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An assessment of oceanic seabird abundance and distribution off the southern Brazilian coast using observations obtained during deep-water fishing operations

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(With 7 figures)

Abstract

The use of discarded fish over baited hooks used in longline fishery, and fish caught in gillnets, as a food source for gulls, albatrosses and petrels has been intensively studied in northern and southern oceans. This study describes the occurrence and abundance of seabirds observed from 20 foreign vessels which operated during the period between July 2001 and May 2005, off the southeastern and southern Brazilian coast. A total of 353,557 seabirds were observed; comprising eight families and 28 species. The most abundant species was *Procellaria conspicillata* followed by *Daption capense*, *Puffinus gravis*, *Thalassarche melanophrys* and *Oceanites oceanicus*. Ten species of seabirds (392 individual birds) were incidentally captured in gillnets; and 122 birds (9 species) by longline hooks, with *P. gravis*, *D. capense* and *Procellaria aequinoctialis* having the largest capture rates.

Keywords: oceanic seabird, vessels operations, on board observers, Brazil.

Uma avaliação da abundância de aves marinhas oceânicas e distribuição do Sudeste e Sul do Brasil a partir de observações durante operações de pesca em águas profundas.

Resumo

A utilização dos descartes sobre as iscas dos anzóis em pescarias de espinheis e peixes capturados por redes de deriva como fonte de alimento por gaivotas, petréis e albatrozes têm sido intensamente estudados nos Oceanos Norte e Sul. Este trabalho tem como objetivo registrar a ocorrência e abundância das aves marinhas observadas a partir de 20 embarcações estrangeiras arrendadas que atuaram durante o período de julho de 2001 a maio de 2005 na costa sudeste-sul do litoral brasileiro. Foi registrada a ocorrência de 353.557 aves marinhas distribuídas em oito famílias e 28 espécies, com a maior participação de *Procellaria conspicilatta*, seguido de *Daption capense*, *Puffinus gravis*, *Thalassarche melanophrys* e *Oceanites oceanicus*. Foram capturadas incidentalmente 392 exemplares de aves marinhas pelas redes de emalhe e 122 pelos anzóis dos espinhéis, distribuídos em dez e nove espécies, respectivamente, com as maiores taxas de captura sobre *P. gravis*, *D. capense* e *Procellaria aequinoctialis*. Este estudo mostra uma pequena parcela das aves capturadas no litoral brasileiro, uma vez que as embarcações fiscalizadas representam a minoria das que estão em atividade. O acompanhamento de Observadores de bordo capacitados deve ser intensificado para avaliar o impacto das pescarias nas populações de aves marinhas, bem como implementar ações para diminuir suas capturas.

Palavras-chave: avifauna marinha, operações pesqueiras, observadores de bordo, Brasil.

1. Introduction

Fishing operations may interact with seabirds positively, by providing additional food (produced by discards), or negatively, due to non-intentional catch (Thompson, 1992; Bartle, 1991). The consumption of discards by gulls, petrels and albatrosses has been assessed in both the North and the South Atlantic Oceans (Furness et al., 1992; Thompson, 1992; Garthe and Hüppop, 1994; Thompson and Riddy, 1995; Garthe et al., 1996; Martinez-Abraín et al., 2002). As a downside, bait used on longlines, and fish (or other organisms) entangled in the gillnets attract seabirds, which may become victims of fishing gear. In fact, longline fishing has been regarded as the main source of albatross mortality worldwide (Brothers, 1991; Murray et al., 1993). Because it is conducted at such a large scale, longline fishing has been shown to reduce some bird populations to a threatened state (Weimerskirch et al., 1997). In addition, gillnets, another extensively-used fishing gear, have also been shown to cause significant unintentional catches and contribute to anthropogenically induced seabird mortality (DeGange and Day, 1991; Waugh et al., 1999).

Only two species of *Procellariformes* oceanic seabirds nest off the Brazilian coast. However, waters within Brazil's Exclusive Economic Zone (EEZ) are important foraging areas for pelagic species, which disperse from their Antarctic breeding colonies during the austral winter, and primarily concentrate around the subtropical confluence zone between March and October (Veit, 1995; Thomsen, 1962; Pocklington, 1979; Briggs et al., 1987; Ribic and Ainley, 1989; Neves and Olmos, 1997; Weimerskirch et al., 1997). The great biological productivity of the subtropical confluence zone, attracts not only birds, but also pelagic and demersal fishing efforts, thereby resulting in a great number of interactions between pelagic seabirds and fish boats (Neves and Olmos, 1997).

Assessing such interactions (both positive and negative) comprehensively has been a complex task achievable only through the intensive observation of fishing operations and the use of specific survey methods including species identification and census routines. These can hardly be performed by untrained and/or undedicated crew members and, in that sense, despite recent international efforts, our understanding of the distribution oceanic seabirds in Brazilian waters and their interactions with fishing activity is incipient (Vaske-Júnior, 1991).

Since the year 2000, a government-induced vessel-chartering programme initiative has attracted foreign fishing fleets to the Brazilian waters which were not being used by the domestic fleet (Perez et al., 2003; Alvarez Perez et al., 2009). As part of the agreement between Brazil and the foreign fleets, these foreign vessels are required to carry observers during their operations in Brazilian waters, in order to collect data on: (a) the fishing operations and technology; (b) processing and handling practices; (c) distribution and abundance patterns of potential fishing resources; and (d) general impacts on the marine ecosystem (Alvarez Perez et al., 2009). The programme has provided an unprecedented opportunity to collect data on the characteristics and extent of bird and marine mammal bycatch as a function of the employed fishing methods.

Perez et al. (2003) produced a preliminary assessment of all the bycatch resulting from different fishing methods, specifically on the impact of the demersal gillnet monkfish *Lophius gastrophysus* Miranda-Ribeiro, 1915 fishery, including estimates of the total seabird mortality within the demersal gillnet fishery and bycatch rates within fishing zones near the southern limit of the Brazilian EEZ (Perez and Wahrlich, 2005).

In addition to seabird bycatch, a robust data set has been built containing observations of seabirds and marine mammals in the vicinity of the chartered fishing vessels, during their operations off the Brazilian coast. This paper summarises these data, and describes the oceanic seabird composition, abundance and distribution along the southeastern and southern sectors of Brazil's EEZ, and our hypothesis is that different fishing vessels attracted different species and number of seabirds in relation to the sub-areas along the Brazilian coast.

2. Material and Methods

2.1. Area of study

This study included data collected on board of chartered vessels operating off Brazil between parallels 22° and 35° S from July 2001 to May 2005. The Brazilian southeastern coast was divided into three subareas: the first was between 22° and 25°, which includes the north of Rio de Janeiro to the south of São Paulo, the second between 25° and 29° (Paraná and Santa Catarina) and the third between 29° and 35° S (Rio Grande do Sul) (Figures 1, 2, 3 and 4).

2.2. Fishery operations and Census

A total of 2.904 fishing hauls conducted with trawlers, potters, gillnetters and longliners were monitored by 69 observers who performed seabird counts throughout the entire study period. Slope trawlers operated mostly on the lower continental slope (500-800 m) between 22° and 29° S; primarily targeting deep-water shrimp (Family Aristeidae), as well as groundfish (monkfish, hake (*Merluccius hubbsi* Marini, 1933) and others (Alvarez Perez et al., 2009). The bottom gillnet fishery targeted monkfish operating on the slope off Brazil between 2001 and 2002 occupied southeastern and southern Brazil slope grounds between 300 and 600 m depths.

Pot vessels targeted deep-water crab (especially the red crab *Chaceon notialis* Manning & Holthuis, 1989, and the royal crab *C. ramosae* Manning, Tavares & Albuquerque, 1989 (Pezzuto et al., 2006) and long liners to Wreckfish *Polyprion americanus* Bloch & Schneider, 1801, at the 30 ºS between 159 and 800 m, and Pink Cusk-eel *Genipterus brasiliensis* (Regan, 1903), Tope shark *Galeorhinus galeus* (Linnaeus, 1758) and Tile fish *Lopholatilus villarii* (Miranda-Ribeiro, 1915).

During potter operations, seabirds were attracted to the vessels mostly by discarded crab offal (especially from red crabs) and damaged catch, resulting in 1,358 seabird counts made by 25 observers.

The bottom gillnet fishery operating (607 counts by 19 observers) on the slope off Brazil during the study period targeted the monkfish but produced an abundant unintentional catch mostly rejected as the nets were retrieved (same board), during a nearly 12-hour operation (Wahrlich et al., 2004; Perez and Wahrlich, 2005).

During the bottom trawling vessels, 17 observers made 761 counts of seabirds during the discard round of unwanted parts of the target species (tails, offal and carcasses) and by catch.

In long line boats, eight observers compiled 175 records of birds on the rejects (fish heads, tails and entrails)

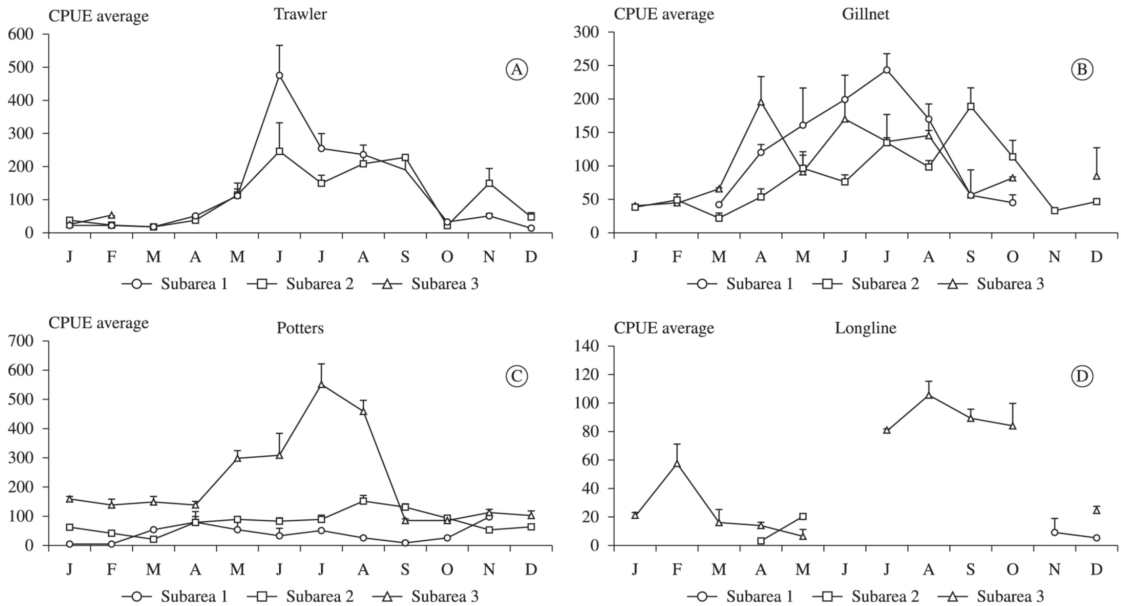

Figure 1. Total number of seabirds observed around different gear fisheries off the southern coast of Brazil, in subareas I, II and III. Trawler (A), Gillnet (B), Potter (C) an Longline (D).

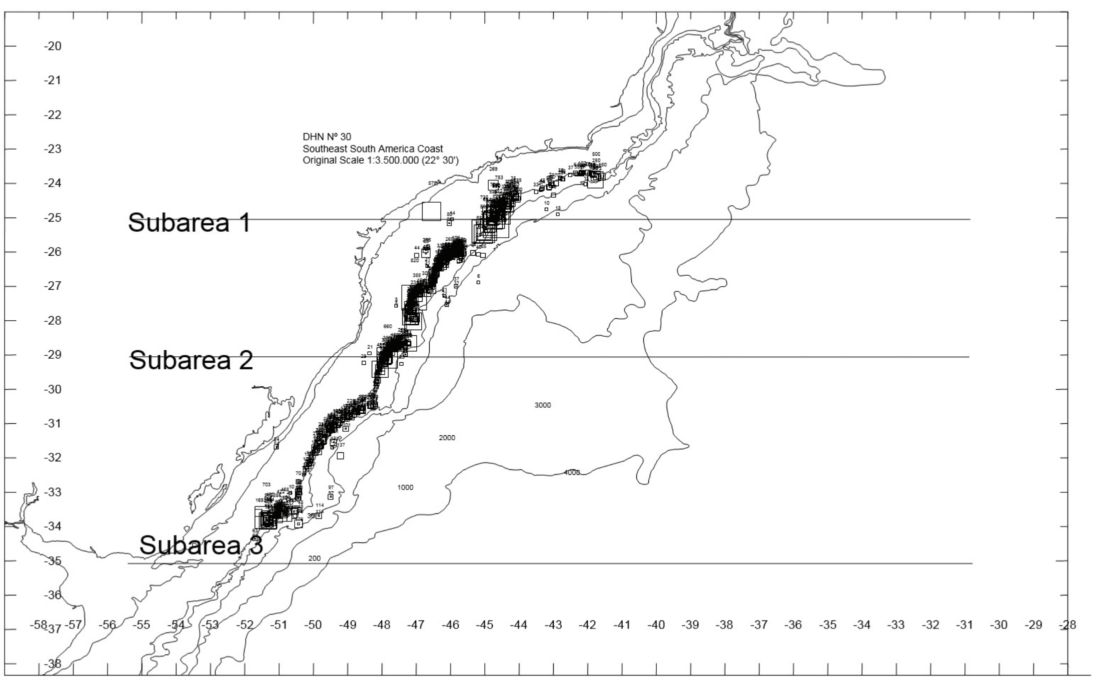

Figure 2. Occurrence of seabirds around gillnet fishing, in three subareas along the Brazilian coast.

discarded on the opposite side of the vessel in which the lines with baited hooks were released. This modality has sought to reduce the incidental capture of seabirds using the launch night and the line bogey (or scare tore lines).

During the vessel trips, spreadsheets, weighing and measuring instruments, seabird identification manuals (Vooren and Fernandes, 1989; Harrison, 1996; Onley and Bartle, 1999), photographic records and videos, were all used on-board. Seabird counts around the boat were taken with the naked eye and 10×50 binoculars, when necessary, and the information stored in computers (Weimerskirch et al., 2000; Chiaradia, 1991).

2.3. Data analysis

The Catch Per Unit Effort (CPUE) as the standard measure used in this study was calculated based on the number of birds on each count in a radius of 500 m by 360° around the vessel, and variable time according to

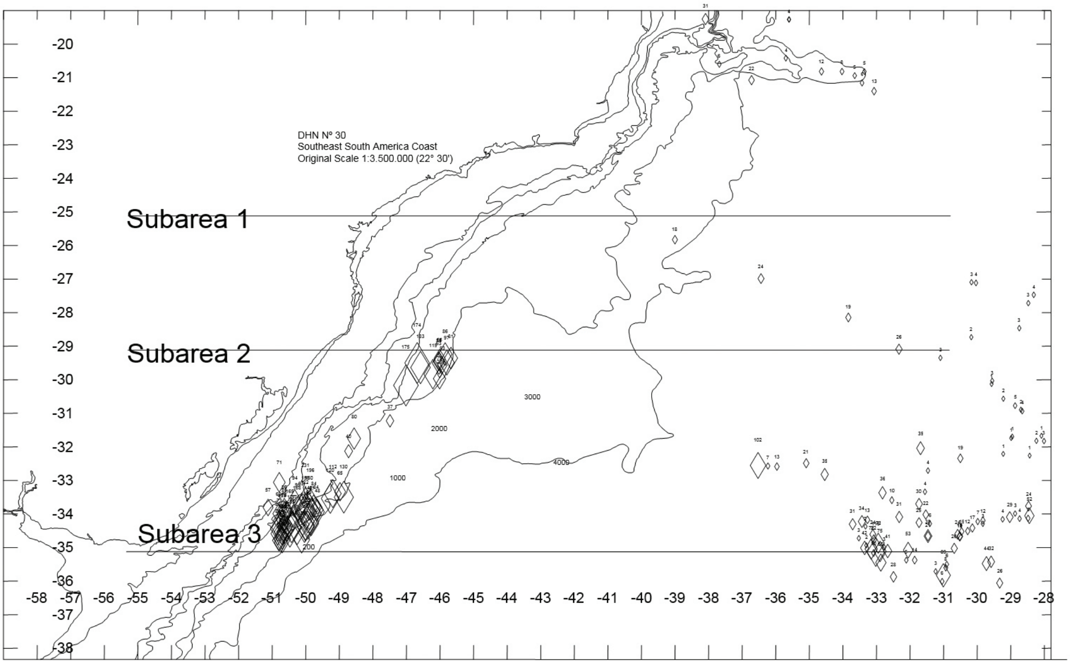

Figure 3. Occurrence of seabirds around longline fishing operations, in three subareas along the Brazilian coast.

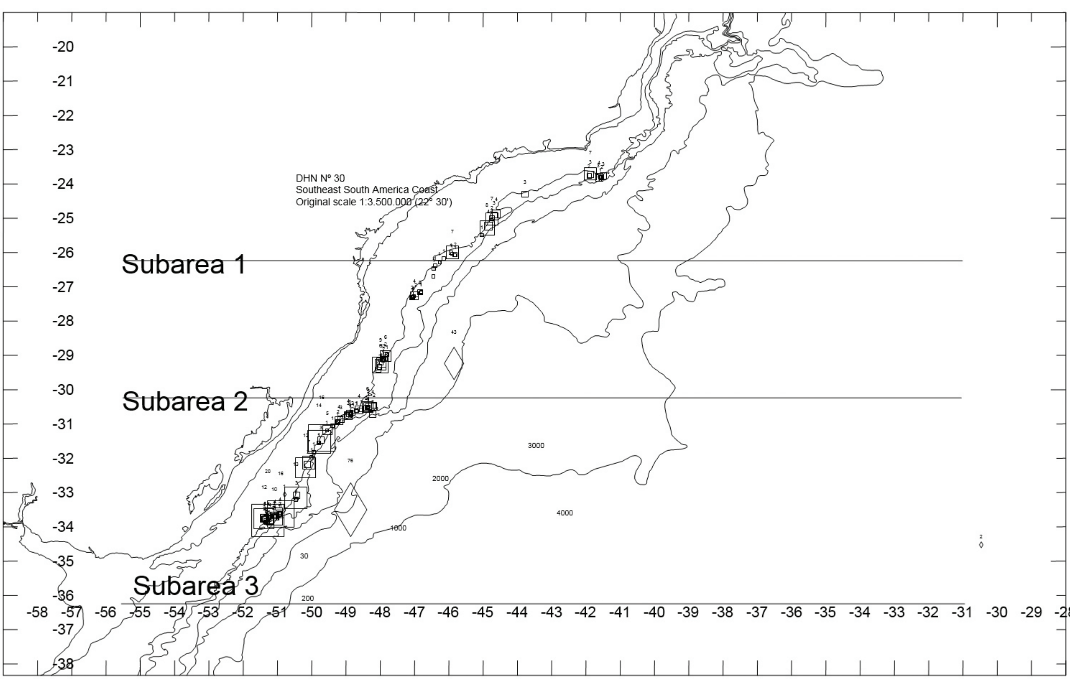

Figure 4. Occurrence of seabirds captured incidentally around gillnet and longline fishing, in three subareas along the Brazilian coast.

abundance. In the case of large concentrations of birds (> 5000), values were estimated by the average of two random scores on the board of the waste disposal lasting 15 minutes (Weimerskirch et al., 2000; Chiaradia, 1991).

The CPUE data were divided into three sub-categorised and geocoded in proportion to the abundance of birds in the counts with the aid of the program SURFER 8.1.

The Chi-square (the "Instats", p <0.0001 and 36 degrees of freedom) was applied in order to test the association or independence between frequency of occurrence oscillation, average abundance of each bird species throughout the study period, in the various methods of fishing.

The totals of each species of birds sighted in different types of fishing were recorded, and tested under the influence of wind directions described as 0 (no wind), 1 (North wind), 2 (Northeast wind), 3 (Northwest wind), 4 (South wind), 5 (Southeast wind), 6 (Southwest wind), 7 (East wind) and 8 (West wind).

3. Results

During the fishing activities, 353,557 seabirds distributed in eight families and 28 species were recorded, where *Procellaria conspicillata* Gould, 1844, *Daption capense* (Linnaeus, 1758), *Puffinus gravis* (O'Reilly, 1818), *Thalassarche melanophris* (Temminck, 1828) and *Oceanites oceanicus* (Kuhl, 1820) contributed with 72.1% of birds along the Brazilian southeastern coast (Table 1).

Potter vessels attracted the greatest number of species and specimens, with a predominance of *D. capense*, *P. conspicillata* and *O. oceanicus*. *Diomedea epomophora* (Lesson, 1825), and *Stercorarius parasiticus* (Linnaeus, 1758) were seen only in this fleet, while the trawlers, ranked second in CPUE, with the predominance of *P. gravis*, *T. melanophris* and *P. conspicilatta*, followed by the gillnets (*Procellaria*, *Calonectris diomedea* Scopoli, 1769) and *T. melanophris*) and bottom long line (*P. conspicilatta*, *P. gravis, D. capense*) (Table 1).

All fishing gear attracted birds over monitored years, with seasonal fluctuations and abundance peak in gillnet vessels in 2002, trawlers and potters in 2003 and long line in 2004; independent of the vessel's equipment, the highest seabird concentrations were observed in October 2001, November 2002 and August 2004, July 2003 and January 2005 (Figure 5).

The mean CPUE recorded on trawler vessels was stable from January to April, with an increase from May to June and fall in the remaining period (Figure 1A). In the case of gillnet, the average seabird's CPUE swung erratically between subareas, with the highest rates occurring in subarea I during July, subarea II in September and subarea III in August (Figure 1B). The seabirds CPUE on potters in subareas I and II showed small fluctuations throughout the period, with the highest values in November and August, respectively, while in subarea III the highest rates were recorded in July, followed by a drop and oscillations to the period's end (Figure 1C). Despite the uneven performance of the longline fleet in the subareas, the fishing effort was higher on the third, with peak values of CPUE in February and August, and absence in June and November; Sub-area I and II was restricted to April and May and November and December, respectively (Figure 1D).

The greatest abundance of birds, which were directly related to the area and fishing effort of trawler vessels, occurred in subarea I, reducing considerably in subarea II and absent in subarea III (Figure 6).

The seabirds distribution along the coast was uniform, with the greatest abundance in subarea II, followed by III and I (Figure 2).

In subarea III, the highest abundance of birds were concentrated in the south, while in other regions they were distributed evenly, with gradual decrease toward the north (Figure 7).

The highest concentrations of seabirds were recorded nearest to the border between Rio Grande do Sul and Uruguay (Figure 3).

According to Table 2, a marked difference in the composition of birds in each modality (c^2_{4-36}=10.5783, p<0.0001) were recorded by independence of samples from seabird abundance, so these values are strongly associated to the type of vessels; *P. a. conspicillata* predominated in trawlers followed by *T. melanophris* and *P. gravis*, in gillnet by *P. a. aequinoctialis* and *P. gravis* and long line by *P. gravis* and *D. capensis*, except in potters (*P. gravis*) followed by *P. a. conspicillata* and *O. oceanicus* (Table 2).

During trawler operations, 13 species were sighted, and 10 were more abundant when a northeast wind was acting and only two (*M. giganteus* and *D. crysostoma*) stood out when the wind was southwest. The northeast wind was responsible for 40.51% of the total abundances and *F. glacialoides* showed higher values when there was no wind (Table 3).

In potters, a similar behaviour of birds in relation to trawlers, eight species were more abundant when the wind was northeasterly (21.82%) and four in the southwesterly (20.44%) (Table 3). In the gillnet, the predominance of species occurred when the wind was northeasterly (10 species), and *D. exulans* showed higher registers when the wind was north, *D. crysostoma* when it was southeasterly and *M. giganteus* when it was southwesterly (Table 3). Finally, in the longline method (Table 3), the predominance of six species were recorded when the wind was northeasterly, followed by southwesterly.

3.1. Incidental catches

During the observations, 392 specimens of seabirds were incidentally captured by gillnets and 122 by longlines, distributed in ten and nine species, respectively, with the highest catch rates of *P. gavis*, *D. capense* and *P. aequinoctiallis* (Table 1). The fishing gear trawl vessels and potters not captured birds during the study period. Incidental catches recorded on board longline vessels were restricted to subarea 3, however, in gillnet vessels, these decreased directly proportional to the increase in latitudes (82 cases in III, 27 in II and 12 in I) (Figure 4).

4. Discussion

With growing competition for marine resources and chemical pollution of the oceans, the search for alternative food sources such as discharges of fisheries, baited hooks and fish caught in drift nets were strategies used by marine birds (Griffiths, 1982; Abrams, 1983; Hudson and Furness, 1989; Ryan and Moloney, 1988; Thompson, 1992; Moore, 1994; Garthe and Hüppop, 1994; Thompson and Riddy, 1995; Weimerskirch et al., 2000).

The waste comes from fish processing and the number of vessels operating in the same area directly affect the number of birds that are attracted, but the interactions are complex and probably also depend on the ecology and

Table 1. Number of seabirds observed in potters, gillnets, trawlers and longlines along the Brazilian southern and southeastern coast. (N = Total number of seabirds, CPUE = Count Per Unit Effort and C. I. = Incidental capture of seabirds). According to CBRO 2010.

Taxon	Potter			Trawler			Gillnet			Longline			Total
	N	CPUE	C.I.	N	CPUE	C.I.	N	CPUE	C.I.	N	CPUE	C.I.	
Procellariiformes													
Diomedeidae													
Phoebetria palpebrata (Forster, 1785)	3	0.07	-	57	1.63	-	127	7.94	2	-	-	-	187
Thalassarche chlororhynchos (Gmelin, 1789)	5344	116.17	-	7491	214.03	-	6781	423.81	2	499	45.36	13	20115
Thalassarche melanophris (Temminck, 1828)	7256	157.74	-	17503	500.09	-	10013	625.81	6	474	43.09	2	35246
Thalassarche chrysostoma (Forster, 1785)	83	1.80	-	7	0.20	-	134	8.38	-	-	-	-	224
Thalassarche sp.	-	-	-	955	27.29	-	1669	104.31	20	-	-	-	2624
Diomedea epomophora Lesson, 1825	8	0.17	-	-	-	-	-		-	-	-	-	8
Diomedea exulans Linnaeus, 1758	213	4.63	-	99	2.83	-	73	4.56	-	107	9.73	1	492
Procellariidae													
Macronectes giganteus (Gmelin, 1789)	3994	86.83	-	64	1.83	-	-	-	-	135	12.27	2	4132
Fulmarus glacialoides (Smith, 1840)	7646	166.22	-	687	19.63	-	264	16.50	28	37	3.36	-	8634
Daption capense (Linnaeus,1758)	59894	1302.04	-	2693	76.94	-	1058	66.13	113	835	75.91	28	64480
Pterodoma molis (Gould, 1844)	162	3.52	-	294	8.40	-	14	0.88	-	2	0.18	-	472
Pterodoma incerta (Schlegel, 1863)	955	20.76	-	205	5.86	-	7794	487.13	-	26	2.36	-	8980
Pachyptila vittata (Forster, 1777)	-	-	-	1	0.03	-	2	0.13	-	-	-	-	3
Pachyptila desolata (Gmelin, 1789)	477	10.37	-	-	-	-	4	0.25	-	-	-	-	481
Pachyptila belcheri (Mathews, 1912)	10	0.22	-	5	0.14	-	25	1.56	-	7	0.63	-	47
Procellaria aequinoctialis Linnaeus, 1758	13320	289.57	-	4671	133.46	-	1664	104.00	49	804	73.09	15	20459
Procellaria conspicillata Gould, 1844	49706	1080.57	-	17042	486.91	-	10414	650.88	31	2960	269.09	12	80122
Procellaria sp.	688	14.96	-	315	9	-	10638	664.88	64	-	-	-	11641
Calonectris diomedea (Scopoli, 1769)	355	7.72	-	-	-	-	10490	655.63	-	-	-	-	10845
Puffinus griseus (Gmelin, 1789)	116	2.53	-	305	56.60	-	222	13.88	-	12	28.63	-	655
Puffinus gravis (O'Reilly, 1818)	15253	331.59	-	32321	923.46	-	262	16.38	83	1623	147.55	40	49459
Puffinus puffinus (Brünnich, 1764)	1578	34.30	-	1981	8.71	-	-	-	-	315	1.09	-	3874
Oceanitinae													
Oceanites oceanicus (Kuhl, 1820)	23364	507.91	-	1909	54.54	-	121	7.56	-	33	3	9	25427
Pelecanoididae													
Pelecanoides magellani (Mathews, 1912)	6	0.13	-	-	-	-	1	0.06	-	526	47.82	-	533
Pelecaniformes													

Table 1. Continued...

Taxon	Potter			Trawler			Gillnet			Longline			Total
	N	CPUE	C.I.	N	CPUE	C.I.	N	CPUE	C.I.	N	CPUE	C.I.	
Sulidae													
Sula leucogaster (Broddaert, 1783)	2	0.04	-	10	0.29	-	-	-	-	-	-	-	12
Fregatidae													
Fregata magnificens Mathews, 1914	11	0.24	-	48	1.37	-	-	-	-	-	-	-	59
Charadriiformes													
Stercorariidae													
Stercorarius maccormicki Saunders, 1893	46	1	-	153	4.37	-	4034	252.13	-	-	-	-	4233
Stercorarius pomarinus (Temminck, 1815)	12	0.26	-	-	-	-	-	-	-	5	0.45	-	17
Stercorarius parasiticus (Linnaeus, 1758)	3	0.07	-	-	-	-	-	-	-	-	-	-	3
Laridae													
Larus dominicanus Lichtenstein, 1823	-	-	-	6	0.17	-	-		-	16	0.6	-	22
Total	190505		-	88822		-	65804		398	8416	507.9	122	353547

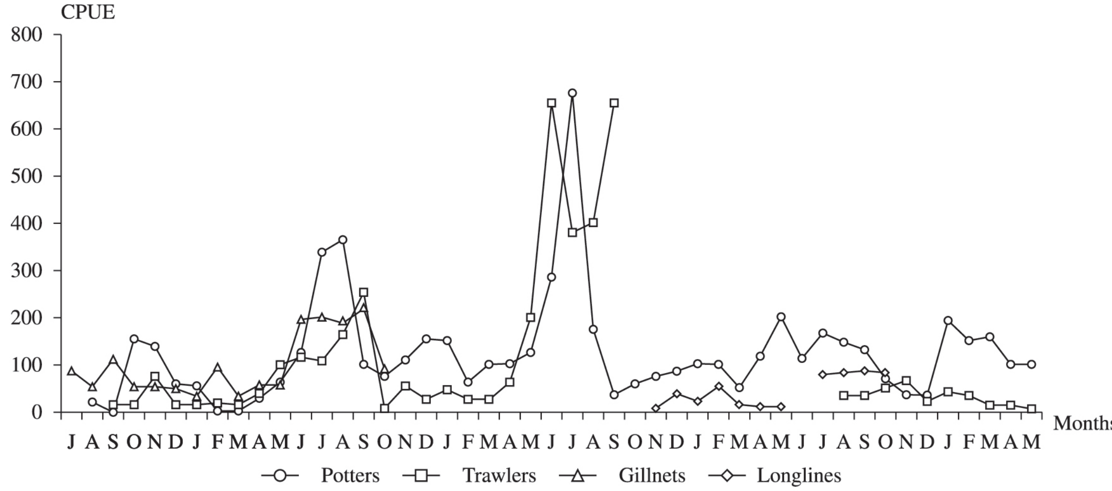

Figure 5. Seabird occurrence around potter, trawler, gillnet and longline vessels fishing off the southern coast of Brazil, from July 2001 to May 2005.

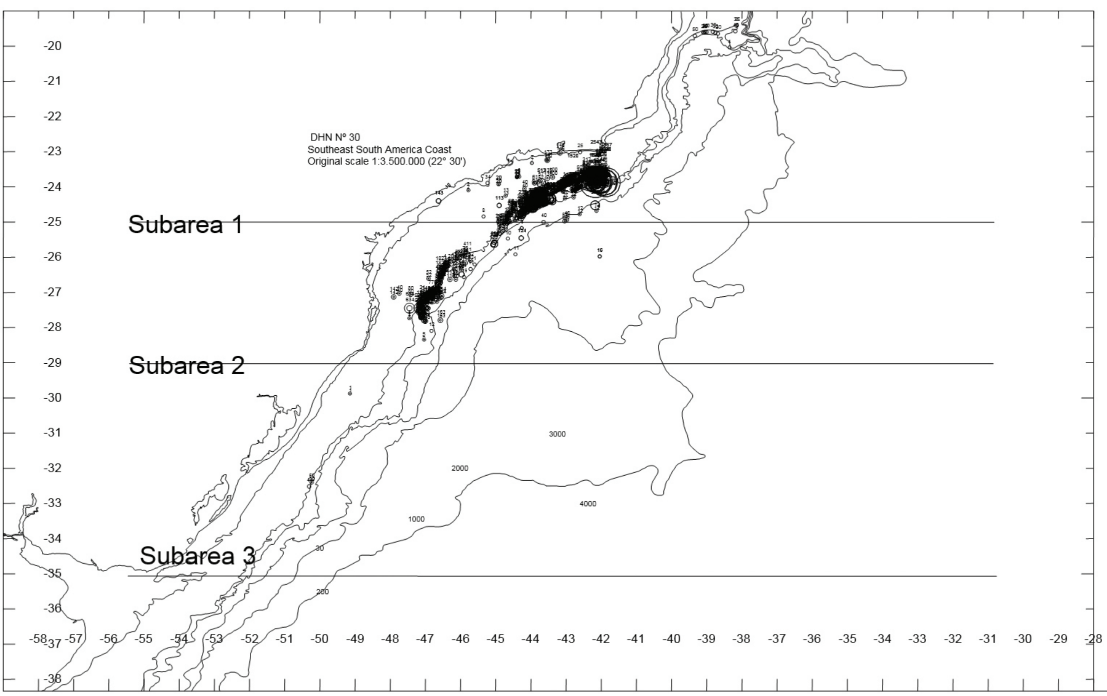

Figure 6. Occurrence of seabirds around trawler fishing operations, in three subareas along the Brazilian coast.

behaviour of different species as well as local conditions and the birds' experience (Weimerskirch et al., 2000).

The number of discarded species (75) by the fleet that served the south-southeastern Brazilian coast (GEP and CTTMar, 2005) was higher than that of the Mediterranean (32 taxa), 29 in the Ebro Delta and 47 in Baleartic waters, and the species most commonly discarded were *Sardina pilchrdus* (22.4) flatfish (19.1) and *Trachurus spp.* (17.3%) (Martinez-Abraín et al., 2002).

In Kerguelen's region, fewer species were recorded of birds attracted around trawlers and long line vessels (24 taxa) than on the south-southeast Brazilian coast. However, the number of birds was higher (497416) in 826 observations (Weimerskirch et al., 2000). Only 15 species were identified along the coast of Rio de Janeiro to a northerly direction (Coelho et al., 1990) and that number rises to 44 in a triangular section in the South Atlantic Ocean including South Georgia and the Strait of Magellan (Veit, 1995).

Several variables influence the number of species that are attracted to vessels, such as time in days from the start of fishing activities, the activity being developed, weather conditions (Weimerskirch et al., 2000), foraging behaviour, which avoids competition for the same resource (Chiaradia,

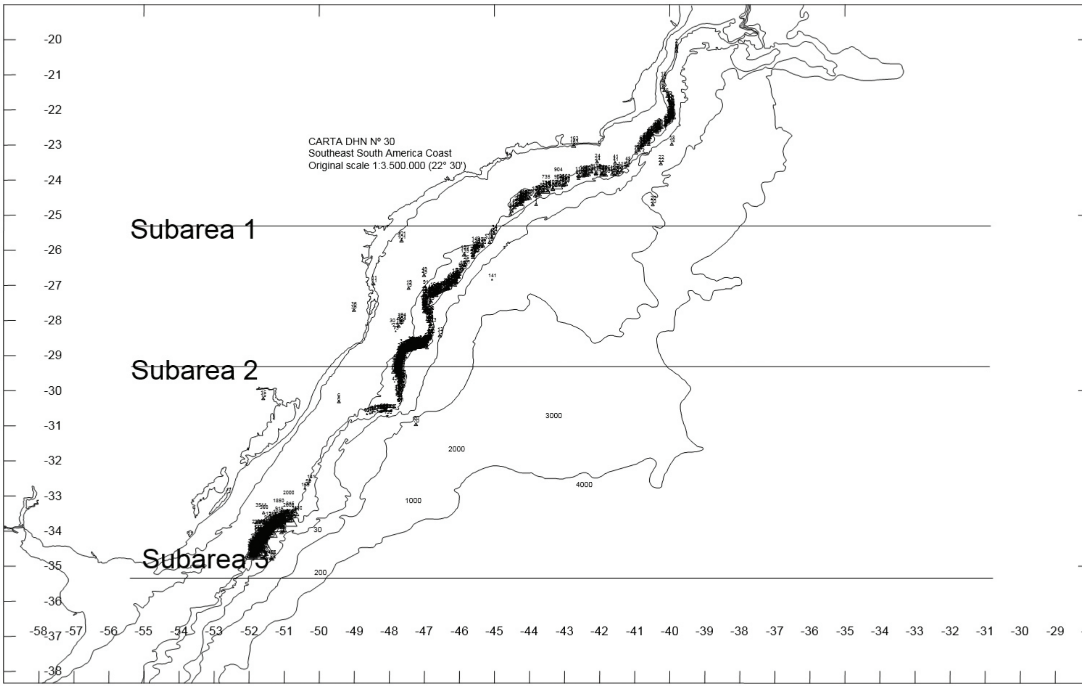

Figure 7. Occurrence of seabirds around potter fishing operations, in three subareas along the Brazilian coast.

Table 2. Total frequency of seabirds at oceanic fisheries off the southeastern Brazilian coast. (Independence test showed significant differences in all vessels operations).

Species	Trawler	Potter	Gillnet	Longline
D. exulans	95	258	224	107
T. melanophrys	17398	8015	9976	474
T. chlororhynchos	7467	5412	7277	499
T. crysostoma	579	83	473	0
Diomedea sp.	383	8	1027	0
M. giganteus	64	3937	249	135
F. glacialoides	687	7631	1630	37
D. capensis	2669	59897	9717	835
P. a. aequinoctialis	4885	12966	10696	804
P. a. conspicillata	15859	52113	12153	2960
P. puffinus	1934	443	482	315
P. gravis	32015	18121	10301	1623
O. oceanicus	1754	23851	4209	559

1991), dominance (Coelho et al., 1990) or positive or negative associations between them (Veit, 1995). The most abundant species in studies along the Brazilian coast were *D capense*, *T. clhororhynchos*, *P. aequinoctialis* and *P. gravis* (Vooren and Fernandes, 1989; Coelho et al., 1990; Vaske-Júnior, 1991; Veit, 1995) corroborating the present study, with the participation of *P. conspicilatta* and *O. oceanicus*. For the different modalities, the influence of wind occurred in the abundance of species seen, with the biggest records for the northeasterly and southwesterly directions.

Potters attracted the greatest number of species and specimens on the southeastern and southern Brazilian coast, which could be explained by the higher number of counts or the area of operation of smaller length, and which may be subject to increased diversity and decreased productivity that occurs in the oceans. As in the study by Weimerskirch et al. (2000), the long line attract more birds by their disposal to be made in mixed mode, different from trawlers that have fewer discharges (whole fish was frozen) without bycatch or being thrown heterogeneously (tails, heads and bones).

Unlike that observed in trawler fleets, the distribution of birds that approached the gillnet was homogeneous, with the highest values occurring in Paraná and Santa Catarina, and potters and longlines in Rio Grande do Sul,

Table 3. Species abundance by fishery type (1 = trawlers, 2 = potters, 3 = gillnet, 4 = longline) in relation to wind direction (0 = no wind, 1 = northerly, 2 = northeasterly, 3 = northwesterly, 4 = southerly, 5 = southeasterly, 6 = southwesterly, 7 = easterly, 8 = westerly).

Species	Vessels	Wind direction									Total
		0	1	2	3	4	5	6	7	8	
D. exulans	1	0	17	42	0	7	5	0	24	0	95
	2	1	24	87	3	25	17	41	48	12	258
	3	0	9	30	6	152	6	14	3	3	223
	4	0	11	22	2	18	14	21	14	5	107
T. melanophris	1	737	241	7068	412	2529	2845	2486	869	211	17398
	2	68	869	1593	524	942	862	1831	901	425	8015
	3	738	785	3537	341	1245	848	1863	415	162	9934
	4	0	46	118	12	89	26	125	18	40	474
T. chlororhynchos	1	763	138	3027	248	737	1088	1008	383	75	7467
	2	121	511	1170	221	802	520	719	774	574	5412
	3	710	467	2533	100	969	963	948	515	67	7272
	4	0	8	126	5	136	75	69	53	27	499
D. crysostoma	1	0	85	32	0	36	0	426	0	0	579
	2	0	2	34	0	33	4	5	2	3	83
	3	110	3	75	0	10	109	44	102	20	473
	4	0	0	0	0	0	0	0	0	0	0
Diomede asp.	1	15	8	115	60	25	34	69	57	0	383
	2	0	0	0	0	0	0	4	1	3	8
	3	108	0	507	0	80	187	0	105	40	1027
	4	0	0	0	0	0	0	0	0	0	0
M. giganteus	1	18	5	9	0	0	0	21	0	11	64
	2	4	629	752	216	409	210	962	389	366	3937
	3	0	7	25	8	31	69	102	1	6	249
	4	0	22	33	8	8	4	46	10	4	135
F. glacialoides	1	311	5	51	0	1	45	266	1	7	687
	2	14	1301	960	596	659	503	2016	546	1036	7631
	3	1	60	658	109	170	109	464	39	20	1630
	4	0	1	10	0	0	0	26	0	0	37
D. capensis	1	466	124	771	22	92	295	681	91	127	2669
	2	122	7352	10781	3274	6941	2688	18584	4034	6121	59897
	3	90	511	3312	316	1002	1148	2480	578	180	9617
	4	0	51	267	14	150	89	147	62	55	835
P. a. aequinoctialis	1	132	222	2192	117	559	330	913	357	63	4885
	2	28	1935	3039	757	1256	752	2891	1519	789	12966
	3	544	985	3876	263	1370	824	2001	633	60	10656
	4	1	40	149	28	141	145	168	56	76	804
P. a. conspicillata	1	559	482	6024	495	1699	2499	2029	1401	571	15859
	2	406	5557	13551	1691	7027	7327	5854	8522	2178	52113
	3	819	493	4168	330	2252	1373	1494	1013	190	12132
	4	2	89	1177	58	295	669	398	223	49	2960
P. puffinus	1	56	64	1149	117	260	99	86	103	0	1934
	2	10	2	125	0	121	86	43	31	25	443
	3	11	0	109	0	96	24	108	108	23	482
	4	0	46	107	25	6	79	43	6	3	315
P. gravis	1	156	2021	13755	2332	1273	7678	3445	516	839	32015
	2	182	2215	4371	872	1583	1420	2445	3788	1245	18121
	3	473	332	4455	372	1230	825	1681	690	241	10299
	4	0	25	549	7	234	390	123	244	51	1623

Species	Vessels	Wind direction									Total
		0	1	2	3	4	5	6	7	8	
O. oceanicus	1	38	12	521	120	389	334	246	92	2	1754
	2	121	3804	5581	985	1984	2055	4001	2815	2505	23851
	3	156	489	1696	52	529	456	484	307	40	4209
	4	1	40	190	12	95	34	124	26	37	559
Total	1	3351	3424	34756	3923	7607	15252	11676	3894	1906	85789
	2	1077	24201	42044	9139	21782	16444	39396	23307	15282	192735
	3	3860	4142	24983	1900	9140	6946	11689	4516	1060	68203
	4	4	380	2750	174	1176	1530	1296	719	355	8348

in the winter when the tropical front reaches the Brazilian south coast bringing nutrients from subantarctic waters, increasing biological productivity, coinciding with the peak of fishing effort in southern Brazil (Veit, 1995; Neves and Olmos, 1997).

The fishing gear trawler vessels and potters did not capture birds incidentally during the studied period, but the mortality in the region of Kerguelen was attributed to the equipment of Ukrainian trawlers (electronic connection between the network and the boat) that affect P. aequinoctialis and other petrels when trying to capture lost items on the bed or in the condenser portion in nets, also when starting or ending the operation (Weimerskirch et al., 2000).

Many studies of incidental capture have been underestimated by extensive sets of data acquired by observers untrained for reporting fishing mortality for birds (Murray et al., 1993; Klaer and Polacheck, 1997), or not dedicated to this function (Brothers, 1991; Neves and Olmos, 1997) as in this study. According to Weimerskirch et al. (2000), when the observer was watching the raising of the hooks, the number of captured birds was 0.25 ± 0.33 to 0.05 ± 0.15 when measuring fish were collected and the number of dead birds at the end were recorded.

Longline fishery is conducted on a major scale and many important features are captured by these vessels, since it is a conservation method, which tends to capture target species without causing destructive effects of bottom habitats with low fuel consumption (Lokkeborg, 1998). However, seabirds are caught when baited hooks are released and this can be a serious problem in the areas of fishing during certain periods in the North Atlantic (Degange and Day, 1991) and South (Weimerskirch and Jouventin, 1987; Brothers, 1991; Lokkeborg, 1998).

F. glacialoides is the largest representative of birds caught by longline in the North Ocean and in certain regions during certain periods, the birds can have a big impact on efficiency and profitability, becoming a major problem for fishermen (Lokkeborg, 1998). According to Weimerskirch et al. (2000) four species were caught, and *P. aequinoctialis* represented 91.8% of the total, followed by *T. melanophris* (35), *D. chrysostoma* (31) and *D. exulans* (12). The main species caught by demersal longline was *P. gravis*, seasonally common on the Brazilian coast and an efficient diver to catch on baited hooks, followed by *T. melanoprhis* (33), *T. chororhynchos* (17), *P. aequinoctialis* (14), *P. conspicillata* (6) *D. exulans* (1) (Neves and Olmos, 1997), corroborating the present study.

The results from this study show that there is, indeed, an association between the type of fishing and the composition of birds sighted. However, some species such as *P. a. conspicillata* and *P. gravis* are the majority represented for all kinds of fishing. Therefore, it can be said that the results of positive association of species composition are the frequency of occurrence variation of other species recorded.

This study did not analyse the abundance of birds throughout the day; however, Neves and Olmos (1997) registered that the highest by-catch along the Brazilian coast occurred at dusk, while in the Northern Ocean, it was during the day since albatrosses are reported to feed at this stage (Harper, 1987; Weimerskirch and Wilson, 1992; Croxall and Prince, 1994) and the number of petrels caught that are also active at night is half of that during the day (Weimerskirch et al., 2000).

The results found in various parts of the world show the difficulty in accurately estimating the risk of extinction of small populations of long life cycle, despite the availability of long series of data that cannot sustain any level of incidental capture (Inchausti and Weimerskirch, 2001). Seasonal closures of fishing areas has been suggested around South Georgia (Croxall and Prince, 1990) and the Kerguelen Islands (Weimerskirch et al., 2000), since most of the catches were recorded in a short period of time and in a relatively small area. Lines posted using the toreline lost significantly fewer baits and captured fewer birds (0.04 birds/1000 hooks) than other methods, since those released without any artifacts captured 99 birds (1.75 birds/1000 hooks) and through tunnels submerged 28 birds (0.49) (Lokkeborg, 1998; Brothers, 1991). However, the use of this artifact appears to be inefficient in fishery in the Ukraine, where the start night was the most efficient method of waste containment, drastically reducing the incidental capture of petrels (Weimerskirch et al., 2000).

Because of the emphasis on the capture of swordfish and sharks, the night launch is standard procedure for many fishing vessels in Brazilian waters and probably contributes to the low rate in the observation of catches in tuna fishery (Chiaradia, 1991; Vaske-Júnior, 1991; Stagi et al., 1997). The lack of necessary knowledge in the seasonal distribution of seabirds in Brazilian waters added to the legal and financial difficulties, and uncertainty regarding the efficiency of closing areas makes this management tool impractical at the moment (Neves and Olmos, 1997).

Following the guidelines suggested by these authors, vessels working along the Brazilian coast used torelines, in-line weights and dyeing bait to minimise the incidental capture of albatrosses and petrels.

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