Shark fin trade and Molecular tools to detect endangered species

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Abstract

In the last decades chondrichthyans populations have sorely declined mainly because of overexploitation due to unregulated fishing. As a result, at the present day, a quarter of the extant chondrichthyans species is considered threaten with extinction. The shark fin trade is a very diverse phenomenon and it targets the whole chondrichthyans class. Once the processed products are on the market, it is not possible to trace them back to the individual of origin, due to the absence of a relationship between catch data and traded products. This aspect makes the impact of shark fin trade on chondrichthyans populations difficult to address. Therefore, the need to develop a tool able to identify the origin of the products seems necessary. Molecular techniques can detect the species of origin accurately, utilising just a small fragment of tissue from products presenting different grade of processing. This essay intends to illustrate the overall framework of the trade in chondrichthyans products, most commonly known as shark fin trade as well as present examples of molecular approaches developed to detect species, in order to help to find new insights and guidelines for chondrichthyans conservation.

1.0 Introduction

In the course of the Anthropocene, sharks have been harvested from the sea and consumed by people, but it is only in the last decades that the trade in shark products has become an effective global market, with a total declared value of USD 1 billion traded per year (Dent & Clarke, 2017). This occurred because of the increasing demand for shark products from economically powerful countries and the possibilities the actual state of globalisation offers. Due to the progress in technology we are facing nowadays, the efficiency in fishing have reached a very high and competitive level, that is leading many fish stocks to collapse (Pauly et al., 2013; Rotman & Getty, 2013). Among them are the shark populations which are heavily threaten and exposed to unprecedent exploitation pressure (Bonfil et al., 1994; Castro et al., 1999; Clarke et al., 2006).

Shark populations might soon be brought to the verge of extinction (Cardeñosa et al., 2018; Dulvy et al., 2014), as it happened and continues to occur with rhinoceros and elephants species intensively hunted by poachers for the ivory in their tusks and horns (Stiles, 2004; Leader et al., 2020). Elasmobranches relate more to great mammals rather than to teleosts, because of their shared K-selected life history traits. Indeed, they show slow growth, late sexual maturity, long life spans, low fecundity (Stevens et al., 2000) and, correlated to their large body size, they all depict a low intrinsic rate of population increase (Smith et al., 1998; Frisk et al., 2001; Hutchings et al., 2012). Unlike the species involved in the ivory trade (Leader et al., 2020), Chondrichthyans show an incredible diversity in species richness, ecology traits and geographical ranges, in such a way that their loss could affect the food web in all its levels. As a matter of fact, most sharks and some batoids are predators with many species occurring at or near the top of the aquatic ecology pyramid, so they influence the energy transfer, vertically through trophic levels, and horizontally across different habitats (migrators). Moreover, they play a role in the vertical integration of trophic cascades, in particular sharks are essential for their top-down control in the trophic dynamics (Cortés, 1999; Hussey et al., 2014; Myers et al., 2007; Stevens et al., 2000).

2.0 Aim of this essay

This essay intends to illustrate the overall framework of the trade in chondrichthyans products, most commonly known as shark fin trade as well as present examples of molecular approaches developed to detect species, in order to help to find new insights and guidelines for chondrichthyans conservation.

3.0. Shark fin trade

The shark fin trade is a fast-growing international market. It consists in the trade of a diverse spectrum of products derived from fishes belonging to the class of chondrichthyans, including sharks, rays, skates, and ghost fishes. It is strongly socially-driven due to the fact that traded products are mostly connected to traditional medicine and display of social status in China.

3.1 Main traded products

The main traded products are shark fins, meat fillet, liver oil, and shark skin and bile, followed by very processed products such as fin trimmings and cartilage pills. Depending on the degree of processing commercial shark products are more or less difficult to be identified to a species level.

Shark fins are the most diverse shark products on the market, mainly utilised for shark fin soup. Based on their size they are divided in high-value and low-value fins. The former are harvested from sharks, while the latter also known as 'white fins' are from shark-like rays (i.e. wedgefish, guitarfish, sawfish) or juveniles stage of large shark species (Kyne et al., 2020). They can be found in different grades of processing, from the wet and dried unprocessed form, still maintaining the original shape and skin, to the slightly chemically processed golden ones, until the very processed products that no longer present the original shape or morphological characteristics (Cardeñosa et al., 2017). This is the case of fin trimmings, low value perishable products employed in the fin soup, (Kyne et al., 2020) and shark cartilage pills, which are considered to be beneficial against age-associated diseases and cancer (Hellberg et al., 2019). They both contain very processed cartilage that often comes from different individuals.

On the other hand, meat fillet is the second very common traded shark product. It is usually found in four forms: kept on ice, frozen or dried and salted. Shark skin and bile are not so common in the market anymore. Whilst, Raw shark liver oil is traded internationally and is processed to be utilised in cosmetics and skin care products (Cardeñosa et al., 2017).

3.2 Historical context in brief

In the course of history, the trend in shark products has changed, following the market demand shaped by socio-economic trends. Shark skin and bile have been recorded as products used in the traditional Chinese medicine during the Tang Dynasty time (618–907 AD) (Traffic, 1996), but they are no longer considered so precious as shark fins and meat.

Shark fin soup is usually held to promote general health in the Chinese tradition. Together with the other shark products, it falls within a high-ranking category of bu food, which includes strengthening, tonic-like typically exotic and wild food items, deemed to be unpolluted and precious and therefore with better beneficial properties. Bu food has always been the food of most prestigious classes, earlier of Emperors (Song Dynasty, 960–1279 AD; Ming Dynasty ,1368–1644 AD) (Freeman, 1977; Rose, 1996) and, according to the political and social changes, of rich people nowadays. It belongs to a long-standing tradition of strict and complex social rules involved with food and social status display. This imply that consumption of luxury food items in China is not to be considered as just the result of an unusual appetite, but rather, as the expression of the social status (Anon. 2010, p. 23).

3.3 Principal actors in the shark fin trade

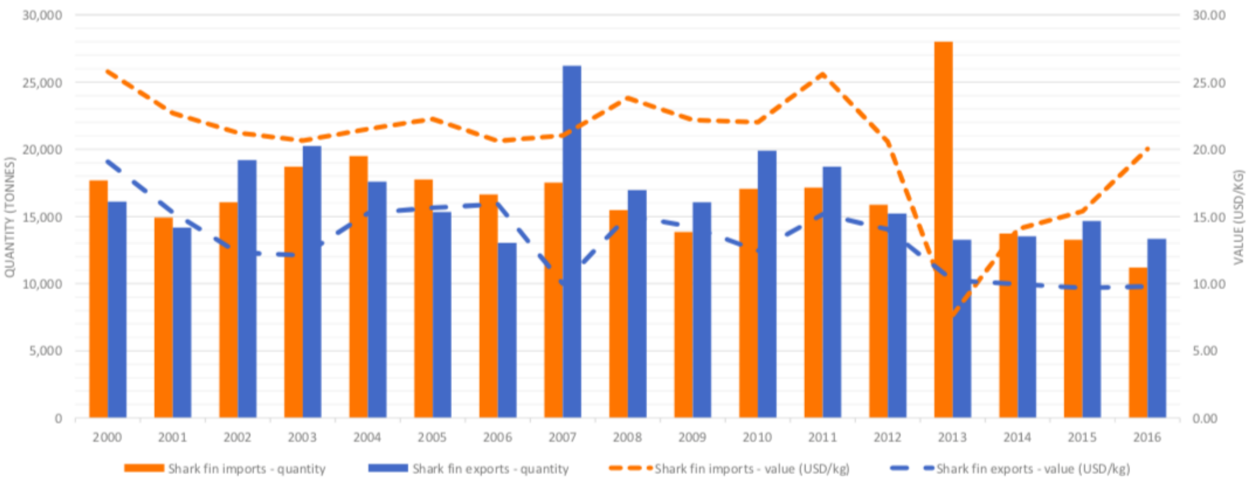

Fig. 1 Economic figures of the shark fin trade between 2000 and 2016
Source: Okes and Sant 2019

The traditional Asian demand of shark fins for fin soup consumption, which is limited to China, Hong Kong SAR, Taiwan Province of China, Singapore, Malaysia and Viet Nam has slightly declined during the last decades (Fig. 1)(Dent and Clarke, 2015). Antithetically, the demand for shark meat, is constantly increasing on a global scale (Fig.2). This increase occurs domestically in developing tropical countries, where shark meat is consumed as a source of protein due to poor living conditions and to the collapse of other fish stocks (Jabado, 2018; Moore, 2017; Moore; Séret, & Armstrong, 2019). Internationally, the shark meat demand is fuelled by regular importers such as Italy, France, Germany, China, and the Republic of Korea. (major importer of skates and rays) and emerging nations, such as Brazil and Uruguay. On the other hand, the meat market is supplied by exporters such as Spain, Mexico, Canada, the United States of America, New Zealand, Costa Rica, India, Portugal, the United Kingdom of Great Britain and Northern Ireland, Morocco, and Taiwan Province of China.

China, Hong Kong, SAR has been the major trader of shark fins since it had been recorded and it is historically considered the most important shark fin entrepôt (Dent & Clarke, 2015). Not only because of the volume of large high-quality fins traded or its duty-free status, but especially because of its classifying system for shark products. It maintains separate codes for unprocessed (dried, frozen) and processed shark fins(Dent & Clarke, 2015). In the last decade, this historical supremacy of the Hong Kong market has weakened. First, when Mainland China entered the market in 2001 (Ferris, 2002) and more recently when Hong Kong was shaded in exports by Thailand. In addition, recent estimates suggest that Japan and Malaysa, main trading partners of Thailand in small low-value fins, are also expanding very quick and may probably enter the top four exporters soon (Dent & Clarke, 2015).

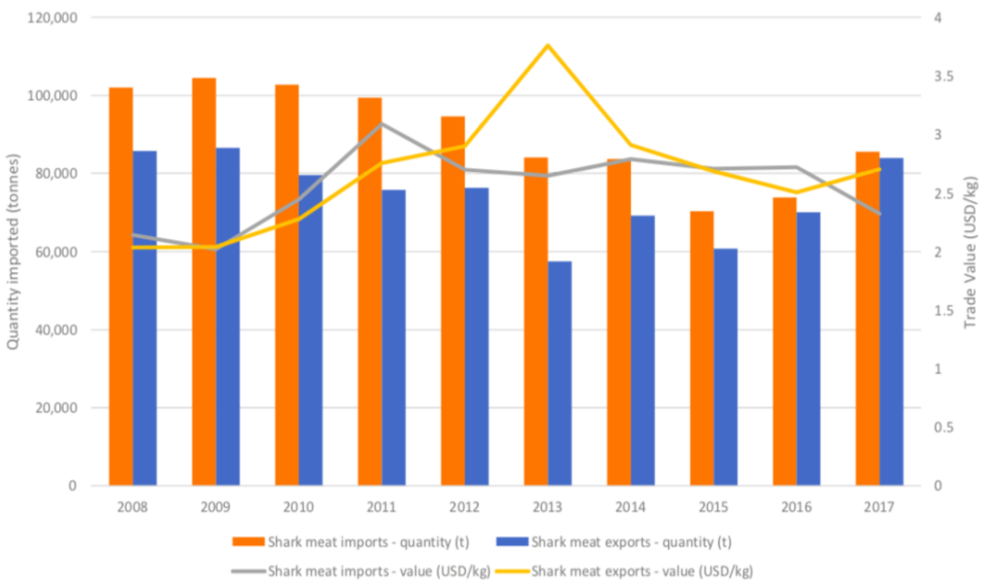

Fig. 2 Economic figures of the shark meat trade between 2008 and 2017
Source: Okes and Sant, 2019

3.4 Main threats to chondrichthyans

Elasmobranches exhibit very much diverse ecological traits, some are pelagic and migrate for long distances, i.e. blue shark, others spend the entire life in a small geographic range, usually in coastal habitat, showing strong philopatry, i.e. wedgefish. They are all subjected to a wide array of threats including habitat loss, climate change, overexploitations as a result of targeted fishing and incidental catches (by catch), which are often associated with the finning practices. Another threat to their status are shark control nets employed to minimise damages to fishing gear and to reduce the risk of (i.e.white) shark attacks (Dulvy et al., 2014; Stevens et al., 2000).

Low priority, lack in regulation and low value per unit weight allowed shark bycatch to become very common in those fisheries using long-line, gillnets and demersal trawls (Baum et al., 2003; Zeeberg et al., 2006). In this regard, Quieroz (et al., 2015) used satellite tracking in the North Atlantic Ocean to show that longliners persistently fish and make use of hotspot areas occupied by pelagic sharks, such as blue and shortfin mako shark.

The limited capacity of fishery's vessels targeting more valuable species as tuna and billfishes or in the long-line high seas fisheries (Shotton, 1999; Fowler et al., 2005), and the little regulation gave rise to the practice of finning. Finning consists of the removal of the valuable fins and the disposal of the carcass at sea, leaving the animal dying by the ocean floor incapable of moving or breathing. This is a kind of practice very common in many cases of unregulated trade where just a certain body part is valuable (i.e. elephants) (Leader et al., 2020).

Heavily affected by overfishing are the shark-like rays, such as sawfishes, wedgefishes and guitarfishes. They fuel a big part of the market with their so called 'white fins' (Kyne et al., 2020; Cardeñosa, 2019). They represent an easy catch, as they inhabit coastal areas and they present a large body size, which are two factors that highly correlate to the risk of extinction. In the last few years, they have been threatened to such a point that at least twenty-eight populations of sawfishes, skates and sharks have been brought, locally or regionally, to extinction (Dulvy et al., 2003; Dulvy and Forrest, 2010; Dulvy et al., 2014).

3.5 Shark fin trade regulation status

The overall increase concern for the chondrichthyans populations lead several studies being conducted in order to estimate the impact of the shark fin trade on chondrichthyans populations (Clarke, 2006a; Walker et al., 1996; Jabado, 2018; Kyne et al., 2020; Dulvy et al., 2014; Kyne et al., 2020; Kyne et al., 2016).

In 2014, the IUCN Shark Specialist Group (SSG), chosen by the Species Survivor Committee (SSC), published the first systematic analysis of threat for a globally distributed lineage of 1,041 chondrichthyan fishes, following the criteria of the IUCN Red List. They estimated that, at the present

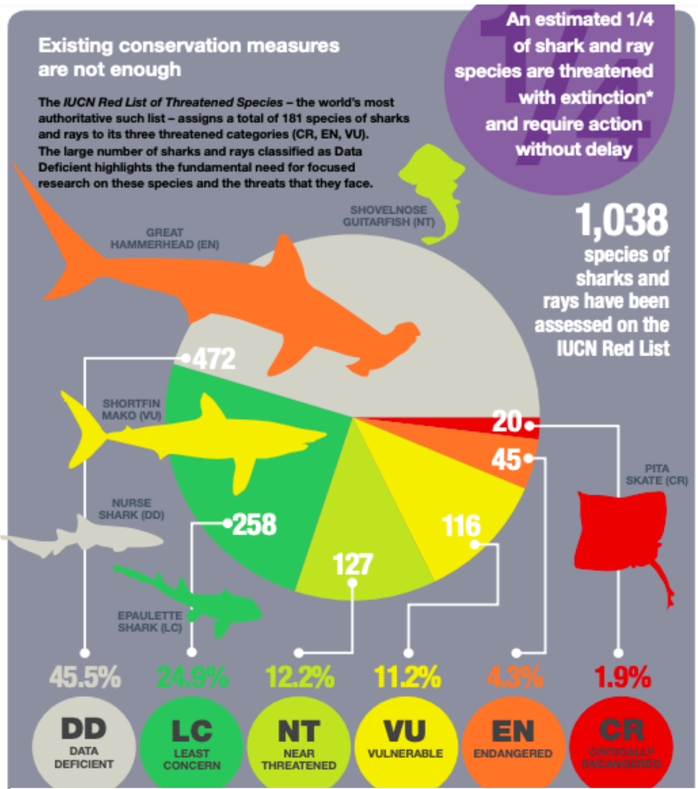

Fig. 3 Percentage of endangered species divided into threatened categories Source: Bräuticam et al., 2015

day, one quarter of sharks, rays, and chimaeras are threatened. Ever since, the Global Strategy for the Conservation of Sharks and Rays (2015–2025) was adopted, involving representants from several organisations: Shark Advocates International, the Shark Trust, TRAFFIC, Wildlife Conservation Society (WCS), and World Wide Fund for Nature (WWF) International (https://www.iucnssg.org/).

The inclusion of the most endangered chondrichthyans species in the CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) appendixes (tab.1) together with the establishment of government policies, such as prohibition of finning, and bycatch policies, founded the bases to give arise to a sustainable shark fin trade. The practice of finning was banned internationally by the WWF in 2005 and in several countries i.e. the USA, the European Union, South Africa, Brazil, Costa Rica (Fowler et al., 2005), Australia, Canada and Taiwan (Dent & Clarke, 2015). Moreover, strategies to reach the public awareness regarding shark conservation were instituted by establishing shark sanctuaries (Ward-Paige, 2017) and starting shark eco-tourism (Cisneros-Montemayor et al., 2013).

Species listed in Appendix I	**Species listed in appendixII**		**Species listed in appendix III**
Pristidae spp.	*Carcharhinus falciformis*	*Manta spp.*	*Potamotrygon schroederi* (Colombia)
	Carcharhinus longimanus	*Mobula spp.*	*Potamotrygon spp*. (population of Brazil)
	Sphyrna mokarran	*Rhincodon typus*	*Potamotrygon constellata* (Colombia)
	Sphyrna zygaena	*Glaucostegus spp.*	*Potamotrygon scobina* (Colombia)
	Alopias spp.	*Rhinidae spp.*	*Potamotrygon motoro* (Colombia)
	Cetorhinus maximus		*Potamotrygon orbignyi* (Colombia)
	Isurus oxyrinchus		*Potamotrygon magdalenae* (Colombia)
	Isurus paucus		*Potamotrygon yepezi* (Colombia)
	Lamna nasus		*Patatrygon aiereba* (Colombia)

Tab. 1 *Chondrychthyans CITES-listed species.* *Source: https://cites.org/eng/disc/species.php*

Notwithstanding, shark populations are still declining and there is still so much more work that needs to be done. First of all, the lack of catch data reported to the Food and Agriculture Organization of the United Nations (FAO) and the illegal, unreported and unregulated trade (IUU) (http://www.fao.org/iuu-fishing/en/) need to be better regulated. It is known that the available FAO data on global shark catches does not include discarded and finned sharks, therefore, underestimates the total shark mortality. In addition, bycatch data are usually not classified by species, in fact just the 15% of all shark catches reported to FAO have been recorded to the species level (Lack and Sant, 2006). Currently, this deficiency of information is slightly buffered using regional estimates. For example in the Western and Central Pacific Ocean, the US fisheries discards are recorded by the Standing Committee on Tuna and Billfish and by organisations such as WWF and IUCN which work together in the joint programme TRAFFIC: the wildlife trade monitoring network (https://www.traffic.org/).

This lack of information poses significant challenges to quantify the impacts of exploitation on a species-specific level and may mask possible declines and regional extinctions that are actually taking place (Dulvy et al., 2000, Dulvy et al., 2014). Despite the implementation of management regulations, Davidson, Krawchuck, and Dulvy (2016) showed that, however, in the last decade landings have declined, this is to be considered the result of an overall steep decline in population size of Chondrichthyans, rather than, a reduction in shark catches.

In order to address the actual impact of illegal and unregulated catches, several modelling studies based molecular data were conducted in order to estimate the effective catches of the shark fin trade, tracking back genetically the traded products to the individuals of origin.(Clarke, 2006; Agnew et al., 2009; Worm et al., 2013; Shivij et al., 2005). Clarke (et al., 2006) applied Bayesian statistical methods to trade data in combination with genetic identification in order to estimate, the annual number of traded shark fins in Hong Kong categorised by species and converted it in global shark catches. The authors demonstrated that the shark biomass harvested, at that time, was three or four folds bigger than the shark catch figures reported in the only global database. (Clarke et al., 2004; Clarke et al., 2006).

4.0 Molecular tools for endangered chondrichthyans species

Given all the aforementioned issues that the trade of shark products presents, this practice really needs to be monitored in a rigid and smart way, paying attention not to encourage the illegal trade and constantly recording the composition in species of the market and tracking the products' origin.

There are two systems for species identification, the older one based on morphological characters and the more recent based on genetic markers. The morphology-based identification system is complex and require a high level of expertise. Morphological keys are applicable only to unprocessed, frozen or dry fins (www.identifyingsharkfins.org; Abercrombie & Hernandez, 2017; Abercrombie et al., 2013). Moreover, it overlooks both phenomenon of phenotypic plasticity and genetic variability and cannot detect morphologically cryptic taxa. (Hebert et al., 2003). Therefore, it is not completely trustable especially in cases where species identification is required.

On the other hand, molecular identification systems were proven to be an efficient tool of diagnosis for biological diversity and were shown to be effective on shark products. They allow discrimination among individuals and species using the information contained in a small fragment of DNA regardless, in the most cases, the degree of processing of the sample (Cardeñosa, 2018). Using the divergence between homologous sites to distinguish among species.

To distinguish among species molecular approaches use the divergence between homologous sites in DNA sequences from different individuals. Overall, mitochondrial DNA is a powerful tool to identify a species, since sequences at its loci evolve, typically, faster than the ones at nuclear loci in most animals. (Vawter and Brown, 1986; Wilson et al., 1985; Hebert et al., 2003; Ivanova et al., 2007). This happens because, due to its maternal inheritance, mtDNA is haploid, hence in species with a sex ratio of 1:1 and with the same variance in reproductive success between male and female, its loci present an effective population size fourfold smaller than nuclear loci. Genetic drift, therefore, occurs faster between alleles at mitochondrial loci than at the nuclear ones (Birky, 1991). In particular, the mitochondrial DNA COI (Cytochrome c Oxidase subunit I) and NADH2 (NADH dehydrogenase subunit 2) regions, as well as the nuclear ribosomal DNA ITS2 (Internal Transcribed Spacer) are the sequences used for species identification, as their sequence divergence among congeneric species is sufficient to ensure a reliable diagnosis (Hebert et al., 2003; Pank et al., 2001; Collins and Paskewitz, 1996; Taylor and Bruns, 1999; Ward et al., 2008). In addition, due to its maternally inheritance mtDNA presents some limitations. It only gives information regarding the maternal lineage and it would not cover the presence of hybrids (Cruz et al., 2015; Donnellan et al., 2015; Martine Berubé & Aguilar, 1998; Morgan et al., 2012). Therefore, it is recommended to conduct further nuclear DNA analysis whether the presence of a hybrid is suspected.

Regarding shark identification, there are five main techniques that have been developed and are continually improved to suit at best the type of product and the logistic needs of the research aims. These techniques are DNA Barcoding, Mini-DNA Barcoding, species-specific PCR, Multiplex real-time PCR and LAMP. The approaches employed to identify the species of origin depends on the quality of the DNA residuals in the product of interest (Cardeñosa, 2018) (Hellberg et al., 2019).

4.1 DNA Barcoding

DNA Barcoding is a sequencing-based assay consisting of the analysis of a 550-650 bp long fragment of the 5' region of the cytochrome c oxidase I (COI) gene, or/and a 574 bp long fragment of the NADH2 gene (Cardeñosa et al., 2017). DNA fragments are first amplified using a universal set of primer via PCR (Polymerase Chain Reaction) and then sequenced. The sequences can then be entered in one of the searchable databases, such as the Barcode of Life Data System (COI only; BOLD, http://www.boldsystems.org/index.php/IDS_OpenIdEngine) the National Center for Biotechnology Information (NCBI) Basic Local Alignment Search Tool (COI or NADH2; BLAST, http://blast.ncbi.nlm.nih.gov/Blast.cgi) and/or using diagnostic bases (Wong et al., 2009).

This approach was used successfully by (Hellberg et al., 2019) to identify the species composition of shark product sold in California. They demonstrated that shark mini-barcoding presents a higher identification rate (54.3%) than fish DNA barcoding (8.6%) to identify CITES-listed species from a more diverse spectrum of processing level in shark products. Although, DNA barcoding, utilising full COI fish primers, was the only method able to identify winter skate from cartilage pills.

4.2 Mini-DNA Barcoding

Mini-DNA barcoding (Fields et al., 2015; Hajibabaei et al., 2006; Shokralla et al., 2015; Meusnier et al., 2008) is an assay very similar in methodology to DNA barcoding, except for the fact that during the amplification it targets smaller fragments within the COI gene in order to allow sequencing of highly degraded DNA. It employs a cocktail of five primers. Three are universal shark primers for the same annealing sites targeted in the barcoding approach. One forward primer at the beginning in conjunction with two reverse primers, overlapping, at the end of the COI amplicon. Whilst, the remaining two are internal primers reverse and forward, respectively, that anneal to two different target sequences within the targeted 5' region of the COI gene. This nested use of primers allows the analyst to simultaneously amplify two complementary fragments of the COI gene and the full COI gene, depending on the quality of the DNA analysed. Therefore, the technique yields two short fragments of the COI gene (~150 bp amplicon and ~200 bp amplicon) and in some cases the full gene, which after the amplification are sequenced. The sequences are, then, entered in one of the searchable databases (as described above) or species are detected on diagnostic bases. (Wong et al. 2009).

This approach was used by (Zahn et al., 2020) to identify sharks to species or genus level from shark cartilage pills.

Cardeñosa (et al., 2017) also developed a mini-barcoding essay that uses multiplex-PCR, which was used by (Cardeñosa et al., 2020) to assess the composition in species of the small, low-value fins traded in the Honk Kong market. They found that low-value fins are mainly from shark-like rays (62.9 % of the samples collected) and juvenile individuals from large (37.1%) shark species.

4.3 ssPCR

Species-specific Polymerase Chain Reaction (ss-PCR) is based on previously optimised primers (species-specific primers) leading to a presence or absence response of the targeted species on an agarose gel. The primers can only amplify targeted DNA sequences allowing to identify species that have their COI gene sequences already published on BOLD or NCBI. Therefore, this approach cannot detect oceanic whitetip and whale shark as a primer haven't been published yet (Cardeñosa et al., 2017). This approach allows to perform the test targeting for more than one species at once, combining multiple species-specific primers simultaneously in one PCR reaction. In addition, to provide information about the presence of DNA in the sample, when annealing to targeted DNA sequences fail, it also includes a positive control universal primer. So far, the technique involves the use of the nuclear ribosomal ITS2 region (which had been demonstrated to be sufficiently conserved within and enough divergent among chondrichthyans species, Pank et al., 2001) or mitochondrial COI gene. This approach applies to cases with prior knowledge of the products' species composition, otherwise, the reaction needs to be run more than one time which then make it more time and cost expensive than a DNA/mini-DNA barcoding.

This approach was used by Clarke (et al., 2006a) to identify the composition in species of the Hong Kong market and by (Shivji et al., 2002) to identify body parts of pelagic sharks.

4.4 Multiplex real-time PCR

Real-time PCR (rtPCR) technique is an alternative to the usual forensic tools (Cardeñosa et al., 2018). It utilises species-specific primers (Abercrombie et al., 2005; Abercrombie et al., 2004; Chapman et al., 2003; Shivij et al., 2002) and fluorescent dye (e.g Taq Man probes, SYBR green) enabling the analyst to visually detect the presence of targeted species and eliminating the need for sequencing and agarose gel. The analyst can, in fact, determine whether the amplification had taken place observing the presence of amplification's products in the reaction tube and distinguish between different species looking at the amplification plot. This graph depicts the amplification's fluorescent signal against the cycle number, giving information regarding the sequences annealed to the species-specific primers. In addition, this approach provides further information on the identification of a target locus or species, since during the last stage of its protocol, the dissociation of the heated double stranded DNA generates melt curves and melt curve temperatures. These curves depict the GC/TA ratio and size of the generated amplicons, since the melting temperature of a DNA strand depends on its composition in GC/TA (Ririe, 1997; Rouleau et al., 2009).

Multiplex rt-PCR utilises rt-PCR thermal cyclers, such as QuantStudio5 System, which together with all the equipment needed are sufficiently portable and present a small footprint. Rt-PCR equipment could therefore, be installed in ports or customs inspection areas, where it could provide a quick and cheap (~4 hours for 95 samples; $0.94 USD per sample) detection of the CITES-listed species presence in the, usually, big shipments of shark products (i.e., 102–103 kg)(Shea & To, 2017). In this way, this approach could provide sufficient information to hold shark products shipments based on the presence of illegally traded CITES-listed species, supplying time to proceed with more robust species identification approaches. With this purpose, Cardeñosa (et al., 2018) conducted three field tests in Hong Kong, collaborating with the Agriculture Fisheries and Conservation Department (AFCD). All the tests give positive results, inasmuch when corroborated the multiplex rt-PCR products with DNA barcoding, the analysis gave four false negative results out of the hundred eighteen samples examined, three of which failed also to be identified to the species level by the DNA barcoding assay.

4.5 LAMP

LAMP, Loop-mediated isothermal amplification, is a rapid DNA amplification technique that uses a DNA polymerase with strand displacing activity at a single temperature (Wilson et al., 1985; Notomi et al., 2000; But et al., 2020). It targets the mtDNA COI and NADH2 regions. Compared to the previously described PCR techniques, LAMP is more sensitive and specific, since it involves two to three pairs of specific primers which are designed to target four to six regions on the targeted DNA strand. When annealed to it, they generate loop-formed DNA allowing to obtain an immediate and accurate detection of all the CITES-listed species, including whitetip and whale sharks (But et al., 2020). It can be conducted outside of the laboratory, since it doesn't need a thermal cycler and it gives an immediate visual detection. It produces, even with degraded DNA, a higher quantity of DNA products than a classical PCR method, and a fluorescent dye binds the DNA amplicons during the reaction. In particular, using SYBR Green I dye all the positive reactions turn to a yellow colour, whereas all the negative reactions turn to orange, under white light. As the rtPCR, this technique generates melt curves and melt curve temperatures (But et al., 2020).

This approach hasn't been employed in any forensic studies yet. Although, it was successfully tested on all the CITES-listed species by the authors (But et al., 2020).

Molecular technique	Pros	Cons	Product's degree of processing
barcoding	the strongest evidence in court	most expensive and time consuming	It works best on unprocessed products, but it also identified the winter skate from cartilage pills (Hellberg et al., 2019)
	it allows the identification of all traded shark species		
mini-barcoding	very accurate	expensive	It works well on highly processed shark products (Cardeñosa et al., 2017; Cardeñosa et al., 2020; Hellberg et al., 2019)
	it provides robust identification to species level of all CITES-listed sharks and to genus of the non CITES-listed sharks		
ss-PCR	cheap	yes or no response	It works on the entire spectrum of shark products (Clarke et al., 2006a; Shivij et al., 2002)
	quick	needs priors knowledge of the species composition	
rt-PCR	detection in real-time	allows the identification of 9/12 of the CITES-listed species	It works on the entire spectrum of shark products (Cardeñosa et al., 2018)

	can be used outside the lab	needs prior knowledge of the species composition	
LAMP	detection in real-time can be used outside the lab no need for sequencing -> cheap allows the detection of all the CITES-listed species	needs prior knowledge of the species composition	It works well on all kind of processing products But et al., 2020

Tab. 2 Pros, cons, and product's degree of processing to which the aforementioned molecular techniques are applicable.

5.0 Conclusion

In conclusion, it is evident that the shark fin trade is a heavy threat to chondrichthyans populations. In order to give better directions to implement the catches report and conservation policies, it is important to pursue research on the subject, conducting more sampling on local markets all over the world and their molecular analysis in order to assess the actual shark populations status. Furthermore, in combination with ecological and geographical investigations, it would allow deeper information in their roles in the food web, making it possible to reach a better understanding of the global status of chondrichthyans.

Therewithal, it is fundamental to keep in mind that the shark fin trade, as well as meat and fish consumption, holds a foremost social and cultural side which is, the basis of the problem. Accordingly, in order to make the shark fin trade sustainable, it is crucial to significantly decrease the market demand for shark products. This could be achieved by actuating a campaign to raise awareness about the detrimental effects that shark fin consumption can have on human health, mainly within the Chinese wealthy middle class, the major consumers of shark fin soup. It was demonstrated by a number of researches conducted by the Hong Kong government and others, that 10% of all the dried sea food samples, which the majority was shark fins, contained hazardous compounds, such as nitrogen peroxide and formaldehyde and, being sharks apex predators, chondrichthyans products also included high levels of mercury and methylmercury (Anon., 2004; Clarke, 2004b; Man, Wu and Wong, 2014). However, elderly people who perhaps still believe in the traditional health benefits, are obstinate in eating shark fin soup. The younger generations might be more attuned to recent health and conservation warnings.

Another factor that could change the fate of the shark fin trade is the outbreak of the COVID-19. It is general belief that COVID-19 crisis will change our society permanently, not only influencing people behaviour and imposing a new set of restrictions on their everyday life, but it holds the potential to change once for all the wildlife market as they are known today. In fact, there is a group of scientists which is calling on the government to reach a permanent closure and definitely ban the consumption of wildlife in China (Niang, Peng and Zhang, 2020). Conversely, other experts fear that a wildlife market ban would just fuel the illegal market (Challender, 2019; Lemieux et al., 2009). Whether this will happen or not it is very difficult to say, especially because wildlife trade is a very profitable business, and therefore a controversial topic.

To conclude, this essay shows that throughout the last two decades there has been rising concern regarding chondrichthyans populations. Nonetheless, it also appears that there is still a lot more work that needs to be done both ecologically and socially, in order to share sustainably our oceans. This can be pursue only changing our traditions around these charismatic class of fish, which is one of the oldest and most diverse group of vertebrates on Earth.

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