Chapter 10
Elasmobranchs Consumption in Brazil: Impacts and Consequences

Hugo Bornatowski, Raul R. Braga, and Rodrigo P. Barreto

Abstract Commercial fisheries struggle to apply regulatory and legal mechanisms that depend on reliable species-specific data, and the shark industry faces an even greater obstacle to transparency with sellers changing product names to overcome consumer resistance. Fraudulent representation or mislabeling of fish, including sharks and rays, has been recorded in some countries. In Brazil, for instance, sharks are sold as "cação" – a popular name attributed for any shark or ray species; however, according to consumer's knowledge of a large city of southern Brazil, more than 70% of them are often unaware that "cação" refers to sharks. Today, the Brazilian market has a high interest in encouraging people to eat "cação" meat, mainly because of their attractive prices. This raise a number of questions, mainly in respect to the knowledge of people/consumers, as what are they eating, and why the Brazilian meat market has grown so much in the last years.

10.1 Introduction

The Chondrichthyes, or cartilaginous fish (i.e sharks, rays, skates and chimaeras), are among the oldest taxa of vertebrates and have survived on planet earth for over 400 million years, including 4 mass extinction events (Camhi et al. 1998; Musick 1999). It can be considered an evolutionary successful group because it has diverse reproductive strategies (including parthenogenesis), ranging from planktivorous to top predators, occupying practically all aquatic niches (Priede et al. 2006; Snelson

H. Bornatowski (✉)
Centro de Estudos do Mar, Universidade Federal do Paraná, Curitiba, Brazil
e-mail: anequim.bio@gmail.com

R.R. Braga
LEC-Laboratório de Ecologia e Conservação/Universidade Federal do Paraná, Curitiba, Brazil

R.P. Barreto
Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Sudeste e Sul do Brasil (CEPSUL/ICMBio), Itajaí, Brazil

M.R. Rossi-Santos, C.W. Finkl (eds.), *Advances in Marine Vertebrate Research in Latin America*, Coastal Research Library 22,
DOI 10.1007/978-3-319-56985-7_10

et al. 2008). Sharks, skates, and rays composes the subclass Elasmobranchii (i.e. elasmobranchs) currently comprising a group of approximately 1150 species (Nelson 2006). Due to the development of a differentiated mandibular apparatus and an accurate sensorial system, elasmobranchs became predominantly predators, usually occupying higher or intermediate trophic levels (Camhi et al. 1998; Musick 1999). Therefore, they usually occur in relatively smaller abundances than species of lower trophic levels (Walker 1998; Stevens et al. 2000) though playing an important role in maintaining marine ecosystems healthy (e.g. control of genetic quality of populations, Holden 1974).

Elasmobranchs are long lived species characterized by low productivity rates which generally implies in small litters, slow growth rates and late onset of sexual maturity (Cortes et al. 2002; Garcia et al. 2008). These features are associated to high vulnerability and extinction risk, whereas populations have limited recovery capacity following overexploitation by fishing and even habitat losses and/or degradation (Smith et al. 1998; Stobutzki et al. 2002). A great diversity of elasmobranchs has been explored by modern fisheries, regularly caught as by-catch (i.e incidental) and more recently (>1990) as target, especially in longline, trawl and gill nets fisheries (Bonfil 1994; Baum et al. 2003; Barreto et al. 2016).

Population declines have been documented for several elasmobranchs species worldwide (Hutchings 2000; Baum et al. 2003; Ferretti et al. 2010; Clarke et al. 2011; Barreto et al. 2016). There are well-documented cases of elasmobranchs populations that collapsed such as *Lamna nasus* in the North Atlantic; *Galeorhinus galeus* in California and Australia; *Cetorhinus maximus* in England; *Squalus acanthias* in the North Sea and British Columbia; *Pristis pectinata* in Florida and Louisiana, and large coastal sharks off the west coast of the United States, such as *Carcharias taurus* and *Carcharhinus obscurus* (International Union for Conservation of Nature – IUCN). The IUCN reports that approximately 30% of elasmobranchs are threatened with extinction (Dulvy et al. 2014). Worryingly, 47% of extant species do not have minimal information to be evaluated under the IUCN classifying system (Dulvy et al. 2014; Mace et al. 2008).

10.2 Elasmobranch Fisheries in Brazil

South Atlantic fisheries, specifically assessed from Brazil during the late 1990s reached critical levels for spinny angel shark *Squatina guggenheim*, hidden angel shark *S. occulta*; Brazilian guitarfish *Rhinobatos horkelli*, scalloped hammerhead shark *Sphyrna lewini*, sand tiger shark *Carcharias taurus*, school shark *Galeorhinus galeus* and narrownose smooth-hound *Mustelus schmitti* (Vooren 1997; Lessa et al. 1999). More recently (between 2010 and 2012), Brazil reassessed elasmobranchs following the IUCN's system, resulting in 33% of species in threatened categories (VU = 19; EN = 8; CR = 28), and 36% for which the available information did not allow for any sort of categorization (i.e. Data Deficient-DD) (ICMBio 2016). This result overcomes the global rate of threatened species (approximately 25% – Dulvy et al. 2014).

The situation of large pelagic elasmobranchs currently is very worrying. According to Barreto (2015), which analyzed CPUE and demography of pelagic shark species from Brazil, most populations are currently depleted. Around 13 species have been caught by local and international longline fishing fleets since the 1950s, specifically: shortfin mako shark (*Isurus oxyrhinchus*), longfin mako shark (*I. paucus*), porbeagle shark (*Lamna nasus*), blue shark (*Prionace glauca*), oceanic whitetip shark (*Carcharhinus longimanus*), dusky shark (*C. obscurus*), night shark (*C. signatus*), crocodile shark (*Pseudocarcharias kamoharai*), common thresher shark (*Alopias vulpinus*) and bigeye thresher shark (*A. superciliosus*), scalloped hammerhead shark (*Sphyrna lewini*), smooth hammerhead shark (*S. zygaena*) and great hammerhead shark (*S. mokarran*) and the pelagic stingray (*Pteroplatytrygon violacea*).

These species have historically sustained the international fin market (Amorim et al. 1998; Hazin et al. 2008; Domingo et al. 2014) and since the 1990s, more precisely after the Brazilian finning ban, became one of the most cheap sea food to be consumed in Brazil. The blue shark, for instance, probably for being the only species that apparently has not yet collapsed, is currently supporting an industry that has grown absurdly in recent decades. Although this species has no capture restrictions in the region, it is currently the main target of longline pelagic fisheries in the South Atlantic, especially in periods where catches of other pelagic fish of high commercial demand (i.e. tunas and billfishes) are lower. Worryingly, both in tuna fishing and swordfish, as in fishing for blue shark, a number of other extremely sensitive sharks, with considerably lower population abundances than the target species are often caught. Finally, Brazil has been recently identified as a global flow channel for shark carcasses (world's largest importer) (Dent and Clarke 2015). Over the last 15 years the country has imported large quantities of shark carcasses from international fleets (>20) which also export fins for international luxury markets channels.

While for oceanic species, despite the limitations, there is some catch information available (mainly due to the industry and their obligations with the government, i.e. fishing statistics, commercial and financial transactions) coastal shark species are far to have their catches known. Large species such as hammerhead sharks, sand-tiger, and also the medium sized daggernose, blacknose and the southern squatinids are at great risk due to coastal fisheries (Barreto et al. 2011; Lessa et al. 2016) and for small and medium-sized species, there is no information about fishing or life history. These species are commonly caught by small-scale fisheries, which in a country with one million registered fishermen in this category, which contributes with 45% of the total fish produced in the country is too big to be ignored (B. Padovani, personal communication). The combined effect of oceanic industrial fishing and the coastal small-scale fisheries can be additive or even synergistic on population depletion due to its spatial complementarity. This relation still needs small-scale fisheries catch data to be assessed.

Rays production in Brazil has always been neglected. In the state of Santa Catarina, main Brazilian elasmobranch producer and one of the last to stop their fishing statistics collection, the ray production increased more than threefold in ten years (from 452,367 kg in 2000 to 1,425,792 kg in 2010). This state reported that more than 2300 tons of elasmobranchs were landed in 2010, whereas over 85% were not identified at species level (UNIVALI/CTTMar 2011). This broad identification levels of landed species makes species-specific regulation very difficult (Bornatowski et al. 2011, 2014), precluding fishing controls. Major concerns however lie in the categorization of ray's species. In Brazilian fisheries some ray species are grouped under a category called "emplastro". Within this label there are at least seven species: bignose banskate (*Sympterygia acuta*, endemic); smallnose fanskate (*S. bonapartii*, endemic), rio skate (*Rioraja agassizi*, endemic); spotback skate (*Atlantoraja castelnaui*, endemic); la plata skate (*A. platana*, endemic); eyespot skate (*A. cyclophora*); and the bluntnose stingray (*Dasyatis say*). Today, the demand of ray meat ("emplastro" group) for the Korean markets is so great that was one of the critical steps to invalidate the Normative Instruction-445 (Brazil 2014), which the main goal was to regulate the use of seafood products.

10.3 The Problem of Mislabeling

Commercial fisheries struggle to apply regulatory and legal mechanisms that depend on reliable species-specific data, and the shark industry faces an even greater obstacle to transparency with sellers changing product names to overcome consumer resistance. Fraudulent representation or mislabeling of fish, including sharks and rays, has been recorded in some countries (e.g. Barbuto et al. 2010; Jacquet and Pauly 2008; Lamendin et al. 2015; Smith and Benson 2001; Wong and Hanner 2008), highlighting the impacts on the economy and ecosystem services (Jacquet and Pauly 2008). The European Union, on the other hand, requires listing the species name on shark products (see Fig. 10.1) to avoid fraud and to aid conservation (Council Regulation No. 104/2000 – December/1999). With these measures rates of seafood fraud appear to have decreased from 2011 to 2015 (Oceana 2016).

While many developing countries depend of fish meat (including shark and ray meat) for their subsistence, many other countries view shark meat as low-quality and therefore commercialize them under generic names to overcome consumer resistance (Vannuccini 1999; Bornatowski et al. 2013, 2015; Dent and Clarke 2015). This measure impedes consumers to link the meat they buy to the animals they know. For instance, the spiny dogfish is sold under names like "saumonette" in France, "schillerlocken" or "seeaal" in Germany, and "spinaroli" in Italy (WildAid 2007). Shortfin mako (*Isurus oxyrinchus*), porbeagle (*Lamna nasus*) and thresher sharks (*Alopias* spp.) are considered to have a highly palatable meat worldwide and sometimes even comparable to swordfish (*Xiphias gladius*) in Europe and USA (WildAid 2007). On the other hand, blue shark (one of the most important shark species in fisheries) is considered one of the less preferred species for human consumption due to its soft and strong flavoured meat.

Fig. 10.1 *Raja brachyura* sold in a fish-market in Peniche, Portugal. Note the popular name, scientific name and site of catch (Photo: Hugo Bornatowski)

In Brazil, sharks are sold as "cação" – a popular name attributed for any shark or ray species (Fig. 10.2). People frequently purchase shark meat in pieces as '*fillet'* or '*thermidor*'. The most common dish made with elasmobranch meat is a traditionally dish called "Muqueca". This dish is originally from Espírito Santo, in the Southeast of Brazil, and also from the state of Bahia, in the Northeast.

Curiously, shark meat were not part of the traditional Brazilian diet and is considered to be low-value seafood (values around U\$2.00/Kg^{-1}) if comparable to more common fish such as tilapia (*Tilapia* spp. and *Oreochromis niloticus*), flatfish (Paralichthyidae family), salmon (*Salmon salari*), croacker fish (*Cynosion* spp.), snook (*Centropomus* spp.), groupers (Serranidae family) and snappers (Lutjanidae family) and others. However, today the Brazilian market have a high interest in encouraging people to eat "cação" meat, mainly because of their attractive prices (as cited above), unfamiliarity with the product and to avoid meat waste (Ministério da Agricultura, Pecuária e Abastecimento – MAPA). The high interest of Brazil for elasmobranch meat turns it into the perfect "port for meat discard" (finning is prohibited in several regions).

Furthermore, shark meat is traded without labeling and at substantially lower prices under the name of "cação" and not as "shark" or "ray" (Fig. 10.2). This raise a number of questions, mainly in respect to the knowledge of people/consumers, as what are they eating, and why the Brazilian meat market has grown so much in the last years.

Fig. 10.2 (**a**) Shark meat sold in a market in southeastern Brazil beside of Chilean Salmon (*Salmo salar*) (Credit: Dr. Fernando F. Mendonça.); (**b**) Shark and ray meat sold in a market in southern Brazil (Photo by: Rodrigo Barreto); (**c**) Frozen slices of sharks sold as "cação"

10.4 Decision-Making, Health and Conservation. The Concerns Grow!

According to consumer's knowledge of a large city of southern Brazil, more than 70% of them are often unaware that "cação" refers to sharks, and more than half of respondents claimed to have already eaten "cação" but never eaten sharks or rays (Bornatowski et al. 2015). So, consumers are buying "a pig in a poke". Beside of that, in surveys made in southeastern Brazil (states of São Paulo and Rio de Janeiro), 62% of fish sold as groupers were actually sharks (Estrella et al. 2014). This mislabeling provokes a 25% increase in revenue. Unfortunately, the problem does not stop there and this may be only the tip of the iceberg.

The mislabeling may preclude people from taking health- and/or conservation-related decisions concerning the consumption of elasmobranch meat and thus interfere with efforts to reduce consumption or redirect consumption towards non-threatened species (Barbuto et al. 2010; Bornatowski et al. 2013; Jacquet and Pauly 2008). Furthermore, misleading product descriptions is a crime according to Brazilian Consumer Protection Code (n° 8078/1990) (Brazil 1990). A recent study found that samples labeled under the name "cação" in Brazil were in fact made up of endangered scalloped hammerhead (Carvalho et al. 2015). Another study showed that 55% of "cação" samples were actually large-tooth sawfish, *Pristis perotteti*, a species considered by the IUCN to be critically endangered and for which trade is prohibited in Brazil (Palmeira et al. 2013). The generalization of species in a single name (such as "cação") is therefore puting in risk several threatened species. In 19 October 2016, an online journal published a matter on "Sharks and rays threatened that are irregularly commercialized in Brazil" (http://economia.uol.com.br/noticias/efe/2016/10/19/tubaroes-e-raias-em-extincao-sao-comercializados-irregularmente-no-brasil.htm). More than 16 different species of sharks and rays were sold as "cação", with special concern to the hidden angel shark *Squatina occulta*, and scalloped hammerhead shark *Sphyrna lewini* (23% of samples) classified as critically endangered and vulnerable respectively according IUCN redlist. In southern Brazil, artisanal fisheries capture a lot of sharks, including some threatened species that are also sold as "cação" for consumers in local markets (Figs. 10.3 and 10.4).

This lack of knowledge is also of great concern to human health because shark meat contains high levels of heavy metals (lead and mercury) due to biomagnification (Escobar-Sánchez et al. 2011; Lopez et al. 2013; Pethybridge et al. 2009). A study analyzing specifically blue sharks collected from strategical landing points of central and southern Brazil, found 70% of the samples with mercury levels above recommended (Dias et al. 2008). Brazil has less stringent restrictions for heavy metals in seafood than the European Union, North America, and Asia, allowing products

Fig. 10.3 Scalloped hammerhead sharks (*Sphyrna lewini*) and other *Carcharhinus* spp. captured by artisanal fisheries in Paraná coast. Specimens are without heads and will be cut in slices and sold as "cação" (Photo by Isabella Simões)

Fig. 10.4 Scalloped hammerhead sharks (*Sphyrna lewini*) and other *Carcharhinus* spp. sharks captured by artisanal fisheries in Paraná coast. Specimens landed after evisceration (Photo by Isabella Simões)

Fig. 10.5 Children's tests shark meat to be included in the scholar meals system (Photo by: Ana Chaffin, Macaé-RJ)

with high levels of heavy metals, which would not be marketable elsewhere, to be commercialized legally. The worst is that unlabeled shark meat has been served in public schools from several cities to children from 6 to 17 years old, as subsidized meat by the government (http://macae.rj.gov.br/semed/leitura/noticia/alunos-testam-file-de-cacao-na-merenda-escolar) (Fig. 10.5).

10.5 Actions and Suggestions

We therefore emphasize that a small list of actions need to be taken if developing countries, specially Brazil, to overcome major conservation barriers. They are:

1. Use of scientific names on commercialized products, and use of exclusive popular names in labels. A correct species-specific identification would aid in the solution to the mislabeling of shark meat
2. Supermarkets or any other final seller should be held legally responsible for the identification
3. Development of an identification handbook based on morphological characteristics (on muscle, for instance) to be used by regulatory agencies. This would be a cheap method to prevent fraud in identification. Muscle tissue identification methodology is already applied for teleostean fish (http://www.agricultura.gov.br/arq_editor/manual%20pesca.pdf), and could be used for elasmobranchs also.
4. Use of genetic techniques such as DNA barcoding for species-identification
5. Certification programs such as the Marine Stewardship Council (MSC) and eco-labels, may help consumers to choose more sustainable seafood products (Jacquet and Pauly 2008; Lamendin et al. 2015; Sampson et al. 2015; Von der Heyden et al. 2010). The establishment of species-specific commodity codes can facilitate trade monitoring of protected species, and also inform end consumers. This kind of information should be available to consumers
6. Restructuration of fisheries monitoring programs, and creation of a national program of fishery statistics with wide spatial and temporal coverage, with extensive species-catch monitoring throughout the Brazilian coast
7. Trained personnel to obtain reliable data following the correct identification of elasmobranchs species. Without knowing fishery catches (item 6) and correct species-specific information, any monitoring will fail.

References

Amorim AF, Arfelli CA, Fagundes L (1998) Pelagic elasmobranchs caught by longliners off southern Brazil during 1974–97: an overview. Mar Freshw Res 49:621–632

Barbuto M, Galimberti A, Ferri E, Labra M, Malandra R, Galli P, Casiraghi M (2010) DNA barcoding reveals fraudulent substitutions in shark seafood products: the Italian case of "palombo" (*Mustelus* spp.) Food Res Int 43:376–381

Barreto RP (2015) Historia de vida e vulnerabilidade dos tubarões oceânicos do Atlantico Sul. PhD Thesis, Universidade Federal Rural de Pernambuco, Brazil
Barreto RR, Lessa RP, Hazin FH, Santana FM (2011) Age and growth of the blacknose shark, *Carcharhinus acronotus* (Poey 1860) off the northeastern Brazilian coast. Fish Res 110:170–176
Barreto R, Ferretti F, Mills J, Amorim A, Andrade H, Worm B, Lessa R (2016) Trends in the exploitation of South Atlantic shark populations. Conserv Biol 30:792–804
Baum JK, Myers RA, Kehler DG, Worm B, Harley SJ, Doherty PA (2003) Collapse and conservation of shark populations in the northwest Atlantic. Science 299:389–392
Bonfil R (1994) Overview of world elasmobranch fisheries. Fisheries technical papers. Rome
Bornatowski H, Vitule JRS, Abilhoa V, Corrêa MFM (2011) Unconventional fishing for large sharks in the state of Paraná southern Brazil: a note of concern. J Appl Ichthyol 27:1108–1111
Bornatowski H, Braga RR, Vitule JRS (2013) Shark mislabeling threatens biodiversity. Science 340:923
Bornatowski H, Braga RR, Vitule JRS (2014) Threats to sharks in a developing country: the need for effective and simple conservation measures. Natureza Conserv 12(1):11–18
Bornatowski H, Braga RR, Kalinowski C, Vitule JRS (2015) "Buying a Pig in a Poke": the problem of Elasmobranch meat consumption in Southern Brazil. Ethnobiol Lett 6(1):196–202
Brazil (1990) Lei n. 8.078, de 11 de setembro de 1990. Dispõe Sobre a Proteção do Consumidor e dá Outras Providências. Diário Oficial da República Federativa do Brasil, Brasília, DF, 12 set. 1990. Available at: http://www.planalto.gov.br/ccivil_03/ leis/l8078.htm. Accessed 15 Sep 2016
Brazil (2014) Ministério do Meio Ambiente. Portarias 445, de 17 de Dezembro de 2014, Diário Oficial da União http://pesquisaingovbr/imprensa/jsp/visualiza/indexjsp?data=18/12/2014&jornal=1&pagina=110&totalArquivos=144. Accessed 18 Oct 2016
Camhi M, Fowler S, Musick J, Bräutigam A, Fordham S (1998) Sharks and their relatives, ecology and conservation. Occas. Paper IUCN Spec. Surv. Comm. 39 p
Carvalho DC, Palhares RM, Drummond MG, Frigo TB (2015) DNA barcoding identification of commercialized seafood in south Brazil: a governmental regulatory forensic program. Food Control 50:784–788
Clarke S, Yokawa K, Matsunaga H, Nakano H (2011) Analysis of North Pacific shark data from Japanese commercial longline and research/training vessel records. Western and Central Pacific Fisheries Commission, Pohnpei, Micronesia
Cortés E, Brooks L, Scott G (2002) Stock assessment of large coastal sharks in the U.S. Atlantic and Gulf of Mexico. National Oceanic and Atmospheric Administration, National Marine Fisheries Service Southeast Fisheries Science Center, Sustainable Fisheries Division Contribution SFD-2/03-177
Dent F, Clarke S (2015) State of the global market for shark products. FAO Fisheries and Aquaculture technical paper no. 590. FAO, Rome
Dias ACL, Guimarães JRD, Malm O, Costa PAS (2008) Mercúrio total em músculo de cação *Prionace glauca* (Linnaeus, 1758) e de espadarte *Xiphias gladius* Linnaeus, 1758, na costa sul-sudeste do Brasil e suas implicações para a saúde pública. Cad Saúde Pública 24(9):2063–2070
Domingo A, Forselledo R, Miller P, Jiménez S, Mas F, Pons M (2014) General description of longline fisheries. ICCAT manual, 312. Available from http://wwwiccates/Documents/SCRS/Manual/CH3/CHAP_3_1_2_LL_ENGpdf. Assessed 05 October 2016
Dulvy NK, Harisson LR, Carlson JK et al (2014) Extinction risk and conservation of the world's sharks and rays. elife 3:e00590
Escobar-Sánchez O, Galván-Magaña F, Rosíles-Martínez R (2011) Biomagnification of mercury and selenium in blue shark Prionace glauca from the Pacific Ocean off Mexico. Biol Trace Elem Res 144:550–559
Estrella F, Raposo G, Pascolli J, Gonzalez JG, Motta FS, Moura RL (2014) Comercialização de pescado nas cidades de São Paulo e Rio de Janeiro. https://wwwsosmaorgbr/wp-content/uploads/2014/09/ESTUDO-PESCADO-2014_Relatorio-Finalpdf. Assessed 02 Nov 2016

Ferretti F, Worm B, Britten GL, Heithaus MR, Lotze HK (2010) Patterns and ecosystem consequences of shark declines in the ocean. Ecol Lett 13:1055–1071

Garcia VB, Lucifora LO, Myers RA (2008) The importance of habitat and life history to extinction risk in sharks, skates, rays and chimaeras. Proc R Soc B 275:83–89

Hazin FHV, Broadhurst MK, Amorim AF, Arfelli CA, Domingo A (2008) Catches of pelagic sharks by subsurface longline fisheries in the South Atlantic Ocean during the last century: a review of available data with emphasis on Uruguay and Brazil. In: Camhi MD, Pickitch EA (eds) Sharks of the open ocean: biology, fisheries and conservation. Blackwell Publishing, Oxford, pp 213–227

Holden MJ (1974) Problems in the rational exploitation of elasmobranch populations and some suggested solutions. In: Harden-Jones FR (ed) Sea fisheries research. Elek Science, London, pp 117–138

Hutchings JA (2000) Collapse and recovery of marine fishes. Nature 406:882–885

Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) (2016) Avaliação do risco de extinção dos elasmobrânquios e quimeras no Brasil: 2010–2012. Available in: http://www.icmbio.gov.br/cepsul/especies-ameacadas.html. Accessed 20 Oct 2016

Jacquet JL, Pauly D (2008) Trade secrets: renaming and mislabeling of seafood. Mar Policy 32:309–318

Lamendin R, Miller K, Ward RD (2015) Labelling accuracy in Tasmanian seafood: an investigation using DNA barcoding. Food Control 47:436–443

Lessa RP, Santana FM, Rincón G, Gadig OBF, El-Deir ACA (1999) Biodiversidade de elasmobrânquios do Brasil. Recife Ministério do Meio Ambiente (MMA), Projeto de Conservação e Utilização Sustentável da Diversidade Biológica Brasileira (PROBIO)

Lessa RP, Batista V, Santana FM (2016) Close to extinction? The collapse of the endemic daggernose shark (*Isogomphodon oxyrhynchus*) off Brazil. Global Ecol Conserv 7:70–81

Lopez SA, Abarca NL, Meléndez R (2013) Heavy metal concentrations of two highly migratory sharks (*Prionace glauca* and *Isurus oxyrinchus*) in the Southeastern Pacific waters: comments on public health and conservation. Trop Conserv Sci 6:126–137

Mace GM, Collar NJ, Gaston KJ, Hilton-Taylor C, Akcakaya HR, Leader-Williams N, Milner-Gulland EJ, Stuart SN (2008) Quantification of extinction risk: IUCN's system for classifying threatened species. Conserv Biol 22:1424–1442

Musick JA (1999) Ecology and conservation of long-lived marine animals. In: Musick JA (ed) Life in the slow lane: ecology and conservation of long-lived marine animals. American Fisheries Society Symposium, Bethesda, pp 1–10

Nelson JS (2006) Fishes of the World, 4th edn. Wiley, New York

Oceana (2016) Seafood frau campaign. http://oceanaorg/our-campaigns/seafood_fraud/campaign. Assessed 2 Oct 2016

Palmeira MCA, Rodrigues-Filho LFS, Sales JBL, Vallinoto M, Schneider H, Sampaio I (2013) Commercialization of a critically endangered species (largetooth sawfish, *Pristis perotteti*) in fish markets of northern Brazil: authenticity by DNA analysis. Food Control 34:249–252

Pethybridge H, Cossa D, Butler CV (2009) Mercury in 16 Demersal sharks from Southeast Australia: biotic and abiotic sources of variation and consumer health implications. Mar Freshw Res 68:18–26

Priede IG, Froese R, Bailey DM, Bergstad OA, Collins MA, Dyb JE, Henriques C, Jones EG, King N (2006) The absence of sharks from abyssal regions of the world's oceans. Proc R Soc B 273:1435–1441

Sampson GS, Sanchirico JN, Roheim CA et al (2015) Sustainability: secure sustainable seafood from developing countries. Science 348(6234):504–506

Smith PJ, Benson PG (2001) Biochemical identification of shark fins and fillets from the coastal fisheries in New Zealand. Fish Bull 99(2):351–355

Smith SE, Au DW, Show C (1998) Intrinsic rebound potentials of 26 species of Pacific sharks. Mar Freshw Res 49:663–678

Snelson FF Jr, Roman BL, Burgess GH (2008) The reproductive biology of pelagic elasmobranchs. In: Camhi MD, Pikitch EK, Babcock EA (eds) Sharks of the open ocean: biology, fisheries and conservation. Blackwell Publishing, Oxford, pp 24–53

Stevens JD, Bonfil R, Dulvy NK, Walker PA (2000) The effects of fishing on sharks, rays, and chimeras (chondrichthyans), and the implications for marine ecosystems. ICES J Mar Sci 57:476–494

Stobutzki IC, Miller MJ, Heales DS, Brewer DT (2002) Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. Fish Bull 100:800–821

UNIVALI/CTTMar (2011) Boletim estatístico da pesca industrial de Santa Catarina – Ano 2010. Universidade do Vale do Itajaí, Centro de Ciências Tecnológicas da Terra e do Mar, Itajaí

Vannuccini S (1999) Shark utilization and trade. Food and Agriculture Organization technical paper, n.389, Rome, Italy

Von der Heyden S, Barendse J, Seebregts AJ, Matthee CA (2010) Misleading the masses: detection of mislabelled and substituted frozen fish products in South Africa. ICES J Mar Sci 67:176–185

Vooren CM (1997) Demersal elasmobranchs. In: Seeliger U, Odebrechet C, Castello JP (eds) Subtropical convergence environments. The coast and sea in the southwestern Atlantic. Springer, Heidelberg, pp 141–146

Walker T (1998) Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. Mar Freshw Res 49:553–572

WildAid (2007) The end of the line? Global threats to sharks. http://www.wildaid.org. Accessed 10 Mar 2015

Wong EHK, Hanner R (2008) DNA barcoding detects market substitution in North American seafood. Food Res Int 41:828–837