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Source: The Wilson Journal of Ornithology, 123(4):709-719. 2011.
Published By: The Wilson Ornithological Society
DOI:
URL: http://www.bioone.org/doi/full/10.1676/11-023.1

The Wilson Journal of Ornithology 123(4):709–719, 2011

FISHERY DISCARDS AND INCIDENTAL MORTALITY OF SEABIRDS ATTENDING COASTAL SHRIMP TRAWLERS AT ISLA ESCONDIDA, PATAGONIA, ARGENTINA

CRISTIAN JAVIER MARINAO[1,3] AND PABLO YORIO[2]

ABSTRACT.—We evaluated seabird attendance and incidental mortality at coastal trawl vessels targeting Argentine red shrimp (*Pleoticus muelleri*) in the Isla Escondida fishing area, Argentina, during 2006–2007 and 2007–2008. Eight seabird species attended vessels, and the most frequent and abundant seabird (percent occurrence, mean number per haul) in the two seasons was the Kelp Gull (*Larus dominicanus*) (100%, 112.3 and 100%, 263.4, respectively), followed by the Black-browed Albatross (*Thalassarche melanophris*) (85%, 17.6, and 90%, 32.4, respectively). Eleven Magellanic Penguins (*Spheniscus magellanicus*) and one Imperial Shag (*Leucocarbo atriceps*) were killed in nets with a mean capture rate of 0.003 and 0.0003 birds per haul, respectively. The estimated total number of birds killed was 53 penguins and five shags considering the total number of hauls made by the fishery in the two seasons. No contacts between seabirds and warp cables were recorded. Coastal shrimp vessels generally operated between 15 and 20 km offshore, at a mean distance from the main Kelp Gull colony (Punta Tombo) of 43.9 km. At least 100 fish and invertebrate species were discarded, mostly Argentine hake (*Merluccius hubbsi*). Total amount discarded per season by this coastal fishery in the two seasons was estimated at 3,284 and 6,590 tonnes, respectively. The coastal shrimp fishery in the Isla Escondida area appears to have a small impact on seabirds in terms of incidental mortality but provides significant amounts of supplementary food during the breeding season of the Kelp Gull. *Received 27 January 2011. Accepted 22 May 2011.*

Commercial fishing can generate important alterations in marine ecosystems and have important effects on top predators (Pauly et al. 2005). Seabirds are among the top predators which most regularly interact with fisheries, and can be negatively affected as a result of incidental capture and competition for common resources (Duffy and Schneider 1994, Tasker et al. 2000, Montevecchi 2002). In addition, due to the low selectivity of fishing gear, trawl fisheries discard large amounts of fish and invertebrates (Alverson et al. 1994) which are used by many organisms, including seabirds (Garthe et al. 1996, Furness et al. 2007). Discard consumption at sea is currently an important component of the trophic ecology of many seabird species (Camphuysen 1994, Garthe and Hüppop 1994), and many studies show that provision of this supplementary food may affect at-sea distribution, body condition, individual survival, and breeding success (e.g., Ryan and Moloney 1988, Hudson and Furness 1989, Oro 1999, Hüppop and Wurm 2000, Grémillet et al. 2008). In addition, it has been argued that discard use can contribute to population growth of some species of seabirds (Furness 2003), although there is some controversy (Camphuysen and Garthe 1999, Thompson 2006). Attraction to vessels may also result in incidental mortality from drowning in fishing gear and/or collisions with warp cables (Weimerskirch et al. 2000, González-Zevallos and Yorio 2006, Sullivan et al. 2006, Watkins et al. 2008, Favero et al. 2011).

The use of fishing discards has been evaluated in several regions worldwide (Abrams 1983, Furness et al. 1988, Blaber and Wassenberg 1989, Thompson 1992, Oro and Ruiz 1997, Branco 2001, Garthe and Scherp 2003, Wickliffe and Jodice 2010). Seabird attendance and discard use in Argentina has been analyzed for several trawl fisheries (Yorio and Caille 1999, Bertellotti and Yorio 2000b, González-Zevallos and Yorio 2006), including the coastal fishery that operates in the Isla Escondida area, Patagonia. However, information available for this fishery includes only identification and frequency of occurrence of attending seabirds (Yorio and Caille 1999) and further information is required to adequately interpret the magnitude of the seabird-fishery interaction. One of the main species taking advantage of discards at this and other Patagonian coastal fisheries is the Kelp Gull (*Larus dominicanus*) (Yorio and Caille 1999, Bertellotti and Yorio 2000b, González-Zevallos and Yorio 2006). Kelp Gull populations have increased since the 1980s, and it has been suggested that human-derived food sources have been an important factor (Yorio et

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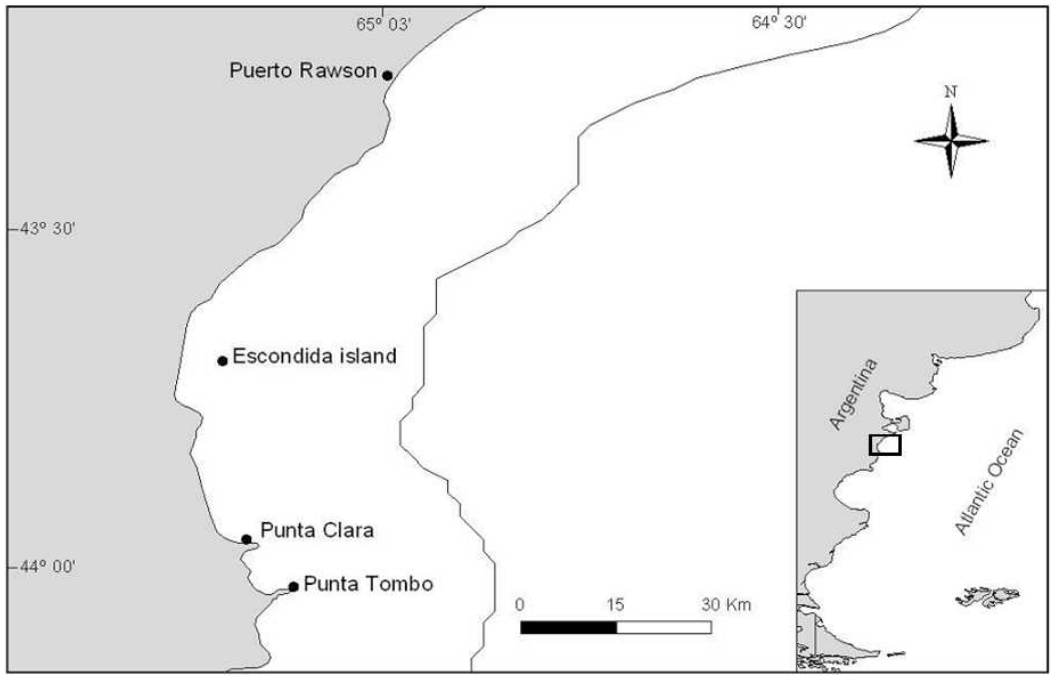

FIG. 1. Isla Escondida fishing area indicating location of Escondida Island, Punta Clara, and Punta Tombo, Argentina, seabird colonies.

al. 1998a, Yorio et al. 2005). Kelp Gulls and other gulls worldwide can negatively affect other coastal birds through predation, competition for breeding space and kleptoparasitism, and generate conflicts with human populations (Yorio et al. 1998a, Frere et al. 2000, Albarnaz et al. 2007). Thus, knowledge of how seabirds use fishery waste provided by the Isla Escondida coastal fishery will contribute to ecosystem-based fisheries management, and provide valuable information on the contribution of supplementary food to an expanding gull population. The goal of our study was to analyze the interactions between seabirds and coastal trawl vessels targeting Argentine red shrimp (*Pleoticus muelleri*) in the Isla Escondida fishing area with emphasis on the Kelp Gull. We identified the species composition of seabirds attending vessels during two fishing seasons, quantified their relative abundance in relation to the fishing season and stages of fishing operations, quantified mortality as a result of incidental capture of birds attracted to the vessels to make use of fishery waste, and assessed the quantity and composition of discards potentially available to seabirds.

METHODS

Study Area and Characteristics of the Fishery.—The study area comprised the coastal waters up to 22.2 km offshore under the jurisdiction of Chubut Province from 43° 20′ S to 44° 02′ S ('Isla Escondida' fishing area) (Fig. 1). The coastal trawl fishery operating at Isla Escondida targets Argentine red shrimp or Argentine hake (*Merluccius hubbsi*) depending on resource availability and market demands, but we only evaluated shrimp vessels which were responsible for about 80% of the effort of the fishery during the study years. The fishery consists of 35–40 coastal ice trawlers, 21 m long, which operate from November to March. Shrimp vessels remain 1 or 2 days in the fishing area, making on average seven hauls per day lasting on average 1 hr each (Secretaría de Pesca de la Provincia de Chubut, unpubl. data). Shrimp are sorted on deck, and non-commercial sizes and bycatch species are discarded overboard either as a constant stream or in pulses depending on the composition of the catch.

The study area includes three breeding sites (Fig. 1) of seabirds which regularly interact with coastal fisheries in Patagonia: Punta Tombo, Punta

Clara, and Escondida Island (Yorio et al. 1998b). Punta Tombo (44° 02′ S, 65° 11′ W) is one of the main breeding sites of Magellanic Penguins (*Spheniscus magellanicus*; 175,000 pairs) on the Patagonian coast, and has the main Kelp Gull colony in this coastal sector (5,400 pairs). Other species breeding at this location include Imperial Shag (*Leucocarbo atriceps*) and Brown Skua (*Stercorarius antarcticus*). Punta Clara (43° 58′ S, 65° 15′ W), 7 km north of Punta Tombo, includes 70,000 Magellanic Penguin and 40 Kelp Gull pairs. About 500 Imperial Shag pairs breed at Escondida Island (43° 43′ S, 65° 17′ W). Kelp Gulls in the study area start laying in early November, most eggs hatch in early January, and chicks fledge during February (Bertellotti and Yorio 1999). Magellanic Penguins arrive at breeding sites in early September, start laying in early October, eggs start hatching in early November, most chicks fledge in February, and the last adults leave the colony for their winter migration during April (Boersma et al. 1990). Imperial Shags arrive at the Punta Tombo colony during August, start laying in late October, eggs hatch in late November, and the last chicks fledge in late March (Malacalza 1984).

Species and Abundance of Seabirds Attending Vessels.—We gathered information on board 15 coastal shrimp trawlers (38% of the fishing fleet) during regular fishing operations from December 2006 to March 2007 and from December 2007 to February 2008. We gathered information during each trip for only one haul per day during midday, totaling 20 hauls (20 fishing days) in each of the fishing seasons. More than 80% of hauls in each season corresponded to the months of January and February, i.e., during seabird incubation and chick rearing. We identified seabirds attending the vessel during all hauls to species level and recorded their numbers. We made counts during a 10-min observation period from the stern of the vessel, only once at the beginning of discarding (sorting and discarding fish while towing the net), covering up to a 100-m radius. We also gathered information during haulback (lifting of the net to the vessel) during the 2007–2008 fishing season and identified Kelp Gulls into adult and young (juvenile and sub-adult) individuals based on plumage characteristics (Bo et al. 1995). We defined frequency of occurrence as the percentage of hauls in which each species was observed. In addition, we recorded the number of fishing vessels operating within sight (<10 km) for each haul.

Seabird Incidental Mortality.—We obtained information on incidental captures of seabirds in nets, including species' identity and number of birds caught in each haul, from the data base of the On-board Observer Program of Chubut Province, of which the first author was part, for the 2006–2008 period (n = 3,149 hauls). In addition, for the 40 hauls in which we evaluated seabird attendance, we quantified their interaction with warp cables to examine the occurrence of contacts and associated mortality. Observations at each haul were made from the stern of the vessel during the period when fish were discarded (~10 min to 3 hrs, depending on size of the catch).

Spatial Distribution of the Fishery and Discard Composition.—We mapped the distribution of hauls in both fishing seasons obtained from the data base of the On-board Observer Program of Chubut Province using ArcView 3.2 (ESRI 1998) to assess the spatial and temporal distribution of operating shrimp vessels. We present haul distribution as density maps on a 5 × 5 km grid. We calculated the distances of each haul to Punta Tombo, Punta Clara, and Escondida Island using the same software.

We estimated the total amount discarded by the coastal trawl fishery in each study year extrapolating the mean value (in kg) corresponding to hauls evaluated by the On-board Observer Program during the entire fishing season (Nov to Mar) to the total number of hauls made by the fishery during that period. We estimated the total number of hauls made by the fishery by dividing the declared catch in the study period (Secretaría de Agricultura, Ganadería, Pesca y Alimentación of Argentina, unpubl. data) by the mean catch of observed hauls (On-board Observer Program of Chubut Province, unpubl. data). We estimated the amounts discarded per haul subtracting the retained catch from the total catch, and obtained the total catch for each haul averaging the independent estimates made by the vessel captain and the on-board observer.

We obtained information on the catch composition by shrimp vessels from the data base of the On-board Observer Program of Chubut Province, totaling 1,219 hauls corresponding to the months of December to March and December to February in the 2006–2007 and 2007–2008 fishing seasons, respectively. Personnel of the On-board Observer Program estimated the abundance of caught prey in each haul and assigned them to one of four

TABLE 1. Frequency of occurrence (%F) and abundance (mean ± SD; range in parentheses) per haul of seabirds attending coastal shrimp trawlers in the Isla Escondida area, Argentina, during fishing seasons of 2006–2007 (n = 20 hauls) and 2007–2008 (n = 20 hauls). (*): Species that breed in Chubut.

Species	2006–2007		2007–2008		Mann-Whitney
	%F	Abundance	%F	Abundance	
Kelp Gull* (*Larus dominicanus*)	100	112.3 ± 68.4 (30–270)	100	263.4 ± 384.3 (32–1,700)	$P = 0.09$
Black-browed Albatross (*Thalassarche melanophris*)	85	17.6 ± 18.0 (0–60)	90	32.4 ± 47.3 (0–210)	$P = 0.39$
White-chinned Petrel (*Procellaria aequinoctialis*)	50	5.9 ± 9.5 (0–30)	90	9.9 ± 11.7 (0–55)	$P = 0.20$
Imperial Shag* (*Leucocarbo atriceps*)	75	7.3 ± 15.3 (0–70)	90	17.8 ± 29.5 (0–100)	$P = 0.14$
Magellanic Penguin* (*Spheniscus magellanicus*)	30	0.8 ± 1.3 (0–4)	55	13.7 ± 24.9 (0–80)	$P = 0.04$
Southern Giant Petrel* (*Macronectes giganteus*)	45	1.1 ± 1.8 (0–6)	25	0.9 ± 2.7 (0–12)	$P = 0.03$
Great Shearwater (*Puffinus gravis*)	5	0.3 ± 1.1 (0–5)	45	1.4 ± 2.2 (0–8)	$P = 0.006$
Sooty Shearwater (*P. griseus*)	30	1.6 ± 3.2 (0–11)	0	0	$P = 0.009$

categories, based on their percent representation in the catch: (1) dominant (Do): >50% of the catch, its presence gives the general appearance to the catch; (2) abundant (Ab): between 25 and 50% of the catch, its presence is easily detected; (3) common (Co): between 5 and 25% of the catch, its presence is detected when paying attention and searching through the catch; and (4) rare (Ra): <5% of the catch, only a few individuals. Similarly, the fate of species caught in each haul was assigned to one of three categories: (1) totally discarded (TDi), (2) totally retained (TRe), and (3) partially retained (PRe). We defined the frequency of occurrence for each caught species as the percentage of hauls in which each species in the catch was observed.

RESULTS

Species and Abundance of Seabirds Attending Vessels.—Eight seabird species were recorded foraging upon discards from the coastal shrimp fishery in the Isla Escondida area (Table 1). The most frequent and abundant seabird was the Kelp Gull, which was present at all hauls evaluated in both years, followed by Black-browed Albatross (*Thalassarche melanophris*) (Table 1). Flock size of both species varied throughout the fishing season, reaching 270 and 1,700 Kelp Gulls, and 60 and 210 Black-browed Albatrosses in the two study seasons, respectively (Fig. 2). Young Kelp Gulls during the 2007–2008 fishing season were recorded at 85% of hauls, but in significantly lower numbers than adults ($\bar{x}$ ± SD, 44.2 ± 88.0.; range = 0–400; n = 20 vs. 219.3 ± 300.8; range = 25–1,300; n = 20, respectively; Wilcoxon test $W = 0.002$, $P < 0.0001$).

Frequencies of occurrence of White-chinned Petrels (*Procellaria aequinoctialis*) and Imperial Shags, particularly during the 2007–2008 fishing season, were relatively high, although abundances were relatively low (Table 1). The highest number of White-chinned Petrels was recorded during the 2007–2008 fishing season (55 individuals). When present, Imperial Shag numbers varied between 1 and 100 individuals (Fig. 2). Magellanic Penguins and Great Shearwaters (*Puffinus gravis*) during 2007–2008 had frequencies of occurrence <50%, but their abundances were low (Table 1). Southern Giant Petrels (*Macronectes giganteus*) and Sooty Shearwaters (*P. griseus*) had low frequencies of occurrence and only a few individuals per haul.

The mean numbers of Magellanic Penguins, Southern Giant Petrels, Great Shearwaters, and Sooty Shearwaters were significantly higher during 2007–2008 than in 2006–2007 (Table 1). Only the Kelp Gull and Black-browed Albatross of the four most frequent and abundant species attending vessels had significantly higher numbers during discarding than haulback (Table 2). Numbers of Kelp Gulls and Black-browed Albatrosses attending a vessel were significantly higher when there were only one or two vessels operating simultaneously than when there were three or more (Kelp Gulls: 569.5 ± 623.1 vs. 132.2 ± 69.9, Mann-Whitney $U = 82$, $P = 0.03$; Black-

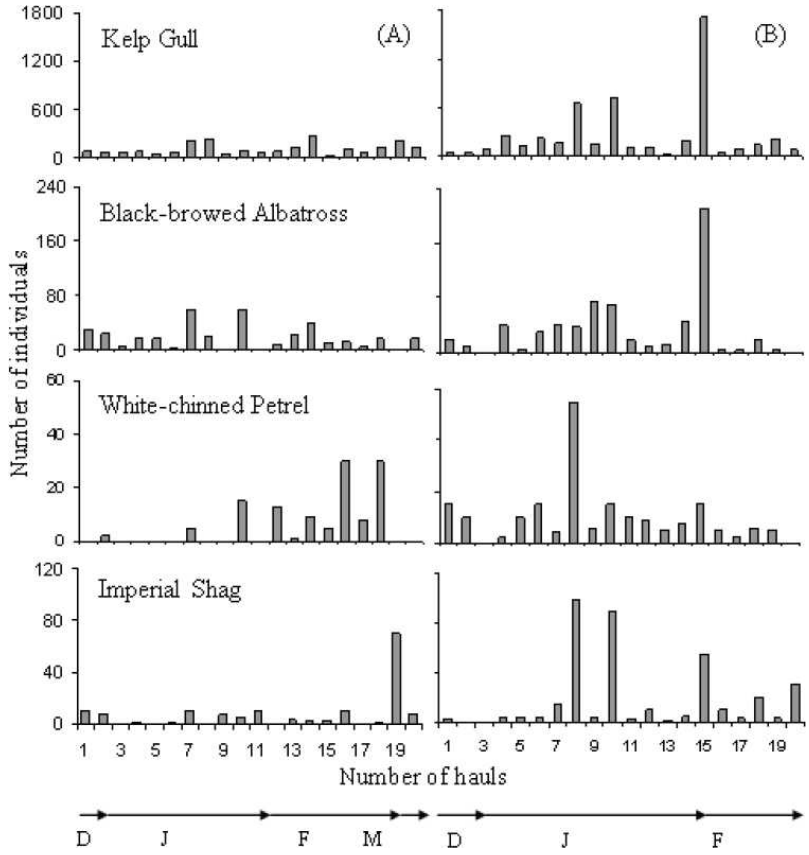

FIG. 2. Numbers of the four most frequent and abundant seabird species attending coastal shrimp trawlers in the Isla Escondida area, Argentina, during the (A) 2006–2007 and (B) 2007–2008 fishing seasons.

browed Albatross: 64.8 ± 73.8 vs. 18.4 ± 22.0, Mann-Whitney $U = 88$, $P = 0.01$).

Incidental Seabird Mortality.—Fifteen individuals were caught in 3,149 hauls evaluated by the On-board Observer Program, of which three were able to escape alive. The 12 birds killed included 11 Magellanic Penguins and one Imperial Shag, resulting in a mean mortality rate of 0.003 and 0.0003 birds per haul, respectively. Extrapolating this value to the total number of hauls by the Isla Escondida fishery in the 2 years ($n = 15{,}232$ hauls), we estimated a total of 53 penguins and 5 shags were killed in nets. These estimates are an indication of the actual numbers of birds killed. No contacts (fatal and non-fatal) between seabirds and warp cables were recorded ($n = 40$ hauls).

Spatial Distribution of the Fishery and Discard Composition.—Hauls were distributed between 43° 30′ and 44° 10′ S during both study years with most occurring between 43° 65′ and 43° 75′ S

TABLE 2. Mean ± SD (range in parentheses) of individuals per haul during two different stages of the fishing operation ($n = 20$), for the four most frequent and abundant seabird species attending vessels in the Isla Escondida area, Argentina, during the 2007–2008 fishing season.

Species	Haulback	Discarding	Wilcoxon test
Kelp Gull	131.5 ± 204.9 (0–750)	263.4 ± 384.3 (32–1,700)	$P < 0.0001$
Black-browed Albatross	21.5 ± 33.3 (0–120)	32.4 ± 47.3 (0–210)	$P < 0.0001$
Imperial Shag	18.8 ± 42.2 (0–160)	17.8 ± 29.5 (0–100)	$P = 0.99$
White-chinned Petrel	7.1 ± 10.2 (0–35)	9.85 ± 11.7 (0–55)	$P = 0.10$

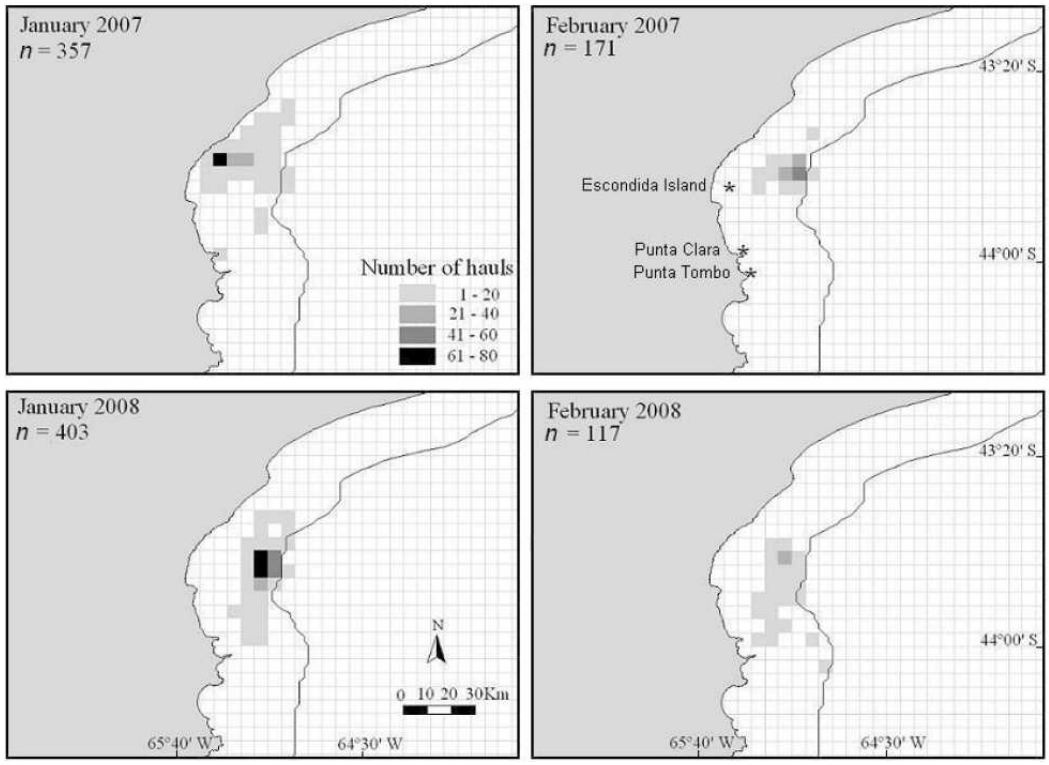

FIG. 3. Spatial distribution of hauls by coastal shrimp trawlers in the Isla Escondida area, Argentina, during January and February 2006–2007 and 2007–2008.

(Fig. 3). Hauls were generally between 15 and 20 km offshore, although in January 2007 some hauls were <5 km from the coast (Fig. 3). Coastal shrimp vessels operated at a mean distance from Punta Tombo of 43.9 ± 10.0 km (range = 7.1–73.3; n = 1,219), while mean distance to Punta Clara was 38.0 ± 9.5 km (range = 1.5–67.5; n = 1,219). Mean distance between operating vessels and the Imperial Shag colony at Escondida Island was 20.4 ± 6.5 km (range = 2.8–46.6; n = 1,219). Distances to these colonies decreased significantly as the breeding season progressed (Table 3).

At least 100 species were discarded in the 1,219 evaluated hauls, of which 48% were fish (Table 4; only species with >20% of frequency of occurrence are shown). Argentine hake was recorded in 76% of hauls. Hake was totally retained in only 0.7% of hauls, while it was discarded (74.3%) or partially retained (25.0%) in the rest of the hauls. Several of the remaining discarded species were present in the catch in relatively high frequencies, but were categorized as rare in over 83% of hauls (Table 4). Thus, the Argentine hake was the main species discarded. The estimated amount of discards per haul was significantly higher in the 2007–2008 than in the 2006–2007 fishing seasons (513.46 ± 576.43 kg; range = 0–8,000; n = 1,152 vs. 305.05 ± 382.86 kg; range = 0–2,490; n = 469) (Mann-Whitney U = 285,847.50 P < 0.0001). Total amount discarded by this coastal trawl fishery was estimated at 3,284 tonnes in 2006–2007 and 6,590 tonnes in 2007–2008.

DISCUSSION

Eight seabird species attended shrimp coastal trawlers operating in the Isla Escondida fishing area, although the seabird assemblage was dominated by the Kelp Gull and Black-browed albatross. Species composition differed from that reported in a previous study in the same fishing area during the mid 1990s, when 16 seabird species were recorded taking advantage of discards (Yorio and Caille 1999). The reason for this difference is not clear, but five of the species not recorded during the present study (Cape Petrel

TABLE 3. Mean distance (± SD; range in parentheses) between seabird colonies and hauls by vessels in the Isla Escondida area, Argentina, during the 2006–2007 and 2007–2008 fishing seasons.

Colony	Fishing season	Dec	Jan	Feb	Kruskal-Wallis test
Punta Tombo	2006–2007	56.0 ± 1.4 (52.5–57.3)	47.9 ± 8.6 (7.1–71.9)	43.2 ± 3.1 (33.8–58.0)	$H = 90.79$; $P < 0.0001$
	2007–2008	50.6 ± 8.3 (31.2–73.3)	39.8 ± 8.9 (11.6–61.6)	36.9 ± 8.7 (8.2–45.8)	$H = 244.71$; $P < 0.0001$
Punta Clara	2006–2007	49.8 ± 1.4 (46.2–51.0)	41.3 ± 8.7 (1.5–65.9)	37.4 ± 3.1 (26.8–52.1)	$H = 55.81$; $P < 0.0001$
	2007–2008	44.4 ± 8.1 (25.9–67.5)	34.2 ± 8.5 (10.1–55.9)	31.4 ± 7.8 (6.2–39.5)	$H = 244.84$; $P < 0.0001$
Escondida Island	2006–2007	26.7 ± 13.1 (23.4–27.9)	18.2 ± 9.1 (2.8–42.7)	20 ± 3.1 (7.7–31)	$H = 47.17$; $P < 0.0001$
	2007–2008	23.3 ± 6.3 (23.4–27.9)	20.1 ± 4.2 (13.2–34.8)	18.9 ± 4.5 (13.7–46.6)	$H = 69.68$; $P < 0.0001$

[*Daption capense*], Southern Fulmar [*Fulmarus glacialoides*], Manx Shearwater [*Puffinus puffinus*], Brown-hooded Gull [*Chroicocephalus maculipennis*], and Brown Skua) were recorded in only one of the fishing days sampled in the mid 1990s. Yorio and Caille (1999) did not present information on number of birds attending vessels, and comparisons of relative abundances between both studies can not be made.

The Kelp Gull was the only species among the Patagonian breeders that made extensive use of discards. Kelp Gulls in the Isla Escondida area were present at all sampled hauls during both fishing seasons, reaching 1,700 individuals in 2007. These results agree with previous studies, where Kelp Gulls were present in >90% of evaluated hauls and in numbers that often reached several hundred individuals (Yorio and Caille

TABLE 4. Catch composition in the coastal shrimp fishery in the Isla Escondida area, Argentina, during the 2006–2007 and 2007–2008 fishing seasons ($n = 1{,}219$ hauls). Only species with >20% of frequency of occurrence (%F) are shown.

Species	%F	Abundance				Fate		
		Do[a]	Ab[b]	Co[c]	Ra[d]	TDi[e]	TRe[f]	PRe[g]
Argentine red shrimp (*Pleoticus muelleri*)	92.9	68.9	18.2	7.3	5.6	2.5	68.2	29.2
Argentine hake (*Merluccius hubbsi*)	76.0	0.6	1.2	18.8	79.4	74.3	0.7	25.0
Flatfish (Paralichthyidae)	83.6	0.3	0.3	0.2	99.2	98.7	0.7	0.7
Squid (*Loligo* spp.)	75.5	0.2	1.1	2.9	95.8	97.7	1.2	1.1
Butterfish (*Stromateus brasiliensis*)	60.4	0.0	0.1	0.0	99.9	100.0	0.0	0.0
Brasilian flathead (*Percophis brasiliensis*)	59.3	0.0	0.0	7.14	92.9	99.7	0.0	0.3
Rays (Rajidae)	54.3	0.0	0.0	0.0	100.0	100.0	0.0	0.0
Argentine seabass (*Acanthistius brasilianus*)	48.7	0.2	0.6	1.5	97.8	94.4	1.9	3.7
Parona leatherjacket (*Parona signata*)	46.7	3.0	1.5	10.6	84.8	95.0	2.1	2.9
Castaneta (*Nemadactylus bergi*)	46.1	0.4	1.0	15.1	83.5	100.0	0.0	0.0
Argentine shortfin squid (*Illex argentinus*)	44.5	0.0	0.2	0.6	99.2	94.7	1.2	4.1
Elephant fish (*Callorhinchus callorhynchus*)	35.5	0.0	0.0	0.3	99.7	94.6	0.5	4.8
Sharks (Triakidae, Squalidae, and Squatinidae)	29.4	0.0	0.0	0.0	100.0	97.1	0.3	2.6
Banded cusk eel (*Raneya brasiliensis*)	26.5	0.0	0.0	0.0	100.0	100.0	0.0	0.0
Argentinian sandperch (*Pseudopercis semifasciata*)	25.3	0.0	0.0	1.4	98.6	50.5	35.5	14.0
Brazilian sandperch (*Pinguipes brasilianus*)	23.0	0.0	0.0	0.4	99.6	100.0	0.0	0.0
Argentine anchovy (*Engraulis anchoita*)	20.0	6.3	0.0	3.1	90.6	100.0	0.0	0.0

[a] Dominant: >50% of the catch, its presence gives the general appearance to the catch.
[b] Abundant: between 25 and 50% of the catch, its presence is easily detected.
[c] Common: between 5 and 25% of the catch, its presence is detected when paying attention and searching through the catch.
[d] Rare: <5% of the catch, only a few individuals.
[e] Totally discarded.
[f] Totally retained.
[g] Partially retained.

1999, Bertellotti and Yorio 2000b, González-Zevallos and Yorio 2006). The regular presence of Kelp Gulls in this and other fisheries in the region is the result of its generalist and opportunistic feeding habits, which are mainly characterized by coastal feeding and regular use of human-derived food sources (Bertellotti and Yorio 1999, Yorio et al. 2005).

Black-browed Albatrosses are also regularly present at trawl fisheries in the southwest Atlantic (Thompson 1992, Thompson and Riddy 1995, Yorio and Caille 1999, González-Zevallos and Yorio 2006, Bugoni et al. 2011, Favero et al. 2011) and in other regions of the Southern Hemisphere (Abrams 1983, Ryan and Moloney 1988, Petyt 1995). Mean abundance in the Isla Escondida area was relatively lower than observed at coastal trawlers in Golfo San Matías and Golfo San Jorge, Patagonia (Yorio and Caille 1999). In contrast, both abundance and frequency of occurrence of Black-browed Albatross at hake and shrimp high-sea trawlers operating in Golfo San Jorge were larger, on occasions reaching numbers per haul three times greater than recorded at Isla Escondida (González-Zevallos et al. 2007, González-Zevallos et al. 2011). This may be the result of larger amounts of fishery waste discarded overboard and/or the greater distances offshore at which the high-seas trawlers operate (González-Zevallos et al. 2011).

Only the Kelp Gull and Black-browed Albatross of the most abundant seabird species attending vessels had significantly higher abundances during discarding activities. Differences among species may relate to their feeding behaviors. Kelp Gulls and Black-browed Albatrosses obtain food mainly through surface feeding, while Imperial Shags and White-chinned Petrels do so by diving (González Zevallos and Yorio 2006). Thus, diving species start obtaining prey directly from the net or capturing those that fall off the net as it reaches the surface during haulback, while gulls and albatrosses increase in numbers as a result of their attraction when prey start to be available during discarding. Birds were often observed moving among vessels as in other fisheries in Patagonia (Bertellotti and Yorio 2000b, González Zevallos and Yorio 2006).

Argentine hake was the main discard component, as it was one of the most frequently caught species and was totally retained on board in only a few cases. Previous studies in Patagonia have shown that Argentine hake is one of the most taken species by adult and young Kelp Gulls feeding on discards (Bertellotti and Yorio 2000b, González-Zevallos and Yorio 2006, González-Zevallos and Yorio 2011). The Argentine hake is a demersal fish not normally available to seabirds that surface-feed, such as the Kelp Gull, and it constitutes an important supplementary food resource. The use of this food may be advantageous for Kelp Gull breeding success and survival, as several studies have shown that fish are important for both egg formation and chick growth of gulls (Pierotti and Annett 1991, Bolton et al. 1992) and may favor long-term breeding performance (Annett and Pierotti 1999).

The fishing season in the Isla Escondida area coincides with the Kelp Gull's breeding season at Punta Tombo and Punta Clara. However, discards were not uniformly available within the known foraging range of this species during the breeding season. Several studies have shown the relative contribution of supplementary food in gull diets is related to accessibility of these resources (Oro 1995, Bertellotti and Yorio 1999, Pedrocchi et al. 2003, Duhem et al. 2005, Ramos et al. 2009). Thus, the extent of discard use and its potential effect on breeding success in a given locality would depend on the spatio-temporal pattern of vessel distribution. Discard availability could be particularly beneficial for young Kelp Gulls which, in contrast to breeders, are not spatially constrained to the nest during foraging activities. Young Kelp Gulls were recorded in most hauls during this study. Young individuals are in general less efficient than adults in obtaining food (Burger 1987, Hockey and Steele 1990, Bertellotti and Yorio 2000a). Thus, discard use may have an important influence on survival, particularly during February and March when young gulls start to become independent from their parents.

Seabird attraction to vessels to make use of discards may lead to an increase in mortality resulting from interaction with fishing gear (González-Zevallos and Yorio 2006, Sullivan et al. 2006, Watkins et al. 2008). Incidental mortality in nets was associated with diving species such as Magellanic Penguin and Imperial Shag, most likely because these species dive to take prey directly from the net during haulback increasing their chances of becoming entangled. Studies at Punta Tombo show that breeding Magellanic Penguins during December and January forage in relatively coastal areas at mean distances of

110 km north of the colony (Boersma and Rebstock 2009), and may spatially overlap with vessels operating in the Isla Escondida area. Similarly, the distance of operating vessels to the Imperial Shag colony at Escondida Island, particularly during January 2007, was within the foraging range recorded for breeding shags at other locations in Chubut (Yorio et al. 2010; F. R. Quintana, unpubl. data). The population sizes of Magellanic Penguins and Imperial Shags in the study area were estimated at 490,000 and 1,000 individuals, respectively (Yorio et al. 1998b). It is unlikely that mortality in nets at coastal shrimp trawlers has a significant impact on their populations, although adult mortality should not be underestimated given seabird life-history traits (Sæther and Bakke 2000). No interactions with cables were recorded at coastal shrimp trawlers in the Isla Escondida area in contrast to that observed for hake trawlers at Golfo San Jorge, where Black-browed Albatrosses and Kelp Gulls were killed by warp cables (González-Zevallos et al. 2007). This could be the result of differences in fishing gear dimension and configuration. Outriggers in coastal shrimp trawlers stretch about 3–4 m off the side of the vessel and cables do not reach the stern of the vessel where most birds concentrate to make use of discards.

The coastal shrimp fishery at Isla Escondida appears to have a small impact on seabirds in terms of incidental mortality but provides significant amounts of supplementary food. This resource is more relevant as discard provision overlaps with the Kelp Gull's breeding season, although actual use by breeders may depend on the spatial and temporal distribution of hauls. The fishery in the Isla Escondida area can also target Argentine hake, and changes in both net and mesh sizes, and in the characteristics of the fishing operation may result in differences in composition and amounts of discards. These variables can affect the composition and abundance of seabirds attending vessels, the way and effectiveness at which each species uses available dicards, and their probability of being killed in fishing gear (Arcos and Oro 2002, Furness et al. 2007, Favero et al. 2011). Fishing for Argentine red shrimp and Argentine hake may often coincide in time and space. Thus, the effects of coastal hake trawlers on seabirds should be assessed in conjunction with those of shrimp trawlers to obtain a more integrated view of the interaction between the Isla Escondida fishery and seabird populations.

ACKNOWLEDGMENTS

We thank Centro Nacional Patagónico (CONICET) for institutional support, Secretaría de Pesca de la Provincia de Chubut for logistical support and for providing data from the On-board Observer Program, and the Wildlife Conservation Society for financial support. We especially thank M. E. Góngora, D. R. González-Zevallos, N. D. Bovcon, P. O. Dell'Arciprete, J. R. C. Saravia, and the captains and crews of the coastal shrimp trawlers for their help and advice.

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