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Mark-recapture of the endangered franciscana dolphin (*Pontoporia blainvillei*) killed in gillnet fisheries to estimate past bycatch from time series of stranded carcasses in southern Brazil

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ABSTRACT

Incidental fishery mortality estimates of franciscana based on stranding data are biased downwards, as only a fraction of the total bycatch ends up ashore. We estimated the probability of a franciscana incidentally killed by the coastal gillnet fisheries in southern Brazil to wash ashore and used this as a correction factor to back-calculate fishing related mortality from a dataset of carcasses collected between 1979 and 1998. From November 2005 to January 2009, 145 franciscanas incidentally killed in nets were tagged and returned to the sea. Only 11 of the tagged animals were found during beach surveys. Generalized Linear Models were used to model the probability of a tagged franciscana reaching the shore as a function of the covariates wave period, wind direction and intensity, distance from coast and the target species of the fishery. The target species had a significant effect on the stranding probability. The stranding probability of a tagged franciscana was higher in the fishery targeting white croaker (*Micropogonias furnieri*) (median = 0.105; 95% CI = 0.05–0.18) rather than weakfish (*Cynoscion guatucupa*) (0.013; 0.0003–0.069). As the stranding probability estimate for weakfish was imprecise (wide credible interval) we decided to hind cast the number of franciscanas incidentally killed for white croaker season only. The corrected estimate of franciscana mortality was approximately 10 times higher than previous estimates based solely on stranding data. Finally, this novel mark-recapture approach provides a useful correction factor to reduce the bias in incidental mortality estimates derived from stranding data.

1. Introduction

The franciscana, *Pontoporia blainvillei*, is a small cetacean endemic to the western South Atlantic Ocean. Its coastal distribution greatly overlaps with fishing activities, and bycatch in gillnets is the main threat to its conservation (Secchi, 2010). Bycatch in gillnet fisheries is observed throughout the four franciscana management areas (FMA sensu Secchi et al., 2003a) (e.g. Bertozzi and Zerbini, 2002; Kinas, 2002; Santos et al., 2002; Di Beneditto, 2003; Secchi et al., 2003b). However, the highest bycatch is recorded in the coastal waters of Rio Grande do Sul State (RS), which together with the inner shelf of Uruguay represent FMA III.

Data on franciscana mortality have been systematically collected from beach surveys since the late 1970s (e.g. Pinedo and Polacheck, 1999), when gillnet fishery operations started in the coastal region of southern Brazil (Reis et al., 1994). Between 1979 and 1998, 1076 dead franciscanas were found washed ashore on the coast of RS (Pinedo and Polacheck, 1999). In the early 1990s the coastal gillnet fleet began to be systematically monitored (voluntarily recorded data by fishermen through specific logbooks) with the purpose of estimating more accurately the incidental mortality of franciscanas (e.g. Secchi et al., 1997, 2004; Kinas and Secchi, 1998). Bycatch estimates from fisheries, monitored via logbook records, are appreciably higher than estimates from beach surveys, suggesting that only a fraction of the franciscanas incidentally caught in gillnets are washed ashore (Secchi et al., 1997). Logbook monitoring of the gillnet fleet from RS provided an estimated mortality of 946 (CI = 467–1525) franciscanas in 1999 and 719 (CI = CI:

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248–1413) in 2000 (Secchi et al., 2004). These estimates are considerably higher than those reported by Pinedo and Polacheck (1999) for earlier years based on strandings.

Williams et al. (2011) observed that about 2% of carcasses of dolphins dying in the northern Gulf of Mexico are recovered as strandings. Similar values were found by Epperly et al. (1996). These authors used data on sea turtle stranding rates in North Carolina as an indicator of the total number of turtles killed by fisheries and estimated that only 7–13% of animals caught in fisheries washed ashore in winter. Hart et al. (2006) analyzed the spatiotemporal pattern of sea turtles strandings in this region and concluded that stranding rates vary seasonally due to geographical and environmental variables such as wind direction and strength and distance from shore.

While franciscana stranding data have been collected since the late 1970s, the magnitude of incidental mortality remained unknown until the mid 1990s, as there was no direct monitoring of the gillnet fleet in southern RS during that period (Pinedo and Polacheck, 1999). Therefore, franciscana fishing-related mortality estimates, during this period, relied on counts of beached carcasses only (e.g. Pinedo et al., 1989; Pinedo and Polacheck, 1999). Although it was acknowledged that these data likely underestimated the true bycatch rate (Secchi et al., 1997, 2004), no attempt had been made to correct for this bias. This study presents a novel approach to estimate the probability that a franciscana killed in the coastal fisheries in southern Brazil will end up ashore and determines which variables affect this probability. This probability is then used as correction factor to back-calculate the likely number of franciscanas incidentally killed for those years without logbook monitoring, using data on the number of carcasses found ashore. The approach used here presents a novel methodology to utilize stranding data to assess the magnitude of cetacean and other large vertebrates human-derived mortality for periods when data from direct fisheries monitoring are not available.

2. Materials and methods

2.1. Study area

The State of Rio Grande do Sul (RS) is characterized by a straight coast oriented northeast/southwest and presenting a relatively wide continental shelf (60–122 nm at the 180 m isobath) and a smooth slope. This region has a seasonally variable wind regime (Piola et al., 2005), with northeast winds predominating in summer and generating a southward flow of coastal waters, and southwest winds in winter, with coastal waters flowing northward (Möller et al., 2008). The tidal influence is minimal, with mean amplitude of 0.47 m.

2.2. Mark-recapture data

The monitored coastal gillnet fleet is based in Rio Grande (southern Rio Grande do Sul State) and comprises about 140 boats. It operates between Mostardas (31° 13′ S) and Chuí (33° 45′ S), in water depths from 5 to 150 m (Fig. 1). However, 65% of the boats fish in waters of 35 m or less. This fleet is considered the most representative in volume of catch for coastal gillnet fisheries in Rio Grande do Sul State (Reis et al., 1994) and also responsible for a high number of incidentally caught franciscanas (Secchi et al., 2004). The two main target species of the fishery are white croaker (*Micropogonias furnieri*) in spring and summer (October to March) and striped weakfish (*Cynoscion guatucupa*) in autumn and winter (April to September) (Secchi et al., 1997; Ferreira, 2009).

From November 2005 to January 2009, 10–20 boats were monitored. Although the study was conducted based on voluntary

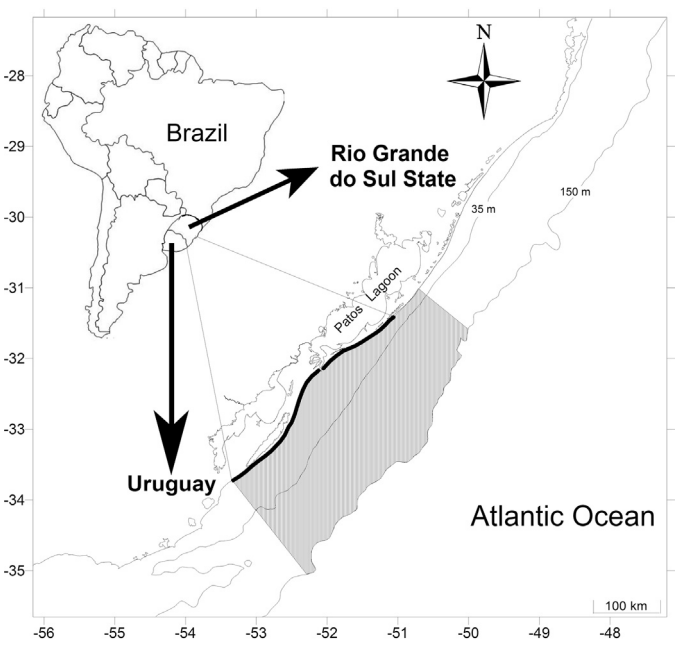

Fig. 1. Rio Grande coastal gillnet fleet fishing ground (shaded gray) and the stretch of beach surveyed for stranded carcasses (dark line). The discontinuity of the dark line represents the mouth of the Patos Lagoon estuary.

cooperation of the fishermen, it was assumed that they were representative of the entire fleet since boat characteristics and fishing operations were similar across the fleet. Each boat received a set of materials containing seals, numbered plastic tags, tools to attach the tag to the carcass and logbooks to register for each fishing day the date and fishing location, depth, initial and end position of the net, target species, number of franciscanas caught (including zero in the absence of capture). Incidentally captured franciscanas were marked (fishermen were instructed to attach the numbered tag between the animal's lower jaws – Fig. 2), and the GPS position where the carcass was returned to sea was recorded. Because during the first two years of the study this information was not available, the position of the returned carcass was assumed to be as the midpoint between the initial and end positions of the net set. The monitored fishermen were visited once or twice a week in order to assess their compliance with this study.

Systematic beach surveys were carried out fortnightly from Lagoa do Peixe (31° 26′ S–051° 09′ W) to Chuí (33° 45′ S–053° 22′ W), the border of Brazil and Uruguay, totaling 370 km (approximately 80% of the latitudinal extent of the fishing ground of the

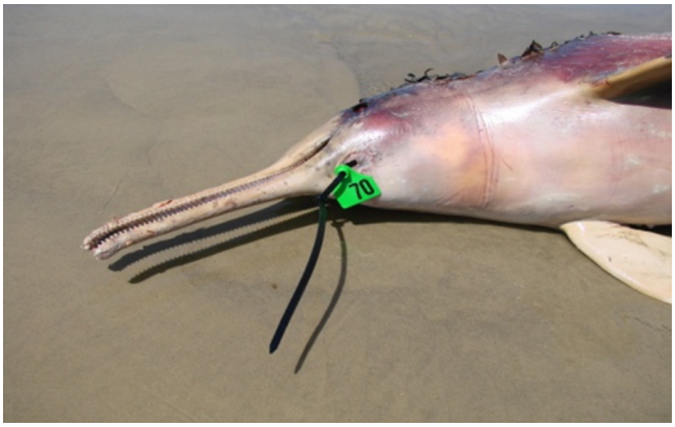

Fig. 2. A marked franciscana recaptured on the beach.