HOOK-AND-LINE FISHERIES IN BRAZIL: DESCRIPTION AND IMPACTS ON SEABIRDS

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Abstract

The decline of populations of seabirds around the world is partially or predominantly related to the incidental capture of animals in large-scale industrial fisheries, with longline fisheries being the major threat. Here we describe a range of poorly known hook-and-line fisheries carried out by the Itaipava fleet, southeastern Brazil, composed by 497 vessels and deploying hooks from 18°S to 35°S, and presented preliminary data on the impact on seabirds caused by the pole-and-line baitboats. According to parameters such as gear, target species, fishing operation, season, areas, as well as their potential threat to seabirds, seven different 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. Capture rates were higher for the surface longline for Dolphinfish (0.15 birds/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. 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.

1. Introduction

Fisheries are a major cause of mortality for seabirds and seaturtles around the world (National Research Council, 1990; Brothers et al., 1999), accounting for the decline of several species (Croxall et al., 1997; Gales, 1997). A major cause of seabird mortality is the interaction with pelagic longlines for tunas (*Thunnus* spp.) and Swordfish (*Xiphias gladius*), which have receive much attention of scientists (e.g. Brothers et al., 1999; Gales, 1997). On the other hand, fisheries such as gillnet, trawling, and dropline have been considered a minor mortality factor (Gales, 1997). Notwithstanding, recent studies show that some other fisheries have high mortality levels of some seabird species. Around Malvinas-Falkland Islands, Sullivan et al. (2006) estimated a mortality rate of 0.47 seabirds per fishing day in the factory trawl fleet for finfish, with severe impact on Black-browed albatross (*Thalassarche melanophris*) and minor numbers of Giant petrels (*Macronectes* spp.). In total, 1,529 birds were estimated to be killed in local waters in a 12-month period and 630 birds (3.00 birds/day) in high seas north of Malvinas-Falklands. Gillnets targeting Monkfish (*Lophius gastrophysus*) off the Brazilian coast were estimated to kill 802 petrels and albatrosses (Perez and Warhlich, 2005).

In the Southwestern Atlantic Ocean, which encompasses waters of Brazil, Uruguay, Argentina, and adjacent international waters, detailed studies on seabird bycatch have focused on pelagic and demersal longlines (Neves and Olmos, 1997; Olmos et al., 2001), while few studies considered other fisheries (e.g. Perez and Warlich 2005). Neves and Olmos (1997) reported 0.12 birds/1000 hooks in pelagic longline, mostly Black-browed albatross, Yellow-nosed albatross (*Thalassarche chlororhynchos*) and White-chinned petrel (*Procellaria aequinoctialis*). Despite seabird mortality is historically related to the longline fishery (pelagic and bottom) carried by the domestic and leased fleet, other fisheries - such as lived baits, gillnetting, trawling, drift netting – have potentially relevant incidental capture rates and must be evaluated (Neves et al., 2006). Brazil holds important populations of seabirds 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).

There is a large fishing fleet in Itaipava port, a small village on the Espírito Santo coast, southeastern Brazil. This high seas pelagic fleet 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). Target species, gear and fishing grounds vary seasonally and the skill of fishermen from Itaipava in using hook-and-line had strongly influenced fishing practices along the southern Brazilian coast. In addition, there was no regulation for vessels or management of resources targeted by this fleet. The size of the fleet and methods used, associated with fishermen's reports of seabirds and seaturtles frequently being captured make it a major conservation concern. The description of fishing methods and potential of bycatch of endangered species is required for fishery management and realistic conservation measures focusing on Itaipava fleet.

The present paper aims to describe the range of different fisheries using hook-and-line methods in Brazil; determine levels of incidental capture of seabirds; identify potential impacts on endangered species and conservation needs. Interactions of pole-and-line fishery with seabirds are also addressed. Traditional pelagic and bottom longline fisheries in the southwestern Atlantic have received attention from other studies mentioned above so we focused on the less well-documented fishing methods.

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 Subantarctic waters northward and meet 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 large (Fig. 1), composed predominantly by unconsolidated substrates and

holding the bulk of Brazilian fishing effort. In northern areas the continental shelf is narrow, with presence of coral reefs, 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 during 16 cruises. Additional data were obtained through interview with fishing masters and from the literature, in order to characterize variations and vulnerability of birds. From 2001 to 2006, 15 cruises departing from ports of Itaipava, Cabo Frio, Santos, Itajaí and Rio Grande were performed, covering the range of different fisheries using hook and line. One cruise was accessed by logbook provided by the master and validated through five other cruises in the same vessel and crew, performed by an observer. A total of 178 fishing days were sampled in the current study, from 18°S to 35°S, close to Uruguayan border (Fig. 1). For the pole-and-line fishery using live-bait and targeting Skipjack tuna, data on potential interaction with seabirds were accessed by observation of activities close to the vessel carrying the observed, as several vessels would fish around a moored buoy. Observers were onboard a vessel targeting Bigeye tuna (*Thunnus obesus*) using pole-and-line in five fishing trips, which simultaneously also used a trolling fishery method. Other cruises also deployed several fishing gears, simultaneously or in different periods, with a single cruise operating exclusively with surface longline for Dolphinfish.

Fisheries were defined according to parameters such as gear, target species, fishing operation, season, areas, as well as their potential threat to seabirds. According to these criteria, fisheries were defined as: 1. fast trolling or 'corrico' fishery targeting tuna and tuna like species; 2. slow trolling for Bigeye Tuna: 3. handlining; 4. surface longline for Dolphinfish; 5. pelagic longline for Swordfish; 6. bottom dropline; 7. pole-and-line with live bait targeting Skipjack tuna.

Fishing effort for surface longline for Dolphinfish and pelagic longline for Swordfish was expressed as number of hooks, and capture rate calculated as birds/1000 hooks. Fishing effort for trolling, handlining, and bottom dropline was defined as 'fishing day', in which at least one set was carried out, and bycatch rate reported as birds/fishing day.

3. Results

3.1. Fast Trolling

Trolling or troll 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 m to 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 is 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 the line is held by hand by a fisherman, who moves his arm rhythmically to simulate the movement of prey, instead of using rubber or other shock absorber and attaching the line to the vessel or outriggers, as is common practice elsewhere.

Pole-and-line Skipjack vessels when prospecting for shoals use shock absorber and gear attached to outriggers. For slow trolling the vessel does not stop for fish to be hauled onboard, while for fast trolling, stopping the vessel is required. Fish are hauled onboard by hand using a large hook attached to the tip of a cable. Once onboard fish are immediately killed, gutted and washed with seawater. Captures are kept in ice for up to three weeks. In Brazil, trolling targets several pelagic fishes. The fleet operating at Espírito Santo and Rio de Janeiro coasts, which includes the important Campos Basin fishing ground, depart from Itaipava and Vitória ports. Target species are the Dolphinfish, but also the small Yellowfin, Albacore, and particularly Skipjack and Blackfin (*Thunnus atlanticus*) tunas for use as bait for larger 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.
During the present study observers gathered data on fast trolling targeting Yellowfin tuna close to oilrigs in Campos Basin, Rio de Janeiro state, and close to moored buoys in southern Brazil (Fig. 1).

3.2. Slow Trolling

Slow trolling is a derivation of the above fishery, basically differing on speed of the vessel, in using the vessel as a FAD, and targeting mainly Bigeye tuna. Their impact on seabirds is consistently different (Table 1) and management also require a different approach, justifying to be treated as a distinct fishery. Bigeye tunas are targeted in southern areas, along Rio Grande do Sul and Santa Catarina states, and vessels depart from Itajaí and Rio Grande ports. Figure 1 shows the spatial segregation in fishing grounds of fast and slow trolling, ports and target species. Simultaneously with the slow trolling are used pole-and-line gear as a secondary fishing method, using the same gear, and an artificial bait (white plastic tube) attached to the large hook. A technique to use the vessel as FAD for Bigeye and Yellowfin tunas was developed by a fishing master recently and few vessels use this technique. Tuna shoal is transferred to another vessel when the main vessel departs to port for landing.
The slow trolling associated with pole-and-line methods was sampled during this study off southern Brazil over waters 2000-3000 m depth. No incidental capture of seabirds was recorded and it is not expected.

3.3. Handlining

For the handlining fishery, each fisherman, either on the starboard or portside deploys one line against the current. Lines are thinner than in the trolling fishery (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 other chumming (sometimes guts of tuna) are released at the same time in order to attract the target fish. This fishery usually targets 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. Boats from Itaipava fleet have tanks with 5,000 to 7,000 litres to keep bait alive. Live bait can be used to increase catches and bait species are Rough scads *Trachurus lathami*, Mackerel *Scomber* spp., Brazilian sardines

Sardinella brasiliensis, squids or small tunas and Skipjack up to 20 cm in length. When trolling for bait, the vessel stops frequently to fish using handlining and recently caught baits. Once the tuna is hooked, the fisherman pulls the line continuously with care controlling for resistance from the fish. The fisherman must let loose some lengths of the line while simultaneously pulling it if resistance is reduced. While the boat is drifting, frequently the hook remains close to the surface several meters away from the vessels, due to small swivel and no additional weight, which makes the chumming and hooks available for albatross and petrels. Fishermen try to avoid birds taking the hook, pulling the line when birds are nearby, but no other mitigation is used. Fishing grounds are distributed along the Brazilian coast, over continental shelf and shelf break, but oilrigs in the north and moored buoys in the south are preferred areas (Fig. 2).

3.4. Surface Longline for Dolphinfish

Descriptions provided are from direct observations, interviews with fishing masters, and the literature (Dallagnolo, 2005; Martins et al., 2005). 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 (Fig. 3). Itaipava fishermen developed this technique and it has spread out to southern ports, as Itajaí and Santos. Nowadays, mainly boats from Itaipava compose the fleet based in Itajaí, which landed 30 metric tonnes of Dolphinfish in 2002 and 711 metric tonnes in 2003 (UNIVALI 2004). In southern Brazil, fishing grounds are up to 200 m depth and season is in November and December. In northern fishing grounds (Rio de Janeiro and Espírito Santo coasts), the fishery is also strongly seasonal, from October to February (Martins and Doxsey, 2006). Set are composed of 600 to 1,200 hooks, deployed once a day with mean immersion time of 13 h, or twice a day with immersion time of 9.5 h. Hooks are deployed around 4 h, and rebaiting is a common practice, i.e. the boat sails along the mainline, hauling caught fish and baiting hooks again. In northern fishing grounds 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. 4).

3.5. Pelagic Longline for Swordfish

Detailed description of the technique and gear used in the pelagic longline for Swordfish is available in other studies around the world (e.g. Brothers et al., 1999) and also in the southwestern Atlantic (Olmos et al., 2001; Neves et al., 2006). However, the fleet based in Itaipava deploys a shorter mainline (12 a 18 nm) and lower number of hooks (800-1000) in comparison with the industrial fishery due to small size of vessels. Fishermen frequently alternate sets of this and other gears during a single trip, such as surface longline for Dolphinfish or bottom dropline. Their potential impacts on seabirds are supposed to be high, similar to the traditional longline. Sets operated by the Itaipava fleet are shown in Figure 4.

3.6. 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 depth. After the shoal is found by echo sounder, fishermen deploy the gear attaching the extremity to the vessel or holding it by hand. Longline consists of a line 60 to 400 m long,

with a swivel close to a stone or other weight (5 kg) used to keep the gear on the bottom (Fig. 5). From the stone follows another main line 30 to 400 m long in which are attached 5 to 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: a small longline, also called 'hand longline' operated by several fishermen simultaneously from the side of the vessel with about 10 hooks and frequently built onboard the vessel by crew; the 'small boat longline' or '*mar novo*' in which a mother vessel releases 8 to 22 small glass fibre 2 m long boats ('caíque'), in which a fisherman operates one or two hand longlines with 25 to 40 hooks each, in a wide area around the mother vessel (Costa et al., 2005; Martins et al., 2005); and the 'big longline' or 'pargueirão', which is attached to a buoy and flag while the mother vessel release 5 to 10 longlines with 70 to 100 hooks each in specific points and sails from one buoy to another hauling fish and rebaiting hooks (Fig. 5). The Itaipava fleet operates from southern Bahia to Santa Catarina, in depths from 40 m 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*). A total of 20 fishing days in two fishing trips using bottom dropline was sampled in the present study. Fishing grounds for both trips are shown in Figure 6.

3.7. Pole-and-line with live bait

Under pole-and-line fishery we refer to industrial baitboat vessels targeting Skipjack tuna. It is a worldwide fishing technique to catch tuna and tuna-like species. In Brazil it consists in locating the school using water surface signs or seabirds feeding over the same prey of tunas (Chiaradia, 1991), and attracting them close to the vessel by a combination of 'shower-like' and live-bait. Usually juvenile Brazilian anchovy (Castello and Habiaga, 1989) or other anchovies or sardines previously captured and kept in tanks on the boat are released in the water. Poles have a short line and a barbless hook and artificial lure, or are baited with the same live bait. Pole-and-line fishing frequently occurs close to moored and floating buoys. The pole-and-line fishery targeting Skipjack tuna started in Brazil in 1979 from Rio de Janeiro port, but quickly shifted to Itajaí and Rio Grande ports following the discovery of highly productive areas in southern Brazil (Castello and Habiaga, 1989; Andrade and Garcia, 1999; Andrade et al., 2005). Fishing takes place all year round, in an area that extends from 20°S to 35°S (Meneses de Lima et al., 2000, Fig. 6), with high catch rates in summer months and areas where sea surface temperature ranges from 23.5°C to 25.5°C (Andrade and Garcia, 1999). The fleet usually targets Skipjack close to the Uruguayan border in summer and moves northward in winter coupled with the oscillations of the SST along the shelfbreak (Andrade, 2003), and when poor weather conditions preclude fishing operations at the south (Andrade, 2003; Santos and Andrade, 2003). Thirty-three vessels operate from the port of Itajaí (UNIVALI, 2004), six vessels from Rio Grande, and a small number from Rio de Janeiro. Catches ranged between 13 and 26 thousand tonnes per year from 1981 to 1997 (Matsuura and Andrade, 2000) and Skipjack composed the bulk of catches (*c.* 90%), while juvenile Yellowfin tuna composed 8% of catches (Santos and Andrade, 2003).

3.8. Seabird Bycatch

A total of 47 seabirds 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 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 seabirds (0.410±0.68 birds/day, Table 1). Seven Black-browed albatrosses, four Great shearwaters *Puffinus gravis*, three Spectacled petrels *Procellaria conspicillata*, one Atlantic Yellow-nosed albatross and one White-chinned petrel were captured. Due to the large size of hooks, most birds were entangled in the line or hooked in the bill. One Great shearwater was severely injured by external hooking.

Handlining accounted for 25 seabirds captured (0.610±1.45birds/day): eleven Spectacled petrels, eight Great shearwaters and six Atlantic Yellow-nosed albatrosses. In spite of a catch 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. Three Spectacled petrels, two Great shearwaters and one adult breeding (with brood patch) Atlantic Yellow-nosed albatross were killed. Incidental mortality was 0.143 birds/day.

In the surface longline for Dolphinfish, a total of six seabirds were caught, a rate of 0.147 birds/1000 hooks (or 0.15 birds/day). Two Atlantic Yellow-nosed albatrosses, one Manx shearwater and one White-chinned petrel were released alive, while two small albatrosses (*Thalassarche* sp.) were dead. 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 low.

In the bottom dropline sampled, no incidental capture of seabird or sea turtle was recorded. Their potential of interaction with seabirds is low, but could have a small capture level of sea turtles, as reported by fishermen, or entanglement in the mainlines as reported in Uruguay (Laporta et al., 2006).

Pole-and-line fishery when used to catch Bigeye tuna has no interaction with seabirds. However, the fleet using live-bait to target Skipjack tuna attracts large numbers of seabirds, mostly Cory´s shearwater (*Calonectris diomedea*), Cape Verde shearwater (*Calonectris edwardsii*) and Great shearwater. Fishermen try to scare birds by hitting them with a metal piece attached to a pole-and-line similar to a whip. Vessels using handlining technique targeting Yellowfin tuna also scared birds in the same way. From a sample of 30 Great shearwaters trapped at sea for another project, five birds (17%) had injuries probably caused by that practice. Injuries included broken legs and scars on the back, neck and head. Injuries reported here were underestimated because they do not include lethal ones. However, 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.

4. Discussion

4.1. Fisheries and Bycatch of Seabirds

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. This fleet is composed of 497 vessels, bigger than the whole national and leased pelagic longline fleet targeting tuna and Swordfish (89 vessels in 2005, Travassos and Hazin, 2006) 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.) and barracuda (*Sphyraena barracuda*). As a tuna-like fishing method it is rather common in southeast Asia and many places in the Central Pacific, as well as in many parts of the Caribbean and the Gulf of Mexico (Majkowski, 2003). Non-targeted fish is seldom captured according to Majkowski (2003), but incidental capture of seabirds is reported in other areas. 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 Shearwater, with low numbers of gulls and terns. In central and western Pacific, Boobies (*Sula* spp.) have been recorded as bycatch in the trolling fishery (Environment Consultants Fiji, 2002). In western Australia, trolling operations were noted to catch Flesh-footed shearwaters (*Puffinus carneipes*) and occasionally Yellow-nosed albatross (Anthony de Fries pers. comm. in Commonwealth of Australia, 2003). Wedge-tailed shearwaters (*Puffinus pacificus*) and Australian pelicans (*Pelecanus conspicillatus*) have also been caught, either by taking hooks or by colliding with gear and becoming entangled, with estimated bycatch lower than 0.125 Flesh-footed shearwaters per day per vessel (Commonwealth of Australia, 2003). The technique and gear used in Brazil has 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). Other Brazilian fleets use trolling fishery for different species, such as the artisanal fishery of Rio Grande do Norte, northeastern Brazil that targets Blackfin tuna (Vieira et al., 2005), or the Maranhão fleet which targets Serra (*Scomberosomus brasiliensis*) and Cavala (*S. cavalla*) (Batista and Fabré, 2001). No data on incidental capture are available from these fisheries.

Handlines are used to catch different species of tunas all around the Pacific Ocean, Indian Ocean, Red Sea, Mediterranean and Atlantic Ocean (Caribbean Sea and off west Africa, Cape Verde, in particular), 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. The Spectacled petrel is endemic to Gough Island, where an estimated 20,000 birds breed, and the population is endangered by longline fisheries (Ryan et al., 2006). Similarly, Atlantic Yellow-nosed albatross population modelling predicts annual rates of decrease of 1.5-2.8% on Gough Island and 5.5% on Tristan da Cunha, and annual survival is inversely correlated with longline effort in the Southern Atlantic Ocean (Cuthbert et al., 2003).

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 during all fishing time and not only during deployment as in the longline for Swordfish and tuna. Dolphinfish fishery landings in Itajaí port shows signs of decline and could collapse in a few years (Dallagnolo, 2005), forcing the fleet to change fishing methods and target, or fishing grounds. The fishery targeting Dolphinfish started in Itajaí in 2001 with an estimated of 2.7 million hooks deployed from 2001-2004, and peak in 2003 of 1.7 million hooks (Dallagnolo, 2005).

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.

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, in particular the pelagic and bottom longline (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 stocks 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. The close relationship between scientists interested in seabirds and Itaipava fishermen revealed the interest to find common solutions for incidental capture, which could benefit fishermen by increasing target fish captures and avoiding waste of time and damage to fishing gear.

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 (Swimmer et al., 2005) is deployed deeper and could also be effective in Brazil, with minimal effects on Dolphinfish catches. 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). The improvement of handling procedures for sea turtles and seabirds, improving after release survival is required and could be attainable by educational campaigns. 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 as with 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.

5. Acknowledgments

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6. References

Andrade, H.A., 2003. The relationship between the Skipjack tuna (*Katsuwonus pelamis*) fishery and seasonal temperature variability in the south-western Atlantic. Fisheries Oceanography 12, 10-18.

Andrade, H.A.,Garcia, C.A., 1999. Skipjack tuna fishery in relation o sea surface temperature off the southern Brazilian coast. Fisheries Oceanography 8, 245-254.

Andrade, H.A., Tozetto, A.L., Santos, J.A.T., 2005. The effect of environmental factors and of the fishermen strategy on the Skipjack tuna (*Katsuwonus pelamis*) CPUE in the Southwest Atlantic. Collective Volume of Scientific Papers, ICCAT 58, 350-358.

Batista, V.S., Fabré, N.N., 2001. Temporal and spatial patterns on Serra, S*comberomorus brasiliensis* (Teleostei, Scombridae), catches from the fisheries on the Maranhão coast, Brazil. Brazilian Journal of Biology 61, 541-546.

Both, R., Freitas , T.O.R., 2004. Aves marinhas no Arquipélago de São Pedro e São Paulo, in: Branco, J.O. (Ed.). Aves marinhas e insulares brasileiras, bioecologia e conservação., Ed. UNIVALI, Itajaí, pp. 193-212.

Brothers, N.P., Cooper, J., Løkkeborg, S., 1999. The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. FAO Fisheries Circular No. 937. 100 pp.

Castello, J.P., Habiaga, R.P., 1989. The Skipjack fishery in southern Brazil. Collective Volume of Scientific Papers, ICCAT 30, 6-19.

Chiaradia, A., 1991. Interação entre aves marinhas e cardumes de Bonito-listado (*Katsuwonus pelamis*) na costa sul do Brasil. Atlântica 13, 115-118.

Commonwealth of Australia, 2003. Seabird Interactions with Longline Fisheries in the Australian Fishing Zone: Assessment Report for the National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra. Available at: http://www.daff.gov.au

Cooper, J., Baccetti, N., Belda, E.J., Borg, J.J., Oro, D., Papaconstantinou, C., Sánchez, A., 2003. Seabird mortality from longline fishing in the Mediterranean Sea and Macaronesian waters: a review and a way forward. Scientia Marina 67, 57-64.

Costa, P.A.S., Martins, A.S. , Olavo, G., Haimovici, M., Braga, A.C., 2005. Pesca exploratória com arrasto de fundo na talude continental da região central da costa brasileira entre Salvador-BA e o Cabo de São Tomé-RJ, in: Pesca e potenciais de exploração de recursos vivos na região central da Zona Econômica Exclusiva brasileira. Costa, P.A.S.A.,Martins, A.S., Olavo, G. (Eds.). Museu Nacional, Rio de Janeiro. Série Livros No. 13, pp. 145-165.

Croxall, J.P., Price, P.A., Rothery, P., Wood, A., 1997. Population changes in albatrosses at South Georgia, in: Robertson G., Gales, R. (Eds.). Albatross Biology and Conservation, Surrey & Beatty Sons, Chipping Norton, pp. 69-83.

Cuthbert, R., Ryan, P.G., Cooper, J., Hilton, G., 2003. Demography and population trends of the Atlantic yellow-nosed albatross. Condor 105, 439-452.

Dallagnolo, R., 2005. Análise da pescaria emergente de dourado (*Coryphaena hippurus*) na costa sul do Brasil a partir de espinhel de superfície. Bachelor's Thesis. UNIVALI, Itajaí.

Domingo, A., Bugoni, L., Prosdocimi, L. Miller, P., Laporta, M. Monteiro, D., Estrades, A., Albareda, D., 2006. The impact generated by fisheries on sea turtles in the Southwestern Atlantic. WWF Progama Marino para Latinoamérica y el Caribe, San José, Costa Rica. 71 pp. (Available at http://assets.panda.org/downloads/impactoffisheriesonturtles.pdf)

Environment Consultants Fiji, 2002. Interactions between seabirds and Pacific Islands' fisheries, particularly the tuna. Final draft for the Secretariat of the Pacific Community, 37 pp.

Gales, R., 1997. Albatross populations: status and threats, in: Robertson, G., Gales, R. (Eds.), Albatross biology and conservation. Surrey Beatty and Sons, Chipping Norton, pp. 20–45.

Hazin, F.H.V., Zagaglia, J.R., Broadhurst, M.K., Travassos, P.E.P., Bezerra, T.R.Q., 1998. Review of a small-scale pelagic longline fishery off northeastern Brazil. Marine Fisheries Review 60, 1-8.

Koch, V., Nichols, W.J., Peckham, H., Toba, V. 2006. Estimates of sea turtle mortality from poaching and bycatch in Bahía Magdalena, Baja California Sur, Mexico. Biol. Conserv. 128, 327-334.

Majkowski, J., 2003. Tuna trolling lines. *In* Tuna fishing techniques. Fishing Techniques Fact Sheets FAO – FIGIS. Available at http://www.fao.org/figis/servlet/fishtech?qid=ft_70000_F1015&st_extra=&ste=st_group,8521&st_group=#8521

Martins, A.S., Doxsey, J.R., 2006. Diagnóstico da pesca no litoral do estado do Espírito Santo, in: Isaac, V.J., Martins, A.S., Haimovici, M., Andriguetto, J.M. (Eds.). A pesca marinha e estuarina do Brasil no início do século XXI: recursos, tecnologias, aspectos socioeconômicos e institucionais. Ed. Universitária UFPA, Belém, pp. 93-116.

Martins, A.S. Olavo, G., Costa, P.A.S., 2005. A pesca de linha de alto mar realizada por frotas sediadas no Espírito Santo, Brasil, in: Pesca e potenciais de exploração de recursos vivos na região central da Zona Econômica Exclusiva brasileira. Costa, P. A. S., Martins, A.S., Olavo, G. (Eds.). Museu Nacional, Rio de Janeiro, Série Livros No. 13, pp. 35-55.

Matsuura, Y. Andrade, H.A., 2000. Synopsis of biology of skipjack tuna population and related environmental conditions in Brazilian waters. Collective Volume of Scientific Papers, ICCAT 51, 395-401.

Meneses de Lima, J.H., Lin, C.F., Menezes, A.A.S., 2000. A description of the baitboat fishery off the south and southeast Brazil. Collective Volume of Scientific Papers, ICCAT 51, 416-463.

National Research Council, 1990. Decline of sea turtles: causes and prevention. National Academy Press, Washington, DC.

Neves, T., Olmos, F., 1997. Albatross mortality in fisheries off the coast of Brazil, in: Robertson G., Gales, R. (Eds.). Albatross biology and conservation, Surrey & Beatty Sons, Chipping Norton, pp. 214-219.

Neves, T., Olmos, F., Peppes, F., Mohr, L.V., 2006. National Plan of Action for the Conservation of Albatrosses and Petrels. Ibama, Brasília.

Odebrecht, C., Castello, J.P., 2001. The convergence ecosystem in the southwest Atlantic, in: Coastal marine ecosystems of Latin America. Seeliger, U., Kjerfve, B. (Eds.). Springer-Verlag: Berlin Heidelberg, Ecological Studies 144, pp. 147-165.

Olavo, G., Costa, P.A.S., Martins, A.S., 2005. Prospecção de grandes peixes pelágicos na região central da ZEE brasiliera entre o Rio Real-BA e o Cabo de São Tomé-RJ, in: Pesca e potenciais de exploração de recursos vivos na região central da Zona Econômica Exclusiva brasileira. Costa, P. A. S., Martins, A.S., Olavo, G. (Eds.). Museu Nacional: Rio de Janeiro, Série Livros No. 13, pp. 167-202.

Olmos, F., Neves, T.S., Bastos, G.C. 2001. A pesca com espinhéis e a mortalidade de aves marinhas no Brasil, in: Albuquerque, J.L.B., Cândido-Jr, J.F., Straube, F.C. Roos, A.L. (Eds.), Ornitologia e conservação, da ciência às estratégias. Editora Unisul, Tubarão, pp. 327-337.

Perez, J.A.A., Wahrlich, R., 2005. A bycatch assessment of the gillnet Monkfish *Lophius gastrophysus* fishery off southern Brazil. Fisheries Research 72, 81-95.

Ryan, P.G., Dorse, C., Hilton, G.M., 2006. The conservation status of the Spectacled petrel *Procellaria conspicillata*. Biological Conservation 131, 575-583.

Santos, J.A.T. Andrade, H.A., 2003. The variability of the species contribution to total catch of the pole and line tuna fisheries in southwest Atlantic Ocean. Collective Volume of Scientific Papers, ICCAT 55, 1926-1939.

Sullivan, B.J., Reid, T.A., Bugoni L., 2006. Seabird mortality on factory trawlers in the Falkland Islands and beyond. Biological Conservation 131, 495-504.

Swimmer, Y., Arauz, R., Higgins, B., McNaughton, L., McCracken, M., Ballestero, J., Brill, R., 2005. Food color and marine turtle feeding behavior: can blue bait reduce turtle bycatch in commercial fisheries? Marine Ecololy Progress Series 295, 273-278.

Travassos, P., Hazin, F., 2003. Report on the Brazilian tuna fisheries, presented during the 2003 Annual Meeting of the ICCAT Standing Committee on Research and Statistics – SCRS, Madrid.

Travassos, P., Hazin, F., 2006. Report on the Brazilian tuna fisheries, presented during the 2003 Annual Meeting of the ICCAT Standing Committee on Research and Statistics – SCRS, Madrid.

UNIVALI, 2004. Boletim estatístico da pesca industrial de Santa Catarina – ano 2003: ações prioritárias ao desenvolvimento da pesca no Sudeste e Sul do Brasil. UNIVALI/CTTMar, Itajaí. 80 pp.

Vieira, K.R. Oliveira. J.E.L., Barbalho M.C., Aldatz, J.P., 2005. Aspects of the dynamic population of Blackfin tuna (*Thunnus atlanticus* - Lesson, 1831) caught in the northeast Brazil. Collective Volume of Scientific Papers, ICCAT 58, 1623-1628

Table 1. Summary of sampling effort for each fishery using hook-and-line in Brazil, seabirds caught and capture rates. --- Not applicable.

Fishery	Effort	No. Birds (Capture rates ± sd)	Bird Species
Fast Trolling	48 days	0	---
Slow Trolling for Bigeye	39 days	16 (0.41±0.68 birds/day, range: 0-2)	7 BBA, 4 GS, 3 SP, 1 AYNA, 1 WCP
Handlining	41 days	25 (0.61±1.45 birds/day, range: 0-7)	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)	2 AYNA, 2 *Thalassarche* sp., 1 MS, 1 WCP
Pelagic Longline for Swordfish	31 days & 11,974 hooks	0	---
Bottom Dropline	20 days	0	---
Pole-and-line with live bait	41 days	0*	---

AYNA - Atlantic Yellow-nosed albatross *Thalassarche chlororhynchos*, BBA - Black-browed albatross *Thalassarche melanophris*, GS - Great shearwater *Puffinus gravis*, SP – Spectacled petrel *Procellaria conspicillata*, WCP - White-chinned petrel *Procellaria aequinoctialis*, MS – Manx shearwater *Puffinus puffinus*. * Interactions with seabirds described in the text (floating dead birds, and 17% of live sampled Great shearwater with injuries).

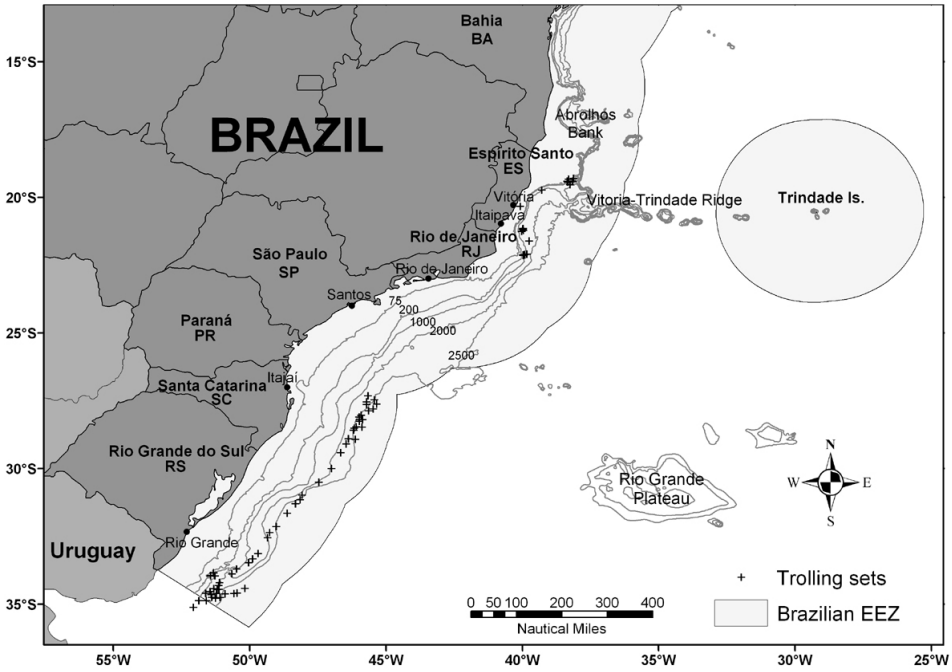

Figure 1. Trolling fishery sets sampled from 2002 to 2006 in southwestern Atlantic Ocean with Brazilian states, main fishing ports and Exclusive Economic Zones (EEZ) indicated. Differences between the north and south fishing grounds roughly reflect differences in fish targeted and landing ports.

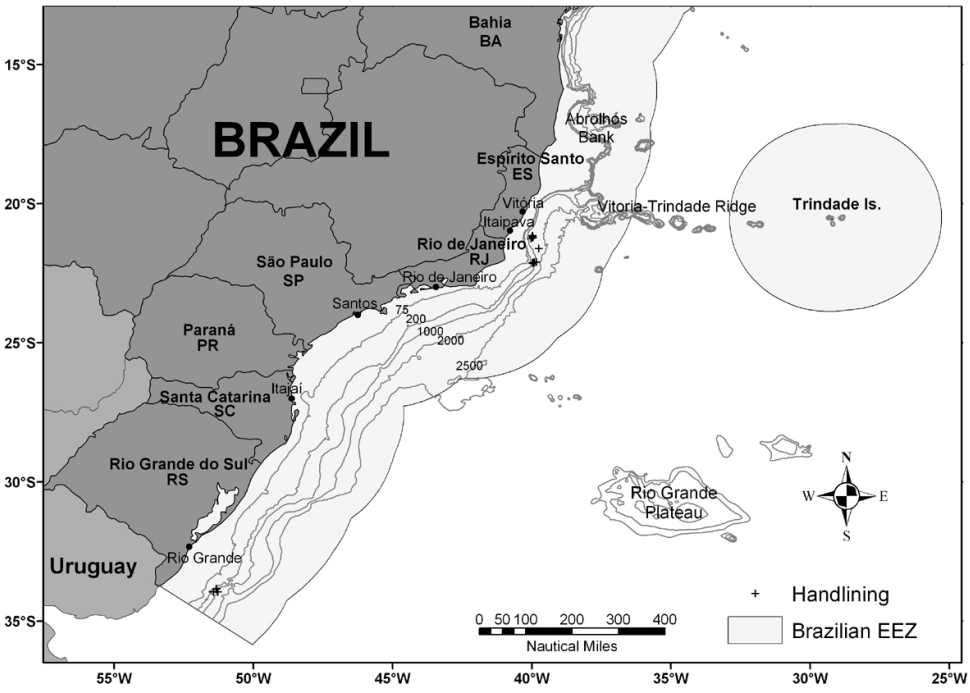

Figure 2. Handlining fishing grounds for tuna operated near oilrigs in northern areas and moored buoys in southern areas. Points indicated fishing places instead of singles sets.

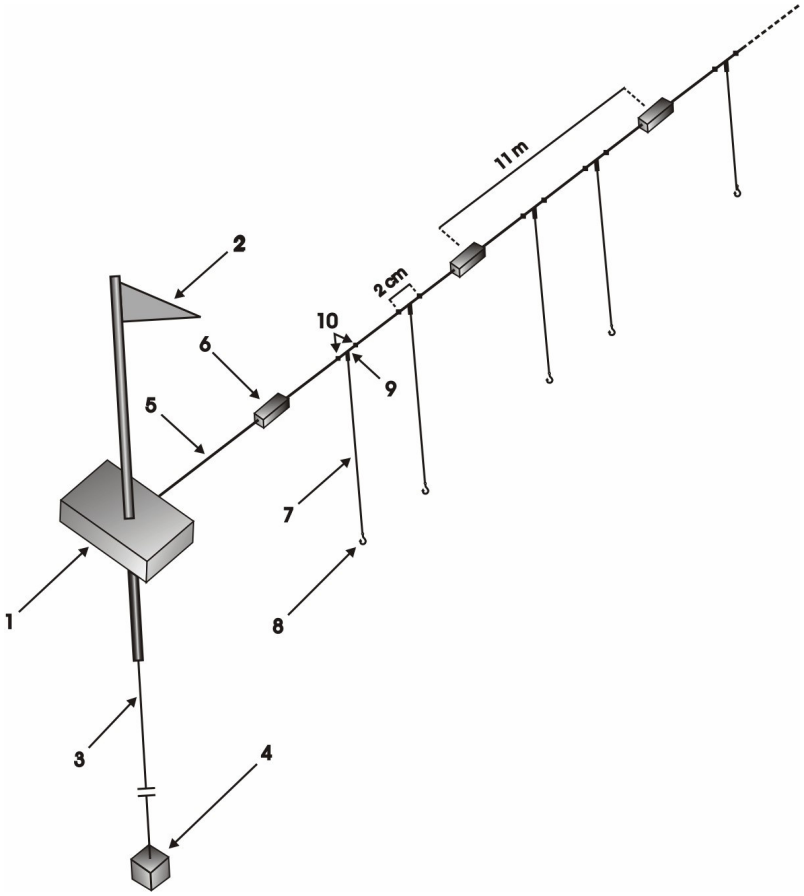

Figure 3. Scheme of the surface longline fishery gear targeting Dolphinfish, *Coryphaena hippurus*, in Brazilian fishing grounds. **1.** main buoy; **2.** flag; **3.** anchor line, 35 m long; **4.** stone, 3 kg; **5.** multifilament main line, 2-5 nautical miles long; **6.** secondary Styrofoam buoys; **7.** monofilament 1.4 mm secondary lines, 2 m long; **8.** 'J' hook, size 12-14; **9.** swivel, **10.** knots at the main line.

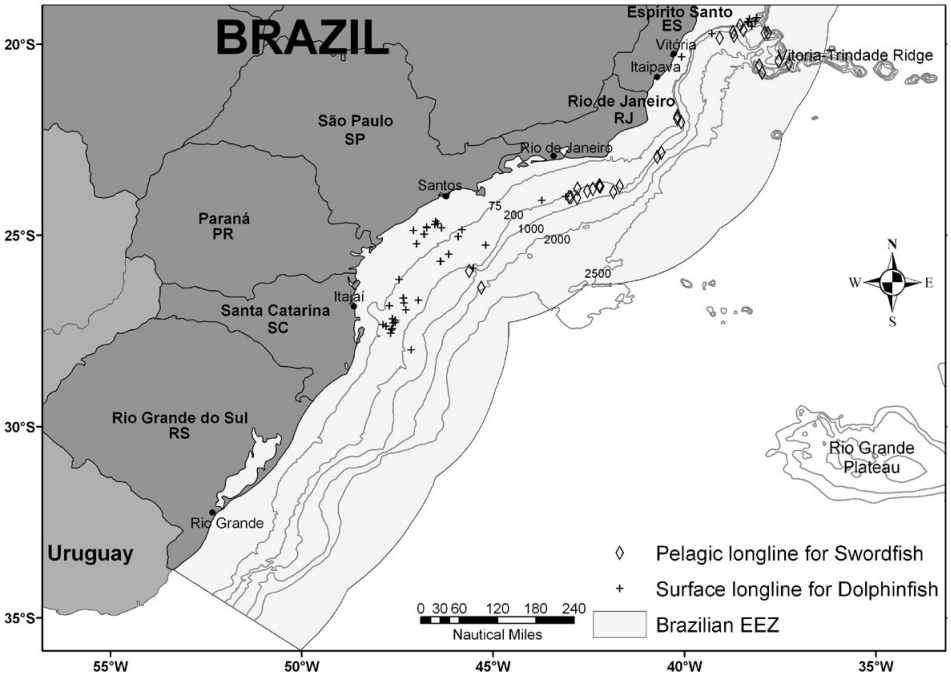

Figure 4. Sets of surface longline for Dolphinfish, *Coryphaena hippurus*, and pelagic longline for Swordfish, *Xiphias gladius*, sampled by onboard observers in Brazil from 2004 to 2006.

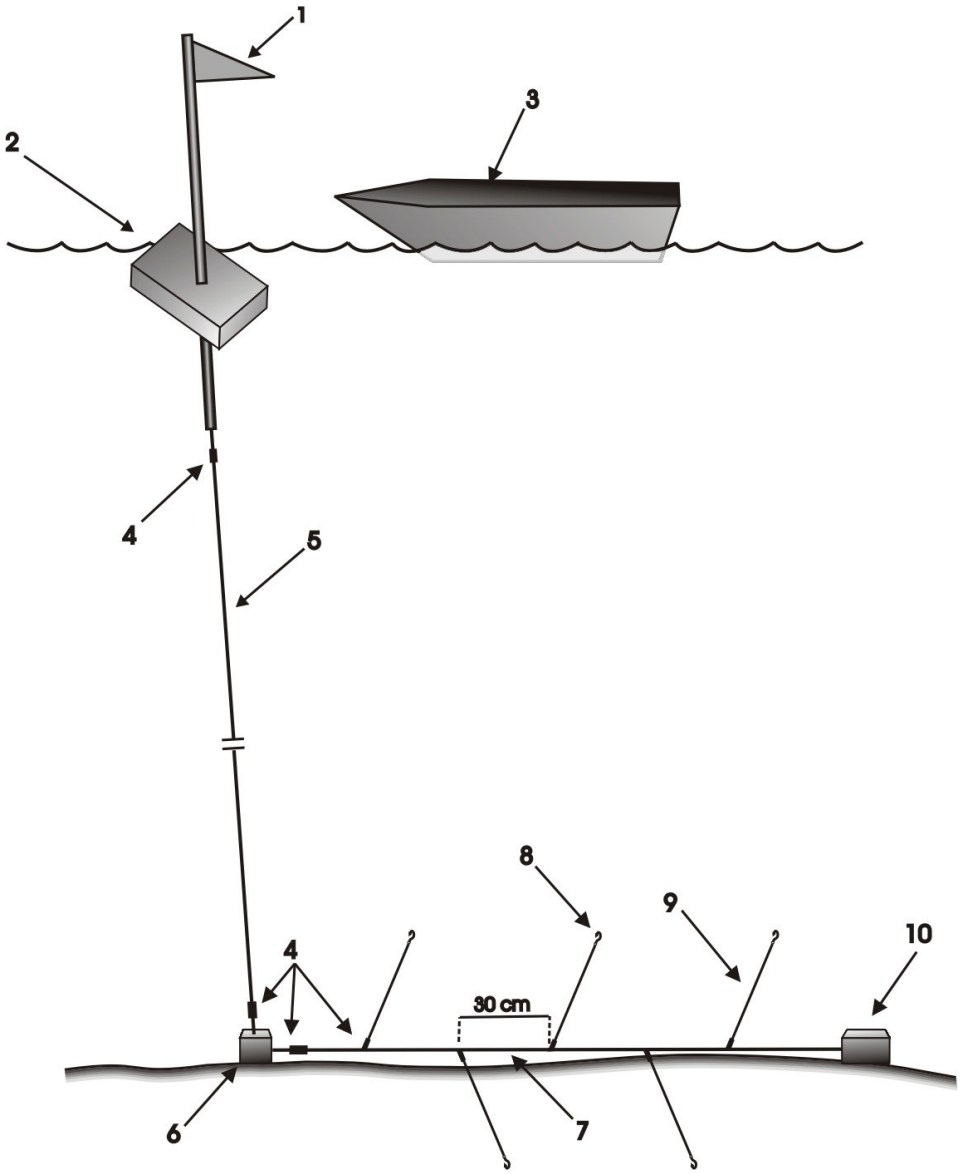

Figure 5. Bottom dropline gear. **1.** flag; **2.** buoy; **3.** small boat, 2 m long; **4.** swivel; **5.** main line, nylon monofilament 3.5 mm, 50 to 400 m long; **6.** weight or stone, 5 kg; **7.** main line, nylon monofilament 2.5 mm, 35 m long; **8.** hook 5 cm total length; **9.** monofilament secondary lines 1.5 mm, 0.4 m long; **10.** weight or stone (10 kg). Fishermen are unlikely to operate with both small vessels and buoy+flag, but both are shown for clarification.

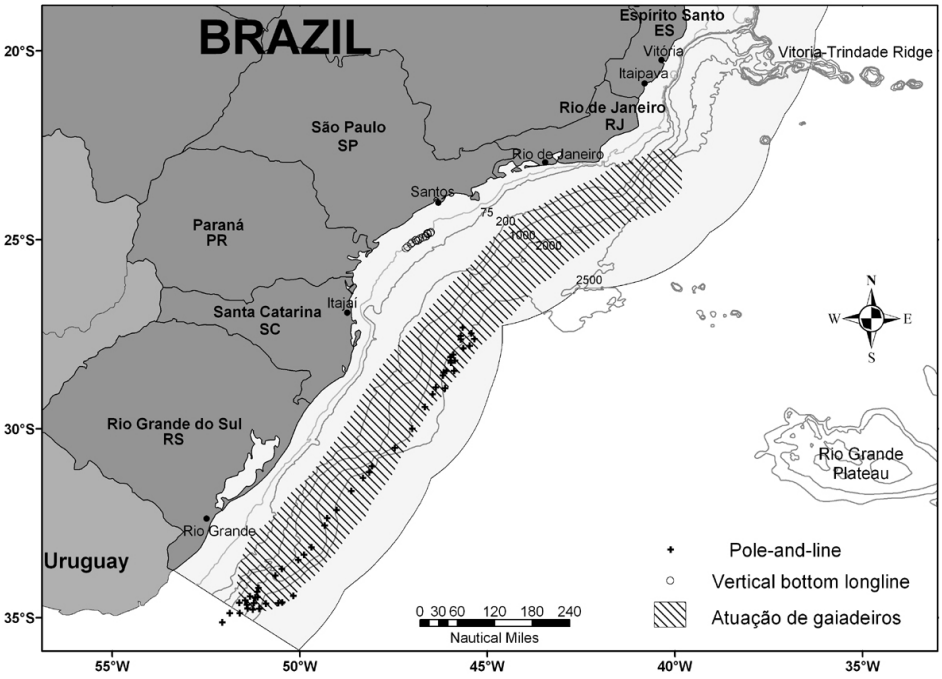

Figure 6. Bottom dropline and pole-and-line fisheries sampled by onboard observers in Brazil in 2004 and 2006. Shaded area corresponds to the fishing grounds for the pole-and-line fishery using live bait and targeting Skipjack tuna (Adapted from Santos and Andrade 2003).