Utilisation of discards from small-scale fisheries by seabirds in coastal waters of Paraná State, Brazil

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Abstract

Fishery discards support scavenging seabird populations in many parts of the world, but little is known of this relationship in Brazil. The present study of the coast of Paraná, southern Brazil conducted monthly surveys over twelve months. We observed nine species of scavenging seabirds taking discards, Magnificent Frigatebird *Fregata magnificens* and Brown Booby *Sula leucogaster* being the most abundant and frequent. The highest numbers of scavenging seabirds were observed during trawling activities, which provided far more discards at sea than driftnet fishing. During a fishing moratorium, when no use of trawl nets was permitted, numbers of scavenging seabirds at boats were lower. It seems likely that scavenging seabird populations of the Paraná coast benefit from this supplementary food supply, but the extent to which their numbers are affected is unknown.

Introduction

Consumption by scavenging seabirds of discards from commercial fisheries is a well-known phenomenon that has been described in many parts of the world (Garthe *et al*. 1996; Hill & Wassenberg 2000; Arcos *et al*. 2001; Martínez-Abraín *et al*. 2002; Garthe & Scherp 2003; Giaccardi & Yorio 2004; Yorio & Caille 2004). Fisheries discards can contribute to increases in populations of scavenging seabirds by making available food they could not obtain naturally, since discards are composed mainly of fish from the seabed that are inaccessible to the predominantly surface-feeding scavengers (Walter & Becker 1997; Valeiras 2003; Krul 2004; Yorio & Caille 2004; Weichler *et al*. 2004).

In Brazil, studies of the interactions between seabirds and fisheries discards are scarce, recent and concentrated in the southeast of the country, and have been related to discard production from relatively large boats with powerful engines (Branco 2001, 2004; Krul 2004; Branco *et. al*. 2006). Here we present data on seabirds feeding on discards from small boats fishing on the inner shelf off the coast of Paraná State, Brazil.

Methods

Study area and its fisheries: This study was carried out on the coast of Paraná State, which extends for 107 km between the Canal of the Varadouro (25°12'S) and the estuary of the River Saí-Guaçu (25°58'S; Figure 1). The fishery area studied extended from Pontal do Sul to Praia de Leste.

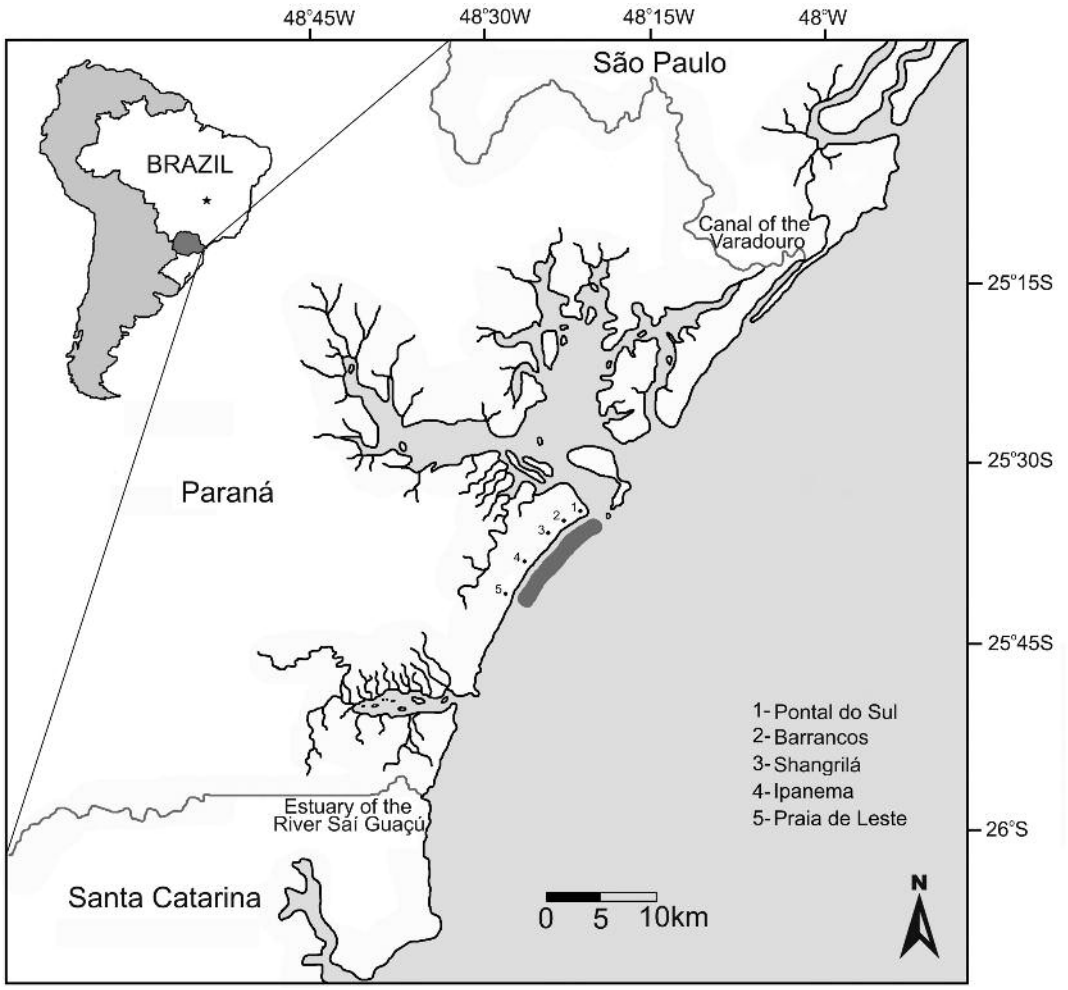

Figure 1. The Paraná coast with the study area at sea indicated (dark shading), and the five main fishing villages that produce discards in Pontal do Paraná.

A fleet of fishing boats, known locally as 'canoes', operates daily from the village ports, up to 5–10 km offshore and in shallow waters of 3–12 m depth (Carniel 2008). Canoes made either from a single carved tree trunk or of moulded fibreglass, with a length c. 10 m (Figure 2), are powered by engines of 11–24 hp, and have a load capacity of c. 2,000 kg of fish (Andriguetto-Filho *et al*. 2006). Most canoes use just one net during trawling, with a small number using two nets. This fleet is found along the entire oceanfront coast of Paraná, and is the least technical and least powerful fishing effort on the inner shelf. Fishermen work either alone or in teams of two and the most common fishing practices are set and drift gillnetting for fish and shrimp, and bottom trawling for shrimp (Andriguetto-Filho *et al*. 2009).

Fishermen in the study area generally made 4–5 trawls per fishing day, discarding fish species of no commercial size or value while at sea. However, after the last

trawl of the day, they just retrieve the net and separate shrimp and fish on the shoreline. During driftnetting, fishermen separate all species while at sea, but when they return to the beach their wives clean the commercially valuable species and dump the offal on the shoreline, along with some non-target species and target species that cannot be sold quickly enough, in the absence of refrigeration or ice to maintain them fresh (Carniel 2008).

The shrimp *Xiphopenaeus kroyeii* and white-shrimp *Litopenaeus schmitti* are the most important economic resource on the Paraná coast. Drift nets with mesh sizes of 4.5–12 cm between opposite knots are used to catch both shrimp and fish (Andriguetto-Filho *et al*. 2006), including several species of weakfish (*Cynoscion* spp.), leatherjacket (*Oligoplites* spp.), King Mackerel *Scomberomorus cavalla,* King Weakfish *Macrodon ancylodon* , Smalleye Croaker *Nebris microps* and Bluefish *Pomatomus saltatrix*. The main fish species discarded from driftnets are Banded Croaker *Paralonchurus brasiliensis* and Bigtooth Corvine *Isopisthus parvipinnis*, together representing > 50% of discards by frequency (Carniel 2008).

The mesh size of trawl nets used in shrimp fishing is smaller (3 cm between opposite knots), making them rather unselective and generating larger amounts of discards. Small fish (6–11 cm in length) represent about 80% of discards produced by trawl fisheries off Pontal do Paraná, mainly Rake Stardrum *Stellifer rastrifer*, Stardrum *S. brasiliensis,* Shorthead Drum *Larimus breviceps* and Banded Croaker *Paralonchurus brasiliensis* (Carniel 2008).

Figure 2. Canoes used in artisanal fisheries at Barrancos and Shangrilá. © Viviane Carniel.

An annual discard production of 130 tonnes was estimated for the study area in 2005 and 2006 from these small boats, produced mainly (64%) by trawling (Carniel 2008), while from larger boats an annual discard production of 3,500 tonnes was estimated for the whole Paraná coast (Krul 2004).

Bird counts and observations of feeding behaviour: We accompanied 18 fishing trips in 2006, following the fishermen's normal routine, and counting from their boats using binoculars (10x60) the number of seabird species and individuals feeding on discards. In March, April, May, July, August and September we monitored both one trawling and one driftnetting trip; in January, February and June we accompanied one trawling trip only each month; during a moratorium on trawling in October, November and December we only monitored one driftnetting trip each month.

Trawling of nets averaged 60 minutes duration (range 14–119 minutes), and driftnets were set for an average of 137 minutes (range 25–505 minutes). On recovering the net (a haul), fishermen separated non-target species into one or more piles, which were later thrown back into the sea either all at once (a 'discard event'), or at different times (several discard events). We monitored 20 trawling hauls with 139 discard events, and 30 driftnet hauls with 113 discard events. The time seabirds spent feeding per haul averaged five minutes (range 1–21) for trawling and nine minutes (range 1–30) for driftnetting.

Observations of the interaction between seabirds and discards were made only during discard events, when we counted the number of seabird species and individuals attracted to discards. The number of seabirds (by species) attending the vessel was recorded as the maximum per haul. A 'fishing day' was defined as a day when at least one haul was made.

Frequency was calculated as: the number of times each species was observed as a percentage of the total number of discard events. The percentage contribution in relation to the total number of individuals of each species present during trawling and driftnetting activities was calculated as: total number of individuals of each species *100/total number of individuals of all species observed feeding on discards.

Statistical analyses: Underlying assumptions of the statistical tests were verified in all cases. One-way ANOVA was used when our data showed normal distribution and homogeneity, with F, degrees of freedom and P values indicated. Values reported are means ± SE. Differences were considered significant when $P < 0.05$. The number of species and individual seabirds using fisheries discards were represented by frequency and abundance in percentages. Differences in seabird attraction levels and fishing methods (trawling versus driftnet) were tested using ANOVA.

Results

We recorded 578 individual seabirds of nine species feeding on discards (Table 1). Brown Booby *Sula leucogaster* and Magnificent Frigatebird *Fregata magnificens* were the most numerous species, with 266 and 253 individuals respectively,

Table 1. Total number of individual seabirds attracted to discards from trawl nets and driftnets.

Species	Total (50 hauls, 252 discard events)	Trawl nets (20 hauls, 139 discard events)	Driftnets (30 hauls, 113 discard event)
Brown Booby *Sula leucogaster*	266	235	31
Magnificent Frigatebird *Fregata magnificens*	253	230	23
Kelp Gull *Larus dominicanus*	25	23	2
Cayenne Tern *Thalasseus sandvicensis*	22	22	0
Neotropic Cormorant *Phalacrocorax brasilianus*	3	3	0
Common Tern *Sterna hirundo*	4	4	0
Royal Tern *Thalasseus maximus*	2	2	0
Sterna sp.	2	2	0
South American Tern *Sterna hirundinacea*	1	1	0
Individual seabirds	578	522	56

Table 2. Frequency of occurrence and abundance of seabirds attracted to discards (per discard event).

Species	Trawl nets		Driftnets	
	Frequency %	Abundance %	Frequency %	Abundance %
Magnificent Frigatebird *Fregata magnificens*	73.3	44.1	19.4	41.1
Brown Booby *Sula leucogaster*	68.3	45.0	77.8	55.3
Kelp Gull *Larus dominicanus*	15.1	4.4	0.8	3.6
Cayenne Tern *Thalasseus sandvicensis*	13.6	4.2	0.0	0.0
Neotropic Cormorant *Phalacrocorax brasilianus*	2.1	0.6	0.0	0.0
Common Tern *Sterna hirundo*	1.4	0.8	0.0	0.0
Sterna sp.	1.4	0.4	0.0	0.0
Royal Tern *Thalasseus maximus*	0.7	0.4	0.0	0.0
South American Tern *Sterna hirundinacea*	0.7	0.1	0.0	0.0

comprising 89.7% of all individual seabirds, with smaller numbers of Kelp Gulls *Larus dominicanus*, terns of four species, and Neotropic Cormorants *Phalacrocorax brasilianus*. All nine species were observed feeding on discards during trawling, which represented 90.3% of the observed interactions between seabirds and discards, while only three species were observed during driftnet fishing (9.6% of interactions). Seabirds were attracted to and fed at every single trawling discard event, but none were recorded at 8.8% (10/113) of driftnet discard events. In both types of fishery, Magnificent Frigatebird and Brown Booby were the most frequent and abundant species attracted to discards (Table 2).

The average number of species using discards during trawling (2.9 ± 0.21 per haul) was higher than during driftnetting (0.9 ± 0.12 per haul; $F_{1,48} = 70.89$, $P < 0.001$). Similarly, more individuals were recorded during trawling (26.1 ± 3.6 per haul) than during driftnetting (1.8 ± 0.3 per haul; $F_{1,48} = 67.23$, $P < 0.001$). The maximum number of seabirds recorded at one haul (from trawling) was 63 Brown Boobies and 24 Magnificent Frigatebirds.

During trawl fishing, the average number of individual seabirds attracted to discards was highest in February (54.3 ± 7.6) and significantly different from other months ($F_{7;12}$ = 5.32, P < 0.001; Figure 3), while the average number of seabird species was highest in July (3.5 ± 0.5), but not significantly different from the other months ($F_{7;12}$ = 1.49, P = 0.2; Figure 4).

During driftnet fishing, the highest average of individual seabirds attracted to discards was in December (5.6 ± 1.2), which differed from the other months (Pos-hoc LSD, P < 0.05; Figure 5). No statistical analysis was possible for the number of species as we observed a range of only 1–3 species feeding on discards during drift-netting activities.

Discussion

Our study presents new information on seabird interactions with discards produced by driftnet fishing off the Brazilian coast, and provides comparison with earlier studies of discards from trawling off southeast Brazil. The shrimps *Xiphopenaeus kroyerii* and *Litopenaeus schmitti* are the main target species for small fishing boats trawling in shallow, inshore waters off Paraná and Santa Catarina States in the south of Brazil (Andriguetto-Filho *et al*. 2006; Branco *et al*. 2006). On the Paraná coast, Krul (1999, 2004) recorded seabirds utilising discards from an 8.9 m boat with a 22 hp engine while in the same area we monitored fishing canoes of a similar length (c. 10 m) but with less powerful engines (11–24 hp). On the Santa Catarina coast, studies were of trawling discards from smaller (6–9 m) but more powerful (15–45 hp) boats (Branco 2001; Branco *et al*. 2006). These differences in engine power are likely to be reflected in the volume of non-target species caught and discarded, while the numbers and species of potentially scavenging seabirds may differ geographically and seasonally.

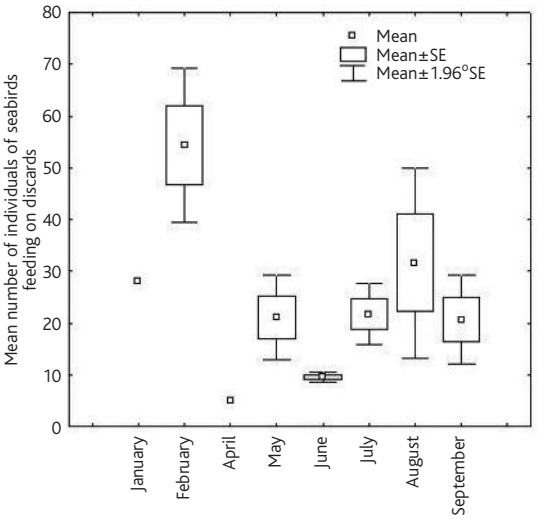

Figure 3. Mean monthly number of seabird individuals feeding on discards per event during trawl fishing.

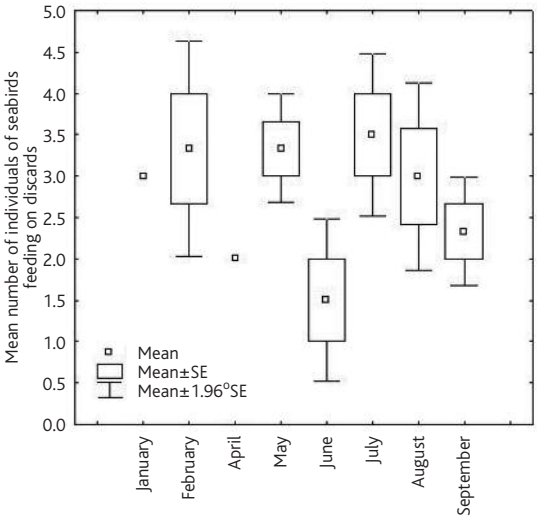

Figure 4. Mean monthly number of seabird species feeding on discards per event during trawl fishing.

We observed 578 individual seabirds feeding on discards during 50 hauls, of which 522 individuals were observed during the 20 hauls from trawling nets (means of 2.9 ± 0.2 species, 26.1 ± 3.6 individuals). Our data differ from observations made by Krul (1999), who recorded 1,037 seabirds during 15 hauls of nets trawled by a more powerful boat on the Paraná coast (7 species, 69.1 ± 45.3 individuals).

Magnificent Frigatebirds and Brown Boobies are resident in the study area, with over 5,000 pairs in total breeding along the Paraná coast (Krul 2004), and were the more frequent species attracted to discards, being present at 73% and 68% of discard events from trawling, respectively; higher frequencies of occurrence (93% for both species) were recorded in the same study area by Krul (1999). Frigatebirds also predominated at discard events off the Santa Catarina coast (Branco *et al*. 2006), although in contrast with our study, in terms of relative abundance boobies were only recorded at 2% of events during 60 counts, with a frequency of occurence of 8%. Brown Booby and Cayenne Tern *Thalasseus sandvicensis* were the most abundant species at discard events from large boats off the Paraná coast, comprising 54% and 19% of individual seabirds respectively (Krul 2004), which for Brown Booby was similar to our data (45%).

Small numbers of cormorants, gulls and terns were also attracted to discards, as has been reported previously on the Paraná (five species; Krul 1999) and Santa Catarina coasts (six species: Branco 2001; Branco *et al*. 2006). The few gulls recorded feeding on discards at sea may be related to their preferred habit of utilising fisheries waste on the shoreline (Carniel 2008), while the small number of Neotropic Cormorants was probably due to their preference for feeding in estuaries (Moraes & Krul 1995) and their seasonal occurrence in the study area, being present mainly from December to March (Krul 1999). The low number of tern species and individuals using discards can be related to their occurrence on the

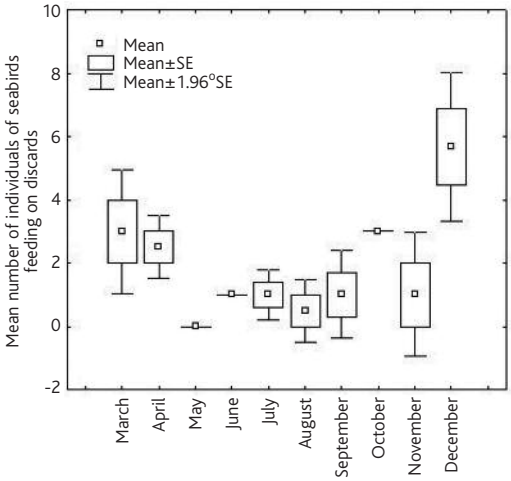

Figure 5. Mean monthly number of seabird individuals feeding on discards per event during driftnet fishing.

Figure 6. A trawl catch before sorting. © Viviane Carniel.

Figure 7. A Magnificent Frigatebird *Fregata magnificens* swooping on discarded fish. © Viviane Carniel.

Paraná coast, being present mainly during winter, from July to September (Krul 1999), and to their preferred feeding behaviour of capturing live fish by plunge-diving, rather than scavenging.

Trawling is the fishing method responsible for most discard production at sea (Hill & Wassenberg 2000; Arcos *et al*. 2001; Mañosa *et al*. 2004; Harrington *et al*. 2005; Carniel 2008). Discards have an important role in the occurrence, distribution and diet of seabirds. In Australian waters, fish discarded from trawlers comprised c. 40% of the diet of Crested Tern *Sterna bergii,* and 15% of Magnificent Frigatebird and 4% of Brown Booby diets (Blaber *et al*. 1995). Fisheries discards comprised over 90% of the diet of Kelp Gulls off northern Patagonia (Berlotti *et al*. 2001), while on the Paraná coast they represented 75% of the diet of Brown Booby and 92% of Magnificent Frigatebird (Krul 1999).

In our study, significantly fewer individual seabirds and species fed on discards from driftnet fishing than from trawling, with the latter usually involving larger amounts of discards after each haul. In the study area, one canoe produced in general an average of 20 kg of discards per trawling haul, totalling 100 kg per day (Carniel 2008), and such large amounts of discards are easily detected by seabirds, which is reflected in the greater number of species and individuals attracted. Discards from driftnets are more scattered and in smaller volume, with an average of 5 kg produced by one canoe per day (Carniel 2008), which can lead to some events being overlooked by seabirds. Seabirds mainly benefit from driftnet fishing through offal on the shoreline after gutting of the fish landed, while during trawling fishermen discard whole fish of non-target species without commercial value while at sea (Carniel 2008).

Fisheries discards may be capable of supporting more seabirds than the total number of individuals present in the area (Martínez-Abraín *et al*. 2002; Catchpole *et al*. 2006). In South America, Bertellotti & Yorio (2000) suggested that discard production in the San Matias Gulf (Patagonia, Argentina) could support over 30,000 gulls, while Yorio & Caille (2004) observed that the 50,000 tonnes of discards produced annually off Argentina could support a population of between 101,000 and 209,000 gulls. Similarly, an annual discard production of 3,500 tonnes produced by larger fishing boats on the Paraná coast could support a population of 40,000 seabirds (Krul 2004), which may represent more than the total number of individuals present in the area. Future investigations will be necessary to evaluate the impact of fisheries discards on the population dynamics of seabirds in the study area.

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