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Sea turtle bycatch in the Chilean pelagic longline fishery in the southeastern Pacific: Opportunities for conservation

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ABSTRACT

Data are presented on sea turtles caught in the Chilean longline fishery targeting swordfish, *Xiphias gladius*, in international waters off Chile. A total of 10,604,059 hooks from 7976 sets were observed, representing 94% of the total number of hooks fished between 2001 and 2005. Leatherbacks, *Dermochelys coriacea*, ($n = 284$) and loggerheads, *Caretta caretta*, ($n = 59$) were the most common species captured. Leatherbacks were caught in less than 4% of the sets, with an overall mean of 0.0268 turtles per 1000 hooks. Loggerheads were caught in less than 1% of the sets with a mean catch rate of 0.0056 turtles per 1000 hooks. Most leatherbacks (97.5% of total) were caught between 24°S and 38°S, while loggerheads were caught primarily in the northern portion of the area fished, between 24°19′S and 25°31′S. All loggerheads were dehooked where appropriate and released alive. A total of two leatherbacks were found dead. Despite the low catch rate of leatherbacks, the potential impact of this fishery on the severely depleted nesting populations in the eastern Pacific could be significant when combined with other fisheries and threats in the region. The very low mortality of bycaught sea turtles observed in our study is encouraging and suggests that there are opportunities for further reducing harmful effects of swordfish longline fishing on sea turtles. Results of spatial analysis of loggerhead bycatch relative to fishing effort show that closure of the northernmost fishing area would eliminate the majority of the loggerhead bycatch.

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1. Introduction

There is great concern over declining populations of sea turtles in the Pacific and the extent to which fishing activities contribute to these continued declines (Sarti et al., 1996; Eckert, 1997; Spotila et al., 2000; Lewison et al., 2004; Kaplan, 2005; Peckham et al., 2007). The four species of sea turtles that inhabit in the South East Pacific Ocean (loggerhead, *Caretta caretta,* leatherback, *Dermochelys coriacea,* green, *Chelonia mydas* and olive ridley, *Lepidochelys olivacea*) are listed as endangered or critically endangered species on the 2009 IUCN Red List of Threatened Species (IUCN[1]). Leatherback populations are at risk of extirpation in the Pacific because of over harvest of eggs, commercial and residential development on nesting beaches, and incidental bycatch in fisheries (Spotila et al., 2000). Declines have been documented at nesting beaches in the eastern Pacific and throughout the Indo-Pacific region, with a complete loss of the Malaysian nesting population (Chan and Liew, 1996), severe declines at nesting beaches in Costa Rica and Mexico (Sarti et al., 1996, 2007; Spotila et al., 2000), and lesser declines at western Pacific nesting beaches (Dutton et al., 2007; Hitipieuw et al., 2007).

Pacific loggerheads generally consist of two distinct breeding stocks; a North Pacific stock originating from nesting sites in Japan (Kamezaki et al., 2003), and a South Pacific stock nesting in Australia and New Caledonia. Both stocks have declined dramatically over the last few decades (Chaloupka, 2003; Kamezaki et al., 2003; FAO, 2004). The North Pacific stock inhabits foraging and developmental areas in coastal neritic and oceanic habitat all the way to the northeast Pacific off the coast of the Baja California Peninsula, and is exposed to threats from pelagic and coastal fisheries (Bowen et al., 1995; Kamezaki and Matsui, 1997; Koch et al., 2006; Peckham et al., 2007). The Australian stock has undergone population declines as a result of nest predation and incidental capture in coastal and pelagic fisheries in the southwest Pacific (Chaloupka and Limpus, 2001; Chaloupka, 2003).

In contrast, key Eastern Pacific olive ridley and green turtle nesting populations have increased significantly in recent years

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[1] IUCN (International Union for Conservation of Nature), 2009. Species Survival Commission. Red List Database 2009. Website: http://www.iucnredlist.org/ (accessed on 19 December 2009).

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(Chaloupka et al., 2004). Olive ridleys are the most abundant species encountered at sea in the Eastern Tropical Pacific (Eguchi et al., 2007; Swimmer et al., 2010).

There is a growing effort to quantify the bycatch of sea turtles in order to enable risk assessment and develop mitigation measures for different fisheries (Carretta et al., 2005; Watson et al., 2005; Lewison and Crowder, 2007; Cox et al., 2007; Gilman et al., 2007, 2010; Brazner and McMillan, 2008; Oceanic Fisheries Programme, 2001; Swimmer et al., 2010). Bycatch rates and species composition vary by fishery type and geographic region (Wallace et al., 2010). The level of threat posed by individual fisheries to sea turtles depends on status of the affected population(s), the level of injury or mortality caused by the gear, the life stages of the bycaught turtles, and the level of fishery effort (Soykan et al., 2008; Lewison et al., 2009; Moore et al., 2009; Wallace et al., 2008, 2010).

Several studies have examined sea turtle bycatch in pelagic longline fisheries in the Atlantic (Witzell, 1998; Domingo et al., 2006; Kotas et al., 2004; López-Mendilaharsu et al., 2007; Marcovaldi et al., 2006; Pons et al., 2010), Mediterranean (Aguilar et al., 1995; Camiñas, 2005; Alessandro and Antonello, 2009) the North Pacific (Kleiber, 1998; McCracken, 2000; Yokota et al., 2009) and the Eastern Tropical Pacific (Swimmer et al., 2010). However there is a paucity of high quality information on bycatch rates in comparable pelagic fisheries operating in the Southeastern Pacific (Lewison et al., 2004; Lewison and Crowder, 2007; Wallace et al., 2010). Furthermore, the data that are available in many cases consist of estimates extrapolated from observer data collected from a small (2–20%) portion of the fleets. These estimates typically have large errors associated due to the relatively low encounter rates between pelagic longline fishing gear and sea turtles in the Pacific (Kleiber, 1998; McCracken, 2004). High bycatch rates have also been shown to be associated with low observed effort in a given region (Sims et al., 2008) and Wallace et al., 2010 point out the importance of comprehensive and stratified observer coverage to improving the accuracy of bycatch assessments.

Telemetry and tagging studies have shown that the coastal and oceanic habitats in the southeastern Pacific are vital foraging destinations and migratory pathways for the depleted eastern Pacific leatherback populations (Eckert, 1997; Shillinger et al., 2008). Mortality resulting from bycatch in small-scale coastal fisheries off Peru and Chile is believed to have contributed to the decline of eastern Pacific leatherback nesting populations (Frazier and Brito-Montero, 1990; Eckert, 1997; Alfaro-Shigueto et al., 2007), however the extent to which leatherbacks and loggerheads interact with high seas fisheries operating in international waters in the southeast Pacific is unclear. Foraging and developmental habitat for the South Pacific loggerhead breeding stock is now known to extend across the South Pacific to include coastal areas off Peru, South America (Alfaro-Shigueto et al., 2004; Boyle et al., 2009), further highlighting the need to assess the additional threats posed to loggerheads by fisheries operating in the southeastern Pacific (Alfaro-Shigueto et al., 2008).

In Chile a commercial fishery was established in 2001 that permitted shallow-set longlining for swordfish (*Xiphias gladius*) with the requirement that vessels took an observer at all times to collect information on the swordfish catch and that all vessels carried a Vessel Monitoring System (VMS) to track their position in real time over the Marynsis-based satellite system (Ley 19521, 1997[2]). The restrictions on swordfish catch include a minimum allowable size of 184 cm Lower Jaw Fork Length (Decreto Supremo No. 406, 1997[3]) with no discarded fish allowed. Fishers are allowed to retain up to 30% of the swordfish below the minimum size, and any excess is confiscated. At the onset of the fishery in 2001, vessels operating in the north caught a large proportion of illegal-sized juvenile swordfish. This area, demarcated by a boundary adjacent to the Cordillera de Nazca (20°S, 83°30′W; 20°S, 78°00′W and 24°S, 83°30′W) was closed to fishing beginning in April 2001 to protect the swordfish nursery area.[4] Furthermore, as a result of growing concern over potential impacts of fishing on declining leatherback populations, the Chilean swordfish observers were trained to collect information starting in 2001 on incidental take of sea turtles as part of a joint program carried out under a bilateral Fisheries Cooperation Agreement between the US National Oceanic and Atmospheric Administration (NOAA) Fisheries Service and the Chilean National Fisheries Service (SERNAPESCA).

Here we present information on incidental capture of sea turtles by the commercial longline fishery targeting swordfish off the coast of Chile (in Zone 87 FAO), based on 94% trip coverage by observers over a 5-year period (2001–2005). We present seasonal distribution and abundance of sea turtle bycatch relative to fishing effort, present catch-per-unit-effort (CPUE) data, and discuss potential measures to reduce bycatch.

2. Materials and methods

2.1. Fishery observations

Information was collected by a trained observer placed on fishing vessels registered as part of the Chilean pelagic longline fleet for the entire fishing season (February–December) each year between 2001 and 2005 (Appendix A). Observers were on board for the entire trip, which averaged 35 days for all trips except those carried out by two of the vessels that were equipped with freezers, which averaged 60 days at sea. This fleet comprised boats 17–42 m in length operating in international waters off the Chilean EEZ, between 70–180°W and 17–39°S. This area encompasses deep (ca. 2000–3000 m) abyssal waters.

All the observed vessels targeted swordfish and retained mako shark (*Isurus oxirhynchus*) and blue shark (*Prionace glauca*) as bycatch (as well as other less important species). They used the American monofilament longline system, as described in Vega and Licandeo (2009) with non-offset "J" hooks (Mustad 9/0) baited with Argentinean shortfin squid (*Ilex argentinus*), or occasionally jack mackerel (*Scomber japonicus*). A yellow or pink chemical light-stick was hung above each hook. Two vessels used the Spanish-style gear configuration where the gangions consist of polyethelene multifilament nylon containing a 5.5 m stainless steel leader (1.5 mm dia) attaching the hook, and are set closer together than the American system, with approx 10–12 gangions along each 350–400 meter section (Barria et al., 2006; Vega and Licandeo, 2009). Vessels using the Spanish system set an average of 2000 hooks on 45 nautical miles (nm) of longline compared with an average of 1300 hooks on 35–55 nm of longline set by vessels using the American system. Vessels fishing with the American configuration generally began setting gear at dusk (1800–1900 h) with sets lasting a total of 18 h including 4 h to set, 8 h soak time, and 6 h haulback time. Vessels fishing with the Spanish configuration began setting gear around 1800–2000 h with sets lasting approximately 20 h including 5 h set time, 7 h soak time and 8 h haulback.

2.2. Bycatch observations

Observers collected data on sea turtle interactions, location, and fishing effort (soak time, number of sets, and for each set the date,

[2] Ley No. 19521. Diario Oficial de la República de Chile, Santiago, Chile, 30 de Octubre de 1997.

[3] Decreto Supremo No. 406. Diario Oficial de la República de Chile, Santiago, Chile, 2 de Abril de 1997.

[4] Resolución No. 157 & No. 641 de la Subsecretaría de Pesca del 29 de Enero & del 12 de Abril de 2001.