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The trade in sharks and their products in the United Arab Emirates

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ABSTRACT

The rapid growth in the demand for shark products, particularly fins, has led to the worldwide overexploitation of many elasmobranch species. Although there are growing concerns about this largely unregulated and unmonitored trade, little information still exists about its dynamics, the species involved and the impact of this pressure on stocks in various regions. Our study provides the first attempt at characterizing the trade in shark products from the United Arab Emirates (UAE), the fourth largest exporter in the world of raw dried shark fins to Hong Kong. A review of trade records and informal interviews with local traders confirmed that the UAE is being used as hub in the broader North Indian Ocean region for the trade in shark products with the Emirati fishery minimally contributing to this trade. Results based on morphological identification of sharks (n = 12,069) and DNA barcoding of tissue samples (n = 655) indicated that the trade was made up of at least 37 species. The most abundant families represented at the Dubai study site were the Sphyrnidae (9.3%), Lamnidae (9%) and Alopiidae (5.9%). While information was mostly limited to shark products originating from the UAE and Oman, results indicated that 45.3% of species traded were considered to be at high risk of global extinction based on the IUCN Red List Global Assessments. Since many of the species found during this survey are likely part of stocks shared with other countries, regional cooperation and management will be crucial to ensure their long term survival.

1. Introduction

The vulnerability of sharks to fishing is directly linked to their K-selected life histories but also to the growing market for shark products, a major driver for the exploitation of many species (Stevens et al., 2000; Clarke, 2002; FAO, 2009). Among fishery commodities, shark products, including meat, fins, oil, skin, cartilage, and jaws, are highly diverse and versatile in both their usage and their value (Clarke, 2004; Hareide et al., 2007). Reports indicate that the greatest quantity of international trade in shark products is in the form of fresh, chilled or frozen, unspecified, shark meat (Clarke, 2004). Other shark derived products have a wide range of utilization (Rose, 1996; Vannuccini, 1999) and yet trade in these products appears to fluctuate over time with substantial declines documented indicating they are unlikely to be driving shark catches (Clarke, 2004). On the other hand, the demand for shark fins, and their high value, is a major driving force for shark mortality worldwide with estimates ranging between 26 and 73 million sharks killed annually to supply fin markets (Clarke et al., 2006b) out of an estimated 63–273 million sharks captured annually (Worm et al., 2013).

The biggest market for shark fins is China, although huge markets exist in Japan, Hong Kong, Singapore and Korea (Vannuccini, 1999). For decades, Hong Kong has been the center of the world trade in shark fins handling between 50% and 85% of global shark fin imports from at least 85 countries (Clarke, 2002, 2004). From 1998 to 2011, Spain, Indonesia, the United Arab Emirates (UAE), Taiwan and Japan comprised the top five countries exporting shark fins to Hong Kong (Clarke et al., 2006b; Hareide et al., 2007; Anon, 2012). However, this trade remains largely understudied and little information is available on the geographic origin of these fins and the species from which they originated (Clarke et al., 2006a).

There are growing concerns regarding the ability of shark populations to sustain fishing pressures driven by market demand in parallel with trade growth (Camhi et al., 1998; Baum et al., 2003; Clarke et al., 2007). Improved and accurate data on shark trade

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volumes and their products are necessary to determine the relative importance of trade as a threat to species, trends in exploitation, and to examine the potential role of trade regulations as an additional measure for shark conservation (Camhi et al., 1998; FAO, 2009).

In the past 15 years, the UAE has emerged as a regional market for fish and has become a hub for fish exports to Gulf Cooperation Council (GCC) countries, the Middle East, Africa and Europe (EU) (Al Mousa et al., 2008). Recent research indicates shark fisheries in the UAE are essentially driven by shark fin export markets (Jabado et al., 2014a) with reports showing exports up to 500 mt of dried raw fins annually to Hong Kong, playing a crucial role in the international shark fin trade as a regional export hub (Fowler et al., 2005; Hareide et al., 2007; WildAid, 2007). However, much of the trade in sharks and their products remains unregulated with little information available regarding species and quantities involved. Since different species have varying natural capacities to respond to fishing pressure, any management and conservation efforts require reliable species-specific catch and trade data (Abercrombie et al., 2005; Clarke et al., 2006a; Holmes et al., 2009).

Various methodologies for characterizing the shark fin trade are now available and include market surveys as well as genetic methods. Using molecular techniques to identify shark species and their body parts from specimens morphologically difficult to identify, or to confirm morphological species identification has become an accepted technique (Shivji et al., 2002; Clarke et al., 2006; Holmes et al., 2009). Because the UAE plays such an important role in the global shark fin trade, a study was urgently needed to characterize shark products traded from this key location. Therefore, the aims of this study were to (1) investigate national and international trade dynamics of various shark products; (2) assess species composition and geographic origin of sharks involved in the trade; (3) confirm field identifications by barcoding a subsample of species from the survey site; (4) assess the conservation status of traded species.

2. Materials and methods

2.1. Study site, samples and species identification

Data collection was ongoing from October 2010 until the end of September 2012 at the Deira fish market in Dubai, the only auctioning site in the UAE for sharks destined for the international trade (Fig. 1). Whole sharks and fins are auctioned here daily from 17:00 to 20:00 h. Data were collected four times a month until January 2012 and then twice a month until September 2012 (Jabado et al., 2014b). While on some days sharks were transported from other emirates (Abu Dhabi and Sharjah) to this site, the large majority of sharks and fins auctioned in Deira originated from Oman. Whole sharks were typically offloaded from trucks and identified to the lowest possible taxonomic level using keys from Compagno et al. (2005) and Last and Stevens (2009), and their geographic origin was recorded. Samples originating from fresh or dried fins could not be identified to species level and only information about their capture location was noted. Furthermore, sharks here were displayed side by side on a platform, making it difficult to move large specimens. Therefore, at occasions, accurate identification was not possible since key morphological characteristics (i.e. fins) were not always visible. To confirm the accuracy of these identifications, tissue samples from 655 specimens originating from Omani transshipments and belonging to 27 morphologically identified species were collected. All samples were immediately preserved in 95% ethanol, and taken to the laboratory for storage at −20 °C until required for analyses.

A total of 182 tissue samples from three species, including great (*Sphyrna mokarran*), scalloped (*S. lewini*) and smooth (*S. zygaena*) hammerheads, were sent to the Red Sea Research Center for genetic analyses. DNA extractions, PCR amplifications and sequencing were undertaken following methods described in Spaet and Berumen (2015).

A total of 473 tissue samples (including 11 fin samples) representing 26 species were sent to the University of Guelph for

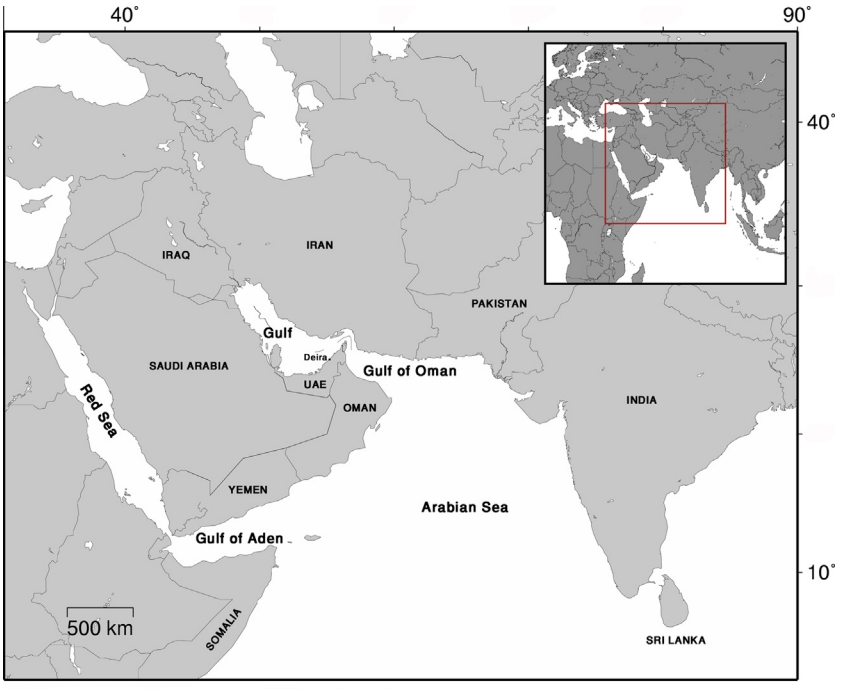

Fig. 1. Map of the Arabian region indicating the Deira market site where the trade survey was conducted.

analyses. Extraction protocols detailed by Ivanova et al. (2006) were followed and employed PCR primers C_VF1LFt1 and C_VR1LRt1 (Ivanova et al., 2007) appended with M13 tails (Messing, 1983). PCR amplification was conducted on an Eppendorf Mastercycler gradient thermal cycler (Brinkmann Instruments, Inc., NY, USA). The PCR thermal cycling employed was: 2 min at 95 °C; 35 cycles of 30 s at 94 °C, 30 s at 52 °C, and 1 min at 72 °C; followed by 10 min at 72 °C. PCR products were labeled using the BigDye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, USA) and sequencing performed on an ABI 3730x1 DNA Analyzer (Applied Biosystems, Inc.). Sequences and sample records can be viewed on the Barcode of Life Data System or BOLD (www.boldsystems.org) under project code GEP (Gulf Elasmo Project).

Species identifications were made using both the BOLD Identification Engine and GenBank nucleotide database (www.ncbi.nlm.nih.ggoc/nucleotide). All sequences have been deposited in GenBank, via the use of BarSTool, under accession numbers KP177224-KP177317 and KP193143-KP193455.

2.2. Trade records, market observations and trader interviews

A comprehensive review of available literature regarding trade in shark products from the UAE was conducted. Furthermore, trade dynamics of various shark products were investigated through market observations and informal, unstructured, trader interviews at the study site. Interviews during each survey trip were conducted before or after the auctions and respondents were the same four to ten traders and middlemen on site. Questions aimed at ascertaining the distribution chain of shark products, their value, final destination and any other insights on this trade. The IUCN Red List status of each shark species traded was also examined to determine their relative risk of extinction based on global assessments.

3. Results and discussion

3.1. Species identification and composition of trade products

A total of 12 069 individuals from 33 shark species were recorded in Deira with the majority of specimens originating from Oman. Of these, 6 751 were identified to species level, while for 5 735 specimens, morphological characters were insufficient for accurate species identification (including 21 fins identified from DNA barcoding). Barcoding was successful for 77.2% of samples analyzed and confirmed that field identification of 26 species was accurate (Appendix A). Of the hammerhead samples analyzed, four *S. lewini* samples returned ambiguous results with misidentifications when matched in the databases and two failed to provide any sequences. Of the remaining samples, 330 yielded good quality sequences suitable for species identification. However, 90 samples failed to provide any sequences; 15 provided low quality sequences that were too short and thus not usable for species identifications; and 38 sequences matched species different than those identified in Deira. This suggests contamination in the field or during transportation in trucks since for example, sequences from species identified in Deira as *Alopias superciliosus* matched *S. zygaena* in BOLD, species distinguishable morphologically and unlikely to have been confused in the field. Therefore, unlike what was noted by Tillett et al. (2012) where overall identification error for shark species was at 19.8%, field identification accuracy in this study was extremely high. Sequences from the analysis of 11 fins did not flag additional species and included pig eye (*Carcharhinus amboinensis)*, silky (*C. falciformis)*, mako (*Isurus oxyrinchus)*, spinner (*C. brevipinna)* and lemon (*Negaprion acutidens*) sharks.

Along with sharks transported from landing sites across the UAE (Jabado et al., 2014b), at least 37 shark species are traded in Deira (Table 1). This likely represents the minimum number of shark species traded in the UAE since products from other species could have been imported directly to Emirati processing sites. It is also important to note that while the UAE is an important destination for Omani products, some Omani traders process shark products on site and export dried shark fins directly to Asia, bypassing the UAE (Henderson et al., 2008). Reports on the fishery sector from Oman indicated that in 2005, 27% of the total fish was exported to the GCC market, particularly to Dubai, while the remaining catches were directly exported to EU and Asian markets (ESCWA, 2007). No species-specific information was available for these exports but it is clear that the UAE only receives a fraction of Omani fish catches and, presumably, shark landings. Furthermore, there is domestic shark consumption in Oman (Henderson et al., 2008) and therefore exploitation levels for many species are likely significantly higher than reported here.

The Carcharinidae family represented 74.9% of identified sharks, followed by Sphyrnidae (9.3%), Lamnidae (9%) and Alopiidae (5.9%). The most common species, together comprising 64.9% of all traded species, were spot tail (*C. sorrah*) (23.2% of all traded specimens), black tip (*C. limbatus*) (9.5%), *I. oxyrinchus* (9%), *C. falciformis* (8%), *C. brevipinna* (7.8%) and milk sharks (*Rhizoprionodon acutus*) (7.3%). Other species important in the trade included *S. lewini*, bull (*C. leucas*), sandbar (*C. plumbeus*) and pelagic thresher sharks (*A. pelagicus*) each representing over 3% of species traded. The remaining 23 species each consisted of less than 3% of the total species traded. Species composition of sharks traded here was different than in the shark fin auction trade in Hong Kong (Clarke et al., 2006a). In their study, 34–45% of the fin trade comprised 14 species whereas six species represented 65% of all species from Oman. The large quantities of *C. sorrah*, *R. acutus*, *C. falciformis* and *C. limbatus*, recorded here are presumably a reflection of their high abundance in Omani waters. Still, several species recorded in high quantities in Hong Kong also comprised a high proportion of the trade in this study (Table 1). For instance, in Hong Kong, hammerheads represented 5.9% of the trade; three species of threshers (including the common thresher, *A. vulpinus*) comprised 2.3%; *I. oxyrinchus* represented 2.7%; and blue sharks (*Prionace glauca*) comprised the majority of fins at 17.3%. While trade quantities of these species from both countries are different, many of the dominant species were similar and as suggested by Clarke et al. (2006a), their prevalence in the trade may reflect their relative abundance in fisheries, a preferential demand for their fins, or a combination of these factors. In fact, traders in the UAE and from other parts of the world confirmed that fins from hammerheads are highly priced and this explains their high representation in the fin trade. Furthermore, *I. oxyrinchus* is well regarded for its meat, recognized for its high quality, and in demand in many parts of the world (Rose, 1996). Contrary to what has been reported from other areas where *P. glauca* is the most widespread and abundant shark species (Bonfil, 1994; Clarke et al., 2006a; Hareide et al., 2007), it was not one of the dominant species traded in our study. Many trade studies were conducted over a decade ago and while it is possible that a reduction of blue shark catches could be attributable to improved management of shark stocks in some areas, it could also reflect a decline in stocks due to overfishing (Lam, 2009). Data from the northwest Atlantic suggested significant declines in *P. glauca* abundance (Simpfendorfer et al., 2002; Baum et al., 2003). Furthermore, this species was not recorded in Oman in over four years of regular landings surveys (Henderson and Reeve, 2011). Reports from Oman have indicated many fish stocks from coastal fisheries have been overexploited due to inadequate management of fish resources (ESCWA, 2007) and therefore, although no data were available on blue shark abundance

Table 1
Total number (n) and percentage of total (%) of species recorded from Oman with their IUCN Red List status and their assessment dates (including fins confirmed as originating from those species ($n = 21$) and individuals of species not measured) (**EN** Endangered; **NT** Near Threatened; **VU** Vulnerable; **DD** Data Deficient; **LC** Least Concern).

Family	Species name	Common name	*n*	%	IUCN
Ginglymostomatidae	*Nebrius ferrugineus*	Tawny Nurse shark	13	0.19	VU (2003)
Stegostomatidae	*Stegostoma fasciatum*	Zebra shark	4	0.06	VU (2003)
Rhincodontidae	*Rhincodon typus*	Whale shark	2	0.03	VU (2005)
Alopiidae	*Alopias pelagicus*	Pelagic thresher	246	3.65	VU (2004)
	Alopias superciliosus	Bigeye thresher	156	2.31	VU (2007)
Lamnidae	*Isurus oxyrinchus*	Shortfin mako	607	9.01	VU (2004)
Triakidae	*Mustelus mosis*	Arabian Smoothhound	26	0.39	DD (2008)
Hemigaleidae	*Chaenogaleus macrostoma*	Hooktooth shark	2	0.03	VU (2008)
	Hemipristis elongata	Snagglетooth shark	11	0.16	VU (2003)
	Paragaleus randalli	Slender Weasel shark	1	0.01	NT (2008)
	Carcharhinus altimus	Bignose shark	132	1.96	DD (2008)
Carcharhinidae	*Carcharhinus amblyrhynchoides*	Graceful shark	20	0.3	NT (2005)
	Carcharhinus amblyrhynchos	Grey Reef shark	5	0.07	NT (2005)
	Carcharhinus amboinensis	Pigeye shark	127	1.88	DD (2005)
	Carcharhinus brevipinna	Spinner shark	530	7.86	NT (2005)
	Carcharhinus dussumieri	Whitecheek shark	9	0.13	NT (2003)
	Carcharhinus falciformis	Silky shark	539	8.0	NT (2007)
	Carcharhinus leiodon	Smoothtooth Blacktip	19	0.28	VU (2005)
	Carcharhinus leucas	Bull shark	348	5.16	NT (2005)
	Carcharhinus limbatus	Blacktip shark	640	9.5	NT (2005)
	Carcharhinus longimanus	Oceanic White tip	30	0.45	VU (2006)
	Carcharhinus macloti	Hardnose shark	12	0.18	NT (2003)
	Carcharhinus melanopterus	Blacktip Reef shark	42	0.62	NT (2005)
	Carcharhinus plumbeus	Sandbar shark	214	3.18	VU (2007)
	Carcharhinus sorrah	Spottail shark	1567	23.25	NT (2007)
	Galeocerdo cuvier	Tiger shark	39	0.58	NT (2005)
	Loxodon macrorhinus	Sliteye shark	168	2.49	LC (2003)
	Negaprion acutidens	Sharptooth Lemon shark	41	0.61	VU (2003)
	Prionace glauca	Blue shark	76	1.13	NT (2005)
	Rhizoprionodon acutus	Milk shark	495	7.34	LC (2003)
Sphyrnidae	*Sphyrna lewini*	Scalloped Hammerhead	365	5.42	EN (2007)
	Sphyrna mokarran	Great Hammerhead	79	1.17	EN (2007)
	Sphyrna zygaena	Smooth Hammerhead	186	2.76	VU (2005)
Total		6751			

there, the low numbers reported here could indicate their stocks have been reduced.

Based on global IUCN Red List assessments, 39.3% of all sharks traded here were considered Near Threatened, 6% Least Concern, while 9% were Data Deficient (IUCN, 2012). Also, 39.3% were considered Vulnerable and 6% were listed as Endangered indicating that 45.3% of species found in Deira faced a high risk of global extinction. It is highly probable that a number of other species threatened on a global scale would also be recorded if further studies were undertaken on all shark species traded through the UAE. Of the species recorded from Oman, the majority represented pelagic and/or highly migratory species, including three hammerhead species, two threshers, the oceanic white tip (*Carcharhinus longimanus*), and the mako sharks that usually inhabit deeper waters (Compagno et al., 2005). However, Henderson et al. (2008) reported that most Omani fishing activity was undertaken in less than 100 m water depth. Therefore, the fact that many pelagic species recorded here frequently move to shallow waters over continental and insular shelves to forage, breed, or partake in social behaviors (Compagno et al., 2005; Dulvy et al., 2008) could explain their occurrence in the trade. For instance, based on data from catches in the Kwazulu-Natal shark nets, makos are reported to move inshore from South African deep waters (Cliff et al., 1990), which could indicate they are captured in Oman during inshore migrations. Indeed, one of the most common threats for these migratory species is that breeding or migrating aggregations are specifically targeted by fisheries increasing their susceptibility to fishing pressure (IUCN, 2007).

Due to the limited state of knowledge on many of these migratory species, it is difficult to determine the global status of their stocks. However, it is assumed that due to their low productivity, they have a limited capacity to withstand high mortalities and intense exploitation from fisheries (Stevens et al., 2000; Dulvy et al., 2008). IUCN Red List assessments are determined based on the quality and quantity of data available regarding each species from different regions (Dulvy et al., 2008). Data on fishing mortality are limited from this region and all assessments for species listed as Vulnerable or Near Threatened such as *C. longimanus* and *C. falciformis* are based on data from other parts of the world. Since no shark species have been assessed regionally, it is critical to monitor them, collect regional data on exploitation rates and determine priorities for conservation. For instance, fishermen in the UAE stated that makos had disappeared from Gulf waters and this species was not found during landing site surveys across the country (Jabado et al. 2014a; Jabado et al. 2014b). However, this species was a substantial component of the trade from Oman and it is clear that exploitation rates need to be assessed regionally. Furthermore, the three hammerhead species found in large quantities here are targets or by-catch species in a wide variety of fisheries throughout their range and are listed as Endangered on the IUCN Red List because substantial population declines are suspected to have occurred in many areas as a result of fishing (Baum et al., 2003; Myers, 2007; Ferretti et al., 2008). Shark fin traders have indicated these species obtain a premium in the trade due to their fin characteristics, and therefore pressure on them is likely to continue without some conservation intervention (Abercrombie et al., 2005). Indeed, Lack and Sant (2009) showed an 80% increase in global reported catch of hammerheads between 2000 and 2007. Therefore, identifying which species are most susceptible and most impacted by exploitation is a critical step to

determine priorities for research and management (Shark Advisory Group and Lack 2004).

3.2. Market observations and trader interviews

Market surveys indicated trade in shark products consisted mainly of fins and meat. Jaws and teeth were infrequently sold to tourists while the market for cartilage was largely non-existent. Liver oil was occasionally traded locally for dhow proofing and shark carcasses were discarded after fins and meat were removed. Although further research needs to be undertaken to determine if fresh fins transported from Oman originated from sharks processed at landing sites or finned at sea, what was clear, is that the majority of sharks were fully utilized. Product distribution methods varied according to specimen origin, size, type of product and end use (Fig. 2).

Small bodied sharks (<1000 mm L_T) caught in UAE waters or imported from Oman were sold fresh locally as 'jarjur' and retailed between AED (Emirati Dirham) 10 and 20 per kg (USD 2.5 to 6 per kg). If unsold for several days, fins were removed while the meat was either discarded or processed. If processed, shark carcasses (without fins and heads) were cut into small cubes, salted and dried, before being packaged into plastic bags and sold locally. Skins were occasionally removed, dried and sold in Deira while fins were dried and packed for exports. Large bodied sharks (>1000 mm L_T) were rarely sold domestically. If found at market stalls, they were usually cut as steaks and sold at AED 15 per kg (about USD 4 per kg). All large sharks caught in UAE waters were either processed at various facilities or transported to Deira in trucks and kept chilled until the daily auction. Sharks from Oman were transported in refrigerated trucks from various locations, i.e. Sohar, Shinas, Muscat, Sur, Masirah island, Mahoot, Dugum and Salalah, for sale to local traders in Deira. On arrival at this site, sharks and fins (without respective carcasses) were displayed according to their geographic origin and size in front of trucks transporting them. Fins were usually fresh with pectoral fins displayed in sets, caudal (whole tail) and first dorsal fins separately, and pelvic and second dorsal fins in mixed piles containing different species. On occasions, large quantities of dried small or large fins packed in gunny sacks, were also sorted and weighed at the site. Furthermore, on rare occurrences trucks full of dried shark skins were also offloaded in Deira. Fins and meat were auctioned in bulk daily. Prices fluctuated between AED 8 000 (USD 2 200) and AED 20 000 (USD 5 500) for 20 large bodied sharks depending on species and sizes. All fins were then immediately removed on site by middle men (crude or straight cut with meat remaining) and bagged. Shark meat was generally not processed in Deira and carcasses were either reloaded onto trucks or if processed, transported on carts to other areas of the Deira site. Processing sites, for drying fins and meat, were generally located in other emirates.

Traders believed the trade in shark meat was becoming more profitable since large quantities of meat could be sold with higher profit margins than fins after drying. Fresh meat was auctioned at approximately AED 6 per kg (about USD 1.7 per kg) but could resell at prices up to AED 40 per kg (USD 11 per kg) after drying. Therefore, unless meat was sold locally, everything was exported. Camhi et al. (1998) reported that even though shark meat was consumed locally in some countries, this product had generally been of low value for export markets. Yet, Clarke (2004) and Hareide et al. (2007) suggested there may be an expanding market for frozen shark meat in mainland China with trade statistics showing a significant increase in imports in the past decade. Indeed, while the focus of shark processing plants in China has remained on fins, the target has shifted to all body parts, including fins from both small and large bodied sharks, to sustain the involvement of smaller plants in this business (Li et al., 2012). It is unclear if the trade in shark meat in the UAE is a relatively new market strategy yet, since this trade is profitable, the full utilization of sharks is ensured.

According to the respondents, the main market for shark meat from the UAE was Sri Lanka but these exports could not be quantified as trade records were unavailable. This, however, seems plausible since there is a high demand for shark meat in Sri Lanka

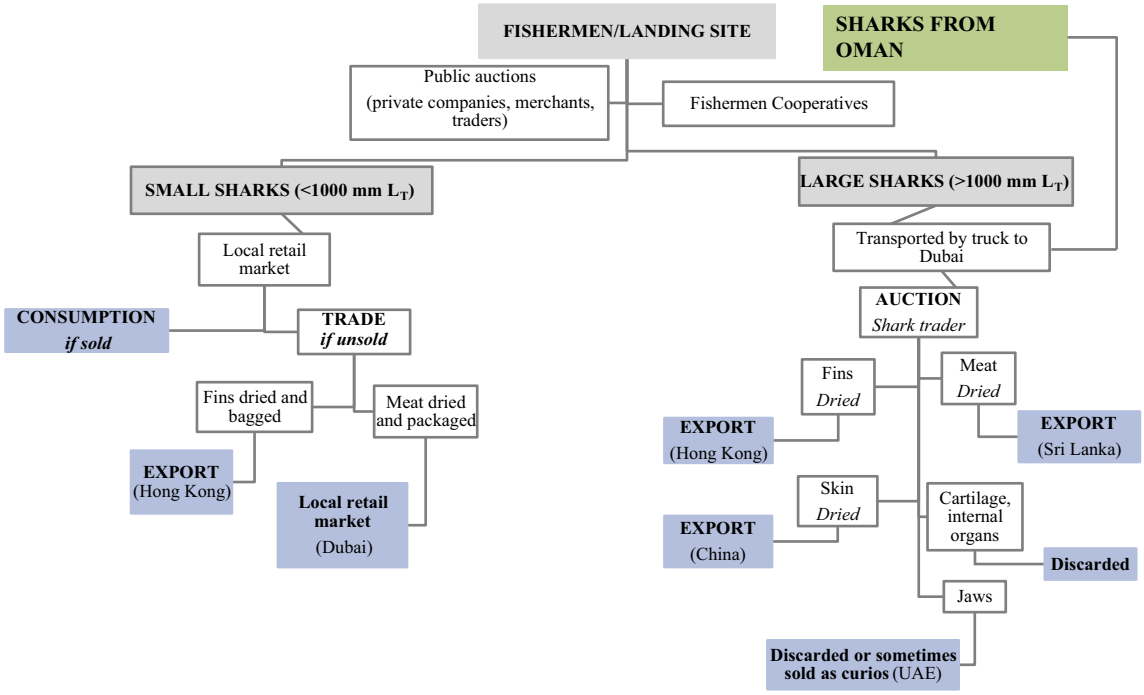

Fig. 2. Distribution chain for sharks landed whole in the UAE and imported from Oman based on interviews with traders. Boxes in grey indicate the final destination of each product.Distribution chain for sharks landed whole in the UAE and imported from Oman based on interviews with traders. Boxes in blue indicate the final destination of each product.

for consumption (Fischer et al., 2012) as it is a significant component of the local diet and provides much of the needed protein requirements for poorer communities (WildAid, 2007). Rose (1996) reported that meat exports were limited because of the difficulty associated with having to process the meat immediately after capturing sharks. The strong smell of ammonia noticeable during auctions where sharks were displayed in the heat, was not a concern for traders and they stated that meat could still be sold after drying. Dried shark meat, packaged and retailed for domestic consumption in the UAE, was unlikely to be marketed for Emiratis as they prefer fresh meat from small bodied sharks (Gubanov and Schleib, 1980; Jabado et al., 2014a). However, it is likely that the market for this product was due to large numbers of Indian expatriates living here since dried shark meat is very popular in India and consumed along many coastal areas (Hanfee, 1997).

Skins imported from Oman were dried and survey respondents affirmed that these were exported directly to China. Rose (1996) reported that the market for skins is limited because they need to be processed immediately in order to preserve the quality, making it difficult to process both skins and meat simultaneously. Traders here suggested that skin may be used for both leather and domestic consumption at its export destination in China. This is corroborated in the literature where skin is used as leather or sandpaper (Vannuccini, 1999; WildAid, 2007), is commonly consumed in some Chinese provinces, where it is fried as a snack or even cooked with soup (Lam, 2009), and is an important component of trade both for export and with processing factories (Li et al., 2012).

An interesting note from this study is that traders mentioned that some species such as carpet sharks and whale sharks (*Rhincodon typus*) were not marketable. In fact, there was no demand for whale shark products and, when captured, specimens were auctioned at very low prices. Whether this was due to the protected status of whale sharks in the UAE and its listing on the Convention on International Trade in Endangered Species (CITES) is unclear. Reports from other countries indicate that this species is valuable and in demand in many markets. Li et al. (2012) noted that whale shark fins in China were some of the most expensive products. Similarly, Hong Kong traders declared that whale sharks were a valuable species for their business (Clarke, 2002).

All traders confirmed that the most lucrative business was the trade in large shark fins, which were almost exclusively destined for the international trade, while fins from small bodied sharks, meat and skin were only marketed for additional income. Sharks with 'white fins' (i.e. from hammerheads) were considered of the highest quality, and, therefore, the most expensive, followed by sharks with 'black fins' (i.e. spinner sharks and many carcharhinids). One large fresh fin could sell for AED 60 (USD 17) while one fin from a smaller shark could sell for prices between AED 20 and 40 (USD 6–11), depending on species. Once dried, fins from small sharks could be sold for AED 60 per kg (USD 17 per kg). Respondents mentioned that the first dorsal, pectorals and lower caudal fins were the most valuable and were displayed in sets at the time of auction which is reported to be the best method to get a better market price for them (Rose, 1996; Vannuccini, 1999).

According to one of the traders interviewed in Deira, only four to five shark trading companies were established in Dubai, each employing up to ten staff. Acquiring a trade license was considered an easy process not involving costly investments. However, competition was fierce and trading in shark products perceived as a risky business since Omani exporters needed to be paid before UAE traders could secure products for export. While survey respondents suggested that prices could fluctuate depending on demand, the general trend in recent years had been falling prices and diminishing profits. This was attributed to the recent economic crisis and a reduction in demand from Hong Kong.

While auctions mainly consisted of local traders, survey respondents here noted that a number of overseas buyers, particularly from Hong Kong, frequently visited the UAE to inspect products and build relationships with sellers. Formal contracts were not signed and trade was on an ad-hoc basis with those offering the best prices. Respondents stated there was a need to establish and maintain good and stable working relationships with buyers abroad, and thus shark products were sometimes sold at a loss to avoid local competitors taking over the business. Clarke (2002) also reported that traders in Hong Kong sent staff overseas to secure supplies and arrange for the processing of various products.

3.3. Trade records

Literature records suggested the UAE has been a transshipment point for shark products and mostly dried shark fins from northern Africa and neighboring countries for decades (Marshall and Barnett, 1997; Ali et al., 2001; Hanfee, 2001; Clarke, 2002; Schaeffer, 2004; Hareide et al., 2007). Several reports indicated that Somalia exported dried shark fins through Dubai which were then re-exported to Hong Kong or Singapore (Rose, 1996; Marshall and Barnett, 1997; Vannuccini, 1999) with an average 8–10 mt traded yearly (Ali et al., 2001). Similarly, imports of dried fins (6 mt yearly between 1995 and 1999) (Raje et al., 2002) and frozen shark meat (20 mt in 1994) originated from India (Hanfee, 2001). Interviews undertaken by Schaeffer (2004) with traders in Zanzibar revealed that the fin trade between North Africa and eastern Asia had been dominated by the UAE since the late 1990s. Finally, an FAO report from Iran described an illegal trade of dried shark fins by local fishermen directly with UAE traders, with prices of fins ranging between USD 4 and 40 per kg depending on fin sizes (FAO, 2009).

FAO capture production data of elasmobranchs for the UAE averaged at less than 3 000 mt per year from 1986 to 2012 (FAO, 2014). Furthermore, the only data currently accessible from the Abu Dhabi Emirate indicate that landings of whole sharks peaked at 187 mt in 2003 but were as low as 10 mt in 2013 (EAD, 2014). Fowler et al. (2002) suggested that many country reports were in fact 'guesstimates' and did not reflect true level of catches. Jabado et al. (2014a) described a targeted shark fishery in the UAE; however, as proposed by Clarke (2002), all these reported quantities seem noticeably low when considering the UAE has been exporting between 400 and 539 mt per year of mainly dried shark fins and other sharks products to Hong Kong since 1995 (Fowler et al., 2005; Hareide et al., 2007; WildAid, 2007; Anon, 2012; FAO, 2014), implying there is a large gap in our understanding of trade dynamics. In fact, the UAE did not report any imports or re-exports of dried fin products to FAO between 1995 and 2012, suggesting FAO estimates of exports were from domestic production or from other country reports (FAO, 2014). Therefore, further research is needed to determine the biomass of sharks by species landed in the UAE, what percentage could potentially contribute to the trade after processing and which countries are actually using the UAE as a transit point.

While some traders mentioned they sometimes received products from Iran, Yemen, India and other neighboring countries, they were not willing to provide details of this trade. Reports from Iran suggested that dried fins are shipped to the UAE, yet no information on quantities traded was provided (FAO, 2009). Marshall and Barnett (1997) also reported that Somali fin shipments were generally transported to the UAE by boat. It is therefore likely that the Deira site is limited to the trade in shark products transported overland from Oman while products from other countries presumably arrive into various ports or airports in the UAE. Assuming that shark products are reported, port surveys and examinations of bill of lading and air waybill records from the UAE may provide a better understanding of the type of products traded (i.e. meat (dried or frozen) or fins (dried or 'salted or in brine')), quantities, and

countries of consignment. This is also likely to provide information on re-export quantities, as well as methods of transportation, from the UAE to Hong Kong since generally 67% of shark fins are imported to Hong Kong by sea and 15% by air (Clarke, 2004).

Data from both FAO and Hong Kong Statistics Department indicate the UAE mainly exports 'dried fins with cartilage' with negligible amounts of 'frozen' and 'salted or in brine' fins (Anon, 2012; FAO, 2014). However, FAO data also shows that in some years, the UAE imported substantial amounts of either 'sharks nei, frozen' (253 mt in 2005) and 'sharks nei, fresh or chilled' products (103 mt in 2002), implying the UAE may also serve as a processing destination for products before they are re-exported. The majority of imports from Oman recorded in this study were in the form of whole sharks and fresh fins, with traders confirming these products would need processing before being re-exported. Also, data from Hong Kong for the 'frozen' and 'salted or in brine' fins categories indicate that quantities of less than 1 mt of these commodities were imported from the UAE (Anon, 2012). On the other hand, the UAE could also be exporting products to countries other than Hong Kong. Clarke (2004) suggested Hong Kong trade may only represent 50% of the global fin trade. Furthermore, Vannuccini (1999) reported that Thailand and Singapore imported shark fins from the UAE. Therefore, other countries in Asia may be trading with the UAE in various products and more research is needed to determine the extent of this trade.

Because many of the species found in the UAE trade can cover vast distances, with some crossing entire ocean basins in their seasonal migration (Compagno et al., 2005), it is crucial they are managed through regional cooperation. In fact, even if the UAE were to regulate the trade, and if Oman were to ban fishing of some species, these measures may have a limited impact. This is particularly true since some of the largest shark fishing countries in the world fish in the Arabian Sea. Lack and Sant (2009) reported that from 1980 to 2007, India, Iran (only from 2000 to 2007), Pakistan and Sri Lanka were amongst the top shark catching countries in the world, landing from 2000 to 2010 a yearly average of 75 222 mt, 13 000 mt, 30 351 mt and 18 476 mt respectively (Fischer et al., 2012). What is perhaps more worrying for regional shark populations was that between 2003 and 2005, all these fishing nations reported declining trends in catches of sharks and fish. For instance, in Iran, approximately 48% of the total fish landed comes from the Oman Sea and a downward trend in catches was noted, even though there has been an increase in fishing effort (FAO, 2009). This declining trend in landings has been attributed to environmental changes and pressures from overfishing (Esmaeili, 2006; Valinassab et al., 2006). In Sri Lanka, sharks are ranked second after tuna in terms of fish quantities landed (Joseph, 1999). India was reported to be the world's highest chondrichthyan fishery in 1997, with 16.6% of world catches (Vannuccini, 1999), but reports show that both catches and sizes of sharks have declined (Hanfee, 1997; Fischer et al., 2012). The Pakistan fishery collapsed in 1983 (Bonfil, 1994) but steadily increased again during the 1990s and the country ranked as the third top shark fishing country in 1997 (Vannuccini, 1999). However, during the last decade, shark catches have dropped from about 50 000 to 10 000 mt (Fischer et al., 2012). Similarly, in Sri Lanka catches dropped significantly in 2004 from over 30 000 to less than 10 000 mt (Fischer et al., 2012). All these declining trends point to overfishing and overexploitation of shark resources. While these countries have some national fisheries legislations in place, sharks do not seem to feature as a priority. All the above countries, as well as Oman, are signatories to the Indian Ocean Tuna Commission which prohibits shark finning and thresher shark landings. Yet, data from India indicate that thresher sharks were one of the dominant species in national shark catches representing 23.9% of total landings (Fischer et al., 2012). It remains unclear which measures have been nationally adopted in Pakistan, Iran and Sri Lanka. While Iran reports that the capture of thresher sharks is banned, there is no ban on shark finning. Sri Lanka has a finning ban but there is limited capacity to enforce regulations and species-specific identifications remain a challenge (Fischer et al., 2012). No shark finning ban has been declared in Pakistan and reports indicate there is limited management of fisheries as well as a lack of capacity to undertake research and enforce legislations (Fischer et al., 2012). Finally, while Oman has a ban on finning in place, it is clear from this study that it does not enforce the ban on thresher shark catches. Furthermore, the transport of fresh fins with no corresponding carcasses suggests that finning may still be taking place, although in limited quantities.

When asked about shark conservation, traders were aware of recent national initiatives by conservation groups to push for a ban on the trade in shark products, as it was well documented in the media. Traders confirmed they were concerned about the potential impact of management measures on their business and were becoming careful when displaying sharks and particularly fresh fins at the auction site. When asked about their reactions if bans were implemented, most traders mentioned they would either change their business or move to Yemen where the trade was booming. Indeed, Yemen is reported as one of the top countries for shark catches (Lack and Sant, 2009) and a major exporter of shark fins to Hong Kong (Fowler et al., 2005). Similarly, traders in Hong Kong and China mentioned they would change supply routes or develop a black market if strict regulations or bans were put in place (Clarke, 2002; Li et al., 2012). Therefore, trade bans are not likely to halt the current pressure faced by many species, especially since as Clarke et al. (2007) suggest, the demand for fins is not likely to relent in the near future. Instead, effective management needs to focus on sustainability (Worm et al., 2013), as well as collecting accurate fisheries and trade data in order to have good estimates of exploitation levels (Clarke et al., 2006b) and make sound recommendations on fishing limits (Hareide et al., 2007; FAO, 2009). With the UAE government recently issuing Ministerial Decree 500 of 2014 regulating the fishing and trade in sharks (MoEW 2014) as well as the CITES listings that went into effect on September 14th 2014, it will be important to monitor the Deira site to determine the impact these management measures will have, particularly on the hammerhead species that were found to represent high quantities of the traded species in this study.

4. Conclusions

This study is the first to characterize and quantify the species composition of traded shark products from a major exporting country. The findings confirm a substantial trade in sharks and shark products fuelled by international demand occurring in the UAE. While data collected were limited to sharks from the UAE and Oman, the study provides an overview on the utilization of various shark products, trade links from the UAE and details of the species composition of the Emirati and Omani trade. This species-specific information provides a step toward evaluating whether exploitation rates for particular species can be sustained and highlights gaps in our knowledge. It is clear that further research is needed to better understand trade dynamics but these results can be used as a first step to develop new management tools for the conservation of many shark species. The fact that boundaries of many shark populations are difficult to define and span across the jurisdictions of many countries highlights the need for actions to be taken at regional and international levels.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2014.10.032.

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