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Untangling the impacts of nets in the southeastern Pacific: Rapid assessment of marine turtle bycatch to set conservation priorities in small-scale fisheries

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ABSTRACT

Bycatch of marine megafauna by small-scale fisheries is of growing global concern. The southeastern Pacific sustains extensive fisheries that are important sources of food and employment for millions of people. Mismanagement, however, jeopardizes the sustainability of ecosystems and vulnerable species. We used survey questionnaires to assess the impact of small-scale gillnet fisheries on sea turtles across 3 nations (Ecuador, Peru and Chile), designed to fill data gaps and identify priority areas for future conservation work. A total of 765 surveys from 43 small-scale fishing ports were obtained (Ecuador: n = 379 fishers, 7 ports; Peru: n = 342 fishers, 30 ports; Chile: n = 44 fishers, 6 ports). The survey coverage in study harbors was 28% for Ecuador, 37.0% for Peru, and 62.7% for Chile. When these survey data are scaled up across the fleets within surveyed ports, the resulting estimate of total annual bycatch across the study harbors is 46 478 turtles; where Ecuador is 40 480, Peru 5 828 and Chile 170 turtles. Estimated mortality rates vary markedly between countries (Ecuador: 32.5%; Peru 50.8%; Chile 3.2%), leading to estimated lethal takes of 13 225, 2 927, and 6 turtles for Ecuador, Peru, and Chile, respectively. These estimates are remarkably large given that the ports surveyed constitute only 16.4, 41, and 22% of the national gillnet fleets in Ecuador, Peru, and Chile, respectively. Limited data from observer-based surveys in Peru suggest that information from surveys are reliable and still informative. Information from surveys clearly highlight Ecuador and Peru as priority areas for future work to reduce turtle bycatch, particularly given the status of regional populations such as leatherback and hawksbill turtles.

1. Introduction

Incidental catch in fisheries, or bycatch (Davies et al., 2009), is thought to pose a major threat to marine vertebrates at a global level (Anderson et al., 2011; Baum et al., 2003; Lewison et al., 2004). This has been confirmed in detail for sea turtles, where many populations face large impacts due to bycatch in industrial fisheries (Crowder et al., 1994; Spotila et al., 2000; Wallace et al., 2010b). In small-scale fisheries, directed harvest is now greatly reduced (Humber et al., 2014) but bycatch is thought to be significant although relatively poorly quantified (Lewison and Crowder, 2007; Peckham et al., 2007; Rees et al., 2016). Onboard observer programs have been shown as the most accurate source of information to estimate bycatch levels (Babcock et al., 2003). However, in cases where data are deficient, such as in small-scale fisheries (Chuenpagdee et al., 2006; Salas et al., 2007), or in which the logistical and funding challenges to implement observer programs are prohibitive (Moore et al., 2010), assessments using interview-based surveys can provide crucial information that can help define the scale and range of fishing effort as well as offer insights into the magnitude of bycatch (D'Agrosa et al., 2000; López et al., 2003).

Sea turtle populations extend over broad spatial scales and the turtles found in the southeastern Pacific originate from across the basin (reviewed by Alfaro-Shigueto et al., 2011). Green turtles (*Chelonia mydas*) foraging in Peru originate in the Galapagos Islands and Mexico (Hays-Brown and Brown, 1982; Seminoff et al., 2008; Velez-Zuazo and Kelez, 2010), leatherback turtles (*Dermochelys coriacea*) originate from breeding colonies in Mexico, Costa Rica, as well as the western Pacific (Dutton et al., 2010; Eckert and Sarti, 1997; Saba et al., 2008).

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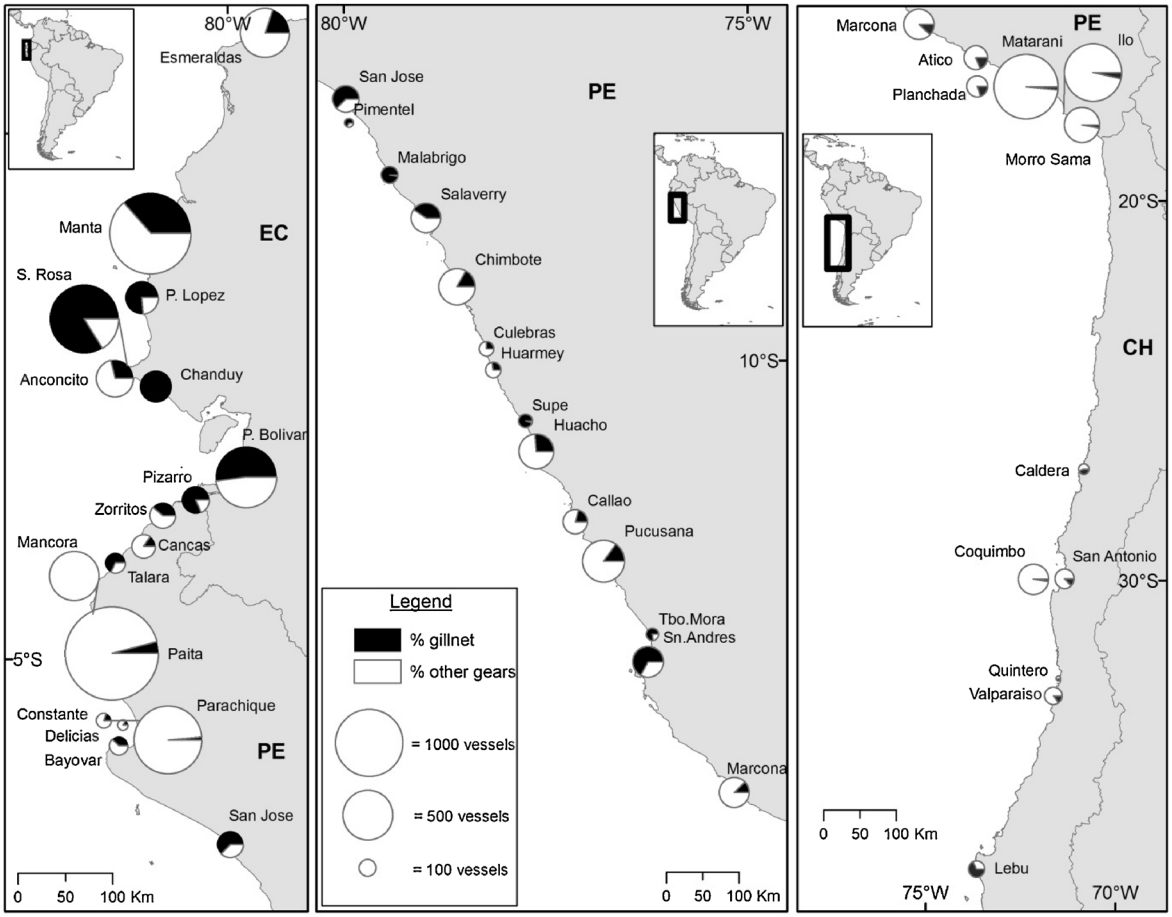

Fig. 1. Distribution of gillnet use at small-scale ports sampled from Ecuador to Chile. From left to right (north to south: EC = Ecuador, PE = Peru, CH = Chile). Circle area indicates the fleet sizes at each port in number of boats, shaded areas show the composition of gillnets in relation with all small-scale fishing fleet at each port (from Supplemental Table 1).

Loggerhead turtles (*Caretta caretta)* foraging in Peru and Chile, originate in Australia and New Caledonia (Alfaro-Shigueto et al., 2004; Boyle et al., 2009), whilst olive ridley turtles (*Lepidochelys olivacea*) inhabiting Peruvian waters come from stocks breeding in Costa Rica, Colombia and Mexico (Velez-Zuazo and Kelez, 2010; Zeballos and Arias-Schreiber, 2001). The hawksbill turtle (*Eretmochelys imbricata*) is relatively rare in Peru, but is likely to be linked to the closest rookery in Ecuador (Gaos et al., 2017). Eastern Pacific leatherbacks and hawksbills are two of the eleven most threatened sea turtle subpopulations in the world (Wallace et al., 2011).

These turtle populations are present year-round in the southeastern Pacific, primarily foraging, thus they interact with multiple fishing fleets, including longlines, trawls, purse seines and gillnets. Seasonal peaks in bycatch interactions have been described for loggerheads and longlines for mahi and sharks during austral summer (Alfaro-Shigueto et al., 2011); for hawksbills in the coastal net fisheries during spring and summer (Alfaro-Shigueto et al., 2010a,b); while for leatherback turtles, peaks of landings in the 1980′s occurred in the summer (Hays-Brown and Brown, 1982), similar to what Alfaro-Shigueto et al. (2007) reported based on strandings and landings reports. There are no similar analyses for seasonality of bycatch for either greens or olive ridleys. However, information from Peru suggests that olive ridleys occur more often from the northern to the central Peru coast, with higher numbers in summer months (Alfaro-Shigueto et al., 2011), while greens are the most common species bycaught year-round in longlines and gillnets along the coast (Alfaro-Shigueto et al., 2011).

These complex inter-relations highlight how bycatch occurring in foraging areas in the southeastern Pacific can have wide ranging detrimental impacts. Empirical information suggests that within small-scale fisheries, gillnets play a major role in the bycatch of sea turtles (Wallace et al., 2010b). Gillnet fisheries include the use of surface nets, usually driftnets, bottom set nets, trammel nets and encircling nets (Nédélec and Prado, 1990). Levels of fishing effort of small-scale fisheries, particularly in gillnets, in the eastern tropical Pacific are among the highest worldwide (Stewart et al., 2010).

Within the vast region of the Southeast Pacific, the waters of Ecuador, Peru, and Chile, form the Major Fishing Area 87 (FAO Major Fishing Areas). By 1999, 84.7% of Ecuadorian ports used gillnets, while the total number of small-scale fishing vessels was 15 494 operated by 56 068 fishers (Solis-Coello and Mendivez, 1999). In Peru, gillnets are the main fishing gear used in small-scale fisheries, which comprised 9 667 vessels operated by 37 727 fishers (Estrella and Swartzman, 2010), and effort has been estimated at ca. 100 000 km of nets deployed each year (Alfaro-Shigueto et al., 2010a,b). In Chile, although the number of small-scale vessels is 12 526 and these are operated by 85 268 fishers (Registro SERNAPESCA de Pesca Artesanal 2011, available at www.sernapesca.cl), gillnet use is currently limited and includes a swordfish *Xiphias gladius* fishery (DecretoNo.657 2002). Landing sites for these three countries total ca. 500 ports in Ecuador (Solis-Coello and Mendivez, 1999), 106 ports in Peru (Alfaro-Shigueto et al., 2010a,b) and 230 ports in Chile (Bernal et al., 1999). Sea turtle bycatch in the region has been reported for the small-scale fleet since the 1970′s and 1980′s for Peru and Chile (Hays-Brown and Brown, 1982; Frazier and Brito Montero, 1990), with more recent information published for Ecuador (Andraka et al., 2013); Peru (Alfaro-Shigueto et al., 2011; Pingo et al., 2017); and Chile (Donoso and Dutton, 2010).