areas targeted by longline fisheries than males (16 vs. 2%), whereas the percentage of time they spent in areas targeted by trawlers and jiggers was similar (Fig. 3b). The percentage of time that females from Isla Observatorio spent in cells in which longliners and trawlers operated was greater than the amount of time the only male petrel studied spent in these cells (6 vs. 0.1% and 98 vs. 68%, for longliners and trawlers, respectively) (Fig. 3b).

Southern Giant Petrel foraging range and jurisdictions at sea

During the breeding period, Southern Giant Petrels ranged within the EEZs of Argentina and Chile, and over the Argentinean Sea and international waters (Table 2). They spent most of their time at sea ranging over the Argentinean Sea (between 46 and 98%) and within Argentina's EEZ (<39%); they spent less than 15% of their time at sea ranging over international waters and within Chile's EEZ

Table 2 Time (mean ± SD, %) spent by Southern Giant Petrels (*Macronectes giganteus*) from Patagonia, Argentina in different marine jurisdictions (*n*, number of birds tracked)

	North colonies		South colony	
	Males (*n* = 6)	Females (*n* = 3)	Males (*n* = 1)	Females (*n* = 6)
Argentinean Sea	78.9 ± 22.9	46.2 ± 8.7	98.0	79.6 ± 21.2
EEZ Argentina	20.3 ± 21.5	39.2 ± 9.9	2.0	20.1 ± 21.0
EEZ Chile	0	0	0	0.3 ± 0.6
International waters	0.8 ± 2.0	14.6 ± 11.7	0	0

(Table 2). Males from both colonies spent more time within the waters of the Argentinean Sea than females (79 vs. 46% and 98 vs. 80% for the North colonies and the South colony, respectively). In contrast, females spent more time within Argentina's EEZ (39.2 vs. 20.3% and 20.1 vs. 2.0% for the North colonies and the South colony, respectively, Table 2). In addition, females from the North colonies used international waters more than males (15 vs. 1%; Table 2). Whereas females from the South colony spent part of their time at sea within Chilean jurisdiction, the male from Isla Observatorio did not range within this area (Table 2).

Discussion

The results presented in this study show that there is a marked spatio-temporal association between the at-sea distribution of the Southern Giant Petrel during the breeding period and the fishing activity on the Patagonian Shelf. In most of the areas used by these seabirds, fishing operations were also recorded and, in general, there was a spatio-temporal overlap between the individuals and the areas with medium–high catch levels for the three types of fisheries examined (jiggers, longliners and trawlers). Most of the information in the literature about the spatio-temporal interactions between the at-sea distribution of albatrosses and petrels and fisheries has focused on longline fisheries (Nel et al. 2000; Hyrenbach and Dotson 2003; Cuthbert et al. 2005; Phillips et al. 2006). This may be attributed to the fact that incidental mortality in longliners seems to be the main cause of these seabirds' declining population sizes.

In our study, petrels from both colonies were mainly associated with trawlers, since these vessels operated in most of the areas where petrels occurred, and where the amount of time that birds spent in these waters was high. As previously reported (Quintana and Dell' Arciprete 2002), sexual segregation in the use of foraging areas was evident during the study period, at least for birds from the North colonies. Whilst males exploited mainly coastal areas, females foraged pelagically. This pattern entails slight differences between sexes in the overlap with fisheries. Both sexes were associated mainly with trawlers, but females spent a greater percentage of their time at sea in areas targeted by longline fisheries. This could produce higher incidental mortality of females than males and consequently affect the population dynamics of the species. However, at the Patagonian Shelf, the Southern Giant Petrel by-catch in longliners is non-existent (Gandini and Frere 2006) or shows a low mortality rate compared with other procellariiform species. Favero et al. (2003) reported a total of 34 Southern Giant Petrels killed between 1999 and 2001. Likewise, although Southern Giant Petrels frequently attend trawlers operating in the San Jorge Gulf (75–83% of occurrence), with a mean number of two to seven, and a maximum of 40 birds, incidental capture of these species by this kind of vessel has not been recorded (González Zevallos and Yorio 2006; González Zevallos et al. 2007). In trawlers operating in waters outside San Jorge Gulf, there have been reports of Southern Giant Petrel contacts with fishing gear or vessels, but the outcome of the interaction was no apparent injury to the birds (Favero et al., unpubl. data). With regard to incidental capture in longline fisheries, at least for the adult population of the North colonies, the low number of captures reported may be attributed to the low overlap between those areas mostly used by petrels and the longline fishing grounds. In addition, considering that the proximity of fishing activity to colonies is one of the variables involved in the incidental capture rate (Moreno et al. 1996; Cuthbert et al. 2005), the location of the North colonies could also be responsible for the low capture rates.

In contrast to the potential negative impact of incidental capture in trawler nets, Southern Giant Petrels may obtain some benefits from their association with this fishery on the Patagonian Shelf by means of the use of discards. Waste provided by these fleets is greater than that produced by fleets that make use of selective fishing gears (jiggers and longliners). Approximately, 100 trawlers operate in the San Jorge Gulf, near Arce and Gran Robredo colonies, and 5 trawlers can be fishing simultaneously in an area of 3 km^2. This fleet produces approximately 15,000 ton of fishing waste every year (Pettovello 1999; González Zevallos and Yorio 2006). Southern Giant Petrels frequently attend these vessels and the abundance increases from approximately one to three individuals when the availability of waste increases (González Zevallos and Yorio 2006). Moreover, Southern Giant Petrels not only use the discards and offal made available by fishing operations (Copello and

Quintana 2003; Copello et al. 2008), but they also feed on seabirds incidentally captured in fishing nets (González Zevallos and Yorio 2006). The marked association between petrels and trawl fisheries, and the consequent intensive use of fishing waste as a supplementary food source may be one of the factors that has contributed to the increase of the breeding population in North Patagonia observed in the last decade (Quintana et al. 2006). Future studies will need to evaluate in more detail to what extent Southern Giant Petrel populations in Patagonia depend on the use of waste and the consequences that would ensue if the fishing activities were to change in the future (e.g. reduction in the amount of discarded waste or changes in the distribution of fishing effort).

Finally, the results presented indicate that the Southern Giant Petrel breeding adults concentrated their foraging over waters under Argentine jurisdiction (the EEZ and the Argentinean Sea), and they spent less time within Chile's EEZ or within international waters. This suggests that, at least during the breeding period (spring and summer), in addition to international efforts and agreements (see CMS 2000; ACAP 2004; IBA 2006), a significant part of the responsibility for the conservation of their populations falls to Argentina. Recent satellite telemetry studies show that the use of the marine environment by adults from the islands discussed here is similar during the non-breeding period (Quintana and Copello, unpubl. data). However, this situation does not apply to juveniles who, in addition to using the Patagonian Shelf, range within EEZs that are far from their natal colonies (Uruguay, Brazil, Chile, Australia and New Zealand) (Quintana and Copello, unpubl. data). The distribution of Southern Giant Petrels from Patagonia, Argentina, across multiple, distant marine jurisdictions, suggests that although national efforts and initiatives are crucial to the conservation of this species, multinational initiatives and efforts are also needed in order to fully understand and mitigate the threats that confront this species.

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