

# CITES-listed sharks remain among the top species in the contemporary fin trade

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## Abstract

Trade-driven overexploitation threatens many sharks. Twelve of the world's most vulnerable shark species have been listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to regulate internationally traded products such as meat and dried fins. CITES records indicate that Hong Kong was the world's top legal importer of dried fins from listed sharks in 2015 ( $N = 8$  species at that time), but traded a relatively small volume, with a few partners, in a small number of shipments (16). In contrast two CITES Appendix II listed hammerheads were consistently the fourth and fifth most common species (out of >80) in processed fin trimmings ( $N = 9,200$ ) collected randomly from the Hong Kong retail dried fin market from February 2014 to December 2016 and were found in 100% of sampling events and in 66% of sampled retail vendors. This difference, and the fact that exporting nations previously known to land these species were not among those to report trade to CITES, suggest that listed species were often imported without CITES documentation in 2015. There are a number of incentives for trade hubs to meet their obligations to this treaty, which they could achieve by scaling up monitoring capacity and increasing inspection efficiency.

## KEYWORDS

*Carcharhinus falciformis*, CITES enforcement, shark conservation, shark fin trade, *sphyrna lewini*, *sphyrna zygaena*, wildlife forensics

## 1 | INTRODUCTION

Widespread overexploitation of sharks has occurred in the past few decades, supplying domestic and international markets for products ranging from meat to dried fins (Dulvy et al., 2014). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a framework for signatory nations ("Parties"; at present there are 186) to regulate international trade of threatened species and is increasingly being applied to sharks (Clarke, 2014; Vincent, Sadovy

de Mitcheson, Fowler, & Lieberman, 2014). CITES embraces three main principles, legality, sustainability, and traceability; every 3 years during the Conference of the Parties (CoP), species threatened by international trade are proposed for listing by at least one party, and subsequently added to one of two major appendices (Appendix I or II) if supermajority supporting vote from all parties present at the CoP is achieved. Species listed on Appendix I are prohibited from international trade with rare exceptions. International trade of Appendix II species requires that each export is accompanied by a permit issued by the CITES Authority of the exporting party

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certifying that specimens have been caught in accordance with national laws, specimens are traceable through the supply chain, and trade is not detrimental for the survival of the species, based on a Non-Detriment Finding (NDF; Vincent et al., 2014). Importing parties are required to monitor incoming trade and ensure that CITES-listed species do not enter the border without this documentation (Vincent et al., 2014). International trade sanctions can be applied to exporting and importing parties that fail to implement CITES regulations (Vincent et al., 2014).

CITES parties have historically been reluctant to list marine fish, including sharks, in part due to concerns about implementation given the difficulty in making the necessary NDFs, the potentially large traded volumes involved, and the challenges in identifying processed products (Vincent et al., 2014). Yet, after nearly a decade with just three shark species being listed on CITES Appendix II (Table 1), three listing proposals involving five shark species passed at the CoP16 in 2013, taking effect in late 2014 (Clarke, 2014). This was a significant change because the species listed prior to 2013 were fully protected in many jurisdictions prior to listing (Fergusson et al., 2009; Fowler, 2000; Fowler, 2005b), while the species listed at CoP16 were a larger part of legal landings in many parts of the world (Chuang, Hung, Chang, Huang, & Shiao, 2016a; Jabado et al., 2015; Tolotti et al., 2015). In 2016, at Cop17, two more proposals involving four species were adopted and took effect in late 2017 (Table 1). The role of CITES in regulating the shark trade is likely to expand even further in the future as parties appear to be increasingly inclined to propose sharks and vote in support of Appendix II listings at future CoPs. It is therefore important that we understand how common listed species are in the contemporary trade, assess compliance with CITES listings, and track how listing affects the trade's species composition over time.

Hong Kong Special Administrative Region of the People's Republic of China (from now on referred as Hong Kong) is one of the largest shark fin trade hubs in the world, importing a total of 5,528,862 kg in 2015, and annually trading with an average of 83 exporting nations (Dent & Clarke, 2015; Shea & To, 2017). Surveys in Hong Kong in 1999–2001 (Clarke, Magnussen, Abercrombie, McAllister, & Shivji, 2006), 2014–2015 (Fields et al., 2017), and a few of their top trading partners (Chuang, et al. 2016a; Jabado et al., 2015; Sembiring et al., 2015) all showed that fins of several species listed at CoP16 were commonly traded prior the listings taking effect. The first objective of the present study was to assess the global position of Hong Kong as legal importer of fins from CITES listed species according to CITES trade records. The second objective was to assess the relative importance of these species in Hong Kong fin market after CoP16 listings were implemented (late 2014; Table 1), including both the legally reported and undocumented imports. The findings of this study provide the first fin trade reference data points

for CoP16 listed species after implementation, and provide an early evaluation of compliance with reporting requirements (e.g., if legal trade records are few and reporting compliance is high, it would follow that these species should be uncommon in the market).

## 2 | METHODS

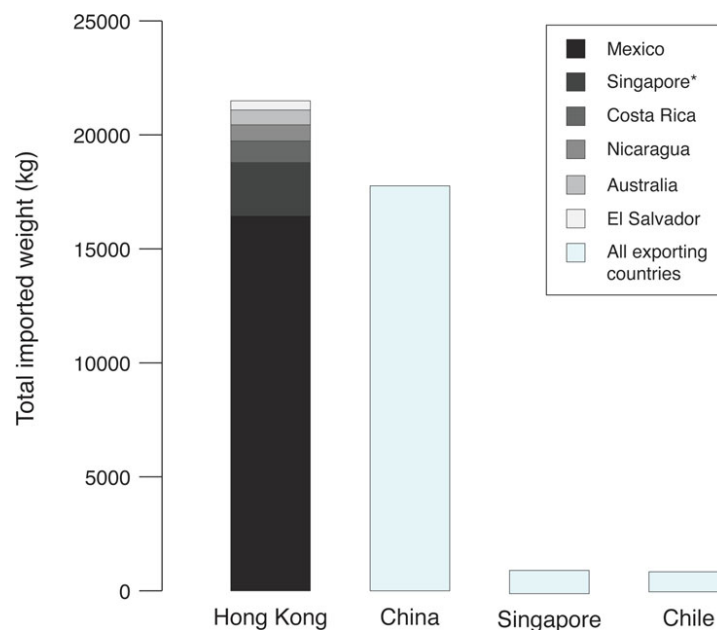
We assessed the global importance of Hong Kong as a legal importer of CITES listed sharks using the publicly available CITES database (<https://trade.cites.org>). We searched the 2015 trade records for all species listed on or prior to CoP16 (8 total; Figure 1). Since we only sampled fins during our Hong Kong retail market survey (see below), we excluded all other products for each species and only included trade of known quantities (i.e., weight in kg), from wild caught specimens (Source: W), and for commercial purposes (Purpose: T). We then aggregated all trade records by country and compared the totals. We also assessed the relative contribution of exporting countries to total imports of each CITES listed species in Hong Kong.

We sampled retail or mixed retail-whole sale shark fin vendors to assess the relative importance of CITES-listed sharks in the contemporary Hong Kong trade after CoP16 listings were implemented, building on an earlier study with the same methodology that was conducted immediately prior to implementation of these listings (Fields et al., 2017). Our sampling methodology consisted of randomly purchasing processed shark fin trimmings (Fields et al., 2017) that are a byproduct of preparing imported fins for the retail market, which are sold by ~300 vendors in bags of 10 to >1,000 pieces. Informal conversations with vendors and importers suggest that imported fins are quickly processed in Hong Kong, in nearby Mainland China or other locations in southeast Asia, with processed fins and fin trimmings from the two latter being reimported to Hong Kong for the retail market (Shea & To, 2017). Trimmings are a low value, perishable product with fast turnover judging from the frequency with which vendors had ran out of supply during our study (i.e., at least one vendor was sold out in 26 out of 46 sampling events, sometimes as many as six were sold out in a single sampling event). We therefore conservatively assumed that trimmings in the retail market provide an index of the species composition of fin imports within the past year (i.e., trimmings present in 2016 likely reflect imports/processing in 2015). During the first year of sampling (February 2014 to February 2015), a total of 75 vendors were randomly selected from the complete vendor list (~300; Fields et al., 2017) every 2 weeks and 2 bags were purchased per vendor from the first 10 vendors visited that had stock. For the rest of the study (March 2015 to December 2016), the same sampling protocol was followed but on a monthly basis. The contents of each bag were counted and 10 trimmings were randomly

**TABLE 1** Summary of shark CITES listings showing the year and the Conference of the Parties where listing was accepted, the Appendix where the different species were listed, and the date when implementation of each individual listing started

Species	CoP/year	Appendix #	Implementation date
Whale shark	12/2002	II	February 2003
Basking shark	12/2002	II	February 2003
Great white shark	13/2004	II	January 2005
Oceanic whitetip shark	16/2013	II	September 2014*
Scalloped hammerhead shark	16/2013	II	September 2014*
Smooth hammerhead shark	16/2013	II	September 2014*
Great hammerhead shark	16/2013	II	September 2014*
Porbeagle shark	16/2013	II	September 2014*
Silky shark	17/2016	II	October 2017
Pelagic thresher shark	17/2016	II	October 2017
Bigeye thresher shark	17/2016	II	October 2017
Common thresher shark	17/2016	II	October 2017

\*Implementation in Hong Kong started in November 2014.



**FIGURE 1** Bar-plot showing Hong Kong's relative position as an importer of CITES-listed shark fins according to the CITES Trade Database. The color-coding of the Hong Kong bar depicts the relative contribution of each exporting nation that reported trading CITES-listed sharks with this hub in 2015 ( $N = 7$ ). The bars for the other importing nations are an aggregate of all the nations that traded with them in 2015. \*Depicts countries that play as re-exporters, in this case, Singapore re-exported fins from CITES-listed species coming originally from Sri Lanka

selected per bag. Subsequently, the genomic DNA of each trimming was extracted, PCR amplified, sequenced, and identified following previously used protocols that enable accurate species identification of all CITES listed sharks and most sharks, batoids, and chimaeras known to occur in trade (Cardeñosa et al., 2017; Fields, Abercrombie, Eng, Feldheim, & Chapman, 2015). A Poisson multinomial model (Baker, 1994; Shelton, Dick, Pearson, Ralston, & Mangel, 2012) was used to estimate species composition of the fin trimmings and a Bayesian framework with noninformative priors was used to estimate the parame-

ters as described by Fields et al. (2017) (Supplemental Material 1). The model was fitted using the JAGS software (Shelton et al., 2012) through R (R2Jags package; (Su & Yajima, 2015), which employs a Monte Carlo Markov Chain (MCMC) algorithm to estimate the posterior distribution of the parameters.

Models were fitted to the data that included species that made up >20 trimmings for each of the 3 years sampled (2014, 2015, 2016), with the exception of *Dalatias licha*, because this species was only found at one vendor, therefore it had the potential to prevent the model from converging.

We used the Deviance Information Criterion (DIC; (Lunn, Jackson, Best, Thomas, & Spiegelhalter, 2013) to determine the model that best predicted the species composition. After the model was fitted to the species that made up >20 trimmings, the cutoff was adjusted downward as long as the model would continue to converge. Species below the cutoff were grouped by genus (*Alopias*, *Carcharhinus*, *Mustelus*, *Rhizoprionodon*, *Callorhinchus*) or binned into an “Other” category, each of which were large enough to be modeled. The proportion of each species in the trimmings was conservatively estimated using the final model output, without any assumptions being made about the unidentified component (i.e., trimmings that did not amplify or produce good quality sequence after multiple attempts), which was included in the model as its own category. All modeled proportions for the identified species and species groups are therefore underestimates if they occurred in the unidentified component (Fields et al., 2017). Models were run for each of the three calendar years sampled (2014 [excluding January], 2015, 2016).

### 3 | RESULTS

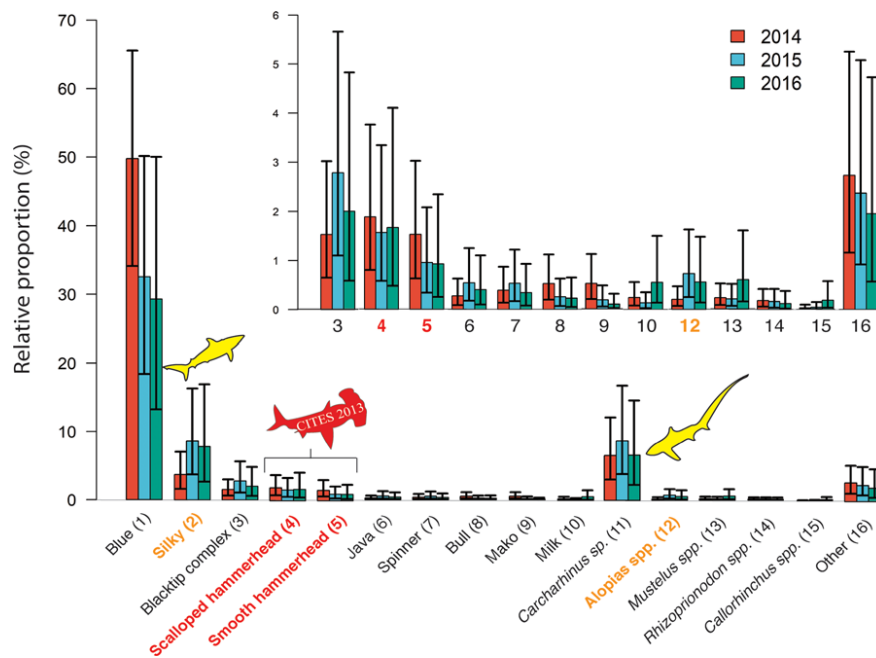
In 2015 Hong Kong was reportedly the world's top legal importer of fins from CITES listed sharks (52% by weight), bringing in 22,348.8 kg from these species according to the CITES Trade Database (Figure 1). This represents the legal trade of listed species into Hong Kong certified through NDFs by the exporting nation and reported to CITES, forming a minor component (~0.4%) of the territories total fin imports that year by weight and 16 individual shipments. Seven nations reported trading CITES listed sharks with Hong Kong (Figure 1), but the majority (76% by weight) were from Mexico. Fins reportedly traded were from scalloped hammerheads (*Sphyrna lewini*; 40.8% by weight), smooth hammerheads (*S. zygaena*, 35%), great hammerheads (*S. mokarran*, 16.8%), oceanic whitetips (*Carcharhinus longimanus*, 5.6%) and white sharks (*Carcharodon carcharias*, 1.1%). Fins were, by far, the dominant product from these species that were traded under CITES. There was no certified trade in the meat recorded under CITES in 2015 for any of the listed sharks, except the porbeagle (*Lamna nasus*).

A total of 9,200 fin trimmings from the retail market were analyzed with a successful identification rate of 80% to the species or complex level, representing a total of 82 species or complexes. The remainder failed to amplify or produce readable sequence after multiple attempts. Scalloped and smooth hammerheads collectively made up 7.9% of the raw trimmings and all three models consistently ranked them fourth and fifth most common out of all species, or species complexes identified (Figure 2). Of 46 retail vendor sampling events (involving 140 different vendors) from February 2014 to December 2016 these species were detected in 100% of events and 66% of ven-

dors at least once. The great hammerhead, oceanic whitetip, and porbeagle (*Lamna nasus*) sharks collectively represented 1.9% of the trimmings sampled for all three sampling years combined, but models did not converge when they were included separately so they were included in the “Other” category. No white (CoP13), whale (*Rhincodon typus*; CoP12), or basking shark (*Cetorhinus maximus*; CoP12) fin trimmings were detected. Of the CoP17 listed species, which took effect in October 2017 after sampling concluded, all three models consistently placed the silky shark (*Carcharhinus falciformis*) as the second most commonly traded species (Figure 2). Listed thresher sharks (Family Alopiidae) were also found in the trade and modeled as the fourth most common family overall (Figure 2).

### 4 | DISCUSSION

CITES records suggest that Hong Kong is the world's top importer of fins from listed sharks and fins are the primary product being internationally traded under CITES. The absence of meat trade records under CITES for any of the listed species, other than the porbeagle, suggests that their meat is not being traded internationally (possibly traded domestically, used for subsistence, or discarded) or their meat is being traded internationally without CITES permits, or both. Most of the reported trade of listed species was from hammerhead sharks (Family Sphyrnidae), which matches what we observed in the retail fin market. We found a diverse range of elasmobranch species over this period but the top five species/complexes in the trimmings were consistent each year from 2014 to 2016: blue (*Prionace glauca*), followed by the silky, the blacktip species complex (*Carcharhinus limbatus*, *C. tilstoni*, *C. leiodon*, *C. amblyrhynchoides*), and the CoP16 listed scalloped and smooth hammerheads. Reported trade volumes were minor relative to the territory's total fin imports in 2015 and represented a small number of shipments. This contrasts with the observation that these species are a relatively important component of the market-derived fin trimmings sampled in 2014–2016 and found in a high proportion of retail vendors. This indicates that compliance with reporting requirements was low in the first year(s) of implementation. We cannot rule out that the time lag between fins entering Hong Kong, and their trimmings becoming available, is longer than we assumed (1 year). However, the low reporting hypothesis is bolstered by the fact that only seven nations reported exports to Hong Kong when this hub trades with an average of 82 nations annually (Shea & To, 2017). Of the top five nations/territories exporting fins directly into Hong Kong, only Singapore reported CITES listed shark exports to Hong Kong in 2015 (Figure 1). Moreover, only one (i.e. Mexico) of the top 10 shark producing nations/territories (Dent & Clarke, 2015) reported exports of CITES listed shark



**FIGURE 2** Bar-plot with 95% confidence intervals from Bayesian models showing the relative proportion of shark species, species complexes, and genera that made up >20 trimmings for each of the three sampled years. Inset provides a closer look into the proportion of species with a mean contribution of <6%. Blacktip complex denotes the species complex comprised of *Carcharhinus limbatus*, *C. amblyrhinchoides*, *C. leiodon*, and *C. tilstoni*. Species that made up <20 trimmings for each of the three sampled years were binned by genus or grouped under “Other.” Frequency of unidentified samples is not shown. Red letters/numbers and shark symbols depict CoP16 listed species (took effect late 2014), yellow letters/numbers and shark symbols depict CoP17 listed species (took effect October 2017)

species to Hong Kong (Figure 1). Many exporting nations previously known to land these species were not among those to report trade, again, suggesting low compliance with CITES reporting requirements in 2015–2016 (Chuang, Hung, Chang, Huang, & Shiao, 2016b, 2016a; Jabado et al., 2015; Sembiring et al., 2015). Relatively low compliance with CITES regulations, especially in the initial phase of implementation, is documented in other taxa including seahorses (Foster, Wiswedel, & Vincent, 2014), tigers, rhinoceros (Cheung, 1995), and turtles (Rehman, Jafar, Ashraf Raja, & Mahar, 2015). This study suggests the same is true for the initial implementation of CoP16 shark listings.

The relative importance of listed species in this high-volume trade highlights the contemporary scale of the CITES implementation challenge. Moreover, the reporting, monitoring, and enforcement burden increased substantially as the silky (second most common species), and thresher sharks’ listings were implemented in October 2017 after this study concluded. While the burden of CITES implementation and reporting primarily falls on the exporting nations/territories (Vincent et al., 2014), major importers of shark products play an essential role in monitoring and enforcing these regulations (Clarke, 2014). Hong Kong has become a major hub for illicit wildlife trafficking (Lau, 2014), and the Hong Kong Agriculture, Fisheries and Conservation Department (AFCD) conducts inspections at 23 control points (i.e., Sea [9], Land

[8], Air [6]), where >5,000 mt of shark fins, along with many other wildlife commodities, are imported annually, but only has 84 officials to help in enforcing and identifying CITES requirements and all other ordinances governed by the department (AFCD pers comm). Our study suggests that CITES listed sharks, particularly silky, scalloped hammerhead, and smooth hammerhead, are relatively important among contemporary fin imports, and are therefore probably still entering the territory frequently and in a large enough cumulative volume to maintain their rank order in the market from 2014 to 2016 and presence in many retail vendors. While there have been investments in improving the quality of existing inspection capacity in Hong Kong and elsewhere (i.e., identification workshops for fins of listed species), resulting in seizure of over 1.3 mt of fins from listed species since late 2014 (AFCD pers comm), the relative importance of CITES-listed species in trade suggests that this capacity is likely already exceeded. Moreover, relatively few parties have produced NDFs for listed sharks, which makes it impossible for traders within these nations to legally export fins and other products from these species (<https://www.cites.org/eng/prog/shark>). CITES capacity building is urgently needed for shark exporting and importing parties worldwide.

There are a number of incentives for Hong Kong and other leading fin importers to better implement CITES for these heavily traded sharks. There is growing public

support for shark conservation in Hong Kong (Shea & To, 2017), prompting the government to ban consumption of shark fin soup at state-sponsored functions “to demonstrate its commitment to the promotion of green living and sustainability” (<https://www.info.gov.hk/gia/general/201406/18/P201406180512.htm>). Increased government investments in CITES monitoring and enforcement would promote sustainable sourcing of fins and thus would align well with this commitment and public opinion. Moreover, if enforcement capacity is clearly not commensurate with the import volume of listed species into Hong Kong, it is possible that the territory could face international trade sanctions under CITES regulations (Vincent et al., 2014). This provides a strong incentive to make these investments given Hong Kong's position as a major trading port for a wide variety of legal wildlife products (Zhang, Hua, & Sun, 2008). Our study suggests scaling up inspection capacity (i.e., employing additional inspectors) and making improvements in efficiency (i.e., by centralizing ports of entry for fins (Shea & To, 2017), conducting real-time DNA testing in the field (Kolby et al., 2014), and conducting risk assessments for shipments based on recent historical landings from the source country) are justified investments that are required to cope with the import volume of fins from CITES listed species. Strong CITES enforcement by importing nations, like Hong Kong, should pressure importers, exporters, and exporting nations to better implement their CITES responsibilities, which is the basis for using this agreement to shift wildlife trade towards sustainability (Vincent et al., 2014). It is also important to consider that stronger enforcement measures in Hong Kong could lead to the creation of black markets and alternative trading routes and hubs. Therefore, independent genetic monitoring approaches, such as the one described here, should be implemented in other large shark fin trade hubs (e.g., China, Thailand, Singapore, Vietnam) to detect changes in trade of fins over time and to assess compliance with CITES reporting requirements. In addition, faster, cheaper, and more portable DNA forensic tools must be developed to increase the capacity of CITES parties to monitor the trade in products, such as meat, that are not easily identified to species and address emerging tactics by illegal actors to conceal fins from listed species by altering their morphology (Jabado & Spaet, 2017). The recent positive momentum for shark trade management by CITES parties has the potential to trigger the promotion of inter-governmental cooperation, funding, and capacity-building to implement new techniques and protocols to ensure more effective implementation of CITES listings for sharks.

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## SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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