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Captures of manta and devil rays by small-scale gillnet fisheries in northern Peru

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ABSTRACT

There is a growing global concern for the conservation of manta and devil rays (Mobulidae). Populations of mobulids are falling worldwide and fisheries are one of the main activities contributing to this decline. Mobulid landings have been reported in Peru for decades. However, detailed information regarding the description of mobulid captures is not available. This study provides an assessment of mobulid captures and fish-market landings by small-scale gillnet fisheries from three landing sites in northern Peru. Onboard and shore-based observations were used to monitor captures and landings respectively between January 2015 and February 2016. All mobulid species known to occur in Peru were recorded from landings, with immature *Mobula japanica* as the most frequent catch. No manta rays (*Manta birostris*) were reported as caught although one specimen was observed as landed. The mean nominal CPUE was 1.6 ± 2.8 mobulids$[km.day]^{-1}$ while the average capture per set (fishing operation) was 2.0 ± 8.09 mobulids$[set]^{-1}$. Smooth hammerhead shark (*S. zygaena*) and yellowfin tuna (*T. albacares*) were target species highly associated with mobulid captures. The majority of mobulid captures occurred in nearshore waters and over the continental shelf off Zorritos and San Jose. Mobulid capture showed a temporal trend, increasing between September 2015 and February 2016, with a peak in October 2015 (10.17 ± 0.23 mobulids$[km.day]^{-1}$), reflected by landings that showed an additional peak in May. A generalized linear zero-inflated negative binomial two-part model (GLM ZINB) indicated that longitude and latitude explained both the zero-inflated binomial model, as well as the count negative binomial model, which also included season as a explanatory variable for differences in mobulid captures. The mean CPUE (mobulids $[km.day]^{-1}$) and mean Variance values obtained from the fitted final model were 1.73 and 25.51, respectively. Results also suggest that high mobulid captures could reflect an opportunistic behaviour of fishermen who catch mobulids when target species are not as abundant. Considering the global conservation status of mobulids, (*Manta* and *Mobula*), and acknowledging that *M. birostris* was the only species not recorded captured in the study but is the only species legally protected in Peru, further studies are necessary to support the possible inclusion of *Mobula* species in national management plans.

1. Introduction

Mobulids are large planktivorous elasmobranchs from the family Mobulidae, represented by manta (*Manta* spp) and devil rays (*Mobula* spp). These rays are mostly identified by their large body sizes, with disc widths (DW) up to 7 m for *Manta* spp and up to 5 m for *Mobula* spp (Notarbartolo di Sciara, 1988; McClain et al., 2015), and the presence of two cephalic lobes on the head. The genus *Manta* includes two species, while the genus *Mobula* groups nine species. Both genera are widely distributed in tropical and subtropical latitudes (40°N–40°S) where seawater temperatures are between 20 and 26 °C (Clark, 2010; Canese et al., 2011; Croll et al., 2012). However, mobulid individuals do not show large ranges of displacement (Camhi et al., 2007).

Although little is known about the ecology of this family (Couturier et al., 2012), some studies have revealed the high vulnerability of mobulids to anthropogenic threats such as fisheries, habitat loss and

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degradation, and climate change (Dulvy et al., 2008; Rohner et al., 2013; Duly et al., 2014b). Their k-selected life histories may make mobulids highly vulnerable to even small population depletions (Couturier et al., 2012; Dulvy et al., 2014a; Croll et al., 2015). The International Union for the Conservation of Nature (IUCN) Red List categorizes four mobulid species as near threatened, four as vulnerable, one as endangered, and two as data deficient. Some specific management measures to protect mobulids have been applied worldwide. International agreements such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) promote better regulations for trade and the establishment of management plans for mobulids. However, there are still limitations in conservation measures among the species, which experts are trying to resolve (Lawson et al., 2017).

Fisheries interactions appear to be the main threat for sub-populations of mobulid species. Estimates of manta and devil rays catches in Africa and Asia have increased from 931 mt in 2000 to > 4000 mt in 2014 (FAO, 2016), with a global catch estimate of ca. 94 000 ind/year (Heinrichs et al., 2011). This information, together with the fact that in some locations mobulid stocks are declining (Ward-Paige et al., 2013; Lewis et al., in press), raises concerns about the status of manta and devil ray populations and their capacities to respond to anthropogenic threats such as fisheries.

Small-scale and recreational fisheries targeting mobulids have been reported for centuries (Croll et al., 2015). Meat, skin, and, more recently, gills, have been used as food, bait (for artisanal fisheries) and leather, as well as in Asian traditional medicine (gills). While only nine countries report having fisheries that target mobulids (Indonesia, Philippines, India, Sri Lanka, Mexico, Taiwan, Mozambique, Gaza Palestinian States and Egypt), it is important to consider other areas where incidental catches of mobulids are used as an “opportunistic catch” due to the increasing values arising from international trade of gills (Couturier et al., 2012; Hall and Roman, 2013; Lewis et al., in press). In addition to directed and opportunistic catches, incidental catches (or “bycatch”) of mobulids have also been reported by small- or large scale fisheries from 30 countries (Croll et al., 2015). The fishing gears with the highest reported quantities of mobulid bycatch were gillnets and purse seines (Alava et al., 2002; Croll et al., 2015,). Of these, tuna purse seine fishing had the highest catch with reports of over 4700 ind/year for the Eastern Pacific Ocean between 1993 and 2009 (Hall and Roman, 2013).

In Peru, the catch and landing of mobulids has also been reported. Gonzalez-Pestana et al. (2016b), ranks it as the 15th country in global batoid landings, representing 11% of total landings worldwide between 2005 and 2011. The study indicates that mobulid landings were 28% of total batoid landings in the country, with the largest proportion of landings coming from the northern coast, and gillnets the main fishing gear used for mobulid captures. Researchers have reported mobulid catches in Peru both in small-scale and industrial fisheries (Ayala et al., 2009; Alfaro-Shigueto et al., 2010; Hall and Roman, 2013). The purse seine tuna fishery off the Peru between 1994 and 2009 reported an average of more than 600 mobulids/year captured as bycatch (Hall and Roman, 2013). Additionally, observations of mobulid bycatch have been reported in the small-scale gillnet fishery operating along the north coast of Peru (Castañeda, 1994; Ayala et al., 2009).

The lack of accurate data at the species level on mobulid landings does, however, prevent a clearer understanding of the catch rates of individual species. Data gaps such as these can lead to inaccuracies in the development or implementation of conservation and management measures. Since 2014, the five species of mobulids present in Peru waters (*M. munkiana, M. tarapacana, M. japanica, M. thurstoni* and *M. birostris*), have been included in the National Action Plan for Elasmobranch Conservation (PAN-Tiburón) (Supreme Decree N° 002-2014 PRODUCE). However, only *Manta birostris* is subject to specific regulations, which establish the ban on its capture, landing, processing, and/or trade. In cases of bycatch, specimens are to be returned to the water without injuries (Ministerial Resolution N° 441-2015 PRODUCE).

The main objective of the present study was to describe the mobulid small-scale gillnet fisheries in three ports in northern Peru (Zorritos, Mancora and San Jose). More specifically, we were interested in (1) estimating the rate of mobulid captures by small-scale gillnet fisheries in the study zone, (2) estimating the landing of mobulids and its fluctuation along the year, and (3) evaluating if mobulid captures are influenced by temporal and/or spatial variables.

2. Methods

2.1. Study area

The study was conducted from January 2015 to February 2016 at three landing sites in northern Peru: Zorritos (3°40′S, 80°40′W); Mancora (4°06′S, 81°02′W) and San Jose (6°45′S, 79°58′W). These sites comprise one of the areas with the majority of elasmobranch and mobulid landings in the country (Ayala, 2014; Gonzalez-Pestana et al., 2016a,b).

The marine ecosystem of Peru comprises the Northern Humboldt Current System (NHCS), known for its unique oceanographic conditions, characterized by strong upwelling and the confluence of many currents, which generate high fishing productivity (Chavez et al., 2008). In northern Peru, the NHCS borders with the Pacific Equatorial System (PES), composed of warm waters and high biodiversity. The study area corresponds to the convergence zone (4° − 7° S) between these two systems (Strub et al., 1998; Flores et al., 2013).

2.2. Onboard observations

Five trained onboard observers collected information aboard small-scale artisanal fishing vessels (maximum of 32.6m^3 GRT, up to 15 m length and operating manually, Supreme Decree N° 012-001-PE) from the above-mentioned ports. Observers monitored the fishing activity of eight surface driftnet vessels during 85 trips (331 individual fishing sets). Skippers (N = 8) whose vessels were monitored participated voluntarily in the project. The pelagic gillnet fishery in the study zone is considered a multi-species activity mainly targeting sharks such as smooth hammerheads (*Sphyrna zygaena*) and thresher sharks (*Alopias* spp.), and pelagic bony fishes such as yellowfin tuna (*Tunus albacares*). The net size is highly variable between vessels. Vessels typically set the net during the afternoon and retrieved the following morning (soak duration ~14.5 h) (Alfaro-Shigueto et al., 2010).

Data related to fishing activities, concerning fishing net dimensions, fishing timing and position (using GPS) per set, and species caught in numbers (target and not target) were recorded. Retained fish were counted as catch since discards in this fishery are typically very low, given its multi-specific nature. Observers did not take part in fishing activities. When conditions allowed, biometric data, sex and weight of mobulids caught were recorded. Identification to the species level was attempted onboard using identification guides provided during this study, as well as on land using pictures of the catch. Data were analysed to the genus level (Mobula spp. or Manta spp) due to difficulties in Mobula species identification (mainly between *Mobula munkiana* and *Mobula thurstoni*) because of challenging sampling conditions at sea.

Observers worked every month (2–3 trips per month per observer) over a total period of 14 months (from January 2015 to February 2016) in order to account for any potential seasonal variability in catch rates. Onboard observer data were managed in a Microsoft Access database.

2.3. Shore-based observations

In order to monitor total mobulid species landings by this gillnet fishery, shore-based observers were also deployed in San Jose from September 2015 to January 2016, and in Zorritos from January 2015 to