Aggregation areas of elasmobranches in Peruvian waters

Final Report

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JUSTIFICATION AND CONSERVATION RELEVANCE

Sharks and batoids (rays and skates) are globally threatened as a result of unsustainable fishery and bycatch (Camhi et al., 2008; Ferretti et al., 2008; Dulvy et al., 2000, 2008, 2014; Kyne et al., 2005). They are vulnerable to overexploitation due to their biological characteristics, such as, large offspring size, slow growth, late maturation, and low fecundity. Important gaps in their knowledge (biology and fishery) hinder the design and implementation of their conservation management.

The Peruvian elasmobranches' fishery is among the third largest in America (Bonfil, 1994) and Peru is one of twelve major countries that supplied shark fins to Hong Kong market between 2002-2008 (Cheung and Chang, 2011). A recent study reported that Peru has the highest accumulated historical shark landings in the Pacific Ocean (González-Pestana et al., 2014) and the highest batoid landings in the southeast Pacific (González-Pestana in process).

In Peru, smooth hammerhead (*Sphyrna zygaena)* is the third shark specie most exploited (González-Pestana et al., 2014) and mobulid rays are the second batoid group most exploited (González-Pestana in process). Nevertheless, no conservation management has been implemented and knowledge about its fishery is scarce (only landings by biomass are reported).

OBJECTIVES

- Identify and characterize the Peruvian aggregation areas of smooth hammerhead sharks and mobulid rays.
- Characterize the fishery in their aggregation areas.
- Constitute a sample bank of smooth hammerhead sharks and mobulid rays.
- Increase awareness and education about elasmobranches in elasmobranch-fishery communities.
- Promote students in elasmobranch research.

RESULTS

Outcome 1: Identify and characterize the Peruvian aggregation areas of smooth hammerhead sharks and mobulid rays

The samples were collected on the landing points of San José, Yacila, Mancora and Cancas. Instead of Pucusana, the landing point of Yacila was sampled instead because of the following reasons: 1) few hammerhead shark and none mobulid rays were reported in Pucusana; 2) the fishery of hammerhead and mobulids is concentrated on northern Peru; 3) focus human efforts in one region (northern Peru) is more practical, coordinated and attainable.

A total of 897 hammerhead sharks and 270 mobulid rays were sampled: Tumbes (393 sharks and 59 mobulids), Lambayeque (309 sharks and 80 mobulids), and Piura (195 sharks and 131 mobulids). Individuals were measured and sexed.

Three aggregation areas of elasmobranchs in northern Peru have been identified where smooth hammerhead sharks and mobulid rays are present between December and May: Tumbes, Piura and Lambayeque (Figure 1).

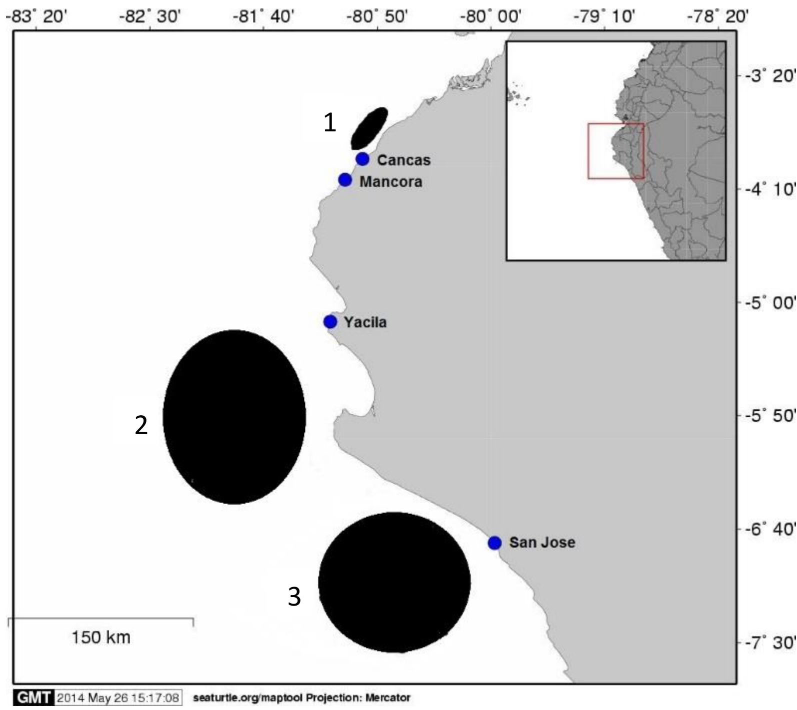

Figure 1. Map of the aggregation areas in northern Peru. Black circles: 1) Tumbes (1-5 miles offshore), 2) Piura (50- 100 miles offshore), 3) Lambayeque (12-100 miles offshore). Blue circles: landing points where the samples were taken.

These areas serve as nursery ground for smooth hammerhead shark between December and May. Pregnant females appeared between December and January to give birth. Therefore, in December the smallest sharks were measured (53 - 70 cm total length, TL) and they showed open umbilical wounds (Figure 2). As months passed their size increased (80 - 95 cm TL) and the umbilical wounds were healed. Hammerheads have placental viviparity: an umbilical connection to the mother. So after parturition the neonate sharks' umbilical wounds are open. Its birth size is 50-60 cm TL (Compagno, 1984). Neonates and juvenile sharks are present in their nursery areas until April or May when they leave these areas. The sex proportion of the neonates and juveniles are 1.1 : 1 (female: male).

Figure 2. Open umbilical wound (between the pectoral fins) of a neonate hammerhead shark.

In Piura and Lambayeque 47 adult female were sampled during late December and early January. These measured between 226 and 360 cm TL. According to Stevens et al. (1984) females mature at about 265 cm TL. Therefore, the 47 females sampled were mainly adults. In conversations with fishermen and personal observations, the females were pregnant with embryos on the last stage of development.

Mobulid rays (*Mobula japanica, M. munkiana, M. tarapacana, M. thurstoni*) are also present in these areas. *M. japanica* predominates in abundance: 86.4% of mobulids sampled in Tumbes, 97.5% in Lambayeque, and 100% in Piura. The aggregation areas of Tumbes and Lambayeque represent the greatest diversity in mobulid ray species: in Tumbes 6.8% of mobulids sampled were represented by *M. munkiana* and *M. thurstoni*, and in Lambayeque 1.3% were *M. tarapacana* and *M. thurstoni*.

The population structure of *M. japanica* is compose by juveniles (74%) and adults (26%) where neonates appeared between January and March. They present lengths between 60 and 288 cm disc length (DL) and their sex proportion are 1.4 : 1 (female: male). In Tumbes and Lambayeque the most common length range was 106-151 cm DL, and in Piura was 197-242 cm DL.

The sites in Lambayeque and Piura present great elasmobranch diversity: thresher sharks (*Alopias pelagicus, A. vulpinus*), blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), silky shark (*Carcharhinus falciformis*), Chilean and Peruvian eagle ray (*Myliobatis chilensis, M. peruvianus*), and whale shark (*Rhincodon typus*). According to IUCN Red List four are vulnerable, two are near threatened, and two have data deficient.

Besides hammerhead sharks and mobulid rays, we were able to collect lengths and sex of three shark species: 61 thresher sharks, 30 blue sharks and 11 shortfin makos. The thresher sharks present lengths between 15 and 63 cm interdorsal length and their sex proportion are 1.9 : 1 (female: male). The blue sharks present lengths between 109 and 252 cm TL and 85% of the individuals sampled are immature. Their sex proportion are 1: 4.8 (female: male). The shortfin makos present lengths between 129 and 344 cm TL and 90% of the individuals sampled are immature. Their sex proportion are 1: 1 (female: male).

The sea surface temperature (SST) between January and April varied according to the location: Lambayeque and Piura present a SST between 19 and 23°C; Tumbes present a SST between 23 and 26°C. Tumbes is located in the marine province of Tropical Eastern Pacific (Equatorial marine current); Lambayeque and Piura are located in the marine province of Temperate South America (transition zone where Equatorial and Humboldt marine currents encounter) (Spalding et al., 2007).

Outcome 2: Characterize the fishery in their aggregation areas

A total of 152 fishery voyages were monitored establishing three aggregation areas of elasmobranches (Figure 1) that are vulnerable to fisheries. Hammerhead´s fishery captures neonates and juveniles (95%), and adults females (probably pregnant) (5%). Mobulids´ fishery captures juveniles (74%) and adults (26%). As a result, most of these elasmobranches are captured before reaching sexual maturity. For these two species/groups, the sex proportion of the captures is approximately 1:1; but for the adult hammerhead sharks it is 1:0 (female: male) (Figure 3).

Figure 3.1 & 3.2: Landings of smooth hammerhead sharks (*S. zygaena*) in northern Peru: neonates and juveniles (3.1) and adult females (3.2); **Fig. 3.3**: sampling of hammerhead sharks; **Fig. 3.4 & 3.5**: *M. japanica* landed on Cancas port; **Fig. 3.6**: landings of mobulid rays (cut in half without a head) on Mancora port; **Fig. 3.7 & 3.8**: boats that fished sharks and mobulid rays (3.7: coastal boats in Tumbes with immature hammerheads on board; 3.8: oceanic boats in Piura and Lambayeque).

The characteristics of the boat and the fishery voyage varied according to the location: Tumbes presents a coastal fishery area where the boats have a storage capacity of 3-5 tones and the voyage lasts 12 hours; meanwhile Lambayeque and Piura are oceanic fishery areas where the boats have a storage capacity of 10 tones and the voyage lasts 5-9 days (Figure 3.7, 3.8).

The hammerhead sharks and the mobulid rays are captured with surface gillnets. The characteristics of this fishery gear varied according to the location: Cancas (in Tumbes) presents gillnets with lengths of 364-728 m, heights of 11 m, and mesh sizes of 89 mm; San Jose (in Lambayeque) presents lengths of 1200-2000 m, heights of 4.6-6 m, and mesh sizes of 228 mm; Mancora and Yacila (in Piura) present lengths of 2160-2160 m, heights of 10-16 m, and mesh sizes of 178 mm.

The number of fishermen and boats per location were the followings: Cancas presents 30-40 fishermen and 15-20 boats; San Jose presents 75-120 fishermen and 15-20 boats; Mancora and Yacila present 250-360 fishermen and 50-60 boats.

The catch per unit of effort (CPUE) of neonate and juvenile hammerhead sharks varied according to the location: Tumbes, Lambayeque and Piura present an average CPUE of 0.15, 0.51 and 0.08 individuals per hour per 100 m of gillnet length, respectively. The CPUE of adult hammerhead sharks was on average 0.005 individuals per hour per 100 m of gillnet length. For the mobulid rays, the CPUE also varied according to the location: Tumbes, Lambayeque and Piura present an average CPUE of 0.0164, 0.0168 and 0 0.0051 individuals per hour per 100 m of gillnet length, respectively.

Besides hammerhead sharks and mobulid rays, other species of elasmobranches are captured in these fishery areas. In Lambayeque the following species are captured: Chilean and Peruvian eagle ray, thresher sharks, blue shark, shortfin mako, and silky shark. In Piura the following species are captured: thresher sharks, blue shark, and shortfin mako.

Outcome 3: Constitute a sample bank of smooth hammerhead sharks and mobulid rays

We collected tissue samples of the following species: 147 samples of hammerhead sharks, 148 of mobulid rays, 50 of thresher sharks, 15 of blue sharks, 8 of shorfin makos. Also, stomach contents were collected: 109 of hammerhead sharks and 12 of mobulid rays. Eight vertebras of hammerhead sharks and three of mobulid rays were collected. We were not able to collect the reproductive part of hammerhead sharks and mobulid rays because most individuals present in these aggregation areas were immature. The main purpose- for conservation- of collecting the reproductive parts is to establish the length at sexual maturity. In this study the samples were chiefly composed of neonates and juveniles; the adults were sampled in oceanic areas where for logistic reasons are landed without guts in order to preserve the meat.

The stomach contents, fishery and aggregation information of the hammerhead shark contributed to my undergraduate thesis which tittle is “Trophic ecology and nursery areas of smooth hammerhead shark (*Sphyrna zygaena*) in northern Peru”. Also, the stomach contents of mobulid rays are being used as part of the undergraduate thesis of a Peruvian marine biologist student.

Outcome 4: Increase awareness and education about elasmobranches in elasmobranch-fishery communities

San José (Lambayeque) is a fishery town that has been targeting elasmobranches for at least 100 years; therefore, their livelihoods, culture and tradition are tangled with them. San Jose reports the highest landings of hammerhead shark and the highest landings of elasmobranches species diversity (González-Pestana et al., 2014). Also, most of the shark and mobula meat that is fished in Peru is commercialized and consumed in San Jose. For these reasons we choose San Jose to perform our environmental educational project who was named “MYSTERY OF THE SEA: SHARKS, KINGS AND GUARDIANS OF THE OCEAN”. For one week 61 children attended the activities were they learned about sharks and rays: threats (fishing, pollution and habitat loss), migratory condition, importance in the marine ecosystem, life cycle, different types of fins and teeth and how these reveals their habitat and prey, the main species of sharks and rays in San Jose and Peru, why hammerhead sharks get closer to Peruvian coast (give birth and nursery area). Many of these kids will grow up to become fishermen; even though, they know little about elasmobranches. So, our goal was to create a personal connection between them and sharks and rays, to inspire and motivate them toward conservation. They were enthusiastic, excited and fascinated for these creatures, and above all curious and deep interested to know more (Figure 4).

Figure 4.1: Children showing their hand-made shark and choosing the food it´s shark eat (inferring from their fins and teeth); **Fig. 4.2**: Children showing the story about the adventures of pregnant hammerhead shark and their friends (elasmobranch caught in San Jose: thresher shark, mobula and Peruvian eagle rays); **Fig. 4.3**: Conciencia Team and children that attended the workshop.

A storytelling book and a guide about the biology, ecology and conservation of sharks were designed. These materials aimed to educate children about elasmobranches and the fragile and important balance of the marine ecosystem. These were presented in the schools of San Jose; so they can be used in science class. Also, the storytelling, the shark guide and the workshop activity guide will be soon accessible in the web page of the Peruvian NGO Conciencia.

Through the popular San José´s local radio program “Viento en Popa” we were able to reach San Jose community and teach them about the Peruvian situation and conservation of elasmobranches. Furthermore, we published an article in the most renowned Peruvian newspaper “El Comercio”. This article presented the Peruvian situation and conservation of elasmobranches, and invited children to our workshop in San Jose.

We attended the schools of “Los Reyes Rojos” and “La Casa Amarilla” that are in Lima, Peru´s capital. Through presentations and workshops, 502 students were educated about the biology, ecology and conservation of elasmobranches.

Outcome 5: Promote students in elasmobranch research

Although, I met and trained five student of marine biology to assist in this project. They were not able to assist for various external reasons. Since they cancelled when the project was undergoing; I preferred to focus my time and effort on collecting data and supervising the project. Even though, a student of marine biology is realizing its undergraduate thesis (“Trophic ecology of mobulid rays”) with the samples of mobulids´ stomach content collected in this study.

CONCLUSIONS

1. A total of 1269 elasmobranches were sampled in four landing points; so three aggregation areas were identified and characterized in northern Peru where 13 species of elasmobranches are present.
2. The smooth hammerhead shark presents three nursery areas in northern Peru where neonates, juveniles and pregnant females aggregate.
3. Fishery occurs in these aggregation areas where chiefly immature individuals are caught.
4. An elasmobranch´s sample bank was constituted composed of 368 tissues, 121 stomach contents and 11 vertebras.
5. A total of 563 Peruvian children were educated about the biology, ecology and conservation of elasmobranches.

FUTURE AIMS

On August 2014, I visited Dr. Peter Klimley (recognized shark scientist and conservationist) at UC DAVIS. As far as I know he is the scientist who has studied more comprehensively hammerhead sharks, especially in eastern Pacific using chiefly biotelemetry. He offered to be my advisor on the a doctoral program at UC DAVIS where the subject will be the spatial ecology of smooth hammerhead shark. Thus, my objective is to understand their stock structure, movement, migration, and habitat use. Therefore, on December 2015 I applied to UC DAVIS ecology program to realize my PhD. At the moment I have been accepted with the condition I obtain funding; so I'm applying to scholarships.

On July 2014, I defended my thesis and approved it. Now, I'm working on the manuscript to publish my thesis on a scientific magazine.

In collaboration with Peruvian NGO ProDelphinus, we are evaluating the spatial and temporal trophic ecology by sex and length of the most caught species of elasmobranches in northern Peru. Currently, three students of biology and fishery are elaborating their thesis with the samples collected in this project.

In collaboration with an educator and artist, we are working on a story that aims to educate children about the marine environment (particularly sharks, rays and the fragile and important balance of the marine ecosystem).

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ANNEXES

Table 1. Funds accounting (prices in £ sterling).

	Items	Number	Price per unit	Total
Field & Laboratoy Materials	Alcohol (1lt)	381	1.4	533.4
	Containers (stomachs)	100	1.5	150
	Tubes (tissue)	370	0.3	111
	Tape meassure	12	25	300
	GPS	1	60	60
	Ziploc	50	0.2	10
	Surgical scissor	10	3	30
	Twizer	10	1	10
	Styrofoam boxe	5	6	30
	Box of Gloves	5	2.3	11.5
	Masking Tape	10	1.2	12
	Samples´ shipment	13	5.6	72.8
	Print sheet to collect data	160	0.1	16
	Total (Laboratory & Field Materials)			**1346.7**
Workshop Materials	Cardboard	200	0.3	60
	Package of colored pencils	30	3	90
	Scissor	20	2	40
	Materials for hand-made shark activity			30
	Print educational guide, book and activities	100	6	600
	Total (Workshop Materials)			**820**
Travel allowances	Transportation			800
	Food (days)	55	15	825
	Accomodation (days)	72	15	1080
	Total (Travel Allowances)			**2705**
Collect information	Fishermen payment	30	5	150
	Inspectors payment	80	5	400
	Total (Collect information)			**550**
	Total			**$5,422**