Characterizing the knowledge and attitudes towards sharks and the domestic use of shark meat and fins in Peru

by

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ABSTRACT

Shark populations show evidence of declines at a global scale. Knowledge of the socio-economic consequences of changes in their abundance is limited. Furthermore, research on the status of peoples' knowledge and attitudes towards sharks and how these affect their values, behaviours and actions is lagging behind the pursuit of biological and ecological concerns.

Framed within Peru's National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras, the present study sought to: *(1)* characterize coastal Peruvian's general knowledge and attitudes towards sharks and shark meat consumption; *(2)* describe the domestic market and trade flows of shark commodities; *(3)* estimate the apparent consumption of shark meat and fins in Peru; and *(4)* reconstruct the catches required to maintain the estimated local levels of shark consumption.

Using data from over 2000 surveys provided by OCEANA Peru, I determined that a limited proportion of the Peruvian coastal population was aware of sharks' presence in the country's waters, and of these, only a minor subset was capable of naming shark species found locally. Furthermore, Peruvians have very negative attitudes towards sharks, driven by fear and prevalent misconceptions regarding their feeding habits and behaviour, which are reinforced by mass media.

Using public data, provided by various organizations within the Peruvian government, I determined that shark meat consumption in Peru is high and growing, although its contribution to national food security remains low. Nonetheless, most shark meat consumers are not aware that they are eating sharks due to deceptive advertising.

Improvements on seafood traceability have only been observed on exports, as data associated with landings, local markets and imports remains highly aggregated. Moreover, official statistics severely underestimate the catches required to maintain the Peruvian supply (by 39%) and demand (by 85%) of shark products.

These findings can be used to inform the design of communications campaigns and government policies seeking to: (i) improve people's knowledge and attitudes towards sharks in Peru, (ii) increase seafood traceability, (iii) protect seafood consumers, and (iv) advance towards the incorporation of these dimensions in the quantitative evaluation of policy outcomes for achieving sustainable shark fisheries.

LAY SUMMARY

The present study sought to elucidate two key aspects of the relationship between sharks and Peruvians that are important for adequately characterizing the socio-economic drivers behind local threats to shark populations: *(1)* Describe what coastal Peruvians know and feel towards sharks; and *(2)* Estimate the consumption of shark meat and fins by Peruvians.

Peruvians know little about sharks and manifest very negative attitudes towards them. Consumption of their meat and fins is increasing rapidly. As the country is not able to satisfy the growing demand for sharks with its own fisheries, dependence on imports has increased. Due to issues of seafood traceability and deceptive advertising, most shark meat consumers are not aware that they are eating sharks.

These findings can be used to develop, and assess the success of, policies aiming to improve knowledge and attitudes towards sharks, shark meat awareness and seafood traceability, supporting Peru's current shark conservation efforts.

PREFACE

I wrote this entire thesis under the guidance of my supervisor Villy Christensen.

In Chapter 2, I analyze a subset of a much larger survey on the knowledges and attitudes of coastal Peruvians towards the sea and seafood, focusing only on the questions related to sharks and shark meat consumption. The survey was designed by Rocio Lopez de la Lama and Juan Carlos Riveros and its implementation was fully funded by Oceana Peru. The data analyzed was collected by more than one hundred professional pollsters of the Instituto Nacional de Estadística e Informática (INEI, Peru) under the supervision of Rocio Lopez de la Lama. A version of this chapter is in the process of being submitted to a peer-reviewed journal with co-authors Rocio Lopez de la Lama and Juan Carlos Riveros.

In Chapter 3, I analyze data officially requested to the Peruvian Ministry of Production (Ministerio de la Producción del Perú, PRODUCE), the Peruvian Institute of the Sea (Instituto del Mar del Perú, IMARPE) and the Peruvian Customs Agency (Superintendencia Nacional de Aduanas y Administración Tributaria, SUNAT), on shark landings, shark meat processing and the international trade of shark products. I designed the methods, analyzed the data and wrote the manuscript, with comments and revisions provided by Villy Christensen. A version of this chapter is in the process of being submitted to a peer-reviewed journal with Villy Christensen as co-author.

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Equation 2.1: $$n = \frac{pq(1.96)^2}{d^2}$$

Equation 2.2: $$SMD = P_{Tot} \sum_{c=1}^{3} I \times P_c \times f_c$$

Equation 3.1: $$EP_T = Fro_{sm} + Cur_{sm} + Fre_{sm}$$

Equation 3.2: $$NE_{sm} = \left(E_{fst} - I_{fst}\right) + \left(E_{fs} - I_{fs}\right)$$

Equation 3.3: $$AC_T = EP_T - NE_{sm}$$

Equation 3.4: $$AC_{sf} = PP_{sf} - NE_{sf}$$

LIST OF ABBREVIATIONS

AAS	Average Attitude Scores
$AC_{coastal}$	*Per capita* apparent consumption of shark meat by coastal citizens
AC_{pc}	Per capita apparent consumption of shark meat
AC_{sf}	Total apparent consumption of shark fins
AC_T	Total apparent consumption of shark meat
ADEX	Peruvian Exporters Association
AP	Attitude Profiles
APEGA	Peruvian Society for Gastronomy
AT	Albacore tuna
BH	Benefits to humans
BS	Blue shark
CD	Corvina drum
CHI	Chimbote
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIY	Chiclayo
cm	Centimeter
CPI	Consumer Price Index
CPUE	Catch per unit of effort
CT	Common thresher shark
Cur_{sm}	Cured shark meat
cv	Coefficient of variation
DHC	Direct human consumption
EBK	Ecological and biological knowledge
EEZ	Economic exclusive zone
E_{fs}	Exported weight of shark meat in fresh shark trunks
E_{fst}	Exported weight of shark meat in frozen shark trunks
ELE	Elementary education
EP_T	Total edible production of shark meat
F	Female
FAO	Food and Agriculture Organization of the United Nations
f_c	Frequency of shark meat consumption
FF	Fine flounder
FOR	Former consumers
Fre_{sm}	Fresh shark meat
Fro_{sm}	Frozen shark meat
GAS	General Attitude Score

GDP	Gross Domestic Product
Gs	Groupers
HS	Humpback smooth-hound
IAS	Individual Attitude Score
I_{fs}	Imported weight of shark meat in fresh shark trunks
I_{fst}	Imported weight of shark meat in frozen shark trunks
ILO	Ilo
IMARPE	Peruvian Institute for Marine Research
kg	Kilogram
LIM	Lima
M	Miscellaneous
M	Male
MINAM	Peruvian Ministry of the Environment
MOL	Mollendo
n.d.	No date
n.s.f.	No significant difference
N/A	No answer
NE_{sf}	Net shark fin exports
NE_{sm}	Net shark meat exports
NF	Negative feelings
NGO	Non-Governmental Organization
NO	Negative outcomes of human-shark interactions
No.	Number of participants
NT	Negative traits
OCAC	Overseas Community Affairs Council of the Executive Yuan of the Taiwan (Republic of China)
OCC	Occasional consumers
PA	Pacific angelshark
PAN-Tib	National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras
PF	Positive feelings
PG	Peruvian grunt
PIS	Pisco
PIU	Piura
PP_{ff}	Potential production of fresh shark fins
PP_{sf}	Potential production of processed shark fins
PRODUCE	Peruvian Ministry of Production
P_{sm}	Shark meat production
PT	Positive traits

P_{Tot}	Total population
REG	Regular consumers
RQ	Reporting quality
SCD	Specific commercial description
SD	Standard deviation
SEC	Secondary education
SH	Smooth hammerhead shark
SM	Short-fin mako shark
SMD	Shark meat demand
SRV	Shark-related vocabulary
SUNAT	Peruvian Customs Agency
t	Metric tonne
TCN	Tacna
TEC	Technical education
TL	Total length
TRU	Trujillo
TUM	Tumbes
TWF	Total word frequency
UK	United Kingdom
UNI	University education
UNU	Unusual consumers
USA	United States of America
USD	Dollars (USA)

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DEDICATION

To the sharks, the fishers, the processors, the wholesalers, the retailers, the traders, the chefs and the consumers that created this fascinating puzzle.

CHAPTER 1: INTRODUCTION

Sharks are a very diverse group of cartilaginous fishes that have roamed the oceans for millennia (Grogan & Lund, 2004; Weigmann 2016). Their diversity and adaptive nature has allowed them to occupy multiple habitats and ecological niches, showcasing a variety of life-history strategies to perpetuate their survival, whilst playing key ecological roles in the environments they inhabit (Priede *et al.* 2006; Snelson *et al.* 2008; Ferretti *et al.* 2010; Heupel *et al*. 2014; Dulvy *et al.* 2017).

Shark populations, however, show evidence of declines due to both targeted overfishing and bycatch (Worm *et al.* 2013; Dulvy *et al.* 2014; Davidson *et al.* 2015; Oliver *et al.* 2015). Their late age-at-maturity and low fecundity have made them less resilient to fishing pressure, in comparison to teleosts (Shiffman & Hammerschlag 2016). Moreover, sharks have received little attention from fishery managers and stock assessment scientist (McAllister *et al.* 2008), resulting in their fishing mortality being 'exceptionally under-managed' (Dulvy *et al.* 2017).

This is in part due to: *(i)* the misconception that sustainable shark fisheries are impossible (Simpfendorfer & Dulvy 2017), and *(ii)* the generalized negative attitudes that people have towards sharks (Simpfendorfer *et al.* 2011). These issues have prevented countries from adequately supporting initiatives that would bring them closer to developing fishing policies suitable for sharks, and have also lead to poor enforcement of the limited management measures in play (Dulvy *et al.* 2017).

Nonetheless, the uncontrolled removal of sharks from ecosystems has very real ecological and socio-economic consequences (Ferretti *et al.* 2010; Dulvy *et al.* 2017). The latter, however, are the least understood. Research on the values, behaviours, attitudes and actions of the people that depend on sharks is lagging well behind that which focuses on shark biology and ecology (Simpfendorfer *et al.* 2011). For example, although sharks are known to be important for food security in developing nations (Dulvy *et al.* 2017), the domestic use of their products (e.g., rates of consumption of shark meat and fins) is not well known (Dent & Clarke 2015), nor is the importance of sharks as sources of income and employment for coastal communities (Simpfendorfer *et al.* 2011).

Improving our knowledge on these issues would allow for a better characterization of threats to shark populations, strengthening fisheries management plans and policies, as well as the quantitative evaluation of their outcomes (McAllister *et al.* 2008; Simpfendorfer *et al.* 2011). This is a priority for shark conservation, particularly in the developing world were food security concerns need also be addressed (Dulvy *et al.* 2017).

Peru is a developing country with globally important shark fisheries (Dulvy *et al.* 2017), and a historic tradition of shark meat consumption that dates back for thousands of years (Rostworowski 2004; Lavallée *et al.* 2011; Prieto 2015). Moreover, it is a major source of shark fins for the Asian markets

and a growing importer of shark meat from Ecuador and the high seas (González-Pestana *et al.* 2104; Dent & Clarke 2015).

Sharks in Peru are mainly caught by small-scale long-liners and gillnetters (González-Pestana *et al.* 2014). However, Peruvian shark fisheries and their contribution to the national economy (e.g., employment and income) are dwarfed by the size of its fisheries sector (Christensen *et al.* 2014). Because of this, for decades, shark conservation and management has not been a priority for the country. For example:

- Peru possess a high diversity of shark species (Cornejo *et al.* 2015), but their misidentification by the government personnel tasked with monitoring their landings is somewhat common (Velez-Zuazo *et al.* 2015).
- Reports of the official landing statistics tend to aggregate multiple taxa into uninformative categories such as 'sharks' (González-Pestana *et al.* 2014), which limits their traceability along the value chain.
- Published data on catch per unit of effort (CPUE) of shark fisheries is fragmented and unstandardized (Elliot *et al.* 1995; 1996; 1997a; 1997b; Ayala & Sánchez-Scaglioni 2014; Doherty *et al.* 2014). Thus, CPUE trends and their implications on the status of shark populations are hard to interpret.
- As sharks are caught by small-scale fishers, they are practically exempt of input controls (i.e. they are open access fisheries) and the number of boats, their size, the amount of gear used and the trip duration are all increasing (Sueiro & De la Puente 2015).
- Some targeted shark species have regulated minimum landing sizes (Monteferri *et al.* 2017). However, landings of juvenile sharks are very high and prevalent (Castañeda 2001; Doherty *et al.* 2014).
- Only the smooth hammerhead shark (*Sphyrna zygaena*) has fishing seasons with total allowable catches regulated by law, but the government's ability to enforce this regulation is weak (Monteferri *et al.* 2017).
- Although shark fishing nations committed to elaborate National Plans of Action for Sharks by 2001 (Dulvy *et al.* 2017), the Peruvian government only approved its National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras (PAN-Tib) in 2014 (PRODUCE 2014).

The approval of PAN-Tib however, marks an important milestone for science-based policy in Peru. This document highlights the need to improve our knowledge on the biological, ecological, social and economic dimensions of shark fisheries, as means to improve the design and assessment of nation-wide management and conservation strategies for chondrichthyans (PRODUCE 2014).

PAN-Tib's first Specific Action (Strategic Line of Action No. 2) is to: "*Develop baselines on the state of knowledge of chondrichthyans to assess future changes in the level of knowledge of this group of fishes*" (PRODUCE 2014). Knowledge, attitudes and behaviours are closely related and influence people's actions and decision-making processes (Mascia *et al.* 2003; Schultz 2011). Furthermore, as suggested by Simpfendorfer *et al.* (2011) it is necessary to change people's perception from needing protection from sharks to seeking to protect them. Thus, aligned with PAN-Tib's information needs, Chapter 2 explores the knowledge and attitudes towards sharks manifested by the inhabitants of Peru's largest coastal cities.

Additionally, the tenth Specific Action of the second Line of Action of the PAN-Tib is to: "*Characterize the trade of shark products in Peru*" (PRODUCE 2014). As suggested by Dent & Clarke (2015) the lack of case studies on the domestic use of shark products globally prevents comprehending how the local and international demand for shark products drives fishing pressure. Thus, public data on shark landings, processing and international trade were used in Chapter 3 to: *(i)* reconstruct the shark catch required to sustain the Peruvian demand and supply of shark meat and fins, and to *(ii)* estimate the total and per capita apparent consumption of these products.

Both chapters raise issues regarding consumption patterns, seafood traceability and mislabelling of shark products. Finally, the information generated by the present study could also be used to strengthen the design of communication campaigns, which is aligned to PAN-Tib's Strategic Line of Action No. 4, whose objective is to: "*Develop training programs and communication campaigns for public and private entities, fishing communities and the public, aimed at promoting the conservation and sustainable use of chondrichthyans"* (PRODUCE 2014).

CHAPTER 2: EXPLORING THE KNOWLEDGE AND ATTITUDES OF COASTAL PERUVIANS TOWARDS SHARKS

2.1. Introduction

Despite recent glimmers of hope in favour of the development of sustainable shark fisheries around the world (Simpfendorfer & Dulvy 2017), the success of shark conservation initiatives has been limited by the negative public image of sharks (Jacques 2010; Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Garla *et al.* 2015; Neff 2015). Mass media has reinforced inaccurate knowledge about this group of species for decades, depicting them as vicious man-eating murderers that need to be put down for our safety (Thompson & Mintzes 2002; Ferguson 2006; Garla *et al.* 2015; Neff 2015). This in turn has led to their social marginalization, the legitimization of permissive harvesting rules, and the lack of action in favour of their recovery (Jacques 2010; Simpfendorfer *et al.* 2011).

For example, shark coverage by newspapers in Australia and the USA has focused almost exclusively on shark attacks and their negative effects on humans, neglecting other pressing issues such as their current conservation status or ecological roles (Muter *et al.* 2012). In Northeastern Brazil, lower levels of understanding of the situation faced by sharks and its implications on human well-being, and negative attitudes[1] towards sharks among coastal citizens, have resulted in non-engagement and disregard for conservation actions seeking to safeguard shark populations (Garla *et al.* 2015). Similarly, negative public perceptions and lack of knowledge also played important roles in limiting community engagement for shark conservation initiatives in the UK (Friedrich *et al.* 2014).

Knowledge has been recognized as a vital component of an individual's perception towards the ocean and its resources, as well as a key component for effective environmental policy implementation (Kollmuss & Agyeman 2002; Steel *et al.* 2005; Fletcher & Potts 2007; Jacques 2010). Increased knowledge about sharks has been linked to greater public concern about their conservation in the USA (O'Bryhim & Parsons 2015); and it is believed that a well-informed society will be in a stronger position to exert pressure over politicians to address environmental concerns (Simpfendorfer *et al.* 2011; Friedrich *et al.* 2014; Garla *et al.* 2015).

Attitudes, knowledge and behaviors are closely related, influencing actions and decision making (Mascia *et al.* 2003; Schultz 2011). Studies suggest that educational interventions and other activities that increase knowledge can strengthen positive attitudes and effectively improve pro-environmental behavior (Zelezny 1999; Thompson & Mintzes 2002; St. John *et al.* 2010; Garla *et al.* 2015). Additionally, increased public awareness and understanding of environmental problems can help build the capacities required to solve them (Steel *et al.* 2005; Jacques 2010; Simpfendorfer *et al.* 2011).

[1] Attitudes are defined as enduring feelings towards a person, an object or an issue (Kollmuss & Agyeman 2002).

Thus, the growing call for stronger public engagement in the governance of marine resources, like sharks (Simpfendorfer *et al.* 2011; Friedrich *et al.* 2014; Dulvy *et al.* 2017), requires research on public opinion and values, as well as on knowledge, attitudes and behaviours of the people regarding sharks and shark conservation (Jacques 2010; Simpfendorfer *et al.* 2011; Friedrich *et al.* 2014). These fields of research are lagging well behind other more traditional ones (e.g., ecology, biology, fisheries), but are also key to promote the sustainable use of these fishes (Jacques 2010; Simpfendorfer *et al.* 2011).

Peruvians have been using shark meat as a food item for over 9,000 years (Rostworowski 2004; Lavallée et al. 2011; Prieto 2015). Peru is currently a major player in the international trade of shark meat and fins (Dent & Clarke 2015); and shark fisheries are significant sources of employment and revenue for Peruvians (Christensen *et al.* 2014), despite declining trends in landings over time (González-Pestana *et al.* 2014).

In 2014, the National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras (PAN-Tib) was approved by the Peruvian Government (PRODUCE 2014). PAN-Tib highlights, among other things, the need to develop: *(1)* baseline information about the state of knowledge of sharks in Peru, and *(2)* training programs and communication campaigns to promote the conservation and sustainable use of sharks (PRODUCE 2014).

In spite of the Government Action Plan, no studies regarding people's knowledge and attitudes towards the sea, seafood, marine organisms and fisheries have been ever developed in Peru. Thus, aligned with PAN-Tib's objectives, this study seeks to characterize coastal citizens' general knowledge and attitudes towards sharks and shark meat consumption, providing a baseline for future comparison and generating information that hopefully will be used to inform the design and content of communication campaigns promoting sustainable shark fisheries and shark meat consumption.

2.2. Methods

2.2.1. Survey characteristics

The anonymous survey that was used as a basis for this study was designed by consultants and staff members of Oceana Peru <http://peru.oceana.org/en>, an NGO that promotes sustainable fisheries and marine conservation around the world, including in Peru. The scope of Oceana's survey was much larger than that of issues regarding sharks. It consisted of 59 questions divided in seven sections: *(1)* Personal information; *(2)* Seafood consumption; *(3)* Relationship with the sea; *(4)* Knowledge about fisheries; *(5)* Seafood preferences; *(6)* Knowledge and attitudes towards anchoveta; and *(7)* Knowledge and attitudes towards sharks. The implementation of individual surveys lasted approximately 40 minutes, and all surveys were conducted by professional pollsters hired by Oceana. Data collection took place between June and October 2016.

The surveyed population only included adult residents (i.e. of age ≥ 18 years) of the selected cities (Figure 2.1). Pollsters were distributed to maximize representation of the cities' full demographic spectrum, and were implemented in all neighbourhoods of the selected cities, covering their most important public spaces (e.g., shopping malls, heavy transited streets, public plazas, among others).

Survey data provided by Oceana for this study were limited to the following information:

1. *Survey ID*: A four-digit code that differentiates each individual survey.
2. *Year of birth*: The year of birth of the participants.
3. *Gender*: The gender of the participant. Answers included: Male / Female / N/A.
4. *Highest completed level of education*: Answers included: Elementary (ELE) / High-school (SEC) / Technical Post-Secondary Institution (TEC) / University (UNI) / N/A.
5. *Have you eaten 'tollo'?* Answers included: Yes / No / Does not know.
6. *With what frequency do you eat 'tollo'?* Answers included: Once a week / Twice a month / Once a month / Hardly ever / Do not recall / Used to, but not anymore. This question was only asked if the answer for the previous was yes.
7. *Do you believe that sharks are found in Peruvian waters?* Answers included: Yes / No / Does not know.
8. *What species of shark are found in Peruvian waters?* Answers included up to three common names for sharks. This question was only asked if the answer for the previous was yes.
9. *Have you ever eaten 'tiburon'?* Answers included: Yes / No / Does not know.
10. *What words come to mind when you hear the word 'sharks'?* Answers included up to three words.

The order of the previous list follows the order in which the questions were asked to the survey participants. Questions 6 and 9 both relate to shark consumption. 'Tiburon' is the direct Spanish translation of the word 'shark' and 'tollo' is a common/generic name originally used for hound-sharks (Triakidae)[2] (Chirichigno & Cornejo 2001). However, 'tollo' is currently being used indiscriminately to market shark meat inside Peru (Appendix 01). For example, blue sharks (*Prionace glauca*) that would be sold in retail and wholesale markets as 'tiburon azul' (direct Spanish translation of blue shark), are commonly offered as 'tollo azul' (i.e. blue hound) or even 'azul' (i.e. blue) or just as 'tollo' (i.e. hound), eliminating any direct reference to the word shark (*pers. obs.*). Thus, the question 'have you ever eaten sharks?' is effectively asked twice to each participant.

[2] Depending on the region, 'tollo' might also be written as 'toyo'. The words sound the same in Spanish and convey the same meaning.

2.2.2. Study area

Peru has 25 first-order administrative divisions called Regions (Law No. 27783), eleven of which are coastal. One city was selected within each Region for data collection purposes. These cities had: *(i)* more than ten thousand inhabitants, *(ii)* their city centres were located within the first 60 km from the coastline, and *(iii)* were politically and/or economically important for the Regions (Figure 2.1).

The only exception to this rule was the Callao Region. As Callao is located 15 km away from Lima's city centre, and within the Lima Region, surveys conducted in Lima were assumed to be representative of Callao as well.

2.2.3. Survey validation and estimation of the minimum sampling size

Before the survey was conducted in the selected cities, it was validated by Oceana staff that interviewed 85 people in Lima during March 2016. Given that 93% of the participants of this preliminary survey believed that 'sharks were present in Peruvian waters', this proportion was used to estimate a statistically significant sample size per city, which would guarantee an approximate 95% confidence interval in the responses (Equation 2.1, Rose *et al.* 2015).

$$n = \frac{pq(1.96)^2}{d^2}$$

(Equation 2.1)

Where: *n* is the sample size, *p* is the proportion of the population that correctly manifested the pre-assess believe (i.e. shark presence in Peru), $q = 1 - p$, and *d* is the degree of precision (d=0.05 denotes a margin of error of 5%). The minimum sample size per city, estimated using Equation 2.1, was of 158 participants.

2.2.4. Data processing and analysis

Descriptive statistics, correlations and statistical tests were computed using R (*ver.* 3.4.0). All variables were tested for normality (Shapiro-Wilk 1965) and did not follow the normal distribution. Thus, non-parametric tests, like the Wilcoxon-Mann-Whitney test (Fay & Proschan 2010) were implemented to identify statistically significant differences between subsets of the surveyed population.

2.2.4.1. Levels of consumption

To facilitate the characterization of the surveyed population, participants were classified into five categories according to people's claims regarding their frequency of shark meat consumption:

- Regular consumers (REG): people who eat shark meat at least twice a month;
- Occasional consumers (OCC): people who eat shark meat once a month;

- Unusual consumers (UNU): people who almost never eat shark meat or do not recall the frequency at which they do;
- Former consumers (FOR): people who used to eat shark meat but not anymore; and
- Non-consumers: People who do not eat and have not eaten shark meat.

Additionally, the demand of shark meat was estimated for each surveyed city by applying Equation 2.2:

$$SMD = P_{Tot} \sum_{c=1}^{3} I \times P_c \times f_c$$

(Equation 2.2)

where: SMD is the shark meat demand estimated for each surveyed city; P_{Tot} is the total population of the surveyed city according to INEI (2017); I is the amount of shark meat required to prepare traditional Peruvian seafood dishes (e.g., 150-250 gr dish^{-1} person^{-1}; Acurio 2015); c is the level of consumption (e.g., REG, OCC and UNU); P is the proportion of the population that belongs to a certain level consumption; and f is the frequency of consumption of shark meat (dishes year^{-1}) according to each level of consumption. It is important to highlight that the proportion of REG within each city was subdivided between people who ate shark meat once a week (f_c: 52 dishes year^{-1}) and twice a month (f_c: 24 dishes year^{-1}). For OCC and UNU, the f_c levels used were 12 dishes year^{-1} and 1 dish year^{-1} respectively.

2.2.4.2. Attitude scores and profiles

Attitudes towards sharks were explored via word association, a qualitative method commonly applied in psychology (Roininen *et al.* 2006). The premise of this technique is that the first words that come to mind -in relation to an object or concept- are the most relevant for the person (Donoghue 2000; De Andrade *et al.* 2016). The words provided by the survey participants (Question 10, Section 2.2.3.) were used to build a 'vocabulary' that allowed for the exploration of the attitudes commonly associated with sharks through word frequencies and word categorization.

Words were classified and scored as negative (-1 point), neutral (0 points) and positive (1 point). Then, based on the information they conveyed, they were included in one of eight sub-categories, which were:

Positive sub-categories:

- Benefits to humans (BH), which included words that denote knowledge of the direct or indirect benefits that sharks, their fisheries and trade generate for Peruvians (e.g., food, work, tourism);
- Positive traits (PT), which included words that describe characteristics or anthropomorphic attributes of sharks that are regarded as desirable by society (e.g., grand, pretty, smart); and

- Positive feelings (PF), which included words that reference emotions aligned with pro-environmental behaviours (e.g., respect, awe, admiration).

Negative sub-categories:

- Negative outcomes of human-shark interactions (NO), which included words that reference lethal and sub-lethal outcomes of shark attacks (e.g., blood, death, screams);
- Negative traits (NT), which included words that describe characteristics or anthropomorphic attributes of sharks that are rejected by society (e.g., dangerous, murderer, evil); and
- Negative feelings (NF), which included words that reference emotions that typically result from the belief that sharks are a threat to humans (e.g., fear, desperation, tears).

Neutral sub-categories:

- Ecological and biological knowledge (EBK), which included words that indicate basic knowledge of shark ecology and biology (e.g., aquatic, predator, carnivore); and
- Miscellaneous (M), which included words not directly associated with sharks and that could not be classified as part of the other categories (e.g., movie, dolphin, beach).

The average value of the three words mentioned by each participant is referred to as their 'Individual Attitude Score' (IAS). Furthermore, Average Attitude Scores (AAS) were also calculated for each surveyed city and a General Attitude Score (GAS) was calculated for all coastal Peru. Values for all attitude scores range between -1 and 1. Finally, Attitude Profiles (AP) were developed for each surveyed city based on the frequency of occurrence of words within each sub-category; allowing to further characterize the words and concepts most associated with sharks.

2.3. Results

2.3.1. General results

A total of 2004 surveys were conducted along the Peruvian coast, exceeding the minimum sample size in all cities. A general description of the participants (i.e. number, age, sex ratio and education level) of each surveyed city is included in Table 2.1. Participants of this survey were born between 1924 and 1999, and had an average age of 40 (± 13.8) years.

Additionally, 56.0% of the surveyed population identified themselves as women, 42.4% as men and 31 people did not provide an answer. Ilo had the highest proportion of females (72.5%), followed by Chiclayo (64.3%); whilst Chimbote (56.4%) and Tumbes (53.5%) had the highest proportion of males.

Most surveyed participants (67.1%) had finished post-secondary studies (UNI: 38.6%; TEC: 28.5%). The remaining participants had finished high-school (27%) or elementary school (4.9%), and only 19 people did not provide data about their education.

2.3.2. Proportion of shark meat consumers

Shark meat is popular amongst coastal Peruvians, as 72.4% of the surveyed population (n=1451) claimed to eat or have eaten sharks (Selachimorpha). However, shark meat can be purchased using different names in the local seafood markets (Appendix 01). Most shark meat consumers (76.2%, n=1106) claim to only have eaten 'tollo', whilst a very limited proportion of them claims to have exclusively eaten 'tiburon' (1.7%, n=24). The remaining consumers stated that had eaten shark meat under both names (22.1%, n=321).

Shark meat consumption was higher in male participants (72% eat 'tollo'; 22% eat 'tiburon') than in female participants (70.4% eat 'tollo'; 14% eat 'tiburon'). Consumption of 'tollo' was highest in participants who had concluded secondary school (ELE: 67.7%; SEC: 73.2%, TEC: 70.6%; UNI: 70.6%), however 'tiburon' consumption was highest in participants with post-secondary levels of education (ELE: 14.1%; SEC: 14.6%, TEC: 18.2%; UNI: 18.9%).

A significant negative correlation was identified between the decade in which participants were born and (a) the proportion that claimed to eat 'tollo' ($r=-0.953$, $p=0.001$), as well as (b) the proportion that claimed to eat 'tiburon' ($r=-0.780$, $p=0.039$) (Figure 2.2). Participants born in the 1990s were 36.8% less likely to claim to have eaten 'tollo', and 61% less likely to claim to have eaten 'tiburon', than those born in the 1930s.

Shark meat consumers represented a higher proportion of the surveyed population in the northern regions of Peru and significantly decreased towards the southern regions ($r=0.957$, $p=0.00001$) (Figure 2.3A). Similarly, shark meat consumers represented a larger segment of the population in cities where the *per capita* seafood consumption was higher ($r=0.799$, $p=0.006$) (Figure 2.3B).

Assuming that people who claim to have eaten 'tollo' but not 'tiburon' ignore that 'tollo' is in fact a commercial name used for multiple shark species, then 77.5% of the 'tollo' consumers in Peru ignore that they have eaten sharks. In other words, only 22.5% of the 'tollo' consumers are 'conscious shark meat consumers', and 54.8% of them were male.

Awareness of shark meat consumption by 'tollo' consumers varied between the surveyed cities (Figure 2.4). In Ilo, for example, the city with the least number of 'tollo' consumers, 60.3% of them acknowledged that they ate sharks. Mollendo and Tumbes followed, but in those cities the proportions only reached 30.8% and 27.2%, respectively. In the remaining surveyed sites, less than 25% of 'tollo'

consumers acknowledge them as sharks. This was particularly dramatic in Piura where 96% of the surveyed population claimed to eat 'tollo' but only 16.6% recognized them as sharks.

No significant correlations were found, however, between participant's awareness of 'tollo' being sharks, and the decade of their birth (r=-0.649, p=0.115), nor their level of education (r=0.921, p=0.079). Nonetheless, a significant positive correlation was identified between the proportion of sharks in the regional landings of fish for direct human consumption[3], and the proportion of 'conscious shark meat consumers' per city (r=0.676, p=0.032).

2.3.3. Frequency of shark meat consumption

Shark meat consumers were mostly regular (29.8%) or unusual consumers (29.8%), followed by occasional (23.5%) and former consumers (16.9%). As expected, the frequency of shark meat consumption was not homogeneous along the Peruvian coast (Figure 2.5). The cities with the highest proportion of regular consumers were Chiclayo (69.1%), and Tumbes (50.3%), followed by Trujillo (40.2%) and Piura (31.8%). Ilo (7.4%), Mollendo (9.9%) and Tacna (11%) were the cities with the least proportion of regular consumers and the largest proportion of unusual consumers – 45.6%, 41.6% and 56.1%, respectively.

Most regular (61.1%), occasional (51.6%) and unusual (58.4%) consumers were female, whilst most former consumers were male (50.8%). No significant correlations were found between the decade of birth of the surveyed population and their rate of consumption[4].

Regardless of the category of consumption, the proportion of 'tollo' consumers per city with elementary studies was significantly smaller than that of consumers with other levels education (Table 2.2). The proportion of regular consumers with university level education was significantly higher than that of consumers with technical post-secondary studies. Nonetheless, no significant differences were found between the remaining levels of education and the frequency shark meat consumption (Table 2.2).

Finally, after accounting for non-consumers, only 56.4% of the surveyed population claimed to currently eat 'tollo'. The total shark meat demand (SMD) for the surveyed cities ranged between 13.1 to 21.9 thousand tonnes year^{-1}, where Lima concentrated 80% of the market for shark meat (Table 2.3). Nonetheless, *per capita* SMD was highest in the cities with the greatest proportions of regular consumers.

[3] Values for 'shark landings as a proportion of the total regional landings' were estimated for each region using data provided by IMARPE, which is included in Appendix 02.

[4] REG: r=0.429, p=0.338; OCC: r=0.456, p=0.304; USU: r=-0.337, p=0.460; FOR: r=-0.647, p=0.117.

2.3.4. Knowledge about sharks

More than half of the surveyed population (57.6%) knew that sharks inhabit Peruvian waters. However, results differed between cities (Figure 2.6).

Tumbes had the highest proportion of people that knew that sharks were found in Peruvian waters (82.6%), whilst Pisco had the lowest (38.8%). Only 18.4% of the surveyed population claimed that sharks were not found in Peru, and they were mostly present in Tacna (30.3%) and Pisco (29.9%). Conversely, Trujillo (35.3%) and Pisco (30.3%) were the cities with the largest proportion of people that could not ascertain that sharks were present in Peruvian waters.

A significant negative correlation was found between the decade in which the participants were born, and the proportion who knew that sharks were found in Peru ($r=-0.903$, $p=0.0054$) (Figure 2.7). For instance, a participant born in the 1990s was 25.2% less likely to know that sharks were found in Peru in comparison to someone born in the 1940s.

Awareness of sharks' presence in Peruvian waters was greater in males (62.6%) than in females (53.6%). No significant correlations were found between the level of education of the participants and the proportion who could correctly ascertain that sharks were found in Peru ($r=-0.597$, $p=0.4033$), nor between the proportion of participants who knew that sharks were found in Peru (per city) and regional shark landings as a proportion of total fish landings for direct human consumption ($r=0.058$, $p=0.1643$).

Additionally, less than half of the participants that replied that sharks were present in Peru could name one or more shark species (46.7%). Of this subset of the surveyed population (n=1155), 72% provided only one name, 22.8% provided two names, and 5.2% could provide three names (average number of shark names per person: 0.63 ± 0.24). When expressed as proportions of the total surveyed population, only 19.4% could name one shark species that lived in Peruvian waters, 6.1% could name two, and 1.4% could name three (average number of shark names per person: 0.36 ± 0.66).

Participants recognized a total of nine shark species present in the waters off Peru (Table 2.4). Ilo and Tumbes were the cities with the highest records of common shark names (n=117 and n=106, respectively) (Figure 2.8). In Lima, Piura, Chiclayo, Mollendo, Trujillo and Tacna, the average number of shark names mentioned per participant fell below the national average. However, Ilo, Tumbes, Piura and Pisco were the cities with the highest proportions of participants mentioning three names (Figure 2.8).

No significant correlations were found between the average number of names mentioned per city, and *(i)* the proportion of the population who knew that 'tollo' is a generic shark name ($r=-0.196$, $p=0.608$), *(ii)* the proportion of the population that claimed to have eaten 'tollo' ($r=0.233$, $p=0.516$), *(iii)* the proportion of the population that claimed to have eaten 'tiburon' ($r=0.444$, $p=0.199$), and *(iv)* shark

landings as a proportion of total regional fish landings for direct human consumption (r=0.241, p=0.503). Similarly, no significant correlations were found between the total number of shark names mentioned per city and parameters *i* (r=-0.173, p=0.633), *ii* (r=0.137, p=0.706), and i*v* (r=0.255, p=0.477). However, the total number of shark names mentioned by city was positively correlated to the proportion of the population that claimed to have eaten 'tiburon' (r=0.896, p=0.0004).

2.3.5. General attitudes towards sharks

The surveyed population mentioned 5,772 words associated with sharks (i.e. total word frequency, TWF), forming a shark-related vocabulary (SRV) of 354 different words (Appendix 03: Table A.2). Only fourteen words were repeated by more than 100 participants, constituting 66.3% of the TWF (Figure 2.9). These were: fear (12.6%), dangerous (9.5%), big (8.3%), blood (6.9%), death (5.1%), teeth (3.4%), sea (3.2%), predator (3.0%), murderer (2.9%), danger (2.8%), terror (2.8%), carnivorous (2.1%), fierce (1.9%) and movie (1.8%).

Most words mentioned by participants had negative connotations (55.4% of the TWF; 31.4% of the SRV). As neutral (32.0% of the TWF; 41.5% of the SRV) and positive (12.6% of the TWF; 27.1% of the SRV) were less frequent, this skewed attitude scores towards negative values, resulting in a General Attitude Score (GAS) for Peru of: –0.43 ± 0.41.

2.3.6. Individual Attitudes Scores

Individual Attitude Scores (IAS) were not significantly correlated with the participant's age (r=-0.122, p=0.326). Females IAS were significantly lower than those of males (Figure 2.10A, Table 2.5), and participants with university degrees had significantly higher IAS than those with technical studies (p=0.046) and secondary studies (p=0.005). IAS of participants with secondary and technical studies did not differ significantly, nor did the IAS of participants with elementary education with all other levels of academic training (Figure 2.10B, Table 2.5).

Although consumers and non-consumers of 'tollo' had similar IAS, consumers of 'tiburon' had significantly higher IAS than non-consumers (Figure 2.10C-D, Table 2.5). However, regular and occasional consumers of 'tollo' had lower IAS than former and unusual consumers (Figure 2.10E, Table 2.5). Finally, participants who knew that 'tollo' is a common name for shark or who knew that sharks are found in Peruvian waters had significantly higher IAS than their less informed counterparts (Figure 2.10F-G, Table 2.5).

2.3.7. Average Attitudes Scores

Average Attitudes Scores (AAS) towards sharks differed between cities. Tacna (–0.28 ± 0.73), Chimbote (–0.31 ± 0.70) and Tumbes (–0.31 ± 0.80) had the highest AAS, despite them being negative. Together with Lima (–0.32 ± 0.68), these cities' AAS were higher than the GAS. Trujillo (–0.59 ± 0.65),

Chiclayo (–0.59 ± 0.63) and Pisco (–0.55 ± 0.69) had the lowest AAS. AAS for Piura (–0.45 ± 0.42), Mollendo (–0.46 ± 0.66) and Ilo (–0.44 ± 0.72) were also below the GAS.

No statistically significant correlations were found between AAS and *(i)* shark landings as a proportion of the total regional landings for direct human consumption (r=-0.338, p=0.340), *(ii)* the proportion of 'tollo' consumers per city (r=-0.262, p=0.463), *(iii)* the proportion of 'tiburon' consumers per city (r=-0.154, p=0.672), *(iv)* the proportion of people in each city who knew that tollo is a common name for shark (r=-0.005, p=0.989), and *(v)* the proportion of people per city who knew that sharks are present in Peruvian waters (r=0.458, p=0.183).

2.3.8. Attitudes Profiles

At a national level, most registered words belonged to the 'Ecological and Biological Knowledge' category (EBK, 26.3%), followed by 'Negative feelings' (NF: 22.3%), 'Negative traits' (NT: 19.1%), 'Negative outcomes of human-shark interactions' (NO: 13.9%), 'Benefits to humans' (BH: 9.4%), 'Miscellaneous' (M: 5.7%), 'Positive traits' (PT: 2.3%) and 'Positive feelings' (PF: 0.9%). The most common words per sub-category are included in Table 2.6.

Attitude Profiles (AP) differed between cities (Figure 2.11). Tacna, Tumbes and Chimbote, the cities with the highest AAS, were those where BH represented over 10% of their total word frequencies. Despite that, their NT values were larger than those found in the cities with the lowest AAS: Trujillo, Chiclayo and Pisco. This highlights that coastal Peruvians living in those cities are relatively more aware of the economic importance of sharks but also regard these fishes as 'dangerous' 'murderers'.

On the other hand, the cities with lowest AAS were those were NF was largest and represented a greater proportion of their total word frequency than EBK. Additionally, these three cities (i.e. Trujillo, Chiclayo and Pisco) also had the largest values of NO (Figure 2.11). This emphasizes that fear is the main driver for their negative attitudes towards sharks.

The remaining cities (Lima, Ilo, Piura and Mollendo) has similar NT, NF, EBK and M values than those with the least negative AAS, but had similarly lower BH, BT and BF scores than those with the lowest AAS (Figure 2.11).

2.4. Discussion

2.4.1. Disinformation and shark meat consumption

Sharks have been part of the Peruvian diet for many centuries (Rostworowski 2004; Prieto 2015) and continue to do so. Survey results suggest that shark meat consumption is common along the coast, but not necessarily frequent, as seven in ten coastal Peruvians claim to have eaten shark meat and only two of them describe themselves as regular consumers. Also, as younger participants were less

prone to claim to have eaten shark meat (Figure 2.2) and the rates of consumption (i.e. regular, occasional, unusual, former) did not differ amongst age groups (i.e. decade of birth), this could imply that the demand for these species might be declining or, *ceteris paribus*, would decline in the future.

Additionally, shark meat consumption was not homogeneous along the Peruvian coast. Seafood consumption is heavily influenced by fish availability in local markets, price accessibility for consumers and culinary traditions (Myrland *et al.* 2000; Can *et al.* 2015; Carlucci *et al.* 2015). Thus, it is not surprising that cities found in the northern regions of Peru concentrated a larger proportion of shark meat consumers (Figure 2.3), and particularly regular shark meat consumers (Figure 2.5). That area of the country is characterized by higher *per capita* consumption of seafood (PRODUCE 2015), greater diversity of commercial shark species (IMARPE 2015) and a historic tradition of shark meat consumption (Clemente 2010a; 2010b; 2010c).

Nonetheless, the proportion of shark meat consumers and the frequency at which they claim to eat sharks might be biased. Surveys are never fully protected from response bias (Furnham 1986), and in this case, it might be a result of ignorance and disinformation rather than participants' conscious provision of false responses. This claim is based on the fact that shark meat trade in Peru has succumbed to mislabelling: the use of wrong, incorrect or misleading denominations for such species to improve their marketability (Jacquet & Pauly 2008).

Consumers predominantly purchase shark meat under the name 'tollo', but only one in five 'tollo' consumers are aware that they are eating shark. As previously mentioned, 'tollo' is a common name for hound-sharks (Triakidae) (Chirichigno & Cornejo 2001). The landings of these species have declined over time, and currently represent a smaller proportion of the total shark landings registered in Peru (Appendix 04: Figure A.1). Moreover, the most common shark species caught in Peruvian waters: blue, short-fin mako, smooth hammerhead and thresher sharks (González-Pestana *et al.* 2014), are commonly offered in seafood markets and supermarkets as 'tollo' (Appendix 01).

To some extent, shark mislabelling in Peruvian seafood markets is expected. On one hand, it seems counterintuitive that seafood consumers would seek to purchase shark meat given the highly negative attitudes that coastal citizens have towards them (Myrland *et al*. 2000; Jacquet & Pauly 2008). On the other hand, the government's and the consumers' capacity to detect shark mislabelling is very limited. For example, recognition of shark species by government officials that monitor small-scale fisheries landings is prone to species misidentification and uses non-informative common names (Velez-Zuazo *et al.* 2015). Most hammerhead, blue and shortfin mako sharks landed by the small-scale fisheries are juvenile fish (Castañeda 2001; González-Pestana 2014; Doherty *et al.* 2014), despite clear regulations that set minimum landing sizes (Resolución Ministerial No. 209-2001-PE).

Once these specimens reach the seafood markets they can either be sold as whole sharks, fillets, medallions (or steaks) or even chopped into tiny pieces for preparing ceviche (*pers. obs.*). Given that

pelagic sharks are much larger than smooth-hounds[5], it would be relatively easier to trick a knowledgeable 'tollo' consumer by using juvenile specimens of larger sharks. Additionally, visual identification of sharks down to species level becomes very difficult, and virtually impossible, as processing increasing, making it easier for mislabelling to remain unnoticed in most markets of the country. Moreover, the usefulness of molecular methods for species diagnostics, such as genetic barcodes, is highly restrictive in developing countries like Peru due to costs (Velez-Zuazo *et al.* 2015); and are not timely enough to strengthen law enforcement and enhance transparency in the local seafood trade yet.

Furthermore, Peruvian legislation lacks regulations limiting valid seafood 'trading names' for the internal markets. Despite 'Deceptive Advertising' has been typified as a felony according to the Peruvian Consumer Defense Code (Law No. 29751), no specific pathways for its implementation have been drafted, limiting the Code's ability to discourage mislabelling by local seafood traders.

It is important to highlight that the economic status of Peruvians has improved over time, particularly in the coastal regions (De la Puente *et al.* 2013), and that higher incomes lead to increased animal protein intake (Jensen 2006). Additionally, the demand for seafood has recently increased in Peru due to a seafood-based 'gastronomic boom' that started in 2006 (Lopez de la Lama 2014; Sueiro & Lopez de la Lama 2014). The apparent consumption of shark meat has significantly increased since 2007 (see Section 3.4.1), as these fishes are effective alternatives for other higher priced species (Appendix 05) that are used for similar recipes. Nonetheless, the extent of mislabeling is suspected to be high, as the total apparent consumption of shark meat in Peru (*See* Chapter 3; Table 3.3) fell within the range of the total estimated shark meat demand of the surveyed cities pooled together (Table 2.3).

Mislabelling of shark meat is a problem that is not limited to Peru. Several case studies of sharks being sold as other less endangered or more valuable shark or teleost species have been documented in Ecuador, USA, France and New Zealand (Jacquet & Pauly 2008).

However, it is worth noting that the proportion of 'conscious shark meat consumers' was not higher in segments of the population that had greater academic training, nor was it a function of age. This suggests that the disconnection between shark meat consumers and sharks transcends economic and generational barriers. Nonetheless, more people were aware that 'tollo' was a shark name in cities where sharks represented a larger proportion of the total regional landings of fish for direct human consumption. For instance, Ilo (Moquegua Region) had the largest proportion of 'conscious shark meat consumers' (Figure 2.4). This city is also the leading landing site for oceanic-pelagic sharks in Peru (González-Pestana *et al.* 2014), and sharks represent 26.5% of the regional landings for direct human

[5] The total lengths for the most common landed species in Peru are: 400 cm for the blue shark, 445 cm for the short-fin mako shark, 500 cm for the smooth hammerhead shark, 573 cm for the thresher shark and 87 cm for the humpback smooth-hound (Froese & Pauly 2017).

consumption (Appendix 02: Table A.1). This would suggest that a heightened regional visibility of shark fisheries and their landings could improve consumer awareness.

2.4.2. Knowledge levels and access to information about sharks

Peruvian sharks and their fisheries are highly relevant locally and globally. Peru is home to 9% of all living chondrichthyans reported around the world (Cornejo *et al*. 2015), it is the 21st most important country in terms of chondrichthyan landings, and 14th in terms of shark fin exports (Dent & Clarke 2015).

Additionally, shark species found within Peru's EEZ represent 6.2% of its marine fish diversity (Chirichigno & Cornejo 2001). Small-scale fishers currently target 32 shark species for their meat and fins (González-Pestana *et al.* 2014; IMARPE 2015). Their catch, as it flows from the sea to the final consumers across the seafood value chain, generated US$50 million and 4,600 jobs in Peru in 2009 (Christensen *et al*. 2014).

Nonetheless, coastal Peruvians were significantly disconnected from the local shark diversity and its role in society. For example, six in ten Peruvians were aware of shark's presence in the country's economic exclusive zone, however only three of them could name one or more shark species. Knowledge of sharks varied little between cities, did not improve with academic development, and was lower in younger participants (Figure 2.7).

Moreover, the surveyed population only mentioned 9 common names for sharks, representing 13.6% of the total species listed locally (Cornejo *et al*. 2015). The most common species referenced had commercial importance (e.g., blue sharks, short-fin mako sharks, smooth hammerhead sharks, smooth-hounds) (González-Pestana *et al.* 2014), or have been featured by local and/or international media (e.g., whale sharks, white sharks, tiger sharks).

However, only one in ten of the words mentioned by coastal Peruvians reference potential shark benefits to humans (BH, Figure 2.11). Words included in this category relate to sharks' relevance for local fisheries, international trade, and as a source of food (Appendix 03: Table A.2). References to non-lethal activities involving sharks that benefit Peruvians were trivial. For example, only three people mentioned 'tourism' (0.005% of the TWF). Hence, a limited proportion of coastal Peruvians is aware of sharks' importance for provisioning ecosystem services, but references to them in the context of cultural or regulatory ecosystem services were negligible (Millennium Ecosystem Assessment 2005).

Additionally, words included in the shark ecology and biology (i.e. EBK sub-category) reveal that coastal Peruvians' knowledge of sharks is limited to them being carnivorous active predators, with large body sizes and teeth. Words suggesting potential knowledge of their conservation status were scarce and hard to interpret (Appendix 03: Table A.2). For example, the word 'extinction' was mentioned 27 times (0.05% of the TWF). There is no clarity on whether the people who mentioned extinction were

aware of declining population trends and the current conservation status of shark species, or if they were thinking about extinct sharks featured in documentaries or on exhibits at the Natural History Museum in Lima[6]. Thus, it would be important to include questions directly addressing Peruvians' awareness of threats to shark populations globally and locally in future iterations of this survey.

The low levels of knowledge found in the largest coastal cities of Peru is alarming. The surveyed population is expected to have the greatest familiarity with the ocean in the country, due to geographical proximity of the city centres to the sea (Steel *et al.* 2005). Thus, people living in the Peruvian Andes and Amazon are likely to have much lower levels of knowledge of sharks, despite also consuming their meat.

Lack of information about cartilaginous fish is a worldwide phenomenon (Friedrich *et al.* 2014). However, Peruvians also have little access to existing information regarding sharks. A recent review of the academic curricula of public schools across the country found that learning objectives' coverage of global and local marine topics was very limited, with no specific references to sharks (Cárdenas-Alayza & Cárdenas-Alayza 2017). No nature-oriented tourism companies promote or offer services related to shark dives (Salgado *et al.* 2015). There are no marine aquariums with a focus on education, and the only exhibit displaying sharks is found within a shopping mall in Lima and features species from the Philippines, China and Thailand (Publimetro 2016). It is not farfetched to claim that the only people in frequent and direct contact with living sharks in Peru are fishers.

2.4.3. Prevalent misconceptions and fear in the collective consciousness of coastal citizens

More than half of the words mentioned by the surveyed population had negative connotations. The extensive use of words like 'fear', 'danger', 'dangerous', 'terror', 'blood', 'death' and 'murderer', suggest that Peruvians see sharks as menacing deadly man-eaters. This view is shared by many around the world and it is related to how these species have been portrayed by the mass media – from newspaper articles to movies (Ferguson 2006; Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Garla *et al.* 2015; Neff 2015).

Even though negative perceptions towards sharks predate the *Jaws* movie franchise (Ferguson 2006), its effect on the SRV and TWF is undeniable ('movie' represented 1.8% the TWF). Additionally, a search of the word 'tiburon' in the websites of local newspapers like: Correo <www.diariocorreo.pe>, El Comercio <www.elcomercio.pe>, El Popular <www.elpopular.pe>, Expreso <www.expreso.com.pe>, La República <www.larepublica.pe>, Ojo <www.ojo.pe>, Peru 21 <www.peru21.pe>, and Publimetro <www.publimetro.pe> show that they routinely cover stories of shark attacks and share dramatic videos of such encounters. This perpetuates the notion that sharks are dangerous and a threat to human survival (Simpfendorfer *et al.* 2011; Neff 2015). However,

[6] Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos <http://museohn.unmsm.edu.pe>.

according to Shark Attack Data (2017), no shark attacks (fatal or otherwise) have been reported in Peruvian waters, and only 15 shark attacks have been reported by Chile and Ecuador between 1900 and 2016.

Given the negative connotation of most words mentioned by the surveyed population regarding sharks, it is not surprising that the GAS and the AAS of all cities were negative. However, it is worth noting that IAS of people with university level education, as well as those who knew that sharks were present in Peruvian waters, and/or that 'tollo' is used as a generic name for sharks, were less negative. This would suggest that there is a positive link between knowledge and attitudes, as seen in other countries and contexts (Thompson & Mintzes 2002; Garla *et al.* 2015; St. John *et al.* 2010; Steel *et al.* 2005).

Nonetheless, the frequency of 'tollo' consumption and the IAS seem to be inversely related (Figure 2.10, Table 2.5). So, although 3.5% of the TWF referenced sharks a source of food, people who eat them the most – although not necessarily knowingly – had lower attitudes towards them. This is further evidence of the disconnection between coastal citizens, the marine environments of Peru, the ecosystem services they provide and how they are linked to human wellbeing.

2.4.4. A call for education and communication campaigns

Lack of knowledge and negative perceptions towards sharks globally act as barriers preventing actions required to tackle threats to shark populations like overfishing, pollution, habitat loss and climate change (Jacques 2010; Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Neff 2015). In Peru, the limited knowledge and highly negative attitudes towards sharks highlight the need to develop nationwide educational campaigns, as required by the National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras in Peru (PAN-Tib) (PRODUCE 2014).

These campaigns should seek to develop a deeper understanding of the local shark diversity, the ecological roles of their populations, the ecosystem services they provide, and how they are linked with human wellbeing, whilst also demystifying the notion of sharks as man-eaters (Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Neff 2015). These efforts are prerequisites for coastal Peruvians to willingly adopt pro-environmental behaviours intended to minimize their negative impact on shark populations (e.g., respecting minimum landing sizes, quotas and seasonal closure; or avoiding the consumption of endangered species) (Kollmuss & Agyeman 2002; Jacques 2010; St. John *et al.* 2010; Simpfendorfer *et al.* 2011; O'Bryhim & Parsons 2015).

The government, together with NGOs and universities, has started to produce species guides (ProDelphinus *et al.* 2013; IMARPE 2015), develop workshops (MINAM 2016) and implement communication campaigns (Oceana 2017) to combat the lack of knowledge regarding sharks and improve their management in Peru under the framework of PAN-Tib (PRODUCE 2014). Nonetheless,

it is difficult to assess the effectiveness of these efforts due to the lack of a baseline for comparison. However, this study could serve that purpose in the future.

Nonetheless, it is key to highlight that these activities should not replace efforts to penalize and prevent illegal behaviours (Nøstbakken 2008; De la Puente & Sueiro 2013). In this case, special provisions are required to prevent mislabelling. A 'one name, one fish' policy (Lowell *et al.* 2015), for example, could facilitate the application of the Law No. 29751, allowing for the implementation of severe fines to seafood retailers that use 'Deceptive Advertising' to boost their revenue. However regulatory changes will require community engagement, and studies show that it is more likely for people to exert pressure on policy makers if they are knowledgeable and have positive attitudes towards sharks (Simpfendorfer *et al.* 2011; Friedrich *et al.* 2014; Garla *et al.* 2015; O'Bryhim & Parsons 2015).

Inserting sharks in popular culture and using positive anthropomorphic traits (e.g., sharks being smart, fast, strong, ancient) could be a starting point for shifting attitudes towards the positive side and develop empathy towards them (Urquiza-Haas & Kotrschal 2015). Such efforts have been previously successful with mammalian megafauna (Feldhamer *et al.* 2003).

Moreover, personal experience is a key factor that influences environmental attitudes and motivates engagement and pro-environmental behaviors (Kollmuss & Agyeman 2002; Jacques 2010; Fletcher & Potts 2007; Friedrich *et al.* 2014). Given that there are no aquariums featuring local shark species in Peru, and that shark dives are not accessible to most segments of the population, perhaps this link could be established through seafood by explicitly increasing awareness of shark meat consumption and by promoting visits to seafood markets and fishing towns. Campaigns that seek to change attitudes and increase knowledge of unpopular seafood items have previously been successful in Peru (Majluf *et al.* 2017). However, these should be implemented with caution not to promote (or increase) a local unsustainable demand for shark meat.

2.5. Conclusions

This study is the first assessment of knowledge and attitudes towards sharks ever developed in Peru. Thus, it can serve as a baseline for future comparison on topics related to: *(i)* awareness of shark meat consumption, *(ii)* shark presence and diversity in local marine ecosystems, and *(iii)* general attitudes towards sharks.

Results suggest that shark meat consumption is high, but not necessarily frequent, potentially declining and higher in the northern regions of the country. However, most shark meat consumers are not aware that they are eating sharks due to mislabelling.

A limited proportion of the coastal population is aware of sharks' presence in the waters off Peru, despite their importance for the country's *(i)* marine ecosystems, *(ii)* fisheries sector, and *(iii)* the cultural

heritage. Moreover, much smaller proportion of the population is capable of naming shark species found locally, highlighting that coastal populations are very disconnected with these species.

Peruvians have very negative attitudes towards sharks. They fear them and view them as man-eaters, despite no shark attacks have ever been reported in the country. Negative perceptions are linked to a generalized lack of knowledge, and on prevalent misconceptions regarding shark feeding habits and behaviour. These attitudes are still reinforced by mass media.

There is a pressing need to develop education and communication campaigns focussed on increasing local knowledge about sharks and their relations with human wellbeing.

2.6. Figures

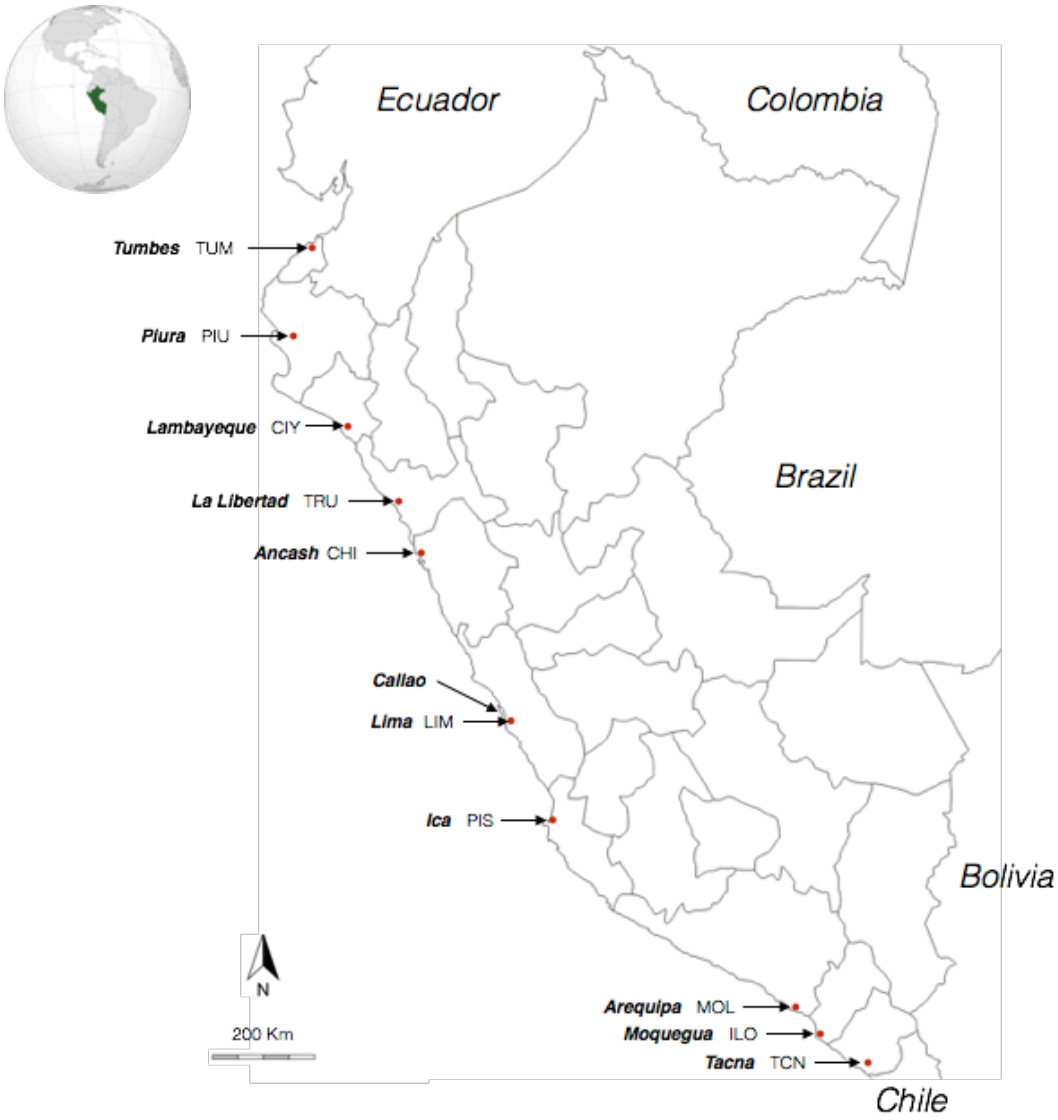

Figure 2.1: Peruvian internal administrative divisions (i.e. Regions), highlighting the coastal cities were the surveys were implemented. Coastal Regions include: Tumbes (surveyed city Tumbes, TUM), Piura (surveyed city Piura, PIU), Lambayeque (surveyed city Chiclayo, CIY), La Libertad (surveyed city Trujillo, TRU), Ancash (surveyed city Chimbote, CHI), Lima (surveyed city Lima, LIM), Callao (not surveyed), Ica (surveyed city Pisco, PIS), Arequipa (surveyed city Mollendo, MOL), Moquegua (surveyed city Ilo, ILO) and Tacna (surveyed city Tacna, TCN).

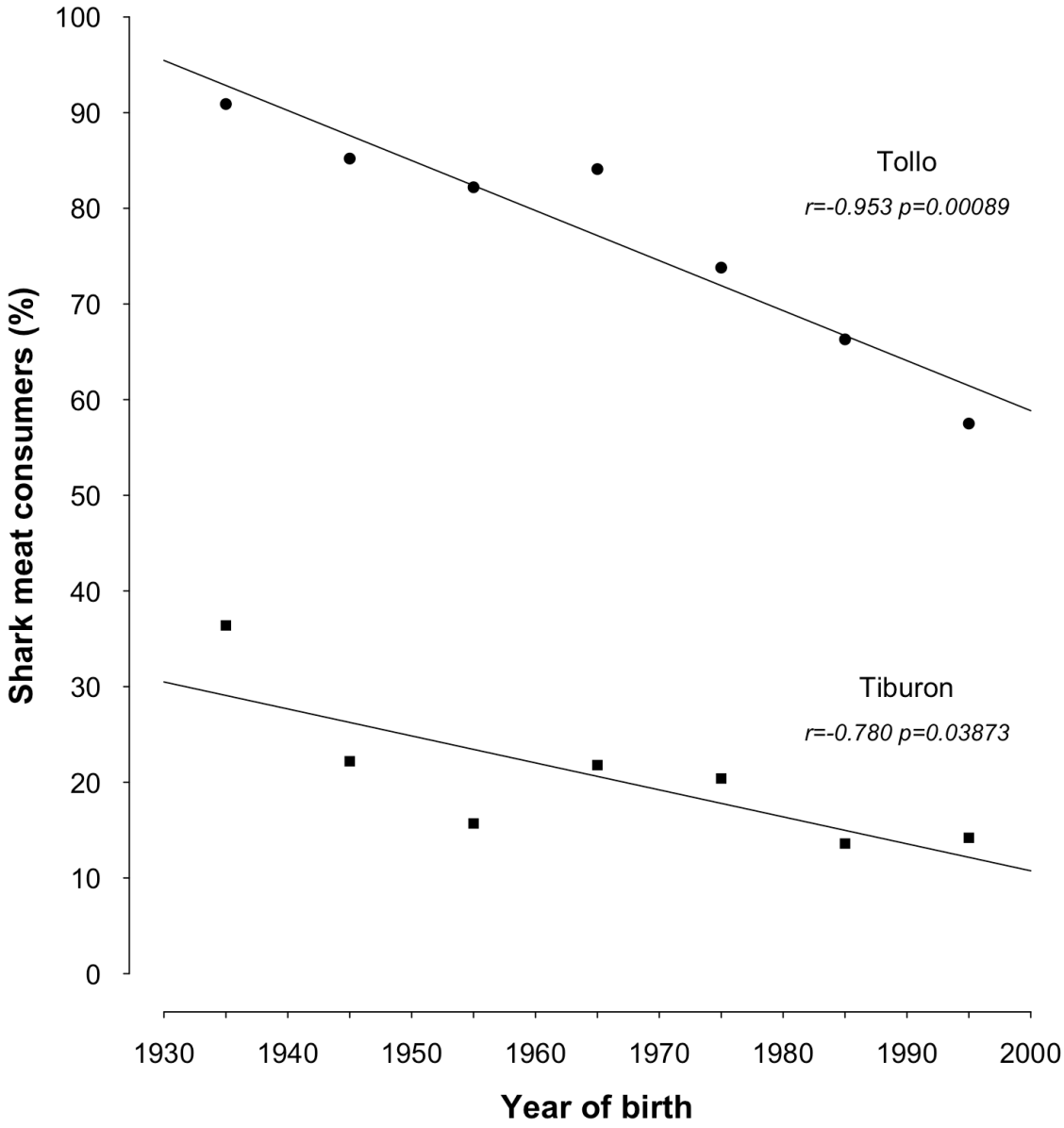

Figure 2.2: Proportion of shark (Selachimorpha) meat consumers as a function of the year of birth (by decade). Shark meat consumers are segregated as people who claim to eat or have eaten ‘Tollo’ and ‘Tiburon.

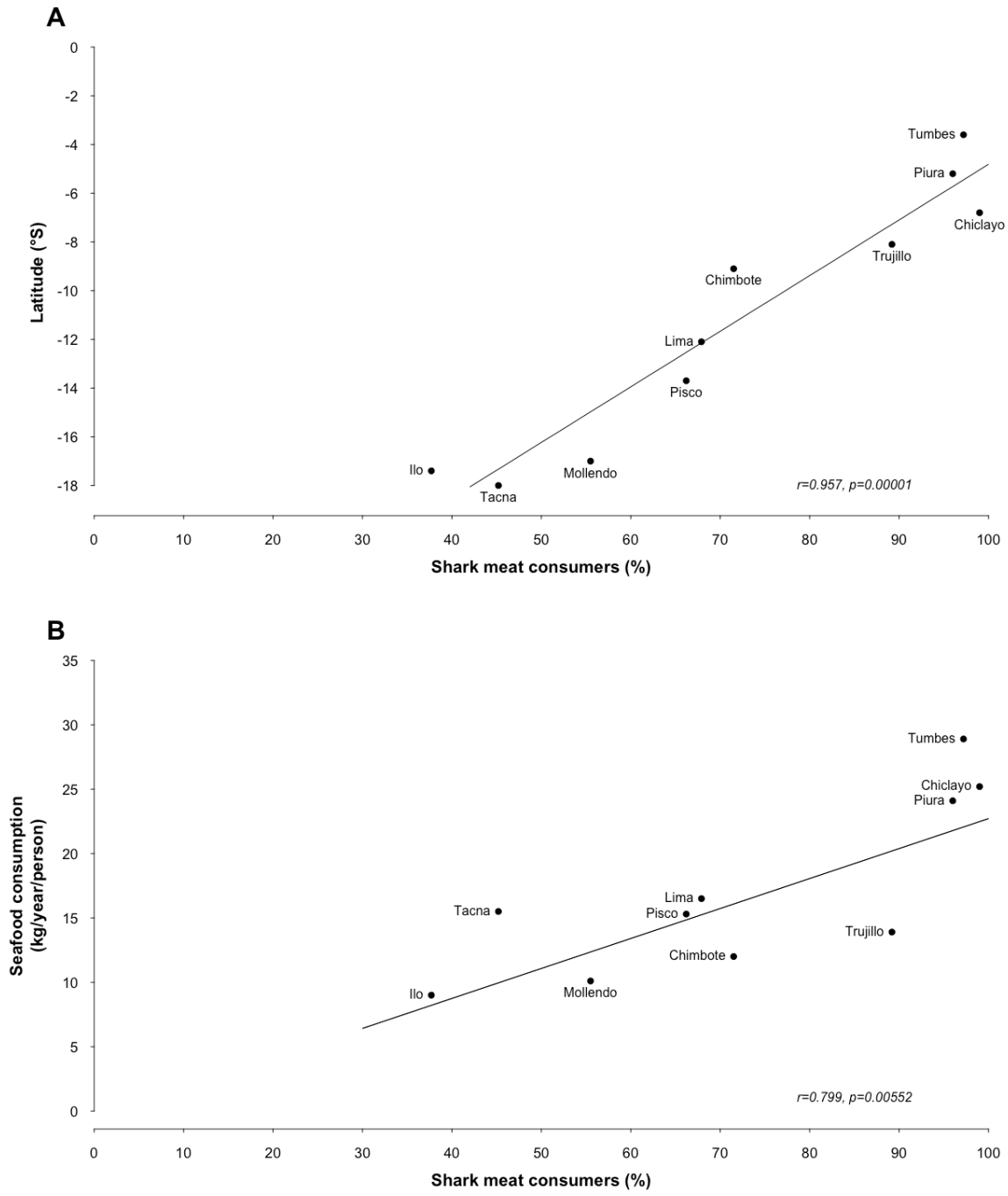

Figure 2.3: Proportion of shark (Selachimorpha) meat consumers per city as a function of (A) latitude, and (B) the *per capita* seafood consumption in 2015.

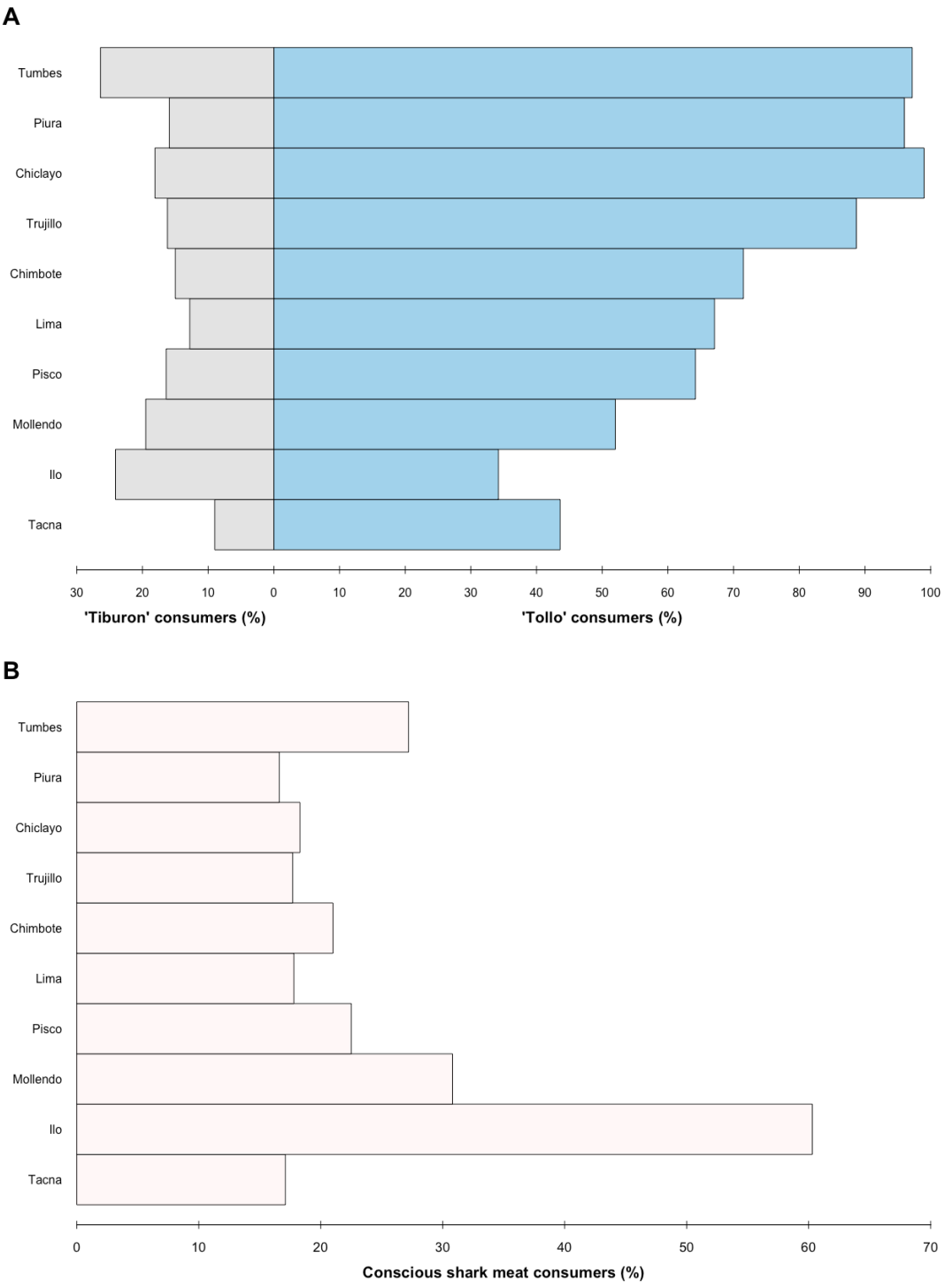

Figure 2.4: Proportion of shark (Selachimorpha) meat consumers per city, highlighting (A) consumers who eat sharks under the 'Tiburon' (grey bars) and 'Tollo' (blue bars) common names, and (B) 'Tollo' consumers who are aware that 'Tollo' is a generic name for sharks (i.e. 'Conscious' shark meat consumers).

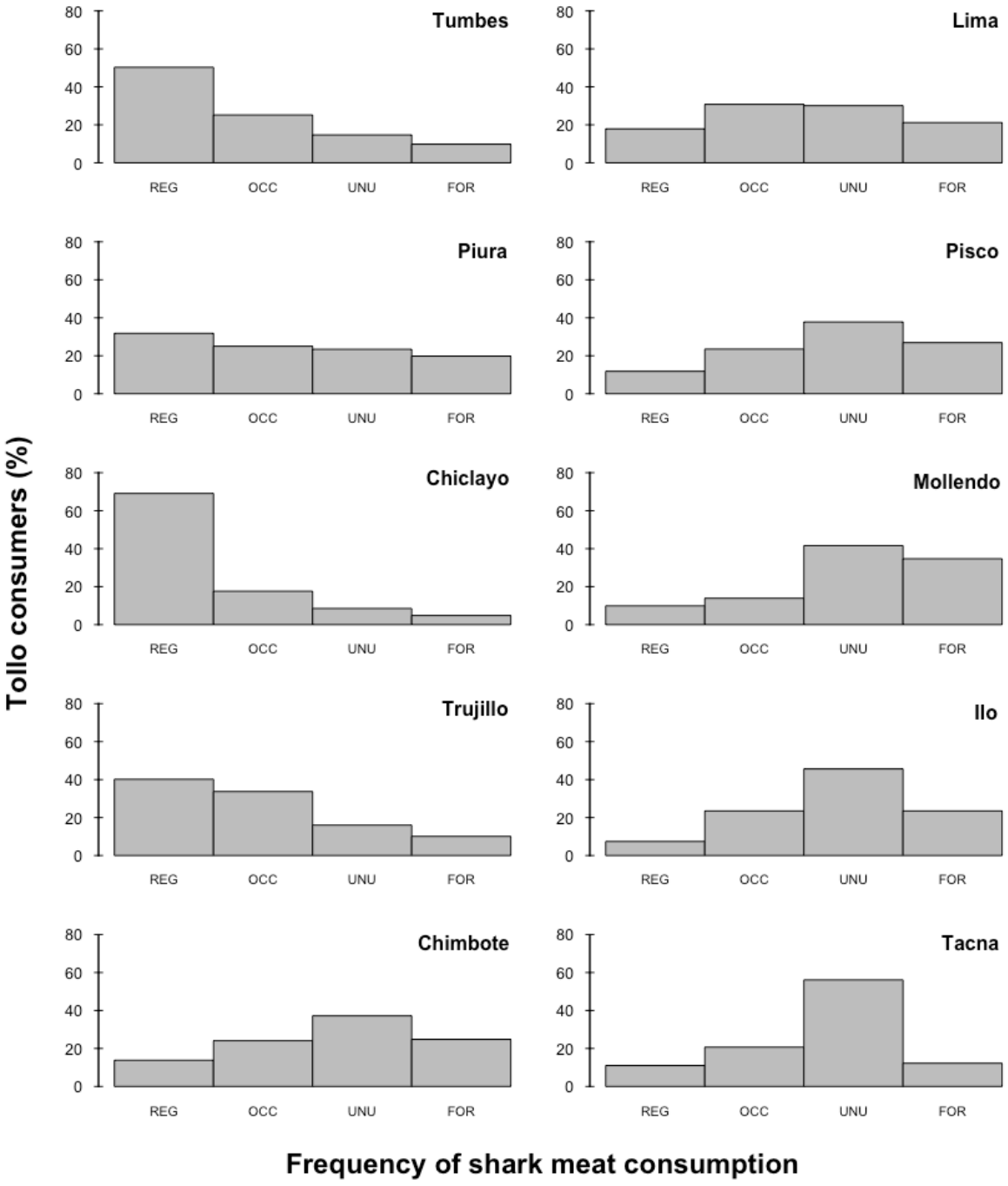

Figure 2.5: Distribution of 'tollo' consumers per city as a function of their frequency of shark meat consumption. Shark meat consumers were categorized into: Regular consumers (REG), Occasional consumers (OCC), Unusual consumers (UNU) and Former consumers (FOR).

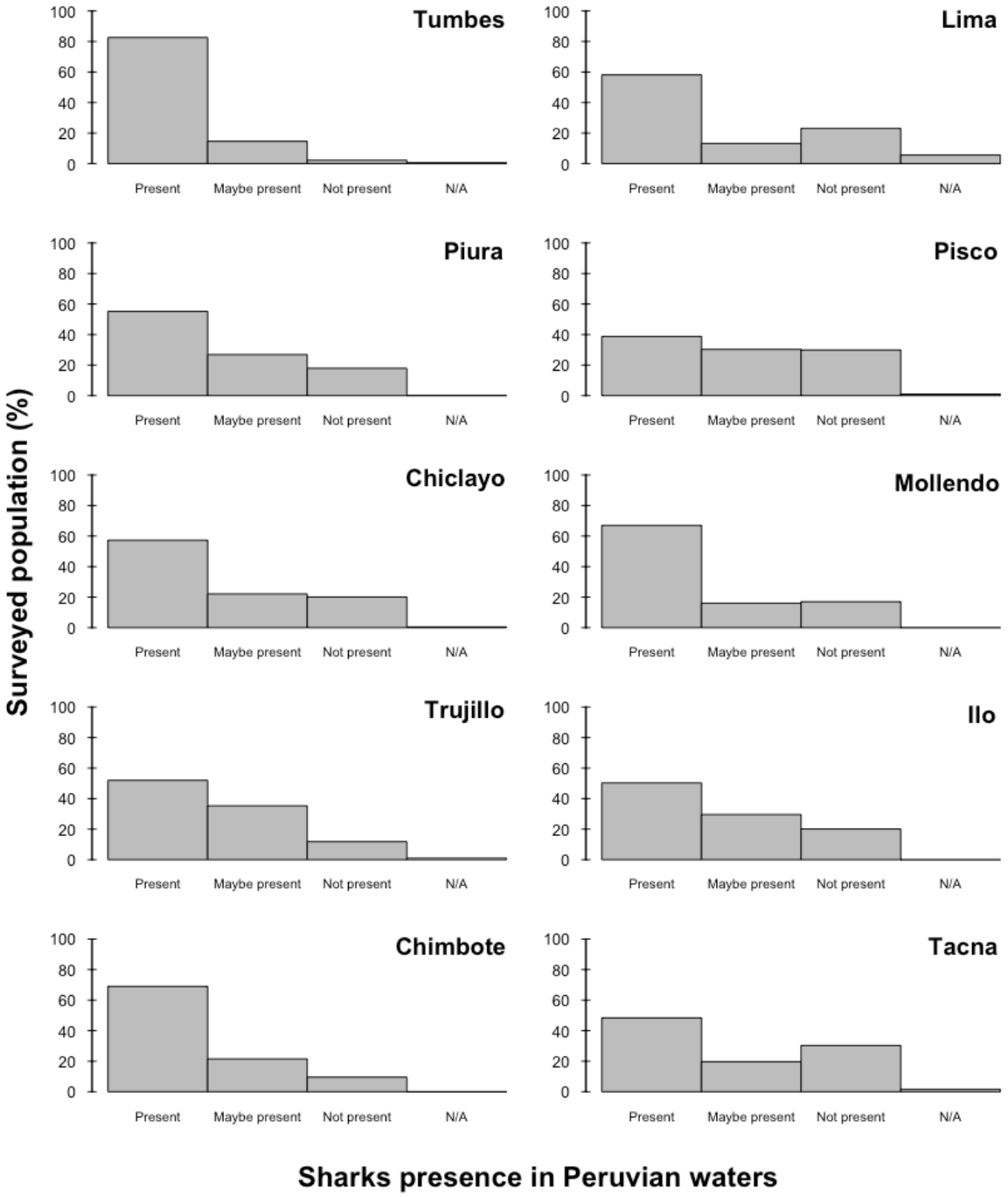

Figure 2.6: Proportion of the surveyed population per city that knows that sharks are present, maybe present, or are not present in Peruvian waters. The proportion of participants that did not answer this question are included in the N/A category.

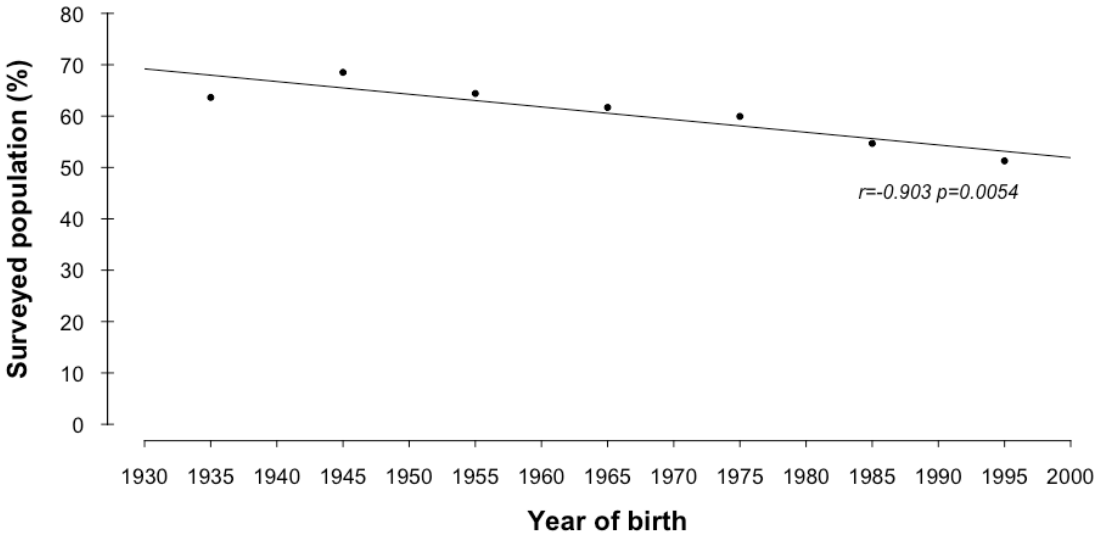

Figure 2.7: Proportion of people who correctly ascertained that sharks are found in Peruvian waters as a function of their year of birth (by decade).

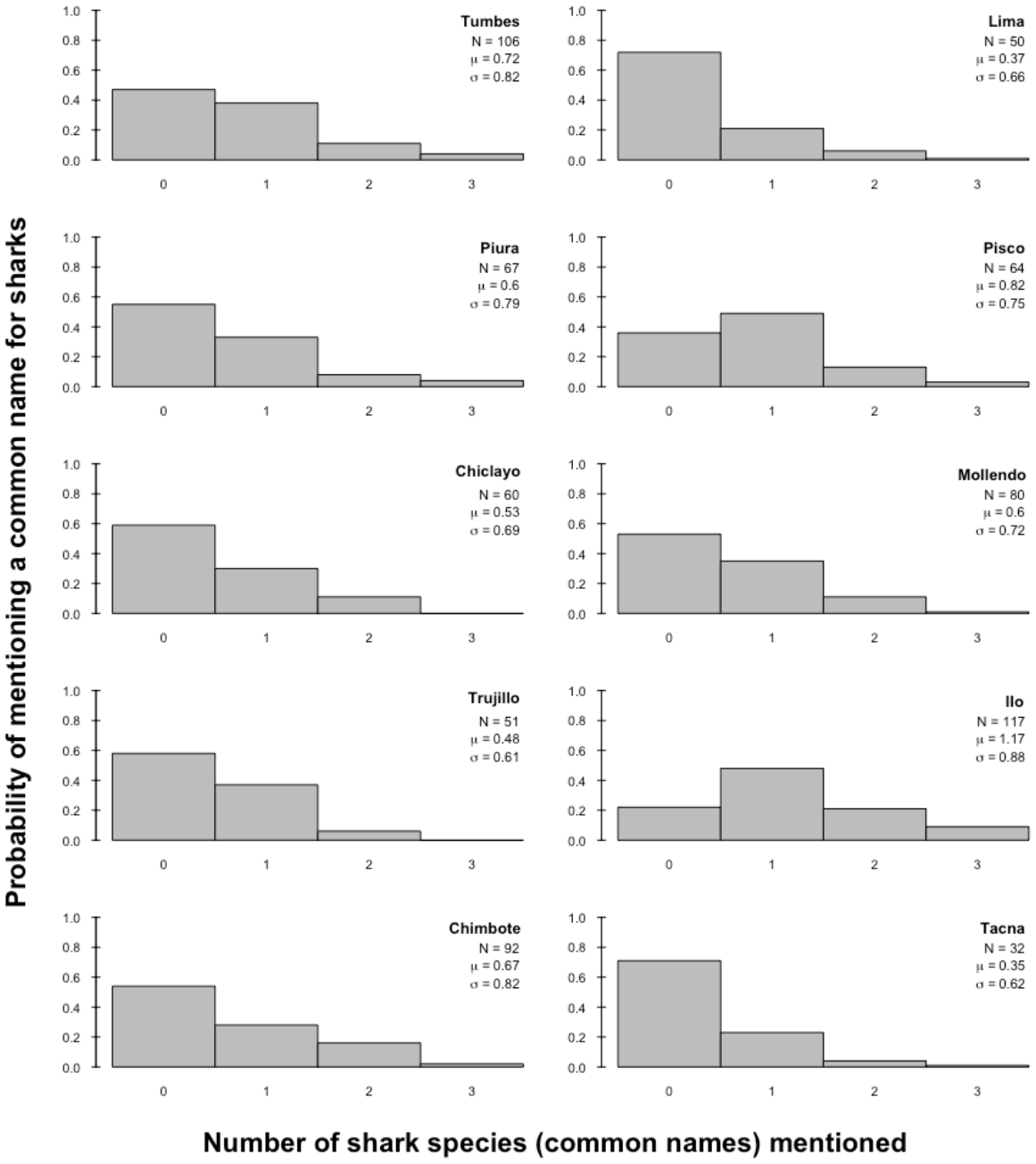

Figure 2.8: Capacity to mention shark names by participants who ascertained that sharks are present in Peruvian waters, segregated city. N references the total number of mentions, μ references the average number of words mentioned per city and σ references its standard deviation.

Figure 2.9: Word cloud highlighting words most frequently associated with sharks by coastal Peruvians. Font size is proportional to word frequency. Words were translated from Spanish (for further details see Table A.2).

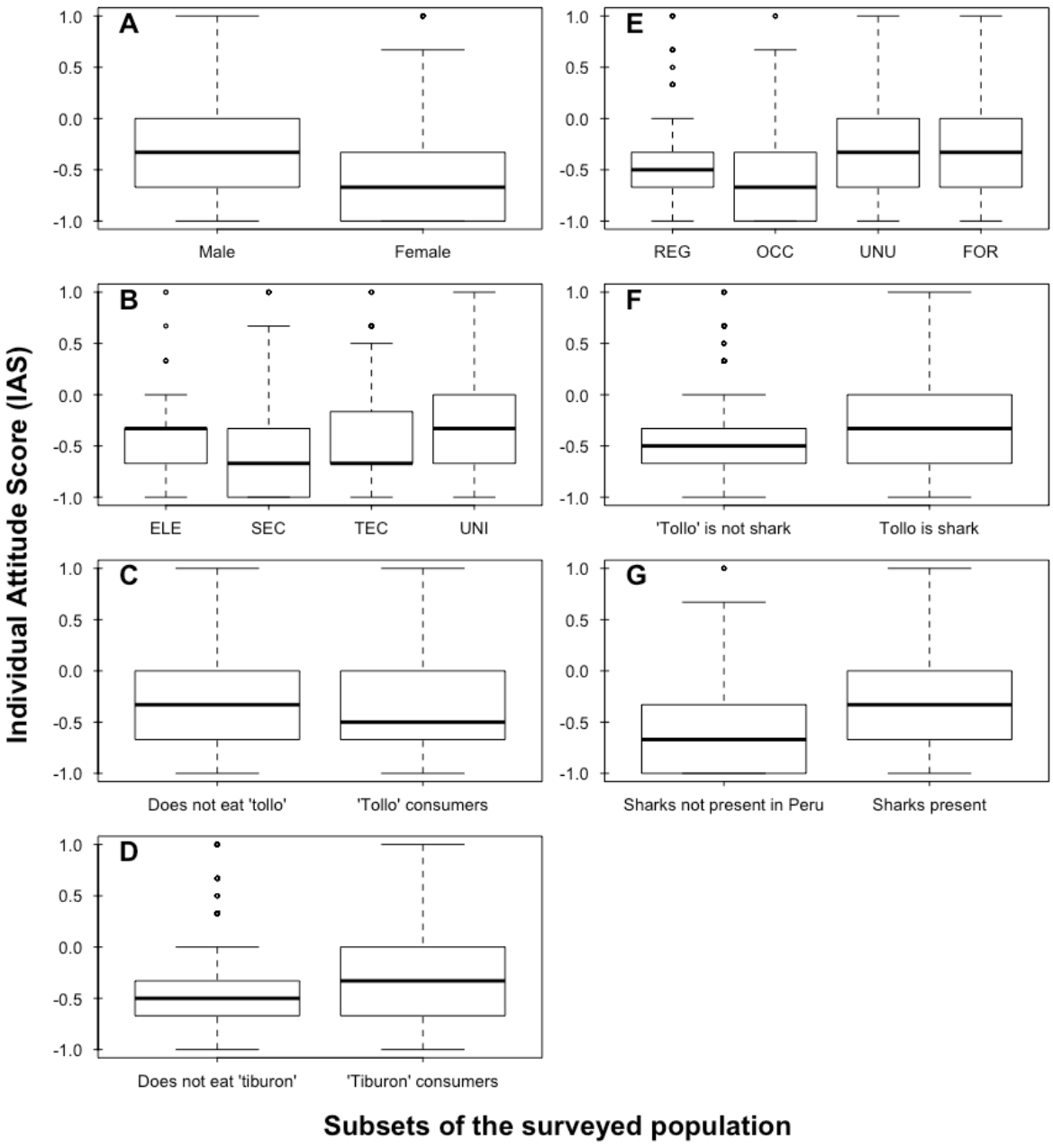

Figure 2.10: Boxplots showing differences in Individual Attitude Scores (IAS) between: (A) genders, (B) levels of education, (C) consumers and non-consumers of 'tollo', (D) consumers and non-consumers of 'tiburon', (E) regular, occasional, unusual and former 'tollo' consumers, (F) participants who know and do not know that 'tollo' is a common name used for sharks, and (G) participants who know and do not know that sharks are present in Peruvian waters. Acronyms in the figure stand for: ELE: Elementary studies; SEC: Secondary studies; TEC: Technical studies; UNI: University studies; REG: Regular consumers; OCC: Occasional consumers; UNU: Unusual consumers; FOR: Former consumers.

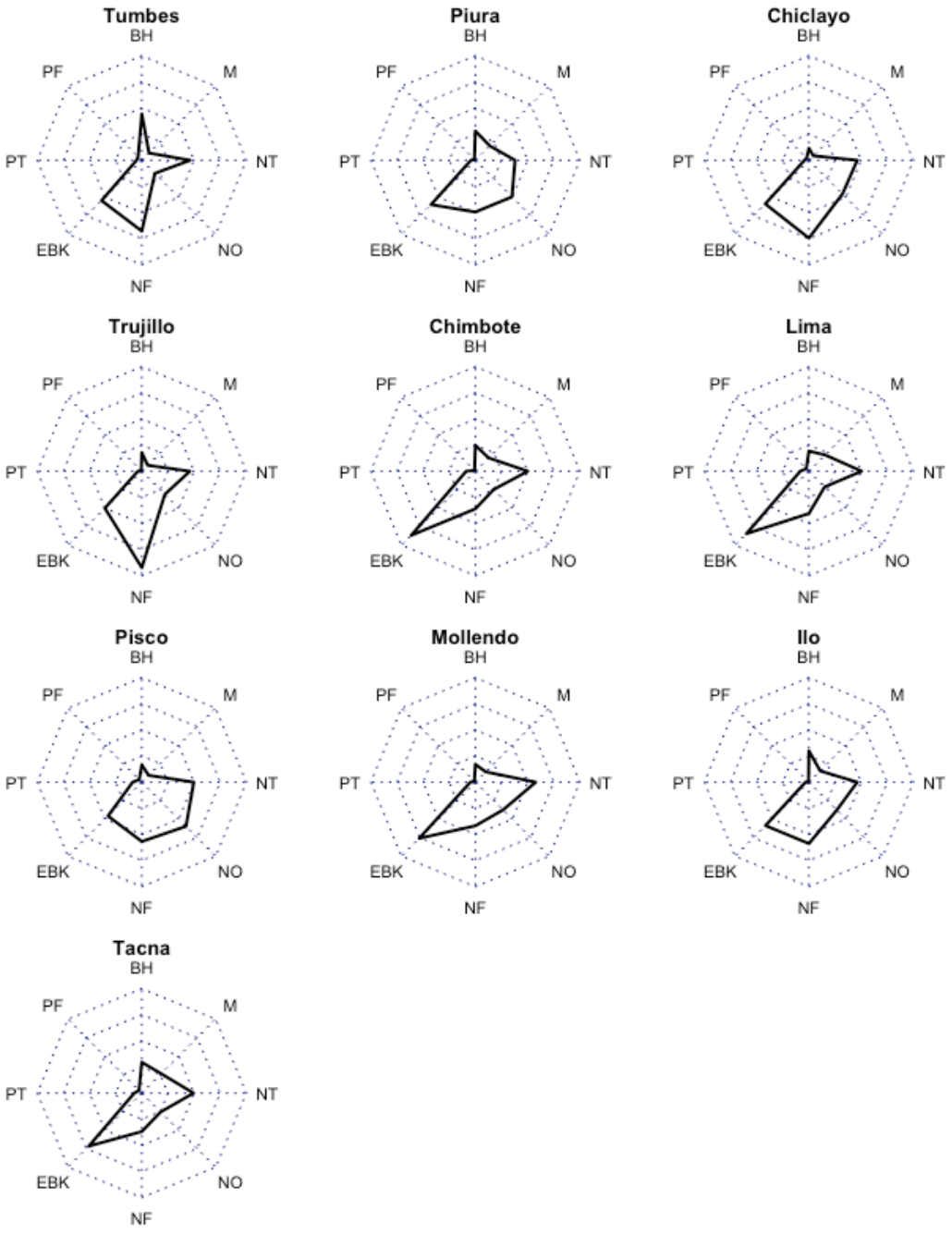

Figure 2.11: Radar plots showing the relative importance of the eight different categories that constitute each city's Attitude Profile. Each radar consists of four concentric octagons that extend from the origin. Each level denotes a 10% increase in the frequency of the words per category, where the origin marks a score of 0% and the outermost octagon of 40%. Acronyms in the figure stand for: BH: Benefits to humans; M: Miscellaneous; NT: Negative traits; NO: Negative outcomes of human-shark interactions; NF: Negative feelings; EBK: Ecological and biological knowledge; PT: Positive traits; PF: Positive feelings.

2.7. Tables

Table 2.1: General description of the surveyed population. The acronyms used in this table stand for: No. - Number of participants; M - male; F - female; ELE. - Elementary; SEC - Secondary; TEC. - Technical; and UNI. - University. In some cities, sex ratios and/or education levels do not sum to 100% as some participants failed to provide this information.

City	No.	Age (in years)			Sex ratio (%)		Education level (%)			
		Average	SD	Range	M	F	ELE	SEC	TEC	UNI
Tumbes	178	45.7	14.4	19-89	53.5	43.5	12.5	45.5	22.5	18.5
Piura	201	40.5	12.6	20-74	45.5	53.5	3.5	44.0	17.5	35.0
Chiclayo	199	40.2	13.7	19-72	34.2	64.3	4.0	20.1	36.7	37.7
Trujillo	204	38.0	10.9	19-78	36.2	63.3	2.5	8.0	37.2	51.3
Chimbote	200	38.0	15.3	19-83	56.4	41.5	2.1	20.1	26.9	50.9
Lima	234	41.6	14.8	19-93	45.3	50.7	7.0	39.3	36.3	14.4
Pisco	201	40.4	12.4	19-76	37.8	62.7	1.5	21.9	24.9	50.7
Mollendo	200	35.0	13.6	19-79	42.6	57.4	3.7	22.3	33.0	41.1
Ilo	199	41.4	12.8	19-84	27.0	72.5	3.9	25.0	25.0	44.1
Tacna	188	39.3	15.0	18-79	43.8	53.9	9.6	25.8	25.8	40.4

Table 2.2: Results of the Wilcoxon-Mann-Whitney tests comparing the proportion of 'tollo' consumers per city between education levels, segregated by their level of consumption. Statistically significant differences are marked with an asterisk (*).

Level of consumption	Education levels	Elementary	Secondary	Technical
Regular consumers	Elementary	-		
	Secondary	W=20, p=0.025*	-	
	Technical	W=17.5, p=0.015*	W=57.5, p=0.596	-
	University	W=5.5, p=0.001*	W=27, p= 0.089	W=20, p=0.026*
Occasional consumers	Elementary	-		
	Secondary	W=7, p=0.001*	-	
	Technical	W=0, p=0.000*	W=40, p=0.472	-
	University	W=4, p=0.001*	W=33.5, p=0.225	W=34, p=0.241
Unusual consumers	Elementary	-		
	Secondary	W=13, p=0.006*	-	
	Technical	W=3.5, p=0.000*	W=54.5, p=0.762	-
	University	W=2, p=0.000*	W=70, p= 0.139	W=29, p=0.120
Former consumers	Elementary	-		
	Secondary	W=9, p=0.002*	-	
	Technical	W=1.5, p=0.000*	W=39.5, p=0.449	-
	University	W=6.5, p=0.001*	W=40, p= 0.472	W=52, p=0.910

Table 2.3: Estimated shark meat demand per surveyed city

Surveyed cities	Population[7] (Number of people)	Shark Meat Demand	
		Total (tonnes)	*Per capita* (kg person^{-1})
Tumbes	111,683	326-542	2.92-4.87
Piura	153,544	309-516	2.01-3.36
Chiclayo	291,777	1,048-1,746	3.59-5.98
Trujillo	318,914	654-1,091	2.05-3.42
Chimbote	214,804	185-308	0.86-1.44
Lima	9,904,727	10,533-17,555	1.06-1.77
Pisco	53,887	36-59	0.66-1.10
Mollendo	22,389	10-16	0.44-0.74
Ilo	66,876	19-31	0.28-0.46
Tacna	85,228	41-68	0.48-0.80
Total	11,223,829	13,161-21,935	1.17-1.95

Table 2.4: Common shark names mentioned by the surveyed populations.

Common name		Scientific name	Frequency of occurrence
Spanish	English		
'Azul', 'Tollo azul', 'Tiburón azul'	Blue shark	*Prionace glauca*	196
'Tollo'	Smooth-hound	*Mustelus* sp. or *Triakis* sp.	130
'Martillo', 'Pez martillo', 'Tiburón martillo'	Hammerhead shark	*Sphyrna* sp.	121
'Tiburón blanco'	Great White shark	*Carcharodon carcharias*	107
'Diamante', 'Tollo diamante', 'Tiburón diamante'	Shortfin mako shark	*Isurus oxyrinchus*	104
'Tigre', 'Tiburón tigre'	Tiger shark	*Galeocerdo cuvier*	30
'Tiburón ballena'	Whale shark	*Rhincodon typus*	13
'Tollo blanco', 'Tollo de leche'	Sharptooth smooth-hound	*Mustelus dorsalis*	14
'Zorro', 'Tiburón zorro'	Thresher shark	*Alopias* sp.	4
		Total	719

[7] Population estimates per surveyed city correspond to 2015 (INEI 2017).

Table 2.5: Results of the Wilcoxon-Mann-Whitney tests comparing Individual Attitude Scores between selected groups. Statistically significant differences are marked with an asterisk (*).

Category	Comparisons	W	p-value
Gender	Male vs Female participants	527120	0.0000*
Education	Participants with elementary education vs participants with secondary education	27440	0.3549
	Participants with elementary education vs participants with technical education	28600	0.5974
	Participants with elementary education vs participants with university education	36008	0.5568
	Participants with secondary education vs participants with technical education	148820	0.4487
	Participants with secondary education vs participants with university education	187580	0.0050*
	Participants with technical education vs participants with university education	206140	0.0460*
Tollo consumption	Consumers vs non-consumers of 'tollo'	412620	0.5748
Frequency of 'tollo' consumption	Regular vs Occasional consumers	73057	0.3891
	Regular vs Unusual consumers	72048	0.0674
	Regular vs Former consumers	44792	0.0076*
	Occasional vs Unusual consumers	54250	0.0124*
	Occasional vs Former consumers	33742	0.0014*
	Unusual vs Former consumers	42086	0.3751
Tiburon consumption	Consumers vs non-consumers of 'tiburon'	317960	0.0002*
Knowledge of 'tollo' being shark	Participants that know vs participants that do not know that ‘tollo’ is a common name for shark	196160	0.0009*
Knowledge of sharks’ presence in Peru	Participants that know vs participants that do not know that sharks are present in Peru	567960	0.0000*

Table 2.6: Most frequent words related to 'sharks' mentioned by coastal Peruvians

Category	Sub-Category	Words	Frequency
Positive	Benefits to humans (BH)	Fins	95
		Food	65
		Cartilage	61
		Oil	54
		Tasty	35
	Positive traits (PT)	Strong	49
		Fast	16
		Grand	11
		Pretty	10
		Quick	6
		Astute	6
	Positive feelings (PF)	Awe	9
		Awesome	9
		Respect	8
		Curiosity	6
		Excitement	5
Negative	Negative outcomes of human-shark interactions (NO)	Blood	396
		Death	297
		Attack	28
		Aggression	22
		Bite	20
	Negative traits (NT)	Dangerous	547
		Murderer	168
		Fierce	109
		Mean	67
		Aggressive	48
	Negative feelings (NF)	Fear	728
		Danger	165
		Terror	159
		Panic	59
		Horror	17
Neutral	Ecological and Biological Knowledge (EBK)	Big	480
		Teeth	194
		Sea	183
		Predator	174
		Carnivorous	124
	Miscellaneous (M)	Movie	104
		White	21
		Blue	14
		Beach	14
		Whale	11

CHAPTER 3: RECONSTRUCTING THE CATCH AND CONSUMPTION PATTERNS OF SHARKS IN PERU

3.1. Introduction

Shark products are highly-traded commodities, with growing markets, to the extent that their global traded value has almost doubled since the late 1990s approaching USD 1 billion year^{-1} (Vannuccini 1999; Dent & Clarke 2015). A rising global demand for shark products has indeed led to increased fishing pressure on shark stocks, and their decreasing population trends, registered over the last decades (Stevens *et al.* 2000; Fong & Anderson 2002; Clarke *et al.* 2006; Simpfendorfer *et al.* 2011; Worm *et al.* 2013; Davidson *et al.* 2015; Dent & Clarke 2015).

However, little is known about what shark species are being caught and traded (Dent & Clarke 2015). On one hand, capture production statistics for chondrichthyans often do not distinguish between species (i.e. landings are aggregated into non-informative groups); and, on the other hand, trade records lack product standardization (Stevens *et al.* 2000; Worm *et al.* 2013; Davidson *et al.* 2015; Dent & Clarke 2015; Simpfendorfer & Dulvy 2017).

Nonetheless, the main traded shark commodities in the global market are *shark fins*, which are mainly used in East and Southeast Asia to prepare highly-valued shark fin soup (Vannuccini 1999; Clarke *et al.* 2006; Dulvy *et al.* 2014; Dent & Clarke 2015); and *shark meat*, which is sold mainly in Europe and South America either fresh, frozen, salted, or smoked (Vannuccini 1999; Dent & Clarke 2015). Other important, but harder to trace, products include *shark liver oil*, which is used by the cosmetic and pharmaceutical industries; and *shark cartilage*, which is grounded to powder and used as a 'natural' medicine (Vannuccini 1999; Stevens *et al.* 2000; Dent & Clarke 2015). Finally, *shark skin*, used for making leather and sandpaper, and *shark teeth*, commonly sold to tourists as jewelry or collectable items (Vannuccini 1999), are commodities with very local markets and with hardly any information available about their use or trade (Dent & Clarke 2015).

Yet, the characteristics of domestic markets and how they influence capture production remain important knowledge gaps for sharks (Dent & Clarke 2015; Dulvy *et al.* 2017). Understanding how local markets work is important for environmental organizations, governments and people involved in shark harvesting, processing and trade (Stevens *et al.* 2000; Worm *et al.* 2013; Davidson *et al.* 2015). These stakeholders are, directly or indirectly, dependent on the sustainable use and conservation sharks for their well-being, food security and/or institutional goals (Simpfendorfer *et al.* 2011; Dent & Clarke 2015; Dulvy *et al.* 2017).

A closer analysis of the international trade flows and patterns can be used to assess changes in country specific demand levels for shark commodities (Davidson *et al.* 2015; Dent & Clarke 2015). Yet, it is key

to highlight that product utilization is not what is being recorded in international trade statistics, and using the latter to describe domestic markets might be misleading. For example, shark meat trade increased globally at an average rate of 4.5% per year between 2000-2011; however, it is not clear if this trend was due to increases in: *(i)* shark meat utilization, *(ii)* the quantity of shark meat in international trade, or *(iii)* the quantity of shark meat reported in trade as opposed to undifferentiated fish (Dent & Clarke 2015).

The quantification of domestic shark meat and fin consumption is challenging and has been described as an 'often impossible' task due to data limitations (Dent & Clarke 2015). The reporting quality of capture production statistics, and what these statistics actually describe (i.e. total catch, or reported catch, or retained catch, etc.), varies significantly between countries (Pauly & Zeller 2016). Also, data on processing yields by product type are not commonly available or tend to be unreliable due to product aggregation (Dent & Clarke 2015). Additionally, seafood consumption varies heavily between countries (Smith *et al.* 2010) limiting our capacity to extrapolate rates of consumption between countries.

However, if data were available, the 'apparent consumption' of shark meat and fins could be estimated by calculating countries' edible production of sharks, adding imports and subtracting total exports (Smith *et al.* 2010).

Peru is one of the major importers of shark meat and exporters of shark fins in the world (Dent & Clarke 2015). Concerns regarding the sustainability of Peruvian shark fisheries have been raised due to decreasing trends in landings (e.g., between 1973-1993 and 2000-2010) and the high prevalence of juvenile shark catches (Stevens *et al.* 2000; Castañeda 2001; Doherty *et al.* 2014; González-Pestana *et al.* 2014).

Given the need to develop case studies to improve our understanding on how markets influence shark populations (Dent & Clarke 2015), and aligned with the information requirements of the National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras (PAN-Tib, PRODUCE 2014), this chapter seeks to: *(a)* characterize the domestic market and trade flows of shark commodities, highlighting trends and changes in trend direction overtime; *(b)* estimate the apparent consumption of shark meat and fins in Peru, highlighting the contribution of the local and foreign sources for these products; and *(c)* reconstruct the catches required to maintain the estimated consumption levels of shark products in Peru. The results of these reconstructions are discussed in the context of traded volumes and value, seafood traceability, and food security.

3.2. Methods

3.2.1. Estimating the total edible production of shark meat (EP_T)

The total landings (i.e. retained catch) of sharks in Peru were segregated by species. This was achieved by using landing statistics provided by the Peruvian Institute for Marine Research (IMARPE) and the Peruvian Ministry of Production (PRODUCE).

IMARPE has since 1996 monitored artisanal fisheries throughout the Peruvian coast using trained observers stationed at key landings sites (Estrella & Swartzman 2010). Landing statistics collected by IMARPE are segregated by species, however their coverage (i.e. the proportion of the total artisanal landings registered) is limited (Sueiro & De la Puente 2015).

PRODUCE, on the other hand, publishes the 'official landings statistics' for all Peruvian fisheries on annual reports (PRODUCE 2016). PRODUCE's landings data are constructed by complementing IMARPE data (Appendix 06: Figure A.3) with: *(i)* information from wholesaler markets collected by PRODUCE, *(ii)* monthly reports on small-scale fisheries landings sent by the Regional Governments, and *(iii)* affidavits provided by the seafood processing companies detailing the amount of inputs (in tonnes) used in their lines of production (i.e. canning, curing, freezing and reduction industries, Sueiro & De la Puente 2015). However, despite having 'full coverage' of the national fisheries landings, sharks are reported using three uninformative categories: Tiburon' (i.e. sharks), 'Tollo' (i.e. smooth-hounds and hound sharks) and 'Angelote' (i.e. angelshark).

Shark landings data, for the 2000-2015 period, was directly requested from IMARPE[8]. The proportional contribution of each species to the annual registered landings by IMARPE were assumed to be representative also of the official PRODUCE landings (Appendix 06: Table A.4). The conversion factors from the IMARPE data were thus multiplied by the total official shark landings reported by PRODUCE (i.e. the sum of landings reported as 'Tiburon', 'Tollo' and 'Angelote'; PRODUCE 2016), to segregate the 'official' shark landings by species.

Larger sharks are not commonly landed whole in Peru (i.e. sharks' heads and viscera are discarded at sea, Elliott *et al.* 1995; 1996; 1997a; 1997b; Castañeda 2001; Romero & Bustamante 2007; Doherty *et al.* 2014). Specimens of the smaller shark species, i.e. of the *Mustelus*, *Triakis*, *Schroederichthys* and *Squatina* genera were assumed to be fully retained (i.e. landings are equal to catches), whilst landings for all other species were assumed to include only the weight of the shark's meat, skin and bone (Table

[8] Requesting access to IMARPE data is a process regulated by the Peruvian government. The interested party must fill and submit Form No. 001 (available at: <http://www.imarpe.pe/imarpe/index.php?id_seccion=I011601060100000000000>) on IMARPE's headquarters in Callao, Peru. After evaluation, the data will be sent via email if the request is considered valid.

3.1). Shark fins are landed attached to the headed and gutted carcasses, however they are removed before the specimens are weighed (Appendix 07).

Data on the use of sharks as inputs for the curing and freezing industries, as well as their outputs (i.e. weight of final products), was directly requested to PRODUCE[9]. The information provided allowed for the estimation of: *(i)* the proportion of the landings destined to each line of production and *(ii)* the input-output ratio for each product type.

As PRODUCE does not report the inputs and outputs of the processing plants (or seafood markets) down to species level, these were reconstructed. For freezing plants, data on exports was used to infer local production per species. The assumptions were: *(i)* the proportional contribution (in weight) of each species listed in the specific commercial description of frozen products included in the exports database (*see Section 3.2.2.*) are representative of the species used as inputs for this type of processing; and *(ii)* exports (and hence production) of frozen shark products that used non-informative labels (e.g., 'sharks') included all registered species in the same proportion as they appear in the total annual shark landings.

Furthermore, as the outputs of the freezing plants were 'frozen shark trunks', the weight of the sharks' bones and skin were subtracted from the trunks using species-specific conversion factors (Kreuzer & Ahmed 1978; Vannuccini 1999) (Table 3.1), resulting in annual shark-meat-in-product estimates.

For the curing facilities and fresh seafood markets, the inputs were segregated per species using their proportional contribution to the total annual shark landings. As curing facilities mainly produce cured shark fillets (*pers. obs.*), the outputs of this line of production were assumed to only include shark meat.

Shark landings not accounted for as inputs for the local seafood processing industries were assumed to be absorbed by the fresh seafood markets across Peru (Christensen *et al.* 2014). Fresh shark meat production was calculated by applying species-specific trunk-to-meat and whole-body-to-meat ratios (Table 3.1); which meant subtracting the weight of the sharks' bones and skin (that are not consumed) from the estimated weight of shark inputs for the local seafood markets.

With this information, the EP_T was calculated by adding together the resulting shark meat production by product type (Equation 3.1).

$$EP_T = Fro_{sm} + Cur_{sm} + Fre_{sm}$$

(Equation 3.1)

[9] Access to public information managed by PRODUCE can be granted by submitting an online request form available at: <http://www.produce.gob.pe/index.php/formularios-de-atencion-al-ciudadano/solicitud-de-acceso-a-la-informacion-publica>.

Where: Fro_{sm}, Cur_{sm}, and Fre_{sm} represent the weight of shark meat in frozen, cured and fresh products, respectively.

3.2.2. Estimating the net shark meat exports (NE_{sm})

Export and import statistics for shark products were downloaded from the Peruvian Customs Agency's (SUNAT) official webpage[10]. Shark products were reported using six different Customs Codes between 01-Jan-2000 and 31-Dec-2015. The information included in SUNAT's data base is listed, with an example, in Table 3.2.

Products were grouped using the general and specific commercial descriptions for each of listed shipments and re-classified into four categories: *(i)* frozen shark trunks (i.e. headed, gutted and finned frozen shark carcasses), *(ii)* fresh shark trunks (i.e. headed, gutted and finned fresh shark carcasses), *(iii)* shark fins (i.e. processed shark fins), and *(iv)* shark cartilage powder.

To estimate the total exports and imports of shark meat, only categories *i* & *ii* were included in the calculations[11]. The weight of the sharks' bones and skin were subtracted from the total weight of the traded goods using species-specific multipliers (Kreuzer & Ahmed 1978; Vannuccini 1999); hence computing the shark-meat-in-product. The net shark meat exports (NE_{sm}) were calculated, per traded product and on an annual basis, by subtracting the estimated weight of shark meat in imports from that in exports (Equation 3.2).

$$NE_{sm} = \left(E_{fst} - I_{fst}\right) + \left(E_{fs} - I_{fs}\right)$$

(Equation 3.2)

Where: E represent exported weight of shark meat and I represent imported weight of shark meat in frozen shark trunks (fst) or fresh shark trunks (fs).

Common names were sometimes listed as part of the Specific Commercial Descriptions (SCDs) of the shipments. When present, these were compared with those listed in the Catalogue of Peruvian Marine Fishes (Chirichigno & Cornejo 2001) to partially reconstruct the exported and imported weight of shark products down to species level. The proportion of the total weight of exports and imports, which could be identified down to species level were used as a measure of reporting quality (RQ). Values for this index ranged from 0% to 100%.

[10] Peruvian statistics for all products being internationally traded (i.e. exports and imports) is available at: <www.sunat.gob.pe>. Custom Codes use for shark products during the studies period were: 0302650000; 0303750000; 0303810000; 0305591000; 0305710000; and 0305791000.

[11] Only seven shipments of shark cartilage were recorded leaving Peru during the studied period (6.45 tonnes; USD 36.6 thousand), and none were registered before 2006 nor after 2012. Thus, they were omitted from the analysis.

3.2.3. Estimating the apparent consumption of shark meat

The Total Apparent Consumption (AC_T) of shark meat was estimated, in metric tonnes and on an annual basis for the 2000-2015 period, by applying Equation 3.3:

$$AC_T = EP_T - NE_{sm}$$

(Equation 3.3)

Where: EP_T stands for Total Edible Production of shark meat and NE_{sm} for Net shark meat Exports.

Annual AC_T estimates were then used to produce the *per capita* Apparent Consumption (AC_{pc}) of shark meat by dividing AC_T by the Peruvian population. This scenario assumes that all Peruvians have equal access to shark meat. Given that most seafood consumption is thought to occur in the coastal regions of Peru, but recognizing that there are no studies suggesting how much shark meat is actually being consumed in those regions, then AC_{pc} was recalculated under two extreme scenarios (i.e. all or none shark meat consumption takes place at the coast) defining the maximum range of error for annual estimates of AC_{pc}. The per capita apparent consumption of shark meat by coastal citizens, in the 100% coastal consumption scenario is referred to as $AC_{coastal}$.

The average number of seafood dishes consumed per person were estimated based on: *(i)* AC_{pc} and $AC_{coastal}$ scenarios, and *(ii)* the average inputs of fish (in kg person^{-1}) required for traditional Peruvian seafood preparations (e.g., a ceviche requires 0.25 kg of fish per person whilst seafood stews or deep-fried fish dishes require 0.15 kg person^{-1}; Acurio 2015).

3.2.4. Estimating the potential production of processed shark fins (PP_{sf}) and the size of the internal market

The reconstructed landings per species were used to estimate the potential production of shark fins (PP_{sf}) by using: *(i)* species specific dressed-weight-to-total-weight conversion factors and *(ii)* shark-fin-to-body-mass ratios from published studies (Mejuto *et al.* 2009; Biery & Pauly 2012) (Table 3.1). When no information was available for a taxa's shark-fin-to-body-mass ratio, then 1:0.05 ratio was assumed.

The input-output ratios for the curing plants (estimated from PRODUCE's data) were applied to the PP_{ff} estimates, generating annual approximations of the potential production of processed shark fins (PP_{sf}). The total apparent consumption of shark fins (AC_{sf}) was then computed using Equation 3.4:

$$AC_{sf} = PP_{sf} - NE_{sf}$$

(Equation 3.4)

where: PP_{sf} is the potential production of shark fins, and NE_{sf} is the net export of processed shark fins.

As for shark meat, NE_{sf} was estimated by subtracting the weight of imports from exports. Measures of RQ were also calculated for the shark fin trade. Additionally, the estimation of the AC_{sf} assumes that all shark fin production that remained in the country was consumed during the year when it was produced. Annual estimates of AC_{sf} were re-expressed as per capita indices by dividing them by the total population size of Peru.

3.2.5. Estimating the catch required to sustain the Peruvian supply and demand of shark meat and fins

The total shark catch required to sustain the Peruvian supply of shark meat and fins was reconstructed using the retained catch estimates per species, based on the same assumptions as used in *section 3.2.1*, and by applying species-specific dressed-weight-to-total-weight ratios from the literature (Table 3.1). Furthermore, using the input-output ratios per product type (estimated from PRODUCE's data), it was possible to back calculate the inputs of the exported and imported goods, and hence the total catch required to sustain the Peruvian demand of shark meat and fins.

3.2.6. Additional calculations

Figures, descriptive statistics, correlations and statistical tests were computed using R (ver. 3.4.0). All variables were tested for normality (Shapiro-Wilk 1965). Parametric tests (e.g., Student's t-test; Zar 1999) and non-parametric tests (e.g., Wilcoxon-Mann-Whitney test; Fay & Proschan 2010) were implemented accordingly to identify statistically significant differences between subsets of the data.

3.3. Results

3.3.1. Total edible production of shark meat (EP_T)

PRODUCE estimates that a total of 135,588 tonnes of sharks were landed in Peru, between 2000-2015, at an average rate of 8,474 ± 2,285 tonnes $year^{-1}$ (Figure 3.1A). Sharks were predominantly used by the fresh seafood markets, which absorbed 91.7% of the total landings at an average rate of 7,768 ± 1,938 tonnes $year^{-1}$. Input-output ratios for fresh shark meat (Fre_{sm}) production oscillated, due to changes in species composition, between 0.72 and 0.78 ($\mu \pm \sigma = 0.76 \pm 0.02$; cv = 0.02). These markets produced a total of 95,209 tonnes of Fre_{sm} at average rate of 5,951 ± 1,242 tonnes $year^{-1}$ (Figure 3.1B).

The remaining shark landings were destined to processing plants for cured shark meat (i.e. salted and sun-dried fillets) and frozen shark trunk production. Between 2000-2015, curing facilities absorbed 4.3% of the total shark landings ($\sum$ = 5,765 tonnes; $\mu \pm \sigma = 360 \pm 317$ tonnes $year^{-1}$), whilst freezing plants took the remaining 4.1% ($\sum$ = 5,537 tonnes; $\mu \pm \sigma = 346 \pm 462$ tonnes $year^{-1}$).

The production of frozen shark trunks recorded during the studied period amounted to 3,847 tonnes at an average rate of 240 ± 324 tonnes $year^{-1}$ (Figure 3.1C). Input-output ratios for the freezing industry

oscillated between 0.44 and 0.93 (μ ± σ = 0.71 ± 0.12; cv = 0.17), perhaps due to changes in the characteristics of the products and/or species composition. After correcting for the weight of the sharks' bones and skin, the total production of frozen shark meat (Fro_{sm}) amounted to 2,902 tonnes at an average rate of 181 ± 243 tonnes $year^{-1}$ (Figure 3.1C).

For cured products, on the other hand, the total shark meat production (Cur_{sm}) amounted to 2,355 tonnes, at an average rate of 147 ± 125 tonnes $year^{-1}$ (Figure 3.1D). Input-output ratios for the curing industry oscillated between 0.38 and 0.46 (μ ± σ = 0.42 ± 0.02; cv = 0.06).

Finally, the total edible production of shark meat (EP_T) during the studied period, amounted to 99,318 tonnes. EP_T values ranged between 3,720.7 tonnes in 2008 to 10,605 tonnes in 2015, and averaged at 6,270 ± 1,678 tonnes $year^{-1}$ (Figure 3.1A).

3.3.2. Net shark meat exports (NE_{sm})

Shark meat products (i.e. frozen and fresh shark trunks) were recorded leaving Peru in 401 shipments, for a total weight of 8,403 tonnes and generating a total value of USD 13.13 million. Exports of fresh shark trunks represented 11.5% of the total shipments exiting the country, 1.2% of the exported weight of shark meat products and 1.5% of the exported value. Exports of this type were only registered until 2008, and at an average rate of 11 ± 14 tonnes $year^{-1}$ (USD 22 ± 28 thousands $year^{-1}$). Contrastingly, exports of frozen shark trunks were recorded throughout the studied period, at an average rate of 519 ± 384 tonnes $year^{-1}$ (USD 808 ± 680 thousands $year^{-1}$), and showing an overall upward trend.

Imports of shark meat products were much larger, valuable and frequent than exports. Between 2000-2015, SUNAT recorded 5,240 shipments entering Peru, with a total weight of 36,162.9 tonnes and for a total value of USD 22.85 million. Imports of frozen shark trunks represented 49.6% of the total shipments entering the country, 50.8% of the imported weight of shark meat products and 74.4% of the imported value. Imports of this type were registered throughout the studied period, at an average rate of 1,204 ± 52 tonnes $year^{-1}$ (USD 1,589 ± 288 thousands $year^{-1}$), and showing an overall increasing trend.

Similarly, fresh shark trunk imports were recorded throughout the studied period. Nonetheless, only 0.4% of the imported tonnage was registered between the years 2000 and 2006. Since 2007, a total of 17,719 tonnes (USD 5,807 thousands) of fresh shark trunks were imported at an average rate of 1,969 ± 617 tonnes $year^{-1}$ (USD 645 ± 1,238 thousands $year^{-1}$).

With this information, estimations for the net exported weight of fresh and frozen shark trunks were computed (Figure 3.2). After removing the weight of the sharks' skin and bones from these products, the net shark meat exports (NE_{sm}) through the studied period amounted to -31,320 tonnes. NE_{sm} were on average -1,958 ± 1,957 tonnes $year^{-1}$ between the years 2000 and 2015, however after 2007 this

value amounted to -3,484 ± 1,092 tonnes year^{-1}. As NE_{sm} were negative and decreasing, then more shark trunks are being imported than exported, and imports are growing much faster than exports (Figure 3.2).

3.3.3. Total and *per capita* Apparent Consumption of shark meat

The Total Apparent Consumption of shark meat (AC_T) increased during the studied period (r=0.79, p=0.0002), reaching its highest value in 2015 (14,303 tonnes) (Figure 3.3A). Moreover, since 2007, 35.9% (± 7.3%) of the shark meat supply for the Peruvian markets originated in foreign waters.

A significant difference (t-test; p=0.003) was identified when comparing AC_T values registered between 2000-2006 (6,071 ± 1,064 tonnes year^{-1}) with those recorded between 2007-2015 (9,793 ± 2,744 tonnes year^{-1}); showing an overall increase of 61.3%. Nonetheless, EP_T values registered before (6,076 ± 1,066 tonnes year^{-1}) and since 2007 (6,310 ± 2,097 tonnes year^{-1}) did not differ significantly (t-test; p=0.777).

As the domestic supply of shark meat (EP_T) did not grow, but the market absorbed the foreign supply, it seems that the growing local demand for shark meat could not be satisfied with the local production, and thus required greater shark meat imports, as can be seen in Figure 3.2.

The *per capita* apparent consumption (AC_{pc}) of shark meat, on the other hand, ranged between 0.166 kg person^{-1} (2003) to 0.459 kg person^{-1} (2015), assuming that all Peruvians had equal access to shark meat. Despite the average AC_{pc} recorded between 2000-2015 was of 0.282 ± 0.085 kg person^{-1}, this parameter showed a significant positive trend (r=0.718, p=0.002) (Figure 3.3B). Since 2010, AC_{pc} values have been consistently above average (0.373 ± 0.061 kg person^{-1}), showing a significant increase (p=0.0005) in comparison to values recorded between the years 2000 and 2009 (0.227 ± 0.035 kg person^{-1}).

It is also important to highlight that if the apparent consumption of shark meat is restricted to the coastal regions, then AC_{pc} estimates decrease, but the $AC_{coastal}$ estimates increase. On average, $AC_{coastal}$ was 59.1% (± 1.0%) larger than AC_{pc} throughout the studied period (Table 3.3).

Using the AP_{pc} value estimated for 2015 (0.459 kg person^{-1}) and the average portions of fish used for making traditional Peruvian seafood dishes (Acurio 2015), then each Peruvian ate between 1.84 and 3.06 dishes featuring shark meat in that year. Nonetheless, under the $AC_{coastal}$ scenario, each coastal citizen ate on average 0.723 kg of shark meat in 2015, which is equivalent to consuming between 2.89 and 4.82 dishes with shark meat during the year.

3.3.4. Potential production and apparent consumption of processed shark fins

The potential production of fresh shark fins (PP_{ff}) ranged from 330 tonnes $year^{-1}$ in 2008, to 939 tonnes $year^{-1}$ in 2015; averaging at 557 ± 155 tonnes $year^{-1}$ (2000-2015) (Figure 3.4A). The curing of PP_{ff} yielded on average 233 ± 70 tonnes $year^{-1}$ of processed shark fins (PP_{sf}). PP_{sf} did not show an increasing trend during the studied period (r=0.331, p=0.196), although the estimated PP_{sf} was highest in 2015 (398.1 tonnes).

In terms of exports, a total of 2,512 shipments carrying processed shark fins were registered leaving Peru between 2000-2015. The total exported volume was 2,857 tonnes (USD 113.41 million), exiting the country at an average rate of 179 ± 71 tonnes $year^{-1}$ (USD 7.09 ± 2.63 million $year^{-1}$) (Figure 3.4B). In contrast, 520 shipments carrying 589 tonnes (USD 6.60 million) of processed shark fins were recorded entering Peru during the studied period. The average rate of imports was of 37 tonnes $year^{-1}$ (USD 413 ± 707 thousand $year^{-1}$). Significant positive trends were observed for exports (r=0.564, p=0.023) and imports (r=0.795, p=0.0002) during the studied period, suggesting that the shark fin trade was growing in both directions. Net shark fin exports (NE_{sf}), however, did not show a significant trend (r=-0.080, p=0.769). The latter oscillated between 53 tonnes (in 2013) and 237 tonnes (in 2007) at an average rate of 142 ± 47 tonnes $year^{-1}$ (Figure 3.4B).

The total apparent consumption of shark fins (AC_{sf}, Equation 3.4) was estimated by subtracting NE_{sf} from PP_{sf}. AC_{sf} ranged from -95 tonnes in 2007 to 190 tonnes in 2015 (Figure 3.4C), with an average value of 91 ± 69 tonnes $year^{-1}$. It is important to highlight that the only year where there is evidence of shark finning is 2007, as more shark fins were exported than the sum of the total production plus imports. Since then, AC_{sf} has been on the rise, suggesting that the internal market for these products, and the local demand for shark fins, is also increasing.

If we assume that all Peruvians have equal access to shark fins, then on average the apparent *per capita* consumption of shark fins amounted to 0.003 ± 0.002 kg $person^{-1}$ $year^{-1}$, between 2000-2015. However, in the last three years, these values have increased to 0.005 ± 0.001 kg $person^{-1}$ $year^{-1}$. Moreover, given that shark fin soups require approximately 42 gr of dried shark fins per person[12], then the AC_{sf} estimated for 2015 resulted in 4.52 million servings of shark fin soup. Thus, roughly 15% of the Peruvian population ate a bowl of shark fin soup in 2015.

3.3.5. Catch required to sustain the Peruvian supply and demand of shark meat and fins

A total of 188,700 tonnes of shark were caught in Peru between the years 2000 and 2015, at an average rate of 11,790 ± 3,260 tonnes $year^{-1}$. Thus, on average, the official shark landings (i.e. retained catch)

[12] A shark fin soup that yields six servings requires 250 gr of shark fins according to an online recipe available at: <https://ifood.tv/chinese/61824-shark-fin-soup>.

underestimated the total catch required to sustain the Peruvian supply of shark meat and fins by 38.9% (± 2.1%) year^{-1} (Figure 3.5).

The potential production of fresh shark fins (PP_{ff}) and the total edible production of shark meat (EP_T) represented 4.7% (± 0.2%) and 52.8% (± 1.7%) of the total annual catches, respectively[13]. Thus, it was possible to back calculate the catches required to sustain the Peruvian demand of shark meat and fins. Between the years 2000-2015, these increased to 251,415 tonnes of sharks, occurring at an average rate of 15,714 ± 5,525 tonnes year^{-1}. The demand and supply diverge after 2006, as since then shark meat imports started to grow significantly (Figure 3.3A).

Across the studied period, the catches required to sustain the Peruvian demand for shark meat and fins exceeded the national supply of sharks by 33.3% and the official reported shark landings by 85.4%.

3.3.6. Reporting quality and trade flows of shark products

It is important to highlight that the species used for making shark products for international trade, are not always included in the commercial descriptions of such commodities (González-Pestana *et al.* 2014; Dent & Clarke 2015). For example, fresh shark exports were completely reported down to species level between 2001 and 2008 (Figure 3.6A). Short-fin mako sharks (63.2%) and blue sharks (36.8%) were the only species exported as 'fresh sharks' during that period, and no further exports of this type were registered since 2009. Conversely, since 2005, fresh shark imports have been exclusively reported under the non-informative category: "sharks" (Figure 3.6A). These imports originated from Ecuador and entered Peru by truck.

On the other hand, the RQ of frozen shark exports and imports have been improving overtime (Figure 3.6B). During the last five years with available data (2011-2015), the RQ of frozen shark exports averaged 96.3% (± 3.6%), reaching 100% in 2014 and 2015. These exports originated mainly from the Callao (94.2%) and Paita (5.8%) ports and reached the Brazilian (93.4%) and Venezuelan (6.6%) markets by freighter. Similarly, the RQ of frozen shark imports averaged at 98.1% (± 0.9%), between 2011-2015. Imports originated almost exclusively from international waters (88.6%), Japan (2.5%), Uruguay (1.9%) and Panama (1.8%), and entered Peru through a maritime terminal. Blue sharks dominated (95.8%) the exports of this type of product, whilst imports were more diverse, including blue sharks (84.1%), short-fin mako sharks (6.4%), thresher sharks (4.3%), hammerhead sharks (2.1%), among others.

The RQ of shark fin exports has been improving since 2011, averaging 25.9% (± 10.6%), and reaching a value of 40% in 2015 (Figure 3.6C). The exported shark fins that could be identified to species level mainly belonged to blue sharks (28.2%). Fins left Peru by freighter (80.6%) or via cargo plane (19.4%),

[13] The catch reconstruction per species, as well as their corresponding shark meat and fresh fin production is included in Appendix 08: Figure A.4.

and were destined almost exclusively to Asian markets (Hong Kong: 81.6%; Singapore: 15.5%; and Japan 2.7%). Shark fins imports, however, had very low RQ throughout the studied period and in the last five years, these have averaged only 0.7% (± 1.1%) (Figure 3.6C). Shark fins were imported mainly from Ecuador via truck (62.5%) and from International waters via freighter (36.8%).

In synthesis, the total RQ of exports and imports show opposing trends (Figure 3.6D). Overall, the RQ of exports improved during the studied period, whilst the RQ of imports progressively decreased since 2007. This decrease results from the growing internal market for the fresh shark meat (Figure13A) and shark fins (Figure 3.4B).

3.4. Discussion

3.4.1. A growing demand for shark meat

The Peruvian market for shark meat increased significantly during the studied period, particularly since 2007. As the local supply did not grow correspondingly, the Peruvian market started to rely much more heavily on shark meat imports. Hence, AC_T and AC_{pc} increased significantly after 2007, despite that the EP_T and the official shark landings did not.

A possible explanation for the behaviour of these variables comes from the seafood-based 'gastronomic boom', which begun in the Peruvian capital in 2006 (Wintersteen 2011). Top chefs promoted the revaluation of local culinary traditions, receiving significant national and international media coverage (Lopez de la Lama 2014). The total number of seafood-based restaurants grew very rapidly across the country, and by 2011 over 11,000 of them could be found in Lima alone (Sueiro & De la Lama 2014). Peru also became South America's leading gastronomic destination in 2012, a title that it has maintained to date (Majluf *et al.* 2017). Moreover, seafood consumption in households also grew rapidly and continuously during these years (PRODUCE 2015; 2016).

This 'gastronomic boom' resulted in a growing demand for seafood and particularly for fish. Fish for direct human consumption (DHC) are mainly supplied by small-scale fishers in Peru (Christensen *et al.* 2014). Nonetheless, the official fish landings for DHC did not increased significantly after 2006 (PRODUCE 2016; Appendix 09: Figures A.5-A.6 and Table A.5).

As reported by Sueiro & De la Lama (2014), the resulting unsatisfied demand for fish promoted an increase in the local commercialization (wholesale and retail) of fish products from aquaculture. However, a closer look at the overall imports of marine fishes for DHC reveals that these have also been growing fast in the last decade and particularly since 2007 (Appendix 09: Figures A.7-A.8 and Table A.5). Total marine fish imports for DHC in 2015 were almost five times larger than those recorded in 2006 (Adex Data Trade 2017). Moreover, a significant positive correlation was found between total shark imports and total marine fish imports for DHC ($r=0.662$, $p=0.05$; Appendix 09: Figure A.9). While

there is considerable import of many fish species, sharks still represented 3% of all frozen, canned, cured and fresh fish imports registered between 2000-2015 (Adex Data Trade 2017).

But why sharks? After an extensive review of published studies on consumer purchasing behavior towards fish and seafood products in Australia, Europe and the USA, Carlucci *et al.* (2015) identified: sensory perception, health benefits, eating habits, convenience preparation, self-efficacy in the fish preparation process, price perception, fish availability, country of origin, production method, preservation method, product development, packaging and eco-labeling as the main factors that influence consumer choices (a description of each factor is included in Table 3.4).

Although the Peruvian socio-economic context is not equal to that of the studies reviewed by Carlucci *et al.* (2015), most of listed factors are still relevant for Peru (Higuchi *et al.* 2017) and sharks. Shark meat is considered a tasty and versatile input for multiple seafood preparations[14]; and it is a good alternative for other scarcer and higher valued fishes such as: fine flounders (*Paralichthys adspersus*), groupers (*Epinephelus* sp.), Peruvian grunts (*Anisotremus scapularis*) and corvina drums (*Cilus gilberti*) (Appendix 05).

Additionally, many, if not all, imported shark species are also present in Peruvian waters (*see section 3.3.6*). Seafood markets, supermarkets and restaurants do not display information on where, when and how the fishes they offer were caught (*pers. obs.*). These issues benefit shark importers, as habit and taste preferences are the main drivers for seafood consumption in Peru (Higuchi *et al.* 2017).

Moreover, wholesalers and retailers do not include information on whether the fish they sell is fresh (chilled) or if it was previously frozen (Sueiro & De la Lama 2014). This benefits the sellers as: *(i)* consumers are not aware, and hence not biased, by the preservation method, and *(ii)* wholesalers can place frozen shark meat with greater ease in 'fresh' seafood markets of the non-coastal regions of Peru – mainly in large Andean cities like Arequipa, Cuzco and Puno (*pers. obs.*).

Furthermore, sharks, as all other fishes, can be cut into fillets or chopped into tiny pieces (for preparing ceviche) at the point of sale, as soon as they are purchased (Sueiro & De la Lama 2014). This satisfies consumers that prefer to buy whole fishes, as well as those who seek for more convenient preparations.

Finally, despite concerns have been raised about sharks' capacity to bio-accumulate and bio-magnify organic and inorganic pollutants in their flesh in Australia (Gilbert *et at.* 2015), Japan (Endo *et al.* 2015), Mexico (Maz-Courrau *et al.* 2012; Terrazas-López *et al.* 2016), South Africa (Bosch *et al.* 2016), South Korea (Kim *et al.* 2016), USA (Nalluri *et al.* 2014), among others; Peruvians have not acknowledged the potential health risks related to shark meat consumption (Appendix 03: Table A.2). This emerges

[14] In ceviche <https://goo.gl/Hd26kG>; in brochettes and served with fried rice <https://goo.gl/YCtvpK>; breaded and fried <https://goo.gl/bo5CZr>; in burgers <https://goo.gl/M9zKWU>; stir-fried with potatoes, onions and tomatoes <https://goo.gl/RmN8Af>; deep-fried with yucca <https://goo.gl/16xfcU>; steamed <https://goo.gl/3aC1vQ>; in pumpkin soups <https://goo.gl/3m4BGv>; slow-cooked with hot pepper sauce <https://goo.gl/YoZX4i>, among others.

from two critical misconceptions: *(i)* shark meat consumers are not aware that they are eating sharks, as these species are regularly mislabelled as 'tollo' in Peruvian seafood markets (*see Chapter 2; Appendix 01*); and *(ii)* seafood consumers in Peru are generally not concerned by the health-related attributes of fish, as they perceive all fishes as healthy food items (Higuchi *et al.* 2017).

In synthesis, market forces, seafood mislabeling and asymmetric access to information between consumers and suppliers in Peru resulted in the observed AC_T and AC_{pc} trends and values (Figure 3.3).

3.4.2. Shark meat in the context of food security

Sharks are minor contributors to Peruvian food security. In 2015 Peruvians ate, on average, 24.4 kg of seafood (PRODUCE 2016), and given the estimated AC_{pc} for that year, sharks represented only 1.7% of the total seafood consumption. Nonetheless, it is difficult to assess whether Peruvian shark meat consumption is high due to a global lack of data on this matter (Dent & Clarke 2015).

The only other country with such information is possibly New Zealand, whose domestic consumption of elasmobranch meat is estimated to be between 4,500 and 5,500 tonnes $year^{-1}$, of which 80-85% consists of sharks (Dent & Clarke 2015). Their AC_T would thus range between 3,600 and 4,675 tonnes $year^{-1}$, whilst their AC_{pc} for 2015[15] would range between 0.78 and 1.02 kg $person^{-1}$. As, New Zealand's average seafood consumption[16] (2009-2013) is estimated to be 25.4 ± 0.6 kg $person^{-1}$ (FAO 2017); then sharks represent between 3.1% and 4.0% of the total seafood they eat.

Peru's 2015 AC_T was roughly three times larger than New Zealand's, whilst their AC_{pc} and the contribution of sharks to their total seafood consumption were roughly two times larger than that of Peru. Thus, although the Peruvian demand for shark meat results in a much higher shark catch, sharks and shark meat consumption are likely to be more present in the collective consciousness of New Zealanders.

3.4.3. A growing demand for shark fins

Trends in the apparent consumption of shark fins (AC_{sf}) mostly correspond to changes in demand rather than supply. The potential production of fresh and processed shark fins (PP_{ff} and PP_{sf}, respectively) directly depends on shark landings, and neither grew significantly during the studied period (Figures 12A; 15A). Additionally, a bi-directional growth in the Peruvian shark fin trade, caused somewhat stable net exports of shark fins (NE_{sf}) (Figure 3.4B). Nonetheless, AC_{sf} increased importantly since 2008 (Figure 3.4C).

[15] Assuming a population size of 4.5957 million in 2015 (World Bank 2017).
[16] FAO data on *per capita* apparent consumption of seafood is only available up to 2013 (FAO 2017).

As argued by González-Pestana *et al.* (2014), Peruvian shark fin imports increased significantly after a 2004 Ecuadorian regulation banning shark fin exports was overturned in 2008. However, that is only half of the equation. Foreign vessels landing frozen sharks trunks in Peru, which were caught on the open ocean, must also keep the corresponding shark fins. These landings are reported as imports originated from international waters, out of the jurisdiction of a specific country's economic exclusive zone.

The well-established network of Peruvian shark fin exporters (Dent & Clarke 2014) possibly saw the growing local demand for frozen shark meat as an opportunity. Given that fins entering Peru have much lower prices than those leaving the country[17], exporting the local production and re-exporting imported fins from Ecuador and the high seas became a booming business.

However, AC_{sf} strongly increased in Peru, particularly since 2009 (Figure 3.4C). This trend possibly results from the joint action of three variables. First, Peru harbors 0.99 million people of Chinese descent (OCAC *n.d.*), which represents 3% of the country's total population. As has been seen in many other countries, shark fins are considered luxury items by Chinese communities, associated to deep rooted cultural perceptions of class and health (Clarke *et al.* 2007; Eriksson & Clarke 2015). Second, the economic status of Peruvians has improved overtime, particularly in the coastal regions (De la Puente *et al.* 2013). Finally, the gastronomic boom has also positively affected the growth of Chinese-Peruvian restaurants ('Chifas'), currently being the third most visited type of restaurant by Peruvians, after rotisseries and seafood restaurants ('Pescaderías y cevicherías') (APEGA 2013).

Given the local context, the overall increase in abundance of available shark fins in Peru (before exports), and the fact that awareness campaigns, conservation efforts and international regulations have started to curb the demand for shark fins in Asian markets (Eriksson & Clarke 2015; Dulvy *et al.* 2017); it is not surprising that internal demand for these products grew during the studied period.

3.4.4. Why is shark finning not a common practice in Peru?

In November of 2016, the Peruvian Ministry of Production (PRODUCE) banned shark finning in Peru via the Decreto Supremo No. 021-2016-PRODUCE. Moreover, it clearly defined economic sanctions for fishers that landed fins not naturally attached to their corresponding shark bodies, as well as for traders and retailers that commercialized shark fins that could not be traced back to the fishers. Nonetheless, the total apparent consumption of shark fins (AC_{sf}) was negative only in 2007 (Figure 3.4C), highlighting that only in that year more fins had been exported than those that could be accounted for by adding the national production and imports.

[17] The total value of shark fin imports recorded between 2000 and 2015 was divided by the corresponding weight of imported shark fins to estimate their 'import price' for the studied period. The same type of calculation was used to derive the 'export price' of shark fins. Import and export prices estimated during the studied period were USD 11.2 kg^{-1} and USD 39.7 kg^{-1}, respectively.

Based on the export prices[18], a kilogram of shark fins was worth 62 times more than a kilogram of shark meat during the studied period. This price differential and the fact that shark fins take much less holding space than shark trunks, have been described as strong drivers for finning (Clarke *et al.* 2007; Camhi *et al.* 2008). Nonetheless, this does not seem to be the case for Peru.

Shark finning is a practice mostly associated with large industrial vessels that target billfish and tunas, operate in the high seas, and consider sharks as by-catch (Camhi *et al.* 2008). Moreover, these fisheries are highly subsidized, as they would not be profitable otherwise (Sumaila *et al.* 2015).

However, sharks in Peru are mainly caught by small-scale vessels equipped with longlines or gillnets (González-Pestana *et al.* 2014). These vessels have low fishing power (i.e. technology), their holds are generally poorly insulated, and lack comfortable quarters for their crews (Sueiro & De la Puente 2015). Moreover, they are not subsidized, and fishers tend to procure significant loans from middlemen, processors or wholesalers, to be able to cover their operational costs (Sueiro & De la Puente 2015). As part of these informal dealings, fishers are then forced to sell their catch to their corresponding lenders, despite other buyers might offer higher off-vessel prices, shrinking their profit margins (Sueiro & De la Puente 2015).

Additionally, fishing costs and competition among fishers are on the rise. This can be inferred as the number of vessels and their sizes, as well as the amount of gear used and the trip duration have all increased significantly since the 1997/98 El Niño (Sueiro & De la Puente 2015), and shark landings have not (see Section 3.3.3). Published data on the catch per unit of effort (CPUE) of Peruvian shark fisheries are very limited, unstandardized and fragmented (Elliot *et al.* 1995; 1996; 1997a; 1997b; Ayala & Sánchez-Scaglioni 2014; Doherty *et al.* 2014). However, some authors argue that CPUE trends indicate a reduction in shark abundance within the Peruvian EEZ (González-Pestana *et al.* 2014).

These suggest that if fishers sought to fill their holds with only shark fins, they would require extending the duration of their fishing trips, which would further increase their operational costs at the risks of fishing at a loss due to loan entrapment. Rising fishing costs coupled with decreases in CPUE limit the profitability of illegal fishing around the world (Sumaila *et al.* 2006). Alternatively, as roughly one fifth of the landed value of the sharks comes from its meat[19], fishers could perhaps cover their operational costs by selling the meat (i.e. even at prices lower than the market price), and then seek for the highest bidders for the fins – increasing their profit margins.

[18] The total value of shark meat exports recorded between 2000 and 2015 was divided by the total weight of shark meat exports to estimate the 'export price' of shark meat for the studied period (USD 0.64 kg^{-1}).

[19] Shark trunks and fins roughly account for 70% and 5% of the shark's weight, respectively (Table 3.1). The estimated exported prices for shark fins and meat during the studied period were USD 39.7 kg^{-1} and USD 0.64 kg^{-1}, respectively. If we assume an average shark of 20 kg, then multiplying the proportional contribution of each of the shark parts with their corresponding export values, would result in a total value of USD 46.3 $shark^{-1}$, where fins would be responsible for 80.6% of its total value.

Although this hypothesis requires further validation with field data, socio-economic and technological constraints apparently limit the incentives for shark finning by the Peruvian small-scale fleet, even before the finning ban was implemented. Moreover, the analysis of the total production and the apparent consumption of shark fins in Peru does not suggest that finning is a common practice locally. Nonetheless, based on export data alone, it is not possible to conclude if fins entering Peru from the high seas or Ecuador are the product of finning.

3.4.5. A call for improving local seafood traceability

Shark species are not necessarily exchangeable commodities (Dent & Clarke 2015). However, PRODUCE still reports their landings using three non-informative categories that group many species. This is particularly discouraging as the information used for all reconstructions presented in this chapter is public and available to them. Furthermore, the reporting quality of the landings could easily be improved by: *(i)* increasing the coverage of IMARPE's artisanal fisheries monitoring program; *(ii)* requesting Regional Governments to disaggregate their landings by species, *(iii)* requesting processing companies to disaggregate their inputs and outputs by species, and *(iv)* reporting the species traded in the wholesaler markets, which are monitored by PRODUCE staff, rather than using groups of species.

Additionally, it is key to highlight that shark landings (in tonnes) do not account for the full fishing mortality exerted on their populations by the small-scale fleet. Thus, based on published conversion factors and broad assumptions about whether a species is landed whole or not (Table 3.1), the catch was estimated to be 28% higher than the official landings. The precision of this estimate could be increased by using local data to:

- Validate the published proportional contributions of each part of the shark (e.g., head, skin, bones, guts, fins, and fillets) to their total weights. This exercise could be repeated to calculate the above-mentioned proportions for species lacking published estimates (e.g., Pacific angelshark).
- Calculate the probability of shark specimens, to be processed onboard as a function of their length. This is an issue particularly for hammerhead sharks, which are not always processed onboard if the specimens are too small (De la Puente 2013).

Moreover, another assumption in this study was that the weight of the shark fins was not considered in the landing statistics because they are not weighed with the shark trunks (Appendix 07). However, its weight is recorded by IMARPE personnel and by traders.

It is also worth noting that the reconstructed catch only includes the weight of discards. Discards, although globally large, are only part of the total unreported catch (Pauly & Zeller 2016; Zeller *et al.* 2017). According to Mendo & Wosnitza-Mendo (2014) the small-scale fisheries catch in Peru is

unreported by a factor of 28% to 40%, where discards amount only to 1% of the total unreported catches. Thus, present estimates should be considered as conservative.

Once the fishes enter the different lines of production (i.e. caning, curing and freezing plants) it is impossible, given the available data, to estimate input-output ratios by species. This is particularly relevant for the curing industry. Shark meat is salted and sundried in very informal conditions and government inspectors, if present, are more concerned with the sanitary conditions than the volumes of production (pers. obs.). Thus, it is not clear whether the reduction in the volume of sharks destined to curing facilities is real and perhaps a result of consumers preferring alternative preservations methods like freezing (Carlucci *et al.* 2015); or if their production is being underestimated as curing sites are harder to monitor by government personnel.

Statistics for the fresh seafood markets in Peru are vast, but also highly aggregated (Clemente 2010d; Sueiro & Lopez de la Lama 2014). Shark species are rarely reported using accurate common names, and mislabeling of pelagic sharks and other species as 'tollo' (Appendix 01) is extended, as can be seen by comparing values in Tables 2.3 and 3.3. As discussed in Section 2.4.1., this issue could be avoided by implementing a 'one name, one fish' policy (Lowell *et al.* 2015) and improving regulations to protect consumers against deceptive advertising. The latter should also be extended to include whether a species was locally caught, and if it is fresh (chilled) or previously frozen. This data would improve our understanding of the flow of fresh and frozen imports across seafood markets in Peru.

Furthermore, the reporting quality (RQ) of exports and imports show opposite trends. The decreasing RQ for shark imports registered during the studied period (Figure 3.6) can be attributed to the growing volume of fresh sharks and shark fins entering the country from Ecuador by truck. It seems that control and enforcement of trade regulations at the Peruvian-Ecuadorian border is much weaker than on the country's maritime terminals. Moreover, although RQ of shark exports improved, their trend is mostly attributed to the inclusion of common names on the specific commercial descriptions of frozen shark meat exports (see Table 3.2). Although the RQ of shark fin exports is improving, there is still much room for growth (Figure 3.6C).

Traceability could be improved by adding three key pieces of information on the specific commercial description of shark products: *(i)* the common and scientific names of the shark species being traded; *(ii)* the proportion of each shark species included in the shipment, as a function of its net weight; and *(iii)* the type of preservation method used for the products. The latter is most relevant for shark fins, as all traded fins were assumed to be dried, and it is likely that some of them were frozen or fresh. However, given the available data, it was not possible to clearly segregate products by their preservation method.

Finally, it is important to highlight that, despite some setbacks, the traceability of shark meat and fins is expected to improve in the recent future. On one hand, the inclusion of several shark species in

appendices I and II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2013 (Vincent *et al.* 2014), and the approval of the National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras (PAN-Tib) in 2014 (PRODUCE 2014) result in specific actions to improve traceability of shark products. Additionally, the internal structure and function of the Ministry of Production (PRODUCE) was changed in 2017 via the Decreto Supremo No. 002-2017-PRODUCE. PRODUCE's makeover and the current political climate are expected to advance sustainable fisheries reforms and strengthen the country's ability to manage their fisheries (Monteferri *et al.* 2017), and this initiative requires improving national accounting of fisheries landings and seafood trade.

3.5. Conclusions

Shark meat and shark fin consumption are increasing in Peru, although their contribution to national food security is low. As the local supply of these products remained stable during the studied period, the country's reliance on imports grew significantly.

The growing demand for shark products is thought to result from the joint action of: *(i)* a seafood-based gastronomic boom, *(ii)* increases in the purchasing power of Peruvians, *(iii)* seafood mislabeling, and *(iv)* asymmetric access to information between consumers and suppliers.

Although shark fins are more valuable than shark meat, socio-economic and technological constraints apparently limit the incentives for shark finning by the Peruvian small-scale fleet; even before the finning ban was implemented.

It is important to improve traceability of shark products from the sea to the final consumer as: *(i)* official landings statistics in Peru are heavily aggregated and severely underreport the total shark catch; *(ii)* data on production, local consumption and international trade lack product standardization and species segregation; and *(iii)* the reporting quality of imports is decreasing.

Finally, it is important to highlight that this study is the first of its kind in Peru. The data here presented helps characterize the national market of shark meat and fins, aligned with the information requirements prioritized by the PAN-Tib. This study also serves as a baseline to assess changes in production and consumption of shark products in the future; particularly after the implementation of communication campaigns and fisheries management policies seeking to improve the conservation status sharks and secure their sustainable use.

3.6. Figures

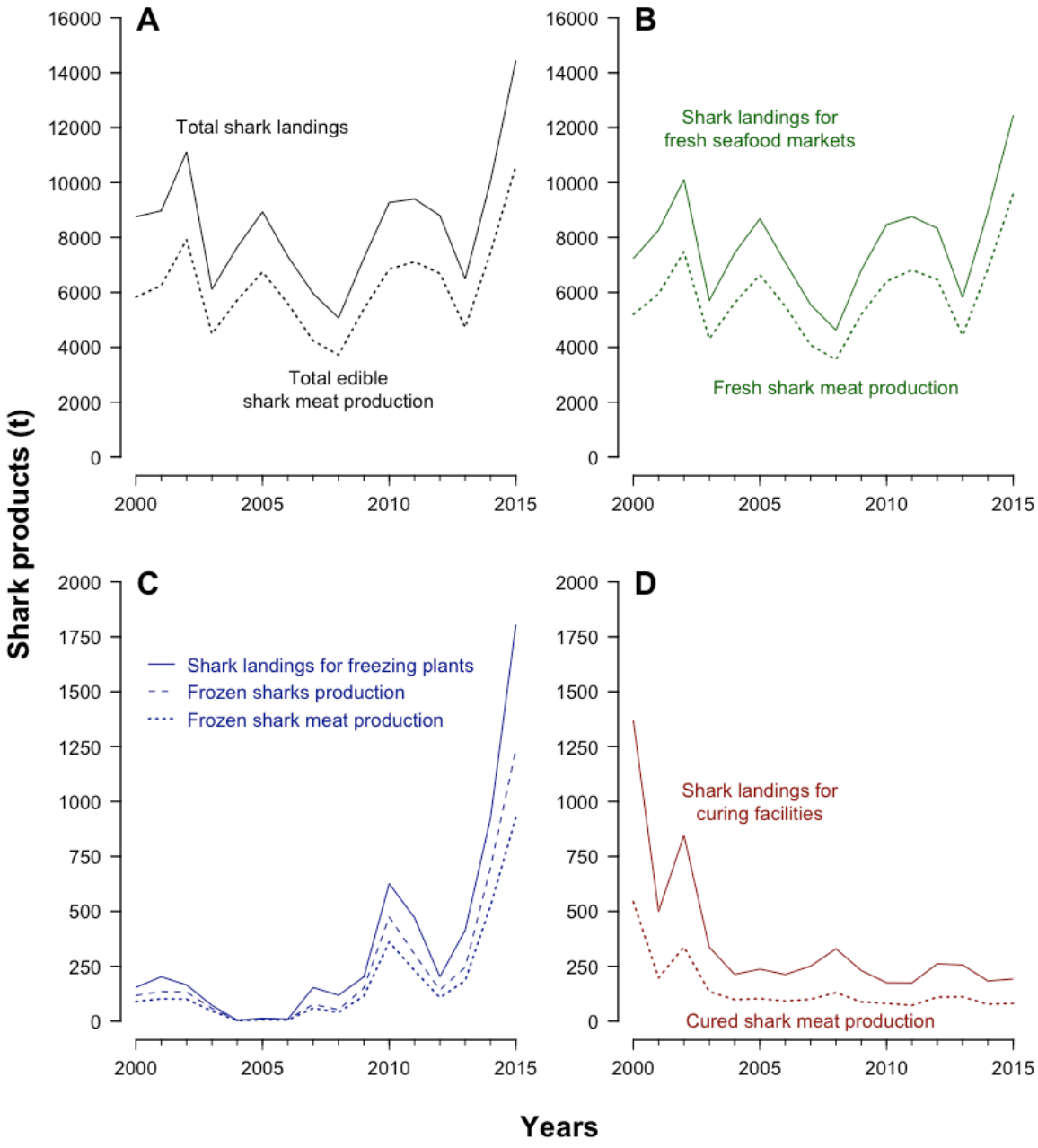

Figure 3.1: Inputs and outputs for fresh, frozen and cured shark meat production in Peru. *A*: Total shark landings and total edible shark meat production; *B*: Shark landings destined for fresh seafood markets and fresh shark meat production; *C*: Shark landings destined for freezing plants, the frozen shark productions and the frozen shark meat production; and *D*: Shark landings destined for curing facilities and cured shark meat production.

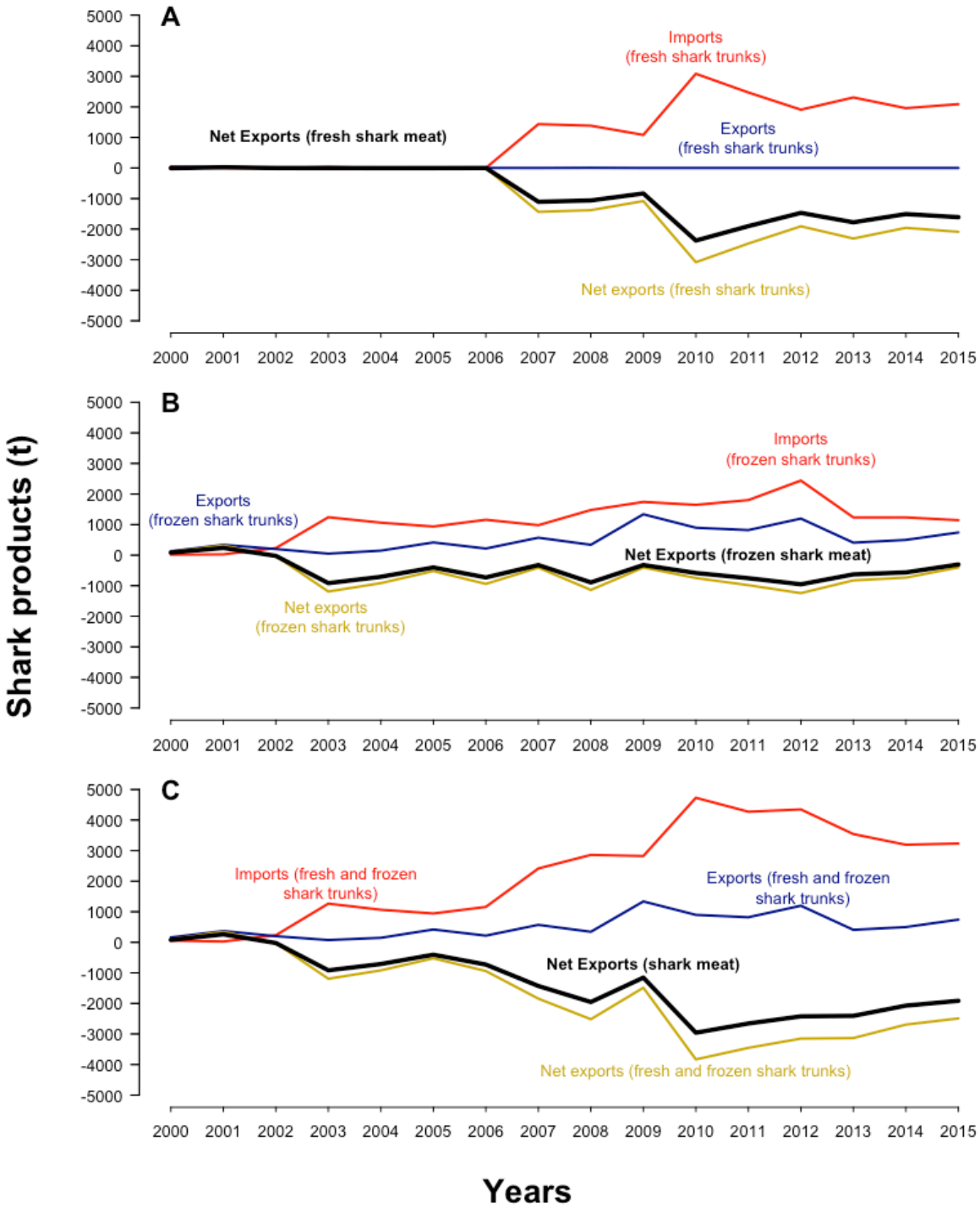

Figure 3.2: Peruvian exports, imports and net exports of different shark products. These include: *(A)* fresh shark trunks, *(B)* frozen shark trunks and *(C)* total shark trunks.

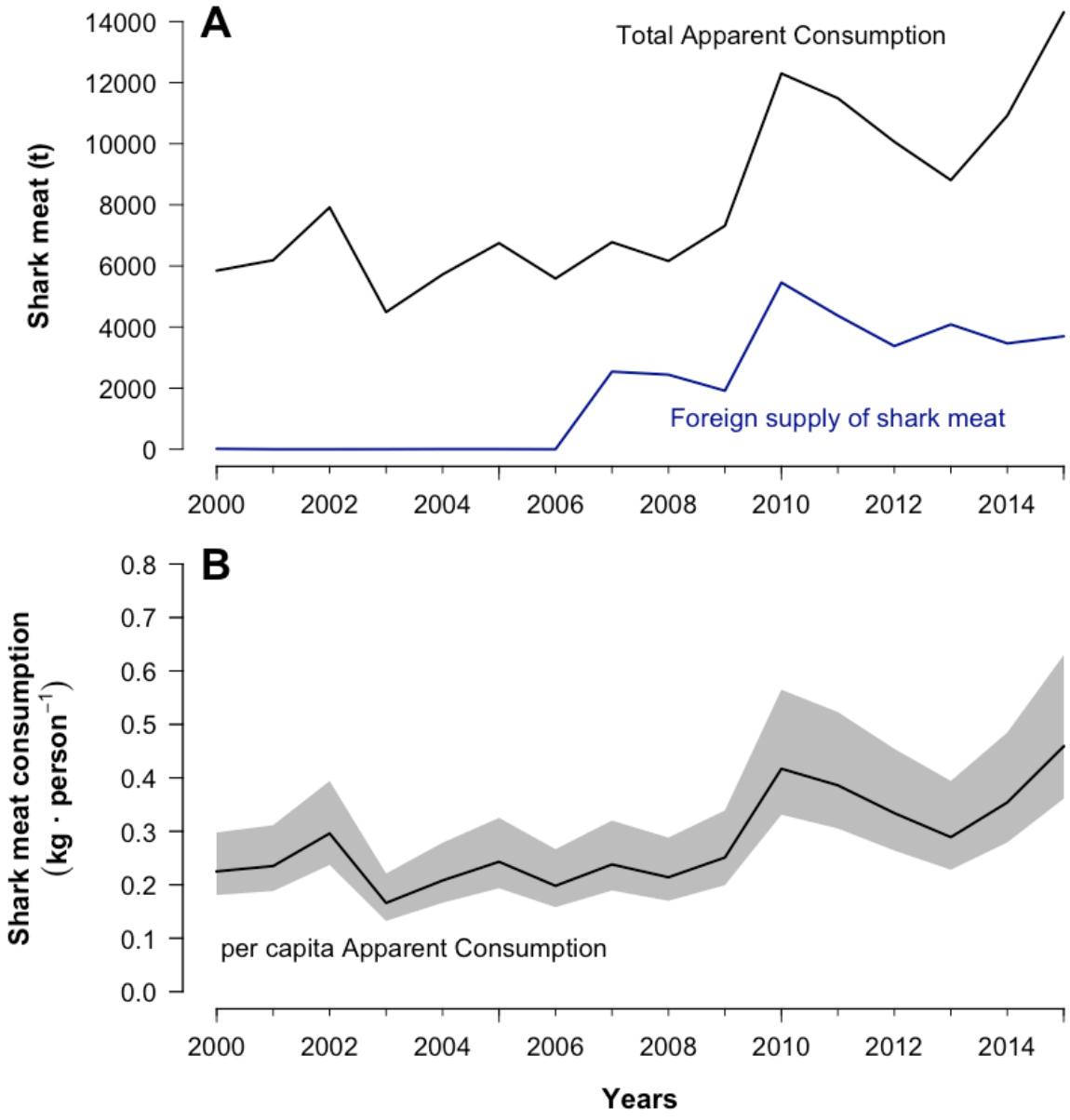

Figure 3.3: Total Apparent Consumption (AC_T) and *per capita* apparent consumption (AC_{pc}) of shark meat in Peru between the years 2000 and 2015. The dark blue line in Figure 3.3A represents the contribution of shark meat imports to AC_T. Similarly, the grey area in Figure 3.3B denotes a confidence interval for AC_{pc} values, assuming that all (bottom line) and none (top line) of the shark meat consumption takes place in the coastal regions of Peru.

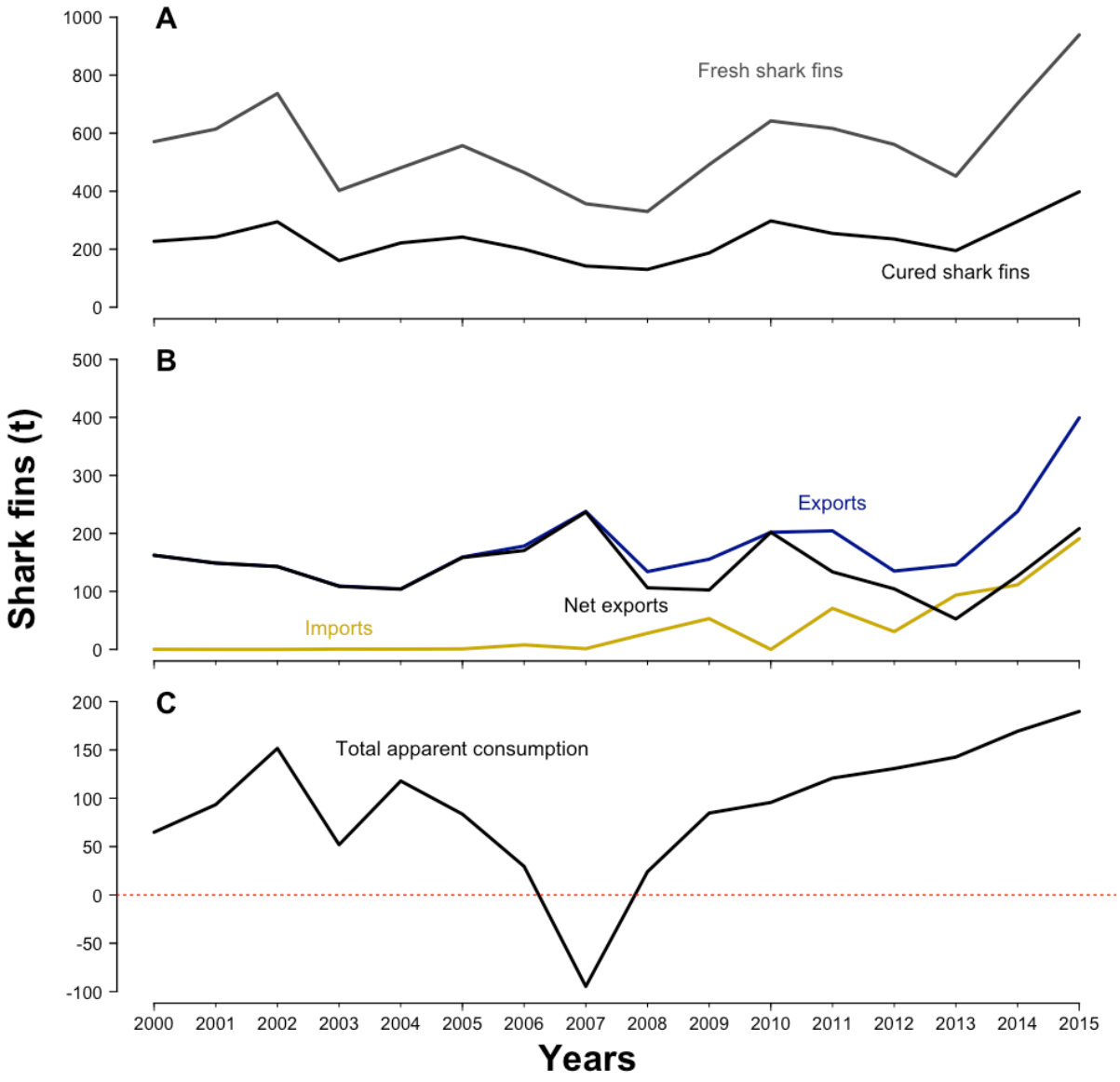

Figure 3.4: Peruvian shark fin production, trade and apparent consumption. (A) Potential production of fresh shark fins and cured shark fins. (B) Exports, imports and net exports of cured shark fins. (C) Total apparent consumption of cured shark fins.

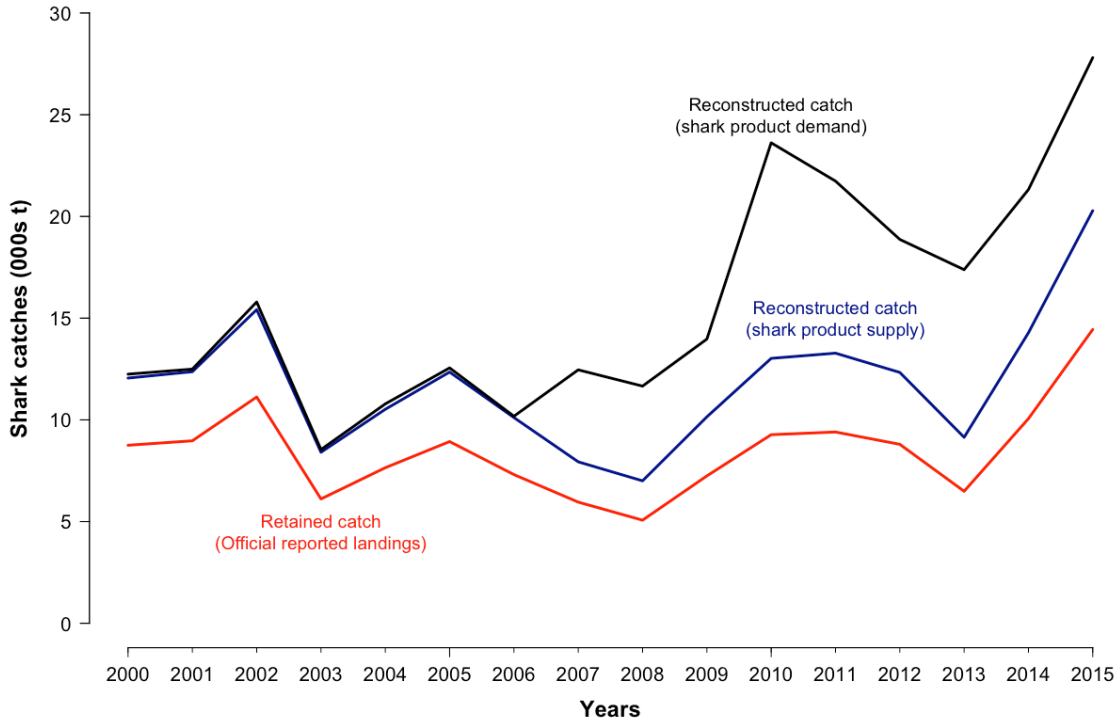

Figure 3.5: Differences between the official reported landings of sharks in Peru and the reconstructed catches required to sustain the Peruvian supply and demand of shark meat and fins. Demand is estimated from local and foreign catches.

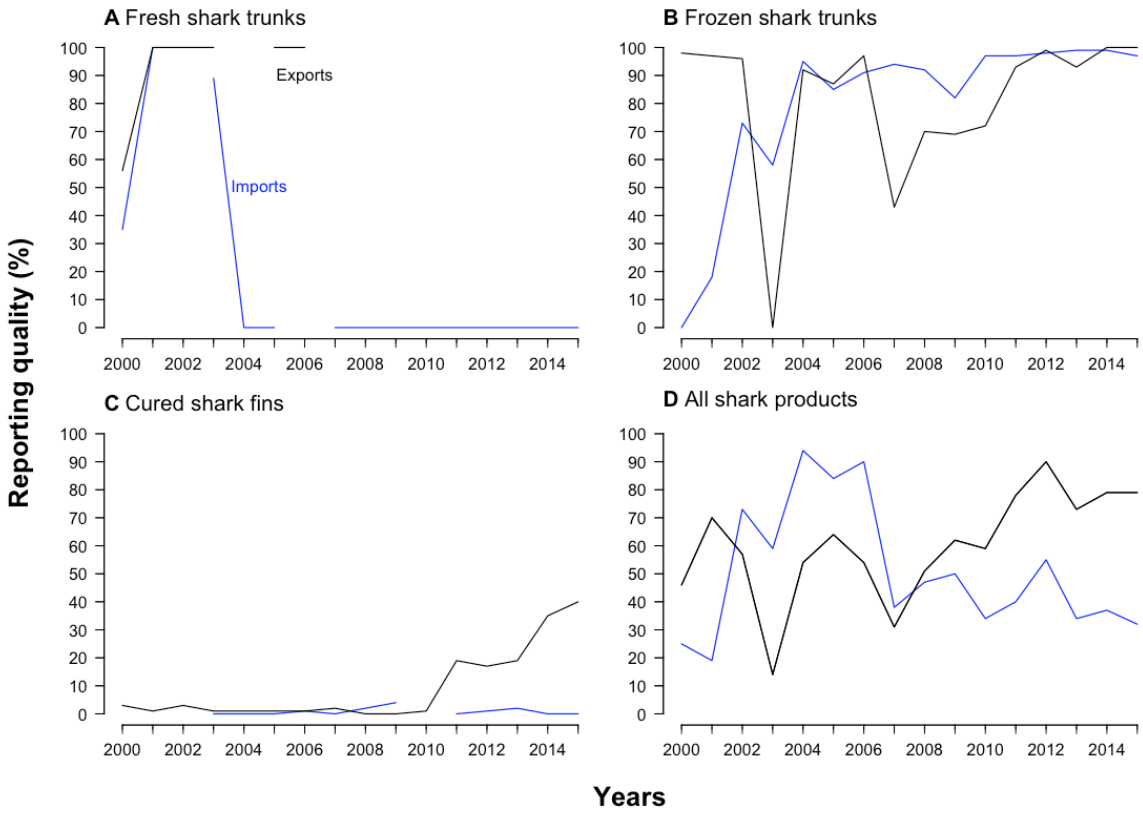

Figure 3.6: Reporting Quality of the internationally traded shark products. (A) Fresh shark trunks. (B) Frozen shark trunks. (C) Cured shark fins. (D) All products together. This measure of RQ was elaborated annually by computing the proportion of the total weight of exports, or imports, which could be identified down to species level.

3.7. Tables

Table 3.1: Proportional contribution to total landings, conversion factors and assumptions regarding shark taxa landed in Peru.

Category	Taxa	Proportion of the landings (2000-2015)	Whole weight to:			Landed whole (Yes/No)
			Dressed weight ratio[20]	Shark meat ratio[21]	Wet fin ratio[22]	
Blue shark	*Prionace glauca*	0.462743	0.674	0.496	0.057	No
Short-fin mako shark	*Isurus oxyrinchus*	0.210022	0.701	0.561	0.031	No
Smooth hammerhead shark	*Sphyrna zygaena*	0.152262	0.764	0.672	0.057	No
Thresher shark	*Alopias* sp.	0.077817	0.743	0.602	0.021	No
Humpback smooth-hound	*Mustelus whitneyi*	0.049996	0.608	0.459	0.031	Yes
Pacific angelshark	*Squatina californica*	0.031481	0.700	0.567	0.050	Yes
Other smooth-hounds, hound-sharks and catsharks	*Galeorhinus galeus*	0.004060	0.608	0.459	0.045	No
	Mustelus mento	0.002674			0.031	Yes
	Triakis maculata	0.002451			0.036	Yes
	Mustelus dorsalis	0.000245			0.031	Yes
	Schroederichthys chilensis	0.000060			0.050	Yes
	Apristurus nasutus	0.000028			0.050	Yes
Other requiem sharks	*Carcharhinus porosus*	0.002833	0.695	0.591	0.026	No
	Carcharhinus brachyurus	0.002501			0.051	No
	Carcharhinus limbatus	0.000383			0.022	No
	Carcharhinus sp.	0.000181			0.026	No
	Carcharhinus leucas	0.000067			0.026	No
	Galeocerdo cuvier	0.000006			0.014	No
Other sharks	*Echinorhinus cookei*	0.000099	0.700	0.567	0.050	No
	Rhincodon typus	0.000088			0.050	No
	Somniosus pacificus	0.000002			0.025	No
	Rhizoprionodon longurio	0.000001			0.019	No

[20] Whole-weight-to-dressed-weight ratios for blue sharks, shortfin mako sharks, thresher sharks and copper sharks were reconstructed based on Elliott et al. (1995; 1996; 1997a; 1997b). Copper sharks were used to inform ratios for the category 'Other requiem sharks'. For the 'humpback smooth-hound' and 'other smooth-hounds, hound-sharks and catsharks' category the whole-weight-to-dressed-weight ratio were taken from Vannuccini (1999) and Kreuzer & Ahmed (1978); whilst for the 'Pacific angelshark' and 'other sharks' categories the ratio was assumed to be 1:0.7.

[21] Whole-weight-to-shark-meat ratios were taken from Vannuccini (1999) and Kreuzer & Ahmed (1978), except for the 'other sharks' and the 'Pacific angelshark' categories, which were assumed to be 0.567.

[22] When no information was available for the whole-weight-to-wet-fin ratio, it was assumed to be 5%. For thresher sharks, this ratio was obtained from Mejuto *et al.* (2009). For all other cases, these ratios were taken from Biery & Pauly (2012).

Table 3.2: Data registered for each shipment coming in or leaving Peru by the Peruvian Customs Agency (SUNAT).

Category	Description	Example	Recorded for exports	Recorded for imports
General Commercial Description	Grouping category of traded products based on their commercial similarity	Shark fins	✓	✓
Customs code	Code assigned to each General Commercial Description	0305710000	✓	✓
Export date	Date at which a shipment left Peruvian territory	03-Mar-2013	✓	×
Import date	Date at which a shipment left Peruvian territory	03-Mar-2013	×	✓
Point of exit	Maritime, terrestrial or aerial terminal by which the shipment left the Peruvian territory	Port of Callao	✓	✓
Origin	Country or territory of origin of the shipment	Peru	✓	✓
Destination	Country or territory of destination of the shipment	Hong Kong	✓	✓
FOB value (US Dollars)	Free on Board (FOB) value of the shipment [does not include costs of shipping]	USD 116,123.00	✓	✓
Net weight (Kilograms)	Net weight of the products being traded within a shipment	4,290.00 kg	✓	✓
Exporter	Peruvian company in charge of the shipment	Exportaciones Rodimac S.A.C.	✓	×
Importer	Peruvian company in charge of the shipment	Pesquera Pontevedra S.A.C	×	✓
Specific Commercial Description	Additional details of the product being shipped	Dried shark fins in 50 kg polypropylene sacks	✓	✓

Table 3.3: Total Apparent Consumption (AC_T) and *per capita* Apparent Consumption (AC_{pc}) of shark meat in Peru. $AC_{coastal}$ represents the *per capita* Apparent Consumption of shark meat by coastal citizens, in the hypothetical scenario were all shark meat is consumed in the coastal regions of Peru.

Year	AC_T (Tonnes)	AC_{pc} (kg person^{-1})	$AC_{coastal}$ (kg person^{-1})
2000	5846.69	0.225	0.362
2001	6187.43	0.235	0.377
2002	7917.33	0.296	0.474
2003	4489.41	0.166	0.265
2004	5720.88	0.208	0.333
2005	6747.85	0.243	0.387
2006	5587.99	0.198	0.316
2007	6777.80	0.238	0.379
2008	6161.46	0.214	0.340
2009	7315.30	0.251	0.399
2010	12299.66	0.417	0.662
2011	11489.16	0.386	0.611
2012	10064.38	0.334	0.528
2013	8808.00	0.289	0.456
2014	10921.41	0.354	0.559
2015	14302.84	0.459	0.723

Table 3.4: Main factors influencing seafood consumer choices. Adapted from Carlucci *et al.* (2015).

Factors	Description
Sensory perception	Consumers' preference for a product's characteristics (e.g., taste, texture, smell and color).
Health benefits	Consumers seek fish products that are linked to health and nutritional benefits and tend to avoid those that have been associated with contaminants and/or harmful microbes.
Eating habits	Consumer choices are strongly affected by habits that emerge from, and are reinforced by, the accumulated outcomes (i.e. degree of satisfaction) of past experiences.
Convenience preparation	Consumers tend to prefer presentations that are 'easy' and not time consuming.
Self-efficacy in the fish preparation process	Consumers' knowledge, skills and self-confidence in selecting and preparing fish has significant and positive effects on fish consumption frequency.
Price perception	Consumers' attitudes towards prices act as barriers for consumption (i.e. the frequency of consumption is inversely related to the costs of the fish).
Fish availability	If a fish species is not available in a market, then it will not be consumed. However, if the available fishes are perceived to be good alternatives, then their consumption frequency will increase.
Country of origin	Consumers tend to prefer domestic fish products that are perceived as being superior to imported fish in terms of quality, safety and freshness.
Production method	Wild caught fishes are perceived as being superior to farmed fish, but this attribute is less relevant than others (e.g., taste, price, freshness).
Preserving method	Consumers tend to prefer chilled (fresh) fish, with a progressive decrease in acceptance for frozen, canned, and smoked/salted fish.
Product development	New consumers tend to prefer the most convenient presentations (e.g., fillets, medallions and steaks), whilst old and regular consumers tend to prefer whole (unprocessed) fish.
Packaging	Regular consumers tend to prefer unpackaged products, whilst new or occasional consumers prefer packaged products for their greater convenience, and for the possibility of evaluating additional information included on their labels (e.g., expiration date, country of origin, branding, and transparent pricing).
Eco-labelling	Labels of this sort are only important for a minor segment of fish consumers. The greater the price premium for the ecolabel, the less likely the product will be demanded.

CHAPTER 4: CONCLUSIONS

This dissertation examines the knowledge and attitudes of coastal Peruvians towards sharks, as well as the national market for edible shark products. These areas of research were prioritized based on the information requirements and strategic objectives of the National Plan of Action for the Conservation and Management of Sharks, Rays and Chimeras (PAN-Tib, PRODUCE 2014). The results here presented could be used to inform the design of communication campaigns aimed at improving the conservation status of sharks in Peru, and provide a baseline to assess the success of interventions, management actions and policies seeking to change behaviors in favor of a more sustainable use of sharks.

This study reveals an elevated general lack of knowledge about sharks that transcends educational and generational barriers throughout the Peruvian coast. Six in ten people living in the coastal regions of Peru asserted that sharks were present within the country's economic exclusive zone. Although over sixty shark species have been reported locally (Cornejo *et al.* 2015), only two in ten Peruvians could name one or more shark species, and only one in one hundred could name three.

Additionally, people manifested very negative attitudes towards sharks, showcasing fear and portraying them as dangerous man-eaters. However, no shark attacks have been reported in the country during the time with records (i.e. in over a century, Shark Attack Data 2017). Moreover, only one in ten coastal Peruvians indicated that sharks could be beneficial for humanity, albeit shark fisheries significantly contribute to the national employment and income (Christensen *et al.* 2014), and are a source of animal protein commonly consumed in the country.

Lack of knowledge and negative attitudes have acted as barriers for shark conservation around the world (Jacques 2010; Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Garla *et al.* 2015; Neff 2015). Knowledge and attitudes influence decision making (Mascia *et al.* 2003; Schultz 2011), and pro-environmental behaviors can be fostered by increasing knowledge (Zelezny 1999; Thompson & Mintzes 2002; St. John *et al.* 2010; Garla *et al.* 2015). However, Peruvians have little access to existing information regarding sharks as their issues. These topics are not covered by the academic curricula of public schools (Cárdenas-Alayza & Cárdenas-Alayza 2017), shark dives are not offered by nature-oriented tourism companies (Salgado *et al.* 2015), and local aquariums do not focus on education and they display foreign shark species (Publimetro 2016).

Based on these findings and those of similar studies in other areas of the world (Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Neff 2015), the communication and education campaigns framed within PAN-Tib (PRODUCE 2014) should seek to develop a deeper understanding of the local shark diversity, the ecological roles of their populations, the ecosystem services they provide and how they are linked with human wellbeing. Campaigns should also seek to demystifying the notion of sharks

as dangerous man-eaters (Simpfendorfer *et al.* 2011; Muter *et al.* 2012; Friedrich *et al.* 2014; Neff 2015).

Moreover, these initiatives should seek to develop empathy for these fishes and build a connection between Peruvians and sharks, and perhaps this could be achieved through seafood. Peruvians love seafood (Lopez de la Lama 2014; Majluf et al. 2017) and seven in ten coastal Peruvians claimed that they had eaten shark meat. Yet, as sharks are commercialized using deceptive names (e.g. 'tollo diamante', Appendix 01), only two in ten shark meat consumers were aware that they were effectively eating sharks. Notwithstanding, over 14 thousand tonnes of shark meat and 190 tonnes of cured shark fins were consumed by the Peruvian population in 2015. This means that up to 95 million dishes featuring shark meat and 4.5 million shark fin soups were served in the country throughout the year.

The consumption of shark products is increasing, yet the way these species are sold (e.g., using deceptive trade names) prevents Peruvians from acknowledging that they enjoy and desire shark meat, ultimately acting as a barrier for improving attitudes towards sharks. Furthermore, the dependence on shark meat imports (i.e. fresh and frozen shark trunks) has grown. Nonetheless, as no information is available for consumers at the point of sale, they lack the ability to identify the shark species they are about to purchase, discern if it was locally caught or imported, learn about when and how it was caught, and if it is a fresh specimen or if it was previously frozen. This asymmetric access to information between consumers and suppliers, prevents consumer acknowledgement of the impact that their consumption has on shark populations (e.g., local scarcity being masked by imports or seafood mislabeling) and makes them vulnerable to uninformed choices (e.g., purchasing sharks below their minimum landing sizes), which could contradict their beliefs and desires (e.g., only eating local or sustainably sourced seafood).

Thus, regulating the information available to consumers at the point of sale, as well as implementing a 'one name, one fish' policy (Lowell *et al.* 2015) could materialize the application of the Peruvian Consumer Defense Code (Law No. 29751) on seafood. This would benefit seafood consumers and the resources being targeted by Peruvian fisheries, including sharks. These actions are not included under the framework of the PAN-Tib (2014), but do fall within the objectives of the Multi-Annual Strategic Action Plan of the Ministry of Production that seek to: (i) increase the competitiveness of local economic agents by promoting, among other things, minimum standards of quality in production and retail, and (ii) increasing the Peruvian seafood value chain by promoting sustainable fisheries and strengthening the internal seafood market (PRODUCE 2017).

Finally, it is important to highlight that shark fisheries management needs to be addressed directly, by defining adequate input and output controls (Hilborn & Walters 1992). However, this process entails addressing trade-offs amongst policy outputs and contrasting management objectives of different stakeholder groups (Walters & Martell 2004). By understanding the role of sharks in Peruvian food

security and how changes in national capture production lead to variations in the local and international trade of shark products (and *vice versa*), it is possible to advance with the incorporation of these dimensions in the quantitative evaluation of policy outcomes (McAllister *et al.* 2008). However, their effective assessment will require improving the accuracy and precision of the current estimates of the apparent shark meat and shark fin consumption. For that purpose, activities aimed at enhancing seafood traceability along the value chain, such as improving the reporting quality scores and accounting of: landings, production, local commercialization and international trade of shark products, are fundamental endeavours. Luckily there is hope for improvement, as they are expected to result from the effective implementation of the PAN-Tib (PRODUCE 2014).

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APPENDICES:

Appendix 1: Photographs of sharks being sold as 'tollo' or 'toyo' in Peruvian seafood markets and supermarkets. All photographs by the author.

1: Shortfin mako shark (*Isurus oxyrinchus*) being offered as 'Toyo Diamante' in Minka Wholesalers Market (Callao, May 2016). **2:** Fillets of blue shark (*Prionace glauca*) being offered as 'tollo azul' in a branch Metro, a supermarket chain of Cencosud Group (Chiclayo, August 2016). **3:** Fillets of smooth hammerhead shark (*Sphyrna zygaena*) being offered as 'tollo cachito' in a branch of Wong, a supermarket chain of Cencosud Group (Lima, June 2014). **4:** Fillets of shortfin mako shark being offered as 'tollo diamante' in a branch of Vivanda, a supermarket chain of Supermercados Peruanos S.A. (Lima, September 2016).

Appendix 2: Importance of shark landings for the coastal Regions of Peru

Table A.1: Total fish landings and shark landings caught by the small-scale fishing fleets of Peru. Landings data collected by the Peruvian Institute of the Sea (IMARPE) on multiple monitored sites was aggregated by coastal Region.

Region	Monitored landing sites	Taxa	2013	2014	2015	Total[23]
Tumbes	Puerto Pizarro and Zorritos	All fishes (tonnes)	4161	5431	4492	14084
		Sharks (tonnes)	34	26	14	74
		Sharks (%)	0.81%	0.48%	0.31%	**0.52%**
Piura	Las Delicias, Paita, Parachique, Puerto Rico and Talara	All fishes (tonnes)	58371	42053	34929	135353
		Sharks (tonnes)	165	101	148	413
		Sharks (%)	0.28%	0.24%	0.42%	**0.31%**
Lambayeque	San José	All fishes (tonnes)	2136	4535	11838	18509
		Sharks (tonnes)	90	130	186	405
		Sharks (%)	4.20%	2.86%	1.57%	**2.19%**
La Libertad	Salaverry	All fishes (tonnes)	1992	2933	2751	7677
		Sharks (tonnes)	565	552	627	1745
		Sharks (%)	28.37%	18.82%	22.81%	**22.73%**
Ancash	Chimbote	All fishes (tonnes)	11109	9541	6974	28434
		Sharks (tonnes)	42	55	56	153
		Sharks (%)	0.38%	0.57%	0.81%	**0.54%**
Lima	Callao, Huacho and Pucusana	All fishes (tonnes)	18176	17171	16973	52320
		Sharks (tonnes)	372	247	338	957
		Sharks (%)	2.05%	1.44%	1.99%	**1.83%**
Ica	Laguna Grande and San Andrés	All fishes (tonnes)	12292	14736	11630	38658
		Sharks (tonnes)	0	2	1	3
		Sharks (%)	0.00%	0.01%	0.01%	**0.01%**
Arequipa	Atico, La Planchada and Matarani	All fishes (tonnes)	6407	8076	5894	20377
		Sharks (tonnes)	62	61	90	212
		Sharks (%)	0.96%	0.75%	1.53%	**1.04%**
Moquegua	Ilo	All fishes (tonnes)	6563	8898	6084	21545
		Sharks (tonnes)	1291	2006	2436	5733
		Sharks (%)	19.67%	22.54%	40.04%	**26.61%**
Tacna	Morro Sama	All fishes (tonnes)	1441	4398	1880	7719
		Sharks (tonnes)	31.897	30.865	70.496	133.258
		Sharks (%)	2.21%	0.70%	3.75%	**1.73%**

[23] Numbers in bold (green shaded cells) were ones used for correlations as indicated in Chapter 02.

Appendix 3: Shark-related vocabulary (SRV)

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'?*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Miedo / Temor	Fear	Negative	Negative feelings	728
Peligroso	Dangerous	Negative	Negative traits	547
Grande	Big	Neutral	Ecology and biological knowledge	480
Sangre	Blood	Negative	Negative outcomes	396
Muerte	Death	Negative	Negative outcomes	297
Diente / Dientes	Teeth	Neutral	Ecology and biological knowledge	194
Mar	Sea	Neutral	Ecology and biological knowledge	183
Depredador	Predator	Neutral	Ecology and biological knowledge	174
Asesino	Murderer	Negative	Negative traits	168
Peligro	Danger	Negative	Negative feelings	164
Terror	Terror	Negative	Negative feelings	159
Carnívoro	Carnivorous	Neutral	Ecology and biological knowledge	124
Salvaje / Feroz	Fierce	Negative	Negative traits	109
Película	Movie	Neutral	Miscellany	104
Aletas	Fins	Positive	Commercial benefits	95
Pez, Peces , o Pescado	Fish	Neutral	Ecology and biological knowledge	67
Malo	Mean	Negative	Negative traits	67
Alimento/ Comida	Food	Positive	Commercial benefits	65
Cartílago	Cartilage	Positive	Commercial benefits	61
Pánico	Panic	Negative	Negative feelings	59
Aceite	Oil	Positive	Commercial benefits	54
Fuerte	Strong	Positive	Positive traits	49
Agresivo / Agresividad	Aggressive	Negative	Negative traits	48
Devorador	Devourer	Negative	Negative traits	41
Rico / Sabroso	Tasty	Positive	Commercial benefits	35
Enorme	Huge	Neutral	Ecology and biological knowledge	34
Carne	Meat	Positive	Commercial benefits	33
Ataque	Attack	Negative	Negative outcomes	28
Extinción	Extinction	Neutral	Ecology and biological knowledge	27
Gigante	Giant	Neutral	Ecology and biological knowledge	26
Come gente	Man-eater	Negative	Negative traits	26
Cazador	Hunter	Neutral	Ecology and biological knowledge	25
Nutritivo	Nutritious	Positive	Commercial benefits	23
Agresion	Aggression	Negative	Negative outcomes	22
Feo	Ugly	Negative	Negative traits	22
Pesca	Catch	Positive	Commercial benefits	21

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Blanco	White	Neutral	Miscellany	21
Animal	Animal	Neutral	Ecology and biological knowledge	20
Mordedura / Mordida / Muerde	Bite	Negative	Negative outcomes	20
Escaso	Scarce	Neutral	Ecology and biological knowledge	19
Horror	Horror	Negative	Negative feelings	17
Susto	Scare	Negative	Negative feelings	17
Agua cálida	Warm water	Neutral	Ecology and biological knowledge	16
Amenaza	Threat	Negative	Negative feelings	16
Veloz	Fast	Positive	Positive traits	16
Medicina	Medicine	Positive	Commercial benefits	14
Azul	Blue	Neutral	Miscellany	14
Playa	Beach	Neutral	Miscellany	14
Advertencia / Alerta	Warning	Negative	Negative feelings	14
Precaución / Caultela	Caution	Negative	Negative feelings	14
Filete	Fillet	Positive	Commercial benefits	13
Cuidado / Preocupación	Concern	Negative	Negative feelings	13
Ceviche	Ceviche	Positive	Commercial benefits	11
Agua	Water	Neutral	Ecology and biological knowledge	11
Ballena	Whale	Neutral	Miscellany	11
Imponente	Grand	Positive	Positive traits	11
Saludable / Salud	Healthy	Positive	Commercial benefits	10
Especie marina	Marine	Neutral	Ecology and biological knowledge	10
Negro	Black	Neutral	Ecology and biological knowledge	10
Tollo	Smooth-hound	Neutral	Ecology and biological knowledge	10
Mamífero	Mammal	Neutral	Miscellany	10
Bonito	Pretty	Positive	Positive traits	10
Comercial	Commercial	Positive	Commercial benefits	9
No común	Not common	Neutral	Ecology and biological knowledge	9
Destrucción	Destruction	Negative	Negative outcomes	9
Mata / Matar	Kill	Negative	Negative outcomes	9
Asombro	Awe	Positive	Positive feelings	9
Sorprendente	Awesome	Positive	Positive feelings	9
Dañino	Harmful	Negative	Negative traits	8
No comestible	Non-edible	Negative	Negative traits	8
Respeto	Respect	Positive	Positive feelings	8
Comestible	Edible	Positive	Commercial benefits	7
Rojo	Red	Neutral	Miscellany	7
Voraz	Voracious	Negative	Negative traits	7

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Carroñero	Scavenger	Neutral	Ecology and biological knowledge	6
Océano	Ocean	Neutral	Ecology and biological knowledge	6
Escalofrío / Escalofriante	Shivers	Negative	Negative feelings	6
Mortal	Lethal	Negative	Negative feelings	6
Curiosidad	Curiosity	Positive	Positive feelings	6
Astuto	Astute	Positive	Positive traits	6
Rápido	Quick	Positive	Positive traits	6
Caro	Expensive	Positive	Commercial benefits	5
Colágeno	Collagen	Positive	Commercial benefits	5
Curativo	Healing	Positive	Commercial benefits	5
Industria	Industry	Positive	Commercial benefits	5
Pastillas	Pills	Positive	Commercial benefits	5
Altamar	High seas	Neutral	Ecology and biological knowledge	5
Nadador	Swimmer	Neutral	Ecology and biological knowledge	5
Arena	Sand	Neutral	Miscellany	5
Colmillo	Fang	Neutral	Miscellany	5
Profundidad	Deep	Neutral	Miscellany	5
Tamaño	Size	Neutral	Miscellany	5
Velocidad	Speed	Neutral	Miscellany	5
Desesperación	Despair	Negative	Negative feelings	5
Fobia	Phobia	Negative	Negative feelings	5
Emoción	Excitement	Positive	Positive feelings	5
Inteligente	Intelligent	Positive	Positive traits	5
Negocio	Business	Positive	Commercial benefits	4
Acuatico	Aquatic	Neutral	Ecology and biological knowledge	4
Inmenso	Immense	Neutral	Ecology and biological knowledge	4
Raro	Rare	Neutral	Ecology and biological knowledge	4
Atlantico	Atlantic	Neutral	Miscellany	4
Cachalote	Sperm whale	Neutral	Miscellany	4
Cetáceo	Cetacean	Neutral	Miscellany	4
China	China	Neutral	Miscellany	4
Come	Eats	Neutral	Miscellany	4
Desconocido	Unknown	Neutral	Miscellany	4
Gordo	Fat	Neutral	Miscellany	4
Angustia	Anguish	Negative	Negative feelings	4
Escapar / Huir	Escape	Negative	Negative feelings	4
Espanto	Fright	Negative	Negative feelings	4
Nervios	Nervousness	Negative	Negative feelings	4
Pavor	Dread	Negative	Negative feelings	4
Prevención	Prevention	Negative	Negative feelings	4
Suspenso	Suspense	Negative	Negative feelings	4

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Heridas	Wounds	Negative	Negative outcomes	4
Cruel	Cruel	Negative	Negative traits	4
Monstruo	Monster	Negative	Negative traits	4
Asombroso	Amazing	Positive	Positive feelings	4
Hermoso / Belleza	Beautiful	Positive	Positive traits	4
Afrodisiaco	Aphrodisiac	Positive	Commercial benefits	3
Barco	Boat	Positive	Commercial benefits	3
Delicioso	Delicious	Positive	Commercial benefits	3
Exportación / Exportar	Export	Positive	Commercial benefits	3
Frito	Fried	Positive	Commercial benefits	3
Harina	Meal	Positive	Commercial benefits	3
Pescador	Fishermen	Positive	Commercial benefits	3
Turismo	Tourism	Positive	Commercial benefits	3
Vitamina	Vitamin	Positive	Commercial benefits	3
Afilado / Filoso / Filudo	Sharp	Neutral	Ecology and biological knowledge	3
Agua fria	Cold water	Neutral	Ecology and biological knowledge	3
Boca grande	Big mouth	Neutral	Ecology and biological knowledge	3
Comunicar	Communicate	Neutral	Miscellany	3
Delfin	Dolphin	Neutral	Miscellany	3
Gris	Grey	Neutral	Miscellany	3
Lejanía	Remoteness	Neutral	Miscellany	3
Orilla	Shore	Neutral	Miscellany	3
Poco	Low	Neutral	Miscellany	3
Sal	Salt	Neutral	Miscellany	3
Correr	Run!	Negative	Negative feelings	3
Llanto	Crying	Negative	Negative feelings	3
Riesgo	Risk	Negative	Negative feelings	3
Accidente	Accident	Negative	Negative outcomes	3
Dolor	Pain	Negative	Negative outcomes	3
Grito	Scream	Negative	Negative outcomes	3
Desagradable / No agradable	Unpleasant	Negative	Negative traits	3
Horrible	Horrible	Negative	Negative traits	3
Ofensivo	Offensive	Negative	Negative traits	3
Rudo	Burly	Negative	Negative traits	3
Audaz	Bold	Positive	Positive traits	3
Interesante	Interesting	Positive	Positive traits	3
Arpón	Harpoon	Positive	Commercial benefits	2
Artesanía	Hand craft	Positive	Commercial benefits	2
Carnoso	Fleshy	Positive	Commercial benefits	2
Consumo	Consumption	Positive	Commercial benefits	2
Extranjero	Foreign market	Positive	Commercial benefits	2
Fierro	Iron	Positive	Commercial benefits	2
Jugoso	Juicy	Positive	Commercial benefits	2
Lanchas	Fishing vessel	Positive	Commercial benefits	2
Protéico / Proteína	Protein	Positive	Commercial benefits	2

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Red	Fishing net	Positive	Commercial benefits	2
Abundante	Abundant	Neutral	Ecology and biological knowledge	2
Grasa	Grease	Neutral	Ecology and biological knowledge	2
Grupos	Groups	Neutral	Ecology and biological knowledge	2
Hambriento	Hungry	Neutral	Ecology and biological knowledge	2
Largo	Long	Neutral	Ecology and biological knowledge	2
Mandíbula	Jaw	Neutral	Ecology and biological knowledge	2
Pequeño	Small	Neutral	Ecology and biological knowledge	2
Pesado	Heavy	Neutral	Ecology and biological knowledge	2
Suave	Soft	Neutral	Ecology and biological knowledge	2
Algas	Algae	Neutral	Miscellany	2
Anemia	Anemia	Neutral	Miscellany	2
Cine	Film	Neutral	Miscellany	2
Diamante	Diamond	Neutral	Miscellany	2
Exterminación	Extermination	Neutral	Miscellany	2
Inexistente	Non-existent	Neutral	Miscellany	2
Martillo	Hammer	Neutral	Miscellany	2
Olas	Waves	Neutral	Miscellany	2
Verano	Summer	Neutral	Miscellany	2
Vivo	Alive	Neutral	Miscellany	2
Alejarse	Distance yourself	Negative	Negative feelings	2
Auxilio	Help!	Negative	Negative feelings	2
Colera / Enojo	Anger	Negative	Negative feelings	2
Espantoso	Frightening	Negative	Negative feelings	2
Mutilación	Mutilation	Negative	Negative outcomes	2
Piernas	Legs	Negative	Negative outcomes	2
Cochino / Suciedad	Dirty	Negative	Negative traits	2
Destructor	Destroyer	Negative	Negative traits	2
Insalubre	Insalubrious	Negative	Negative traits	2
Malvado	Evil	Negative	Negative traits	2
Tirano	Tyrant	Negative	Negative traits	2
Conservación	Conserve	Positive	Positive feelings	2
Grandeza	Greatness	Positive	Positive feelings	2
Majestuoso	Majestic	Positive	Positive traits	2
Tierno / Tiernos	Cute	Positive	Positive traits	2
Unico	Unique	Positive	Positive traits	2
Barato	Cheap	Positive	Commercial benefits	1
Calcio	Calcium	Positive	Commercial benefits	1
Comercio	Commerce	Positive	Commercial benefits	1
Dinero	Money	Positive	Commercial benefits	1

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Económico	Economic	Positive	Commercial benefits	1
Enlatado	Canned	Positive	Commercial benefits	1
Inversión	Investment	Positive	Commercial benefits	1
Omega 3	Omega 3	Positive	Commercial benefits	1
Pesqueria	Fishery	Positive	Commercial benefits	1
Polvo	Powder	Positive	Commercial benefits	1
Precio	Price	Positive	Commercial benefits	1
Procesado	Processed	Positive	Commercial benefits	1
Rendidor	Productive	Positive	Commercial benefits	1
Restaurante	Restaurant	Positive	Commercial benefits	1
Trabajo	Work	Positive	Commercial benefits	1
Abundancia	Abundance	Neutral	Ecology and biological knowledge	1
Aspero	Rough	Neutral	Ecology and biological knowledge	1
Cadena alimenticia	Food web	Neutral	Ecology and biological knowledge	1
Cardumen	Schooling	Neutral	Ecology and biological knowledge	1
Ciego	Blind	Neutral	Ecology and biological knowledge	1
Contaminación	Pollution	Neutral	Ecology and biological knowledge	1
Escamas	Scales	Neutral	Ecology and biological knowledge	1
Escualo	Shark	Neutral	Ecology and biological knowledge	1
Fondo	Benthic	Neutral	Ecology and biological knowledge	1
Liso	Smooth	Neutral	Ecology and biological knowledge	1
Necesario	Necessary	Neutral	Ecology and biological knowledge	1
Ojasos	Big eyes	Neutral	Ecology and biological knowledge	1
Ojos	Eyes	Neutral	Ecology and biological knowledge	1
Piel dura	Hard skin	Neutral	Ecology and biological knowledge	1
Reciclador	Recycler	Neutral	Ecology and biological knowledge	1
Solitario	Lonely	Neutral	Ecology and biological knowledge	1
Solo	Solitary	Neutral	Ecology and biological knowledge	1
Toxinas	Toxins	Neutral	Ecology and biological knowledge	1
Variedad	Diversity	Neutral	Ecology and biological knowledge	1

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Vida larga	Long-lived	Neutral	Ecology and biological knowledge	1
Acción	Action	Neutral	Miscellany	1
Agua dulce	Freshwater	Neutral	Miscellany	1
Agudo	Acute	Neutral	Miscellany	1
Artritis	Arthritis	Neutral	Miscellany	1
Asia	Asia	Neutral	Miscellany	1
Aumenta	Increase	Neutral	Miscellany	1
Australia	Australia	Neutral	Miscellany	1
Bacalao	Cod	Neutral	Miscellany	1
Calentamiento global	Global warming	Neutral	Miscellany	1
Cálido	Warm	Neutral	Miscellany	1
Calor	Heat	Neutral	Miscellany	1
Cantidad	Quantity	Neutral	Miscellany	1
Caribe	Caribbean	Neutral	Miscellany	1
Celeste	Light blue	Neutral	Miscellany	1
Clima	Weather	Neutral	Miscellany	1
Contrabando	Smuggling	Neutral	Miscellany	1
Coral	Coral	Neutral	Miscellany	1
Cornudo	Horns	Neutral	Miscellany	1
Cuchillo	Knife	Neutral	Miscellany	1
Desmenuzado	Crumbled	Neutral	Miscellany	1
Dorado	Golden	Neutral	Miscellany	1
Duro	Hard	Neutral	Miscellany	1
EEUU	USA	Neutral	Miscellany	1
Espada	Sword	Neutral	Miscellany	1
Espinas	Spines	Neutral	Miscellany	1
Esquelético	Skeletal	Neutral	Miscellany	1
Extension	Broad	Neutral	Miscellany	1
Fósiles	Fossils	Neutral	Miscellany	1
Gato	Cat	Neutral	Miscellany	1
Gente	People	Neutral	Miscellany	1
Habilidad	Skills	Neutral	Miscellany	1
Historietas	Stories	Neutral	Miscellany	1
Hombre	Man	Neutral	Miscellany	1
Huesudo	Bony	Neutral	Miscellany	1
Invasion	Invasion	Neutral	Miscellany	1
Japón	Japan	Neutral	Miscellany	1
Limitado consumo	Limited consumption	Neutral	Miscellany	1
Lobos marinos	Sea lions	Neutral	Miscellany	1
Mal uso	Misuse	Neutral	Miscellany	1
Natural	Natural	Neutral	Miscellany	1
Naturaleza	Nature	Neutral	Miscellany	1
Noche	Night	Neutral	Miscellany	1
Normal	Normal	Neutral	Miscellany	1
Nuevo	New	Neutral	Miscellany	1
Nunca visto	Never seen	Neutral	Miscellany	1
Obesidad	Obesity	Neutral	Miscellany	1
Rebelde	Rebel	Neutral	Miscellany	1

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
Sin espinas	Boneless	Neutral	Miscellany	1
Submarino	Submarine	Neutral	Miscellany	1
Tablista	Surfer	Neutral	Miscellany	1
Tragar	Swallow	Neutral	Miscellany	1
Vida	Life	Neutral	Miscellany	1
Videos	Videos	Neutral	Miscellany	1
Volumen	Volume	Neutral	Miscellany	1
Alarmante	Alarming	Negative	Negative feelings	1
Ansiedad	Anxiety	Negative	Negative feelings	1
Arriesgado	Risky	Negative	Negative feelings	1
Asco	Disgust	Negative	Negative feelings	1
Asqueroso	Disgusting	Negative	Negative feelings	1
Asustado	Scared	Negative	Negative feelings	1
Asustar	Frighten	Negative	Negative feelings	1
Atento	Alertness	Negative	Negative feelings	1
Aterrador	Scary	Negative	Negative feelings	1
Decepción	Disappointment	Negative	Negative feelings	1
Defensa	Defense	Negative	Negative feelings	1
Desgracia	Misfortune	Negative	Negative feelings	1
Furia	Fury	Negative	Negative feelings	1
Injusto	Unfair	Negative	Negative feelings	1
Inseguridad	Insecurity	Negative	Negative feelings	1
Lágrimas	Tears	Negative	Negative feelings	1
Pena	Sadness	Negative	Negative feelings	1
Pesadillas	Nightmares	Negative	Negative feelings	1
Piedad	Mercy please!	Negative	Negative feelings	1
Trágico	Tragic	Negative	Negative feelings	1
Vértigo	Vertigo	Negative	Negative feelings	1
Amputacion	Amputation	Negative	Negative outcomes	1
Desgarro	Tear	Negative	Negative outcomes	1
Enfermedades	Diseases	Negative	Negative outcomes	1
Movilizarse	Displaced	Negative	Negative outcomes	1
Rompe mallas	Mesh-breaker	Negative	Negative outcomes	1
Triturar	Crush	Negative	Negative outcomes	1
Voltea botes	Turn boats	Negative	Negative outcomes	1
Amargo	Bitter	Negative	Negative traits	1
Canival	Cannibal	Negative	Negative traits	1
Desabrido	Tasteless	Negative	Negative traits	1
Desalmado	Fiend	Negative	Negative traits	1
Desastrozo	Disastrous	Negative	Negative traits	1
Desmesurado	Excessive	Negative	Negative traits	1
Despiadado	Ruthless	Negative	Negative traits	1
Dificil de pescar	Hard to fish	Negative	Negative traits	1
Enemigo	Enemy	Negative	Negative traits	1
Extrangulador	Strangler	Negative	Negative traits	1
Impuro	Impure	Negative	Negative traits	1
Macabro	Macabre	Negative	Negative traits	1
Molesto	Angry	Negative	Negative traits	1

Table A.2: List of words mentioned by the surveyed population when asked: *What words come to mind when you hear the word 'sharks'? (Continued)*

Words in Spanish	Words in English	Category	Sub-category	Frequency
No saludable	Unhealthy	Negative	Negative traits	1
Perverso	Perverse	Negative	Negative traits	1
Poco amigable	Not friendly	Negative	Negative traits	1
Problemático	Problematic	Negative	Negative traits	1
Rabioso	Mad	Negative	Negative traits	1
Sigiloso	Sneaky	Negative	Negative traits	1
Violento	Violent	Negative	Negative traits	1
Admiración	Admiration	Positive	Positive feelings	1
Atracción	Attraction	Positive	Positive feelings	1
Autoridad	Authority	Positive	Positive feelings	1
Divertido	Fun	Positive	Positive feelings	1
Euforia	Euphoria	Positive	Positive feelings	1
Impresivo	Impressive	Positive	Positive feelings	1
Libertad	Freedom	Positive	Positive feelings	1
Paz	Peace	Positive	Positive feelings	1
Poder	Power	Positive	Positive feelings	1
Agil	Agile	Positive	Positive traits	1
Bueno	Good	Positive	Positive traits	1
Chevere	Cool	Positive	Positive traits	1
Dulce	Sweet	Positive	Positive traits	1
Especial	Special	Positive	Positive traits	1
Espectacular	Spectacular	Positive	Positive traits	1
Extraordinario	Extraordinary	Positive	Positive traits	1
Fenomenal	Phenomenal	Positive	Positive traits	1
Guardián	Guardian	Positive	Positive traits	1
Impresionante	Spectacular	Positive	Positive traits	1
Limpieza	Clean	Positive	Positive traits	1
Lindo	Nice	Positive	Positive traits	1
Listo	Smart	Positive	Positive traits	1

Appendix 4: Relative importance of smooth-hounds for Peruvian shark fisheries

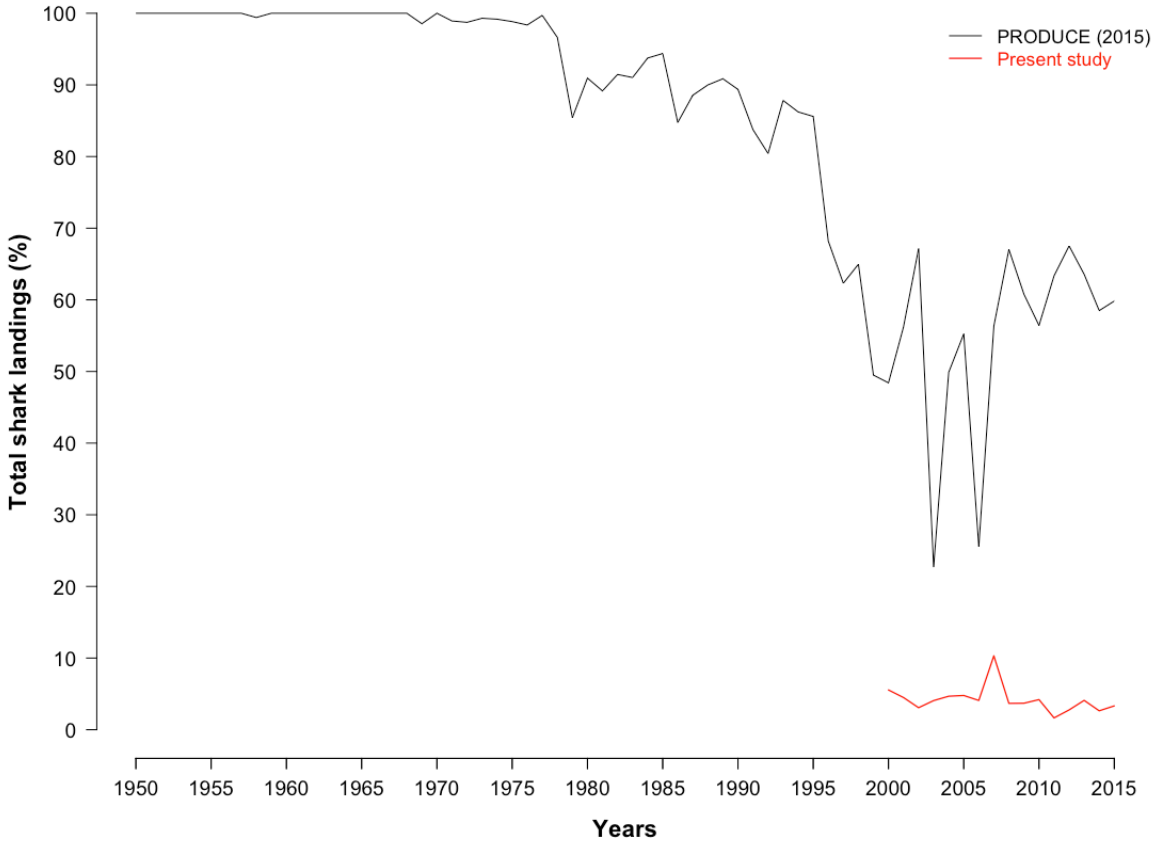

Figure A.1: Landings of 'tollo' as a proportion of the total Peruvian shark catch.

Note: PRODUCE reports shark landings using three categories: Tiburon' (i.e. sharks), 'Tollo' (i.e. smooth-hounds and hound sharks) and 'Angelote' (i.e. angelshark). However, the data included in each of those categories is sorted using common names. The present study segregated PRODUCE's landings statistics by species using data collected by IMARPE that is sorted by scientific name. For more details on the methodology review Section 3.2. The species used to calculate the proportion displayed in Figure A1 as 'Present study' includes only the species that IMARPE (2015) classified as 'tollo". These are: *Mustelus dorsalis*, *Mustelus mento*, *Mustelus whitneyi*, *Triakis maculata,* and *Schroederichthys chilensis* (IMARPE 2015).

Appendix 5: Prices of shark meat and other important seafood items for the gastronomic industry in Peru.

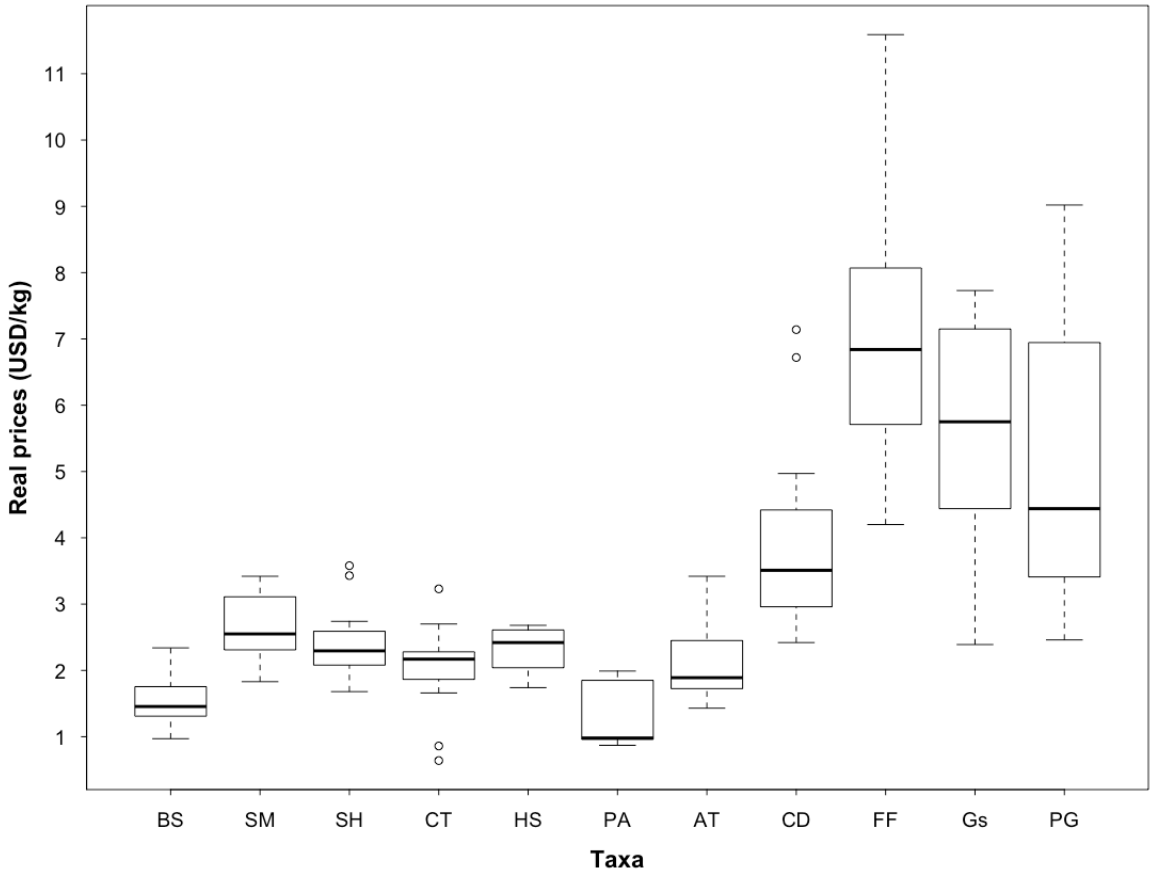

Figure A.2: Real prices for different fish species registered in Peruvian wholesaler markets between 2000 and 2015.

Note: Acronyms included in Figure A2 and Table A3 stand for: BS – Blue shark (*Prionace glauca*), SM – Shortfin mako (*Isurus oxyrinchus*), SH - Smooth hammerhead (Sphyrna zygaena), CT – Common thresher (*Alopias vulpinus*), HS – Humpback smooth-hound (*Mustelus whitneyi*), PA – Pacific angelshark (*Squatina californica*), AT – Albacore tuna (*Thunnus alalunga*), CD – Corvina drum (*Cilus gilberti*), FF – Fine flounder (*Paralichthys adspersus*), Gs – Groupers (*Epinephelus* sp.), and PG – Peruvian Grunt (*Anisotremus scapularis*). Wholesaler price data used in Appendix 05 is available on the official webpage of the Peruvian Ministry of Production (PRODUCE): <www.produce.gob.pe>. Prices were corrected to account for inflation (i.e. real prices) using the Peruvian Consumer Price Index (CPI) for food items, and then converted to US Dollars (USD) using official exchange rates. CPI and exchange rate time series are available in the official website of the Banco Central de Reserva del Peru: <www.bcrp.gob.pe>.

Table A.3: Results of the Wilcoxon-Mann-Whitney tests comparing real prices of different fish species registered in Peruvian wholesaler markets between the years 2000 and 2015.

	BS	SM	SH	CT	HS	PA	AT	CD	FF	Gs
BS										
SM	***									
SH	***	n.s.f.								
CT	*	*	n.s.f.							
HS	**	n.s.f.	n.s.f.	n.s.f.						
PA	n.s.f.	**	**	n.s.f.	*					
AT	**	*	n.s.f.	n.s.f.	n.s.f.	n.s.f.				
CD	***	**	***	***	**	**	***			
FF	***	***	***	***	***	***	***	***		
Gs	***	***	***	***	***	***	***	*	n.s.f.	
PG	***	***	***	***	**	***	***	n.s.f.	n.s.f.	n.s.f.

Note: n.s.f. stands for 'No significant difference. The symbols used (*, **, and ***) represent significant differences of increasing magnitude: * $p > 0.05$; ** $p > 0.005$, and *** $p > 0.0005$.

Appendix 6: Shark landings registered by IMARPE

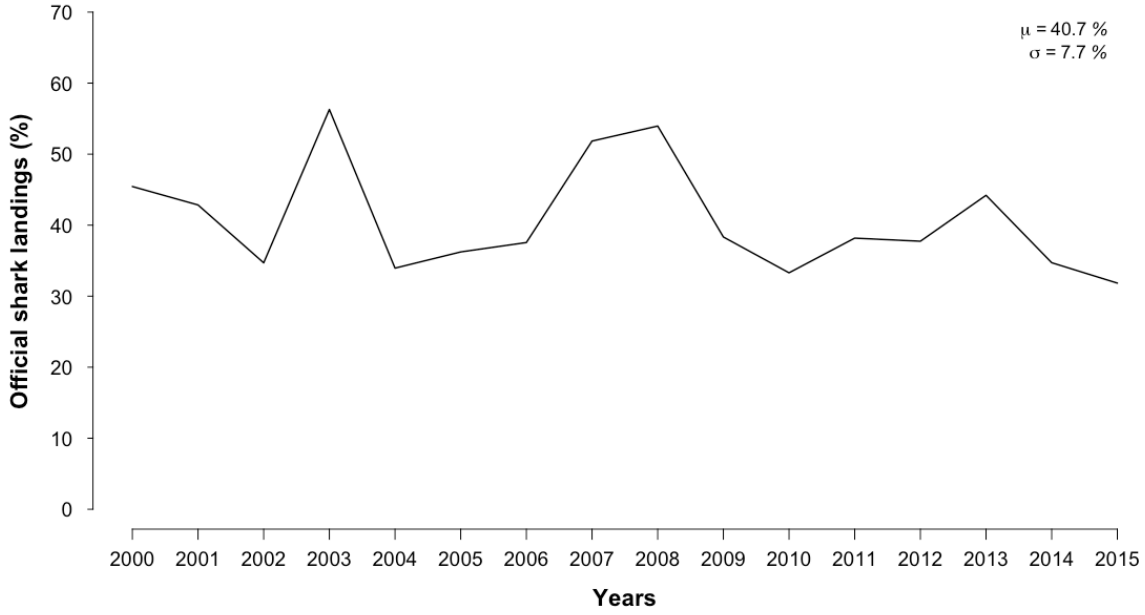

Figure A.3: Proportion of the official shark landings reported by PRODUCE, which also were registered by IMARPE's artisanal fisheries monitoring program between the years 2000 and 2015

Table A.4: Proportional contribution of each shark taxa to the total annual shark landings recorded by IMARPE.

Shark species	2000	2001	2002	2003	2004	2005	2006	2007
Alopias vulpinus	0.0626	0.0235	0.0259	0.0419	0.0800	0.1245	0.0714	0.1027
Apristurus nasutus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
Carcharhinus brachyurus	0.0013	0.0061	0.0095	0.0089	0.0037	0.0043	0.0010	0.0020
Carcharhinus leucas	0.0000	0.0000	0.0006	0.0002	0.0001	0.0000	0.0000	0.0000
Carcharhinus limbatus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000
Carcharhinus porosus	0.0020	0.0018	0.0044	0.0046	0.0060	0.0043	0.0024	0.0028
Carcharhinus sp.	0.0004	0.0002	0.0004	0.0003	0.0003	0.0003	0.0002	0.0002
Echinorhinus cookei	0.0000	0.0000	0.0000	0.0004	0.0001	0.0000	0.0000	0.0000
Galeocerdo cuvier	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
Galeorhinus galeus	0.0050	0.0042	0.0038	0.0032	0.0051	0.0045	0.0037	0.0064
Isurus oxyrinchus	0.2023	0.1762	0.2535	0.2231	0.2512	0.2203	0.2723	0.1868
Mustelus dorsalis	0.0006	0.0008	0.0010	0.0003	0.0001	0.0001	0.0001	0.0003
Mustelus mento	0.0111	0.0132	0.0006	0.0006	0.0009	0.0007	0.0004	0.0007
Mustelus whitneyi	0.0633	0.0457	0.0380	0.0540	0.0615	0.0644	0.0551	0.1344
Prionace glauca	0.5180	0.5503	0.4698	0.4057	0.3772	0.3861	0.3474	0.3128
Rhincodon typus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
Rhizoprionodon longurio	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Schroederichthys chilensis	0.0001	0.0001	0.0001	0.0002	0.0003	0.0001	0.0000	0.0001
Somniosus pacificus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sphyrna zygaena	0.0506	0.0782	0.1098	0.2012	0.1697	0.1725	0.2321	0.1997
Squatina californica	0.0814	0.0976	0.0797	0.0546	0.0424	0.0169	0.0125	0.0490
Triakis maculata	0.0014	0.0020	0.0029	0.0008	0.0016	0.0008	0.0009	0.0019

Table A.4: Proportional contribution of each shark taxa to the total annual shark landings recorded by IMARPE (*Continued*).

Shark species	2008	2009	2010	2011	2012	2013	2014	2015
Alopias vulpinus	0.0827	0.0453	0.0225	0.0916	0.1410	0.0515	0.0825	0.1501
Apristurus nasutus	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
Carcharhinus brachyurus	0.0005	0.0020	0.0006	0.0003	0.0002	0.0000	0.0000	0.0000
Carcharhinus leucas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Carcharhinus limbatus	0.0000	0.0003	0.0005	0.0033	0.0012	0.0000	0.0000	0.0000
Carcharhinus porosus	0.0028	0.0038	0.0011	0.0023	0.0020	0.0020	0.0032	0.0012
Carcharhinus sp.	0.0003	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
Echinorhinus cookei	0.0001	0.0001	0.0000	0.0008	0.0002	0.0000	0.0000	0.0000
Galeocerdo cuvier	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Galeorhinus galeus	0.0028	0.0043	0.0017	0.0043	0.0040	0.0058	0.0052	0.0025
Isurus oxyrinchus	0.2151	0.2162	0.2091	0.2526	0.2151	0.1702	0.1534	0.1689
Mustelus dorsalis	0.0004	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mustelus mento	0.0008	0.0019	0.0007	0.0006	0.0023	0.0017	0.0021	0.0024
Mustelus whitneyi	0.0446	0.0451	0.0547	0.0198	0.0326	0.0536	0.0328	0.0417
Prionace glauca	0.3919	0.4851	0.5337	0.4509	0.4251	0.5496	0.5795	0.4849
Rhincodon typus	0.0000	0.0000	0.0007	0.0003	0.0001	0.0000	0.0000	0.0000
Rhizoprionodon longurio	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Schroederichthys chilensis	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Somniosus pacificus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sphyrna zygaena	0.2231	0.1744	0.1542	0.1623	0.1701	0.1600	0.1365	0.1431
Squatina californica	0.0299	0.0164	0.0167	0.0079	0.0023	0.0034	0.0021	0.0027
Triakis maculata	0.0050	0.0045	0.0035	0.0027	0.0037	0.0024	0.0026	0.0026

Appendix 7: Photograph of shark trunks being weighed without their fins at Pucusana, Lima Region's main shark landing site (Nov. 2012). Photograph by the author.

Appendix 8: Reconstructed shark catch per species

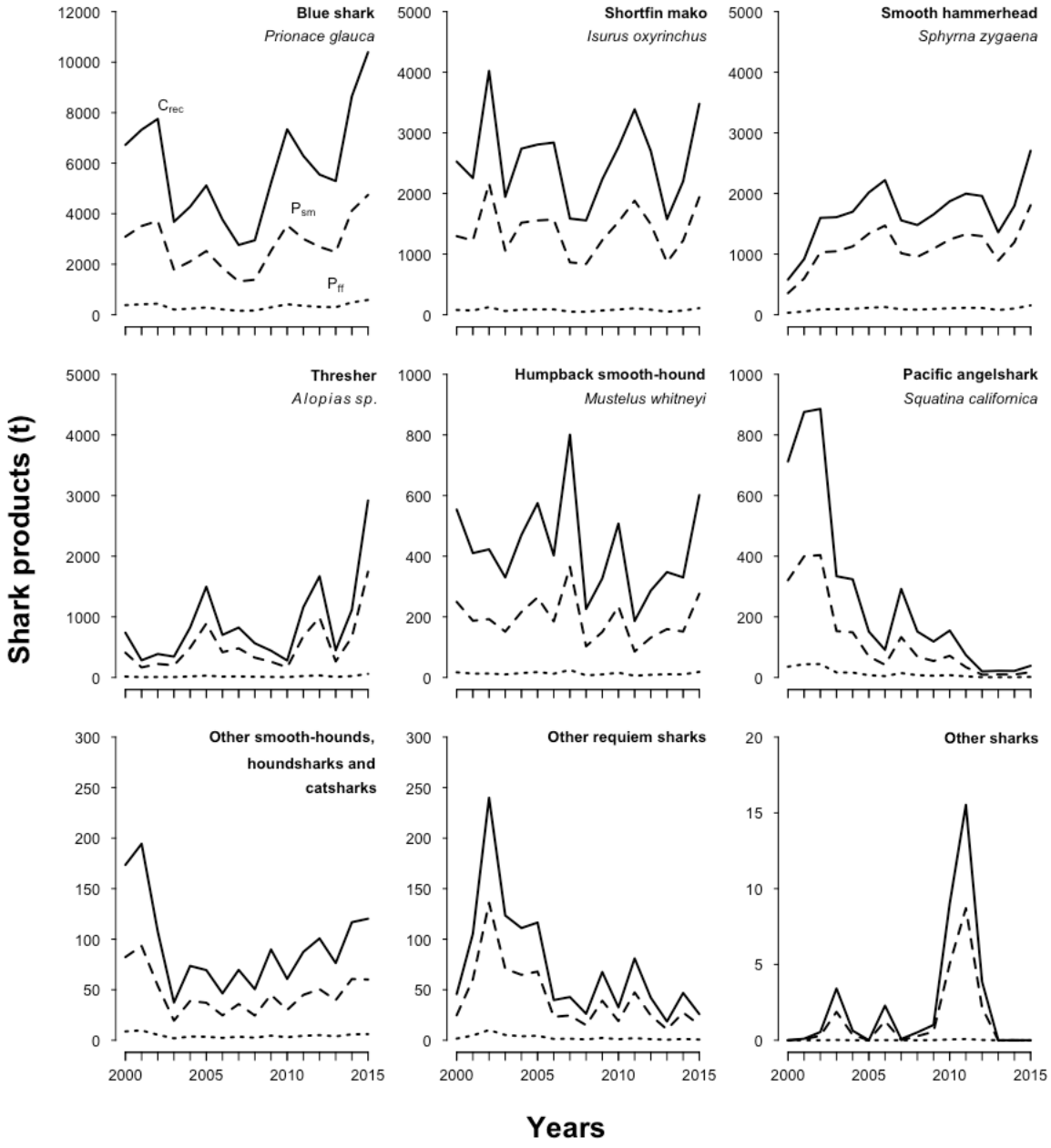

Figure A.4: Reconstructed catch (i.e. whole sharks, C_{rec}), estimated shark meat production (P_{sm}) and potential production of fresh shark fins (PP_{ff}) segregated by taxa targeted by the Peruvian small-scale fisheries. The species included in "Other smooth-hounds, hound-sharks and catsharks", "Other requiem sharks" and "Other sharks" are listed in Table 3.1.

Appendix 9: Peruvian fish landings and imports for direct human consumption

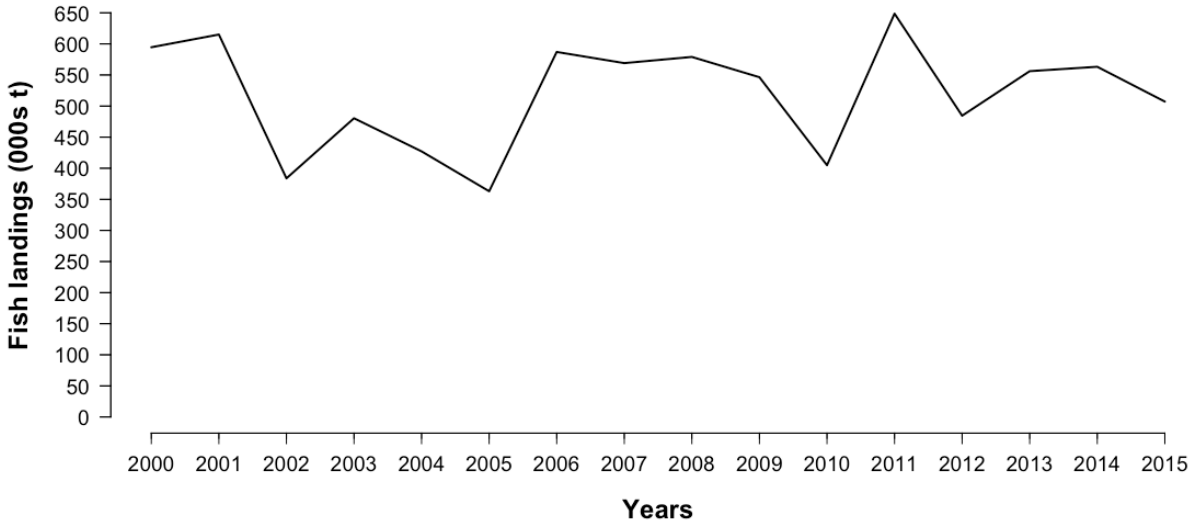

Figure A.5: Official reported landings of fish for direct human consumption. Source of Data: PRODUCE (2015).

Figure A.6: Boxplots showing the distribution of landing statistics of fish for direct human consumption before and since the beginning of the 'Gastronomic Boom'.

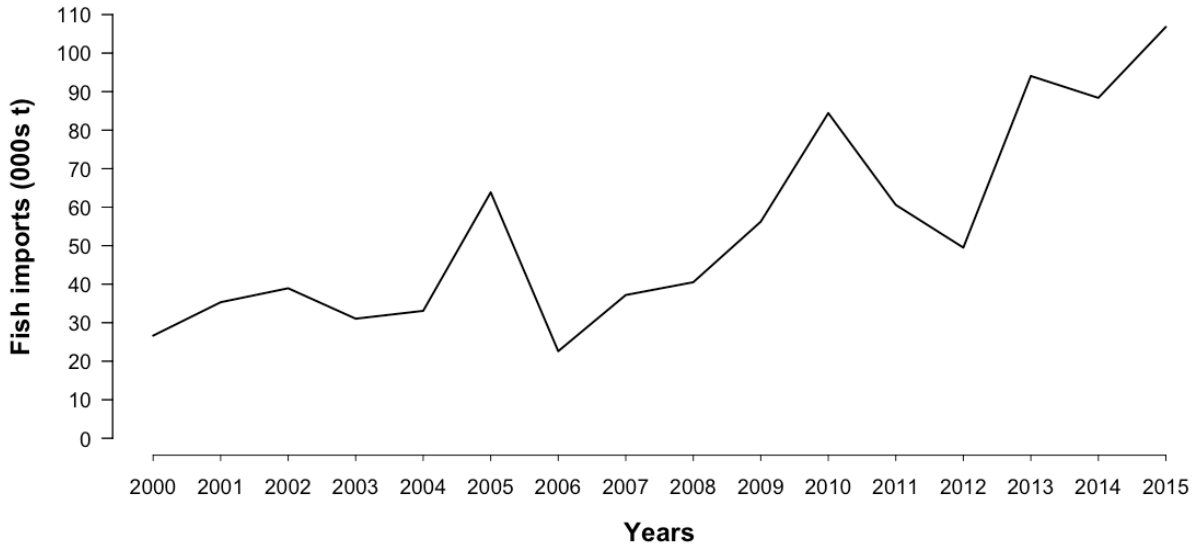

Figure A.7: Peruvian fish imports for direct human consumption. Source of Data: Adex Data Trade (2017).

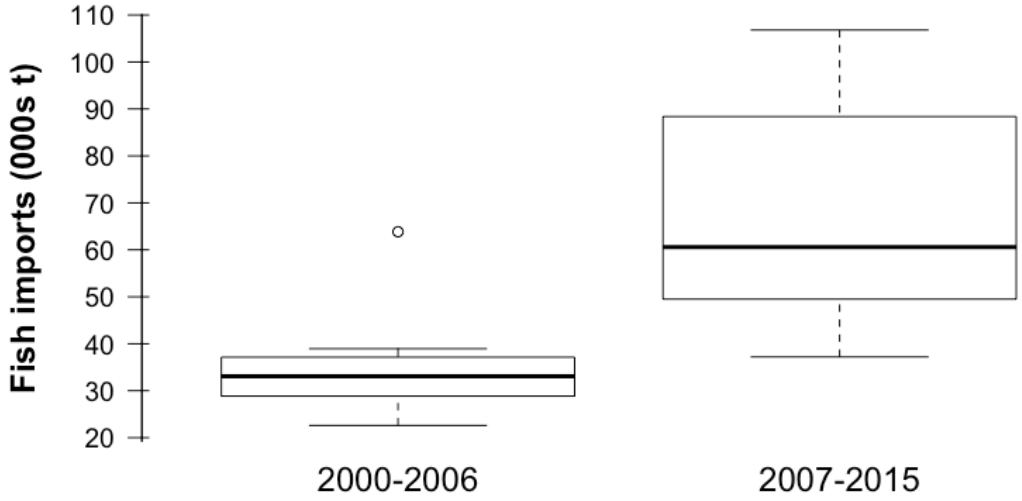

Figure A.8: Boxplots showing the distribution of Peruvian fish imports for direct human consumption before and since the beginning of the 'Gastronomic Boom'.

Table A.5: Results of the Wilcoxon-Mann-Whitney tests comparing landings and imports of fish for direct human consumption before and since the beginning of the 'Gastronomic Boom'. Statistically significant differences are indicated with an asterisk (*).

Variables	W	p-value
Fish landings: pre- (2000-2006) vs post (2007-2015) 'gastronomic boom'	26	0.607
Fish imports: pre- (2000-2006) vs post (2007-2015) 'gastronomic boom'	6	0.005*

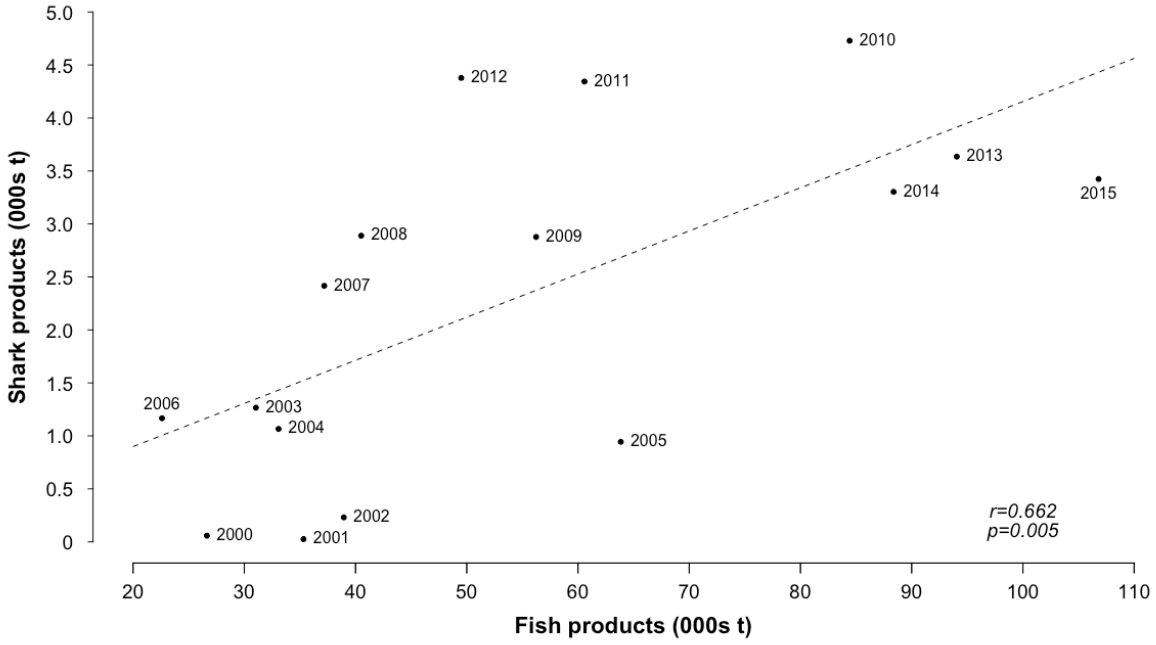

Figure A.9: Correlation between total fish imports for direct human consumption and shark imports registered in Peru between the years 2000 and 2015.