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Potential bycatch of seabirds and turtles in hook-and-line fisheries of the Itaipava Fleet, Brazil

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Abstract

The decline of populations of certain seabirds and sea turtles around the world is partly related to their incidental capture in large-scale fisheries. However, the impacts of small-scale fisheries on endangered seabirds and sea turtles, being carried out in many places around the world, have been largely neglected by scientists and governments. We monitored 178 fishing days and described a range of poorly known hook-and-line commercial fisheries carried out by the Itaipava fleet, southeastern Brazil, composed by 497 vessels and deploying hooks from 18°S to 35°S. Seven fisheries were defined: fast trolling for tuna and tuna-like species, slow trolling for Bigeye tuna, handlining, surface longline for Dolphinfish, pelagic longline for Swordfish, bottom dropline, and pole-and-line with live bait. We observed bycatch of 47 seabirds of six species and 45 turtles of four species. Capture rates were higher for the surface longline for Dolphinfish (0.15 birds/1000 hooks and 1.08 turtles/1000 hooks), slow trolling for Bigeye tuna (0.41 birds/day) and handlining targeting Yellowfin tuna (0.61 birds/day). Endangered Spectacled petrel (*Procellaria conspicillata*), Atlantic Yellow-nosed (*Thalassarche chlororhynchos*), and Black-browed (*T. melanophris*) albatrosses were the main seabirds caught. Immature Loggerhead turtles (*Caretta caretta*) and immature or adult Leatherback turtles (*Dermochelys coriacea*) were the main sea turtles affected by the surface longline for Dolphinfish. Monitoring the fleet and bycatch levels, development of mitigation measures, establishment of educational programs, government control over the fleet, and enforcement, are urgently required for the hook-and-line fisheries described in the present study.

Keywords: Bycatch; Albatross; Petrel; Fishery description; Loggerhead turtle; Leatherback turtle

1. Introduction

Fisheries are a major cause of mortality for seabirds and sea turtles around the world (National Research Council, 1990; Brothers et al., 1999), accounting for the decline of several species (Gales, 1997; Lewison et al., 2004). An important cause of seabird mortality is the interaction with pelagic longlines for tunas (*Thunnus* spp.) and Swordfish (*Xiphias gladius*), which have received much attention of scientists (e.g. Gales, 1997; Brothers et al., 1999). Fisheries such as gillnet, trawling, and dropline have been considered a minor mortality factor for pelagic seabirds (Gales, 1997), but recent studies show that some other fisheries cause high mortality levels. Around Malvinas-Falkland Islands, Sullivan et al. (2006) estimated a mortality rate of 0.47 seabirds per fishing day per vessel in the factory trawl fleet for finfish. Gillnets targeting Monkfish (*Lophius gastrophysus*) off the Brazilian coast were estimated to kill 802 petrels and albatrosses in 2001 (Perez and Wahrlich, 2005).

Trawl, gillnet and longline are the main fisheries reported to capture sea turtles (National Research Council, 1990; Oravetz, 1999). Trawling for fish and shrimp is estimated to kill 150,000 turtles annually around the world, mostly Loggerhead (*Caretta caretta*), Leatherback (*Dermochelys coriacea*) and Green (*Chelonia mydas*) turtles (Oravetz, 1999), while pelagic longlines captured in 2000 an estimated 200,000 Loggerheads and 50,000 Leatherbacks (Lewison et al., 2004). Despite several uncertain-

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ties regarding these estimates, they give an approximation of the global impacts on sea turtles.

In the Southwestern (SW) Atlantic Ocean, which encompasses waters off Brazil, Uruguay, Argentina, and adjacent international waters, detailed studies on seabird bycatch have focused on pelagic and demersal longlines (Neves and Olmos, 1997; Seco-Pon et al., 2007), while few studies considered other fisheries (e.g. Perez and Wahrlich, 2005). Neves and Olmos (1997) reported 0.12 birds/1000 hooks in the pelagic longline fishery mostly Black-browed albatross (*Thalassarche melanophris*), Yellow-nosed albatross (*Thalassarche chlororhynchos*) and White-chinned petrel (*Procellaria aequinoctialis*). Although seabird mortality is historically related to the longline fishery (pelagic and bottom) carried out by the domestic and leased fleet, other fisheries – such as pole-and-line with baitboats, gillnetting, trawling and drift netting have potentially relevant incidental capture rates and must be evaluated (Neves et al., 2006). Regarding sea turtles, a range of fisheries are also important mortality factors (Bugoni et al., 2001) and at least 13 fisheries were identified to capture sea turtles in the SW Atlantic Ocean (Domingo et al., 2006), but detailed information exists only for a few fisheries, particularly pelagic longline, in which bycatch varies from 0.68 to 2.85 turtles/1000 hooks (Domingo et al., 2006).

The SW Atlantic waters have an important role in the life cycle of five sea turtle species nesting in Brazil, as well as migrating sea turtles from other areas, such as Leatherback turtles from Gabon, the second largest nesting ground in the world, and Green turtles from Ascension Island, both migrating to the area after nesting (Domingo et al., 2006). Similarly, Brazil holds important populations of albatrosses and petrels which breed in Antarctic and sub-Antarctic Islands, Patagonia, Tristan da Cunha and Gough Islands, New Zealand, British Isles, Azores, Madeira and Cape Verde Islands (Neves et al., 2006). Some species are found in the area during non-breeding periods, while others perform long foraging trips during breeding to fish in Brazil and feed chicks in remote islands.

While most studies in Brazil and elsewhere have focused on large-scale fisheries, small-scale or artisanal fisheries could also have impacts on seabirds and sea turtles, but have been neglected by scientists and regulatory agencies. For instance, there is a large high seas pelagic fleet in Itaipava port, a small village on the Espírito Santo coast, southeastern Brazil which originated in 1988, after the collapse of coastal resources targeted using artisanal methods and small vessels. Currently, the fleet is composed of 497 vessels up to 14 m long, targeting tunas, Dolphinfish (*Coryphaena hippurus*), and Swordfish, as well as bottom rocky and reef fishes, and using a range of artisanal hook-and-line gears and techniques (Martins et al., 2005). Fishing methods used by the Itaipava fleet have not been described and there is no regulation or management by the government. The size of the fleet and methods used, associated with fishermen's reports of seabirds and sea turtles frequently being captured make it a major conservation concern.

The present paper aims to describe several poorly known fisheries using hook-and-line methods in Brazil, to determine levels of incidental capture of seabirds and sea turtles, and to identify potential impacts on endangered species and conservation needs.

2. Methods

2.1. Study area

The study area stretches from 18°S to 35°S, corresponding to the fishing grounds of the Itaipava fleet or vessels from other southern ports using Itaipava-like methods. The area also encompasses the fishing grounds for the pole-and-line fleet using live bait and targeting Skipjack tuna (*Katsuwonus pelamis*), which departs from Rio Grande, Itajaí and Rio de Janeiro ports.

The Malvinas–Falklands current carries cool sub-Antarctic waters northward and meets the warm waters of the Brazil current flowing southward, forming the subtropical convergence between about 25°S and 45°S, a high productivity area that holds important fish stocks and considerable numbers of top predators (Odebrecht and Castello, 2001). In southern Brazil the continental shelf is wide (Fig. 1), with unconsolidated substrates, suitable for demersal fisheries such as trawling and bottom gill netting. Southern Brazil holds the bulk of Brazilian fishing effort as in northern areas the continental shelf is narrow, with coral reefs and shallow banks, where warm and oligotrophic waters of the Brazil current predominate (Fig. 1; Olavo et al., 2005).

2.2. Sampling methods and effort

Observers collected detailed descriptions of different fisheries, and data on incidental capture of seabirds and sea turtles, during 16 cruises. Additional data were obtained through interview with captains, crew and from the literature, in order to characterize variations and vulnerability of birds and turtles.

From 2001 to 2006, 15 cruises departed from ports of Itaipava, Cabo Frio, Santos, Itajaí and Rio Grande, covering the range of different commercial fisheries using hook-and-line.

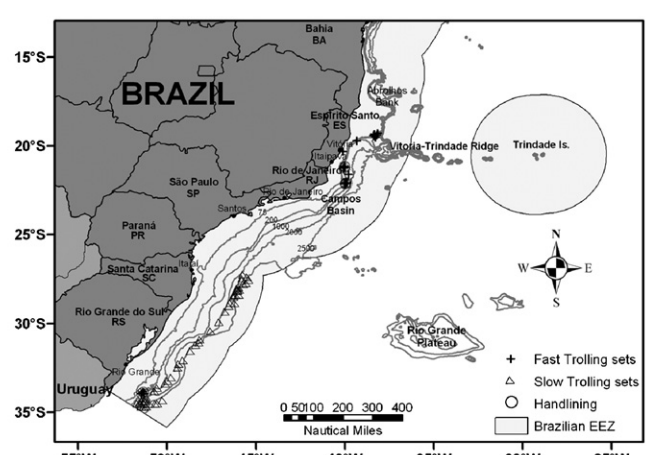

Fig. 1. Slow and fast trolling fishery sets sampled from 2002 to 2006 in SW Atlantic Ocean with Brazilian states, main fishing ports and exclusive economic zone (EEZ) indicated. Handlining fishing grounds for tuna operated near oilrigs in northern areas and moored buoys in southern areas are also indicated.

Table 1
Summary of sampling effort for each fishery using hook-and-line in Brazil, seabirds and sea turtles caught and capture rates

Fishery	Effort	No. of birds (capture rates ± standard deviation)	No. of turtles (capture rates ± standard deviation)	Bird species	Turtle species
Fast trolling	48 days	0	0	–	–
Slow trolling for Bigeye	39 days	16 (0.41 ± 0.68 birds/day, range: 0–2)	0	7 BBA, 4 GS, 3 SP, 1 AYNA, 1 WCP	–
Handlining	41 days	25 (0.61 ± 1.45 birds/day, range: 0–7)	0	11 SP, 8 GS, 6 AYNA	–
Surface longline for Dolphinfish	40 days & 40,717 hooks	6 (0.15 ± 0.58 birds/day, range:0–3 & 0.15 birds/1000 hooks)	44 (1.10 ± 1.72 turtles/day, range:0–8 & 1.08 turtles/1000 hooks)	2 AYNA, 2 *Thalassarche* sp., 1 MS, 1 WCP	21 LH, 14 LB, 8 GT, 1 OR
Pelagic longline for Swordfish	31 days & 11,974 hooks	0	1 (0.032 ± 0.18 turtles/day, range: 0–1 & 0.08 turtles/1000 hooks)	–	1 LB
Bottom dropline	20 days	0	0	–	–
Pole-and-line with live bait	41 days	0*	0	–	–

– Not applicable.
AYNA – Atlantic Yellow-nosed albatross *Thalassarche chlororhynchos*, BBA – Black-browed albatross *T. melanophris*, GS – Great shearwater *Puffinus gravis*, SP – Spectacled petrel *Procellaria. conspicillata*, WCP – White-chinned petrel *P. aequinoctialis*, MS – Manx shearwater *Puffinus puffinus*, GT – Green turtle *Chelonia mydas*, LH – Loggerhead turtle *Caretta caretta*, LB – Leatherback turtle *Dermochelys coriacea*, OR – Olive Ridley turtle *Lepidochelys olivacea*. *Interactions with seabirds described in the text (floating dead birds, and 17% of live sampled Great shearwater with injuries).

One cruise was assessed by logbook provided by the fishing master and validated through five other cruises with the same vessel and crew. Validating was performed by checking for the species reported in the logbook and by contacting the fishing master in the subsequent trips, which made it possible to confirm the accuracy of data provided. A total of 178 fishing days were sampled covering the range of fisheries described here, with sampling effort per fishery varying from 20 to 48 fishing days (Table 1). For the pole-and-line fishery using live bait and targeting Skipjack tuna, data on potential interactions with seabirds were assessed by observation of activities close to the vessel carrying the observer, as several vessels would fish around a moored buoy. In several cruises different fishing methods were used simultaneously or in different periods.

Fishing effort by surface longline for Dolphinfish and pelagic longline for Swordfish was expressed as number of hooks, and capture rate calculated as birds/1000 hooks or turtles/1000 hooks. Fishing effort for all fisheries was also presented as 'fishing day per vessel', and bycatch rate reported as birds/fishing day or turtles/fishing day allowing comparison of impacts among fisheries.

3. Results

3.1. Fishery description

Fisheries were defined according to parameters such as gear, target species, fishing operation, season, areas, as well as their potential threat to seabirds and sea turtles. According to these criteria, seven hook-and-line fisheries were described, as below.

3.1.1. Fast trolling

Trolling fishery, locally known as '*corrico*' is a technique in which lines are trailed from the stern of a boat at different speeds. Lines are usually thick (2.5 mm) with variable length (5–90 m) baited with squid, sardines, skin and meat of Skipjack tuna, fresh pork skin or artificial lures such as strips of white rubber. Hooks are around 11 cm in total length, 'J' type, with flattened eye and barbed, similar to the Mustad® No. 2 'general purpose sea hook'. Length of the line and vessel speed are adjusted according to target fish: lines 5–12 m long and 3 knots for Bigeye tuna, a fishery described below, and 70–90 m long and 7 knots for large Yellowfin tuna *Thunnus albacares*, Albacore *T. alalunga*, and Dolphinfish. The hook is trailed on or close to the sea surface and a fisherman holds the line by hand. The fleet operating at Espírito Santo and Rio de Janeiro coasts, which includes the important Campos Basin fishing ground (Fig. 1), departs from Itaipava and Vitória ports. Target species are the Dolphinfish and tunas.

Fishing operations frequently occur close to oilrigs, moored or floating buoys or other objects. When close to fish aggregating devices (FADs), trolling is frequently used in alternation with handlining: the boat trolls from a given location to the fishing point close to the FAD, when the boat is kept drifting and handlines deployed; after drifting a distance of a few hundred meters, troll lines are deployed and the boat moves again to the fishing point.

3.1.2. Slow trolling

Slow trolling is a derivation of the above fishery, basically differing in speed of the vessel, in using the vessel as a FAD, and targeting mainly Bigeye tuna (Schroeder and Castello, 2007). Its impact on seabirds is consistently different (Table 1) and management also requires a different approach. Simultaneous with slow trolling, pole-and-line gear is used as a secondary fishing method, and artificial bait (white plastic tube) is attached to the large hook.

3.1.3. Handlining

For the handlining fishery, each fisherman deploys a thin line against the current (1.2–1.4 mm) and the hook is around 6 cm in total length, ‘J’ type, similar to the Mustad® No. 7 ‘general purpose sea hook’; or the ‘Japanese type’ hook, which is around 6 cm in total length, rounded, with a ring at the eye and point not curved. Hooks are baited with squid, sardines, and Skipjack or small tunas’ meat. A few sardines or guts of tuna are released at the same time in order to attract the targeted Yellowfin and Albacore tunas associated with FADs. The boat sails against the current and the engine is turned off close to the FAD, lines and hooks released and the fishing takes place while the boat drifts a few hundred meters away from the FAD. Frequently, the boat returns to the point close to the FAD trolling for tuna, as described above. Live baits kept onboard (e.g. Rough scads *Trachurus lathami*, Mackerel *Scomber* spp., Brazilian sardines *Sardinella brasiliensis*, squids or small tunas and Skipjack up to 20 cm in length) are also used. While the boat is drifting, frequently the hook remains close to the surface several meters away from the vessels, due to a small swivel, which makes the chumming and hooks available for seabirds to scavenge. Fishermen try to avoid birds taking the hook, pulling the line when birds are nearby. Fishing grounds are along the Brazilian continental shelf and shelf break, but oilrigs in the north and moored buoys in the south are preferred areas (Fig. 1).

3.1.4. Surface longline for Dolphinfish

The gear consists of a multifilament 5 mm mainline up to 5.2 nautical miles long, two secondary lines between small styrofoam buoys, and hooks around 5 cm in total length, ‘J’ type, similar to the Mustad® No. 8 ‘general purpose sea hook’, baited with frozen Brazilian sardines, Skipjack meat or live bait (mackerel, or sardines). Secondary lines are 2 m long and hooks remain at 2–2.5 m from the surface (R. Dallagnolo, UNIVALI, *umpubl. data*). Itaipava fishermen developed this technique and it has spread to southern ports, with significant landings in Itajaí port (UNIVALI, 2004). It is a strongly seasonal fishery, in November and December in southern Brazil in waters 200 m depth, and from October to February off Rio de Janeiro and Espírito Santo coasts (Martins and Doxsey, 2006). Once or twice a day 600–1200 hooks are deployed for around 4 h, and the boat sails along the mainline, hauling caught fish and rebaiting hooks. This fishery is sometimes carried out during daytime, while the longline for Swordfish is carried at night. In the present study we sampled surface longline sets in both southern and northern fishing grounds (Fig. 2).

3.1.5. Pelagic longline for Swordfish

Detailed descriptions of the technique and gear used in the pelagic longline fishery for Swordfish are available from around the world (e.g. Brothers et al., 1999) and also in the SW Atlantic (Neves et al., 2006). However, the fleet based in Itaipava deploys a shorter mainline (12–18 nm) and lower number of hooks (800–1000) due to the small size of vessels. Their potential impacts on seabirds and sea turtles are thought to be high, as with traditional longlines.

3.1.6. Bottom dropline

The bottom dropline, locally named ‘pargueira’, is an artisanal gear with some variations, used to target large fish over rocks, sea mountains, coral reefs, or steep banks, up to 300 m deep. After a shoal is found by echo sounder, fishermen deploy the gear attaching the extremity to the vessel or holding it by hand. Dropline consists of a line 60–400 m long, with a swivel close to a stone or other weight (5 kg) used to keep the gear on the bottom. From the stone runs another main line 30–400 m long to which are attached 5–100 short secondary lines (0.4 m long) with hooks 5 cm of total length, ‘J’ type, flattened, similar to the Mustad® No. 8 or No. 9 ‘general purpose sea hook’. A distance of 30 cm separates secondary lines and at the end of the line another stone (10 kg) is attached. Basically, there are three variations of the fishery, from 10 to 100 hooks: a ‘hand dropline’ operated by several fishermen from the side of the vessel, the ‘small boat dropline’ or ‘*mar novo*’ in which a mother vessel releases 8–22 small glass fibre boats, operated by one or two fishermen around the mother vessel (Costa et al., 2005; Martins et al., 2005); and the ‘big dropline’, which is attached to a buoy and flag while the mother vessel release 5–10 droplines. The Itaipava fleet operates from southern Bahia to Santa Catarina (Fig. 2), in depths from 40 to 300 m, and the main target species are Snappers (*Ocyurus chrysurus*, *Lutjanus* spp., *Rhomboplites aurorubens*), Wreckfish (*Polyprion americanus*), Tilefish (*Lopholatilus vilarii*), Sandperch (*Pseudopercis munida*), Hakes (*Urophycis* spp.), and Groupers (*Epinephelus niveatus* and *E. marginatus*).

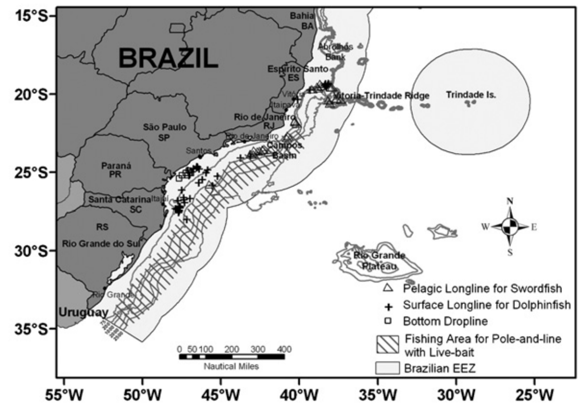

Fig. 2. Sets of surface longline for Dolphinfish, *Coryphaena hippurus*, pelagic longline for Swordfish, *Xiphias gladius*, and bottom dropline sampled by onboard observers in Brazil from 2004 to 2006. Shaded area corresponds to the fishing grounds for the pole-and-line fishery using live bait and targeting Skipjack tuna.

3.1.7. Pole-and-line with live bait

Under pole-and-line fishery we refer to industrial baitboat vessels targeting Skipjack tuna attracted to the vessel using live bait and a ‘shower-like’ method, frequently close to moored buoys and used worldwide to catch tuna. It started in Brazil in 1979 and now operated mainly from Itajaí and Rio Grande ports, all year round, in an area that extends from 20°S to 35°S (Castello and Habiaga, 1989; Meneses de Lima et al., 2000; Andrade et al., 2005, Fig. 2). Thirty-three vessels operate from the port of Itajaí (UNIVALI, 2004), six vessels from Rio Grande, and a small number from Rio de Janeiro.

3.2. Seabird bycatch

A total of 47 albatrosses and petrels were captured in this study, 16 by slow trolling, 25 by handlining and 6 by surface longline for Dolphinfish (Table 1). Other fisheries did not capture seabirds, but pole-and-line also caused seabird injuries and mortality, as reported below.

The trolling fishery had a mean capture rate of 0.069 birds/day, but due to differences in methods the fast trolling for Yellowfin tuna captured no seabirds, while the slow trolling for Bigeye tuna captured all 16 albatross and petrels (0.410 ± 0.68 birds/day, Table 1). However, due to the large size of hooks, most birds were entangled in the line or hooked in the bill with only one Great shearwater (*Puffinus gravis*) severely injured by external hooking.

Overall, handlining accounted for 25 seabirds captured (0.610 ± 1.45 birds/day) with a mortality rate of 0.143 birds/day. In spite of a capture rate comparable to the slow trolling for Bigeye tuna, the use of small hooks, which remain away from the vessel, caused six fatalities, i.e. birds were killed because they swallowed the hook.

In the surface longline fishery for Dolphinfish, four seabirds were caught and released alive and there were two fatalities, an overall rate of 0.147 birds/1000 hooks (or 0.15 birds/day). Due to small secondary lines and floating gear, baits remain available for seabirds during the whole fishing time, but this avoids drowning of hooked seabirds. For the pelagic longline for Swordfish, no seabird was caught, but number of hooks sampled was only 12,000 hooks.

In the bottom dropline sample, no incidental capture of seabird or sea turtle was recorded. The potential of this fishery for interaction with seabirds is low, but could cause a small bycatch of sea turtles, as reported by fishermen, or entanglement in the mainlines as reported in Uruguay (Laporta et al., 2006).

The fleet using live bait to target Skipjack tuna attracts large numbers of seabirds, mostly Cory's shearwaters (*Calonectris diomedea*), Cape Verde shearwaters (*Calonectris edwardsii*) and Great shearwaters. Fishermen try to scare birds by hitting them with a metal piece attached to a pole-and-line. From a sample of 30 Great shearwaters trapped at sea for another project, five birds (17%) had severe injuries (broken legs and scars on the back, neck and head). Injuries reported here were underestimated because they do not include lethal ones. In addition, at least four dead shearwaters (Great shearwater and unidentified *Calonectris*) were observed floating on the sea surface in a single day in February 2006, probably killed in this way, as they were near three pole-and-line and ten handlining/trolling vessels fishing close to a moored buoy.

3.3. Sea turtle bycatch

Sampled fisheries captured 45 sea turtles: 44 by surface longline for Dolphinfish and one by pelagic longline for Swordfish. Other fisheries described here did not capture turtles. Fishermen reported occasional capture of turtles by bottom dropline, but these fisheries probably cause minor impacts on turtles.

Forty-four sea turtles of four species were captured by the surface longline for Dolphinfish, a rate of 1.08 turtles/1000 hooks (1.10 ± 1.72 turtles/day). Capture rate was high for Loggerheads (0.516 turtles/1000 hooks) and Leatherbacks (0.343 turtles/1000 hooks) and lower for Green (*Chelonia mydas*) and Olive Ridley (*Lepidochelys olivacea*). Regarding Loggerheads, eleven were caught entangled in the main and secondary lines or hooked externally, while seven swallowed the hook. Only one Loggerhead was captured dead. Curved carapace length (CCL) of Loggerheads varied from 64 to 80 cm (mean 71.8 cm, $n = 13$). All Leatherbacks ($n = 14$) were entangled or externally hooked, and were large immatures or adults not hauled onboard, which precluded measurements. Green turtles were juveniles with CCL varying from 36 to 52 cm ($n = 5$), also entangled or externally hooked. The only Olive Ridley caught swallowed the hook but was released alive (CCL = 59 cm).

For the pelagic longline fishery for Swordfish, one adult Leatherback turtle (CCL = 131 cm) was entangled and released alive. This gear was deployed in four trips, 30 sets and a total of 11,974 hooks. In two "Swordfish trips" the surface longline for Dolphinfish was also deployed, and captured sea turtles.

4. Discussion

4.1. Fisheries and bycatch of seabirds and sea turtles

The Itaipava fleet operated several different hook-and-line methods depending on fishing grounds, target and season in a large area over the continental shelf and offshore waters, from 18°S to 35°S. Fishing grounds overlap with foraging areas of wintering and breeding albatrosses and petrels, as well as with sea turtles. This fleet is composed of 497 vessels, five times bigger than the whole national and leased pelagic longline fleet targeting tuna and Swordfish (89 vessels in 2005, Travassos and Hazin, Brazilian unpublished report to ICCAT) that was previously recognized as the main threat for seabirds and sea turtles in Brazil. The Itaipava fleet has little to no control from governmental authorities regarding vessel licence, fishing operating licences, landing statistics, and management. Their activities had only recently being considered by scientists (e.g. Martins et al., 2005; Martins and Doxsey, 2006) and a high potential of interaction with seabirds and sea turtles was confirmed in the present study.

The trolling method is used all around the world in fisheries targeting tuna, salmon (*Salmo* spp.), barracuda (*Sphyraena barracuda*) and others (Majkowski, 2003), with incidental capture of seabirds reported. In the Mediterranean, Cooper et al. (2003) reported that small Maltese vessels undertaking trolling for tuna, Bream (*Dentex dentex*) and other predatory fish killed 35 birds, of which 71% were Cory's shearwaters. Unpublished information in several countries reported captures of shearwaters (*Puffinus carneipes* and *P. pacificus*), Yellow-nosed albatrosses, Australian pelicans (*Pelecanus conspicillatus*) and boobies (*Sula* sp.) either by taking hooks or by colliding with gear and becoming entangled. The technique and gear used in Brazil have some differences in comparison with trolling elsewhere, with minor implications for the incidental capture of seabirds when targeting Yellowfin tuna, but with major concern when targeting Bigeye tuna (catch rate of 0.41 birds/day). Information presented here and from other regions suggests that seabird capture in this trolling occurs commonly and needs to be better studied, particularly when the vessels troll lines slowly.

Handlines are used to catch different species of tunas all around the Pacific Ocean, Indian Ocean, Red Sea, Mediterranean and Atlantic Ocean, frequently around FADs. Handlines are also reported to be a selective fishing method (Majkowski, 2003), but we found high levels of incidental capture and mortality in Brazil. The catch rate reported here of 0.61 birds/day is high, particularly if taking into account that 497 vessels compose the Itaipava fleet and that endangered species are being killed, such as the Spectacled petrel (*Procellaria conspicillata*) and the Atlantic Yellow-nosed albatross (Cuthbert et al., 2003; Ryan et al., 2006). Mortality in this fishery is also high because they use small hooks which can easily be swallowed by birds.

Surface longline for Dolphinfish in Brazil had a high bycatch of seabirds (0.147 birds/1000 hooks) above the rate reported in the pelagic longline in Brazil of 0.09 birds/1000 hooks (Neves et al., 2006). However, the traditional pelagic longline captures seabirds during winter months (Neves et al., 2006), while the surface longline for Dolphinfish takes place during summer. In Brazil this gear is deployed considerably shallower than longline for Dolphinfish in Costa Rica, which sets at a depth up to 10 m (Swimmer et al., 2005). A range of characteristics including low depth, deployment during daylight hours, and use of small hooks make it particularly dangerous for seabirds by being available throughout fishing and not only during deployment as in the longline for Swordfish and tuna. Catch rate of sea turtles was also high in the surface longline for Dolphinfish (1.08 turtles/1000 hooks) comparable to rates reported in the longline fishery for Swordfish in the SW Atlantic of 0.68–2.85 turtles/1000 hooks (Domingo et al., 2006). Sizes of Loggerheads and Leatherbacks were similar to specimens captured in traditional pelagic longline for Swordfish in Brazil and Uruguay, with immature Loggerhead and immature and adult Leatherback turtles predominating (Kotas et al., 2004; Domingo et al., 2006). Dolphinfish fishery landings in Itajaí started in 2001 with 2.7 million hooks deployed from 2001 to 2004 (R. Dallagnolo, UNIVALI, unpublished data).

The pelagic longline for Swordfish captured no birds during the present study, nor in another study in the Espírito Santo area (Olavo et al., 2005). However, both studies have low sampling effort and could miss rare stochastic events, as is the incidental capture of seabirds in longlines. Fishermen reported the capture of birds in this fishery and additional data are needed for a definite conclusion. On the other hand, one Leatherback turtle was captured in spite of low number of hooks deployed, consistent with other reports of capture in longline in the area (Olavo et al., 2005 – catch rate 0.297 turtles/1000 hooks; Marcovaldi et al., 2006) and nesting grounds in nearby Espírito Santo beaches (Barata et al., 2004). Espírito Santo is also a major nesting area for Loggerhead turtles in Brazil (Baptistotte et al., 2003) a species captured in high numbers in the SW Atlantic (Domingo et al., 2006; Marcovaldi et al., 2006), which means that both species and the Itaipava fishing fleet overlap and have a high potential of interaction.

4.2. Conservation actions and fisheries management

The fishing methods described here and adopted by Itaipava fleet, in particular the handlining, surface longline for Dolphinfish and the pelagic longline for Swordfish have an important role in the decline of seabirds and sea turtles, previously attributed to other fisheries, such as the pelagic and bottom longlines (Brothers et al., 1999; Domingo et al., 2006). Slow trolling for Bigeye tuna also has high capture rates, but with minor impacts on seabirds because only a handful of vessels use this method. Management actions for the fishery and their impacts on target and bycatch species need to be controlled by regulatory agencies and there is a need for monitoring of the fleet. Currently, the Itaipava fleet is regulated by target fish abundance and inventive capacity of their fishermen to explore new areas and species, with inefficient regulation by government. An effective program of monitoring with onboard observers is important for the assessment of impacts on endangered sea turtles and seabirds and differential vulnerability according to gear variations, fishing methods and environmental variables.

Mitigation measures to avoid the incidental capture of seabirds are available for bottom and pelagic longline and include bird-scaring lines, line setting at night, and dying baits (Brothers et al., 1999). For the pelagic longline for Swordfish described here bird-scaring lines and night setting should be effective. For the slow trolling for Bigeye tuna and the handlining for Yellowfin tuna, scaring lines would probably work, but their effectiveness and impacts on target species catches need to be addressed.

For the surface longline for Dolphinfish, the major concern reported in the present study, alternative measures could be practical such as the deployment of weights, weighted line, or longer secondary lines with large swivels taking hooks below the surface. Longline gear used in Costa Rica, Pacific Ocean, targeting Dolphinfish and tunas is deployed deeper (Swimmer et al., 2005) and could also be effective in Brazil. Blue-dying baits probably will be a poor mitigation measure because the bait used is sardine or Skipjack meat and not squid, and also was not effective in avoiding sea turtle capture (Swimmer et al., 2005). For the mitigation of the capture of sea turtles, no effective measure is obvious, particularly because the bulk of sea turtles, and Leatherback turtles in particular are captured by entanglement. The improvement of handling procedures for sea turtles and seabirds, improving after release survival is required and could be attainable by educational campaigns and distribution of line-cutters and dehookers. Finally, if mitigations in fisheries do not prove effective, drastic actions are encouraged such as banning the fishing methods (e.g. surface longline for Dolphinfish) and establishment of area closures. No measure is expected to be effective in Brazil without continuous monitoring and strong enforcement, as is also the case in other countries such as artisanal fisheries capturing sea turtles in Mexico (Koch et al., 2006). Conservation of declining seabirds and sea turtles require urgent measures also focusing on poorly known fleets and fishing methods, which have not receive attention around the world, but could be a significant mortality factor in several places.

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