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Bycatch of great albatrosses in pelagic longline fisheries in the southwest Atlantic: Contributing factors and implications for management

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ABSTRACT

Pelagic longline fisheries in the southwest Atlantic are a major conservation concern for several threatened seabirds, including four species of great albatrosses: wandering albatross (*Diomedea exulans*), Tristan albatross (*Diomedea dabbenena*), southern royal albatross (*Diomedea epomophora*) and northern royal albatross (*Diomedea sanfordi*). The aim of this study was to examine the spatial and temporal variation in bycatch rates of these species, and to identify the contributing environmental and operational factors. We used data collected by observers on board pelagic longliners in the Uruguayan fleet in 2004–2011, and on Japanese vessels operating in Uruguay under an experimental fishing license in 2009–2011. Bycatch rates for northern and southern royal albatrosses were higher than expected based on previous reports, particularly over the shelf break. Wandering and Tristan albatrosses were caught predominantly in pelagic waters, where there are numerous fishing fleets from other flag states. Bycatch of great albatrosses was highest in April–November, with the peak for royal albatrosses in June–July, and for wandering and Tristan albatrosses in September–November. A range of vessel operational practices and habitat variables affected bycatch rates, among which setting time, moon phase, area and season are useful in terms of risk assessment, and in the development and improvement of conservation measures for these highly threatened species.

1. Introduction

Incidental mortality (bycatch) in fisheries is one of the major threats facing many populations of seabirds (Croxall et al., 2012; Žydelis et al., 2013). The global extent of seabird bycatch in commercial longline fisheries alone is likely to be at least 160,000 birds per year (Anderson et al., 2011). A high proportion of this bycatch is albatrosses (family Diomedeidae) (Brothers, 1991; Anderson et al., 2011). Particularly in the southwest Atlantic, pelagic longline fisheries appear to be a major conservation problem for several species, including great albatrosses (*Diomedea* spp.) (Jiménez et al., 2009a, 2012a). Although captured in very low numbers (Bugoni et al., 2008; Jiménez et al., 2009a, 2010), the great albatrosses originate from small breeding populations and, given these are biennially breeding species, the naturally low productivity means there is limited capacity for recovery following depletion (Croxall and Gales 1998).

The great albatrosses caught incidentally by the pelagic longline fishery in the southwest Atlantic include wandering albatrosses from the South Georgia population (*Diomedea exulans*), Tristan albatrosses (*Diomedea dabbenena*) that are endemic to Gough Island, and southern royal albatross (*Diomedea epomophora*) and northern royal albatross (*Diomedea sanfordi*) from New Zealand (Jiménez et al., 2012a). These are all globally threatened according to the World Conservation Union (IUCN) (http://www.birdlife.org/datazone/home). The first two populations number ca. 1500 breeding pairs each year, and are declining dramatically because of incidental capture in longline fisheries (Croxall et al., 1998; Poncet et al., 2006), exacerbated for the Tristan albatross by predation of chicks by invasive mammals (Cuthbert et al., 2004; Cuthbert and Hilton, 2004; Wanless et al., 2007, 2009). The population trend for northern royal albatross in the Chatham Islands is unknown, and southern royal albatrosses at Campbell Island appear to be stable (ACAP, 2009a,b). Birds breeding at these two archipelagos account for >99% of the respective global populations (ca. 5800 and 7800 annual breeding pairs, respectively; ACAP, 2009a,b). Despite

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the parlous conservation status of these four species and the potentially major impact of pelagic longline fishing, very little attention has been directed at understanding the factors that make the great albatrosses susceptible to fisheries interaction. Even the overall bycatch rates are uncertain because these species are caught in low numbers, only a small proportion of fishing effort is observed, bycatch rates vary a great deal by fleet, vessel, season, location, time of day etc., and very often *Diomedea* albatrosses are not identified to species level (Jiménez et al., 2009a).

Because of the patchy nature of the marine resources upon which albatrosses depend, they should disproportionally target particular habitats or suites of environmental conditions where prey are more abundant or predictable (Pinaud and Weimerskirch 2005; Wakefield et al., 2009, 2011; Louzao et al., 2011). Such areas are usually highly productive and as a result are often exploited by commercial fisheries. Seabirds are opportunistic foragers, and so are attracted to discards provided by fishing vessels (Tasker et al., 2000; Furness, 2003). An overlap between the distributions of fishing effort and seabirds is an obvious prerequisite for bycatch; however, broad-scale spatio-temporal overlap does not necessarily indicate interaction, as not all birds follow vessels (Granadeiro et al., 2011; Torres et al., 2013), and those that do will only be injured or killed if they have a close encounter with fishing gear, which in longline fisheries involves access to baited hooks (Jiménez et al., 2012a). Great albatrosses can dive to <1 m (Prince et al., 1994), and so on their own can only access baited hooks at the sea surface. However, they easily and routinely displace smaller species, and so the risk of bycatch is much greater where they co-occur with petrels and *Thalassarche* albatrosses that can reach hooks at greater depths and return them to the surface (Brothers, 1991; Jiménez et al., 2012b).

Past studies indicate that a number of aspects of fishing operations, including time of setting in relation to daylight, twilight and moon phase, and the use of mitigation measures, influence access to baited hooks and hence the bird bycatch rate (Brothers, 1991; Brothers et al., 1999; Jiménez et al., 2009a; Trebilco et al., 2010). In addition, particular environmental conditions may lead to aggregation of birds around vessels, increasing the likelihood of interaction. These factors presumably explain some of the high inter-specific variation in susceptibility to bycatch. Identifying such factors could be useful for preventing seabird bycatch, by highlighting specific areas and operations where mitigation needs to be particularly effective. Within this framework, and given the broad similarity in the behavior of great albatross species around vessels, we hypothesized that operational variables affect their bycatch likelihoods in a similar way. On the other hand, environmental variables could lead to differences in bycatch rates because of species-specific preference for particular habitats, which is likely to affect the relative overlap of birds with fisheries operations and potentially increase the likelihood of bird-vessel interactions (see Table 1). These species show some degree of inter-specific niche partitioning, particularly in the relative preference for foraging over continental shelves, shelf-slope or deep waters (Nicholls et al., 2002; Xavier et al., 2004; Cuthbert et al., 2005; Reid et al., 2013). In addition, the northern and southern royal albatrosses occurring in the southwest Atlantic are migrants from New Zealand, whereas the wandering and Tristan albatrosses include both breeding and nonbreeding birds, with the relative proportions depending on the time of year. Therefore, bycatch rates are likely to be temporally and spatially heterogeneous. Here, we used the largest data set available on the incidental capture of great albatrosses in pelagic longline fisheries in the southwest Atlantic, including information on specimens collected for further examination, to determine the spatial and temporal variation in bycatch rates of each species, and the contributing environmental and operational variables. The results are discussed in the context of developing effective strategies for mitigating bycatch of these highly threatened species.

2. Methods

2.1. Fishery and study area

The analyses were of observer data from the ''Programa Nacional de Observadores a bordo de la flota atunera uruguaya'' (PNOFA) of the ''Dirección Nacional de Recursos Acuáticos'' (DINARA), collected on board Uruguayan pelagic longline vessels in 2004–2011, and on Japanese vessels operating in Uruguay under an experimental fishing license in 2009–2011 (see Appendix A for details). The Uruguayan pelagic longline fleet targets swordfish (*Xiphias gladius*), yellow-fin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), albacore (*Thunnus alalunga*), and pelagic sharks (mainly *Prionace glauca*). Most of these vessels (20–37 m length) employed an American-style longline (monofilament mainline), and the remainder (two freezer vessels) used a Spanish-style longline (multifilament mainline). Both types of fishing gear are described in Jiménez et al. (2009a) and Domingo et al. (2012). The hook depth during soak time rarely exceeds 80 m for the Uruguayan vessels (DINARA unpublished data). During the study period the fishing area encompassed between 19–47°S and 20–60°W (Fig. 1). Vessels using American-style longlines operated mainly in Uruguayan waters (92% of sets), and those using Spanish-style longlines mostly (91% of sets) in deeper, international waters (Appendix A). The Japanese vessels (48–52 m length) targeted bigeye tuna and albacore with a Japanese-style longline (see Domingo et al. 2011a). The fishing area was between 34–37°S and 49–54°W, and vessels concentrated their effort in Uruguayan waters (99.1% of the sets) near the shelf break (Fig. 2, Appendix A). The average hook depth for Japanese vessels was 133 m (range = 75–210 m; Miller et al., 2012). The main oceanographic influence on the region is the confluence of the Brazil and Malvinas currents, which includes complex frontal systems and the simultaneous presence of warm and cold eddies (Olson et al., 1988; Acha et al., 2004; Ortega and Martínez, 2007).

2.2. Fishing operations

During the study period, longline vessels operating in Uruguay were required to use a single tori (streamer or bird-scaring) line and night setting as seabird mitigation measures; however, implementation took several years (see below). There were no regulations regarding the use of weighted branch lines (a minimum weight within a specified distance from the hook).

In the Uruguayan fleet, the longline is set over the stern, usually around sunset, and setting is generally completed before midnight. A single tori line was first used as a seabird bycatch mitigation measure in 2008, and by 2010 all the trips with observers used tori lines. During the study period, the longline set effort varied between 400 and 2000 hooks (mean = 1117 hooks, SD = 299 hooks) for American longlines, and between 360 and 3740 hooks (mean = 2570 hooks, SD = 647 hooks) for Spanish longlines. The mean distance between the start and end locations of the longline set involving these gear types was 46.9 km (SD = 15.7 km, range 0–94.3 km) and 68.9 km (SD = 21.5 km, range 8.0–135.3 km), respectively. The baits were squid (*Illex argentinus*) or mackerel (*Scomber* spp., *Trachurus* spp.) thawed a few hours before line setting, and occasionally shark belly.

On Japanese vessels the longline was set over the stern, mainly after midnight, and the set completed before sunrise. Night setting was practiced to reduce seabird bycatch, with the exception of the initial fishing period from March to late April 2009 when some sets