4 Characterization of the Global Trade and its Implications for Shark Populations

4.1 Chapter Overview and Purpose

Estimating the number or whole weight of traded organisms by species can serve at least two distinct purposes: it can provide a benchmark for future trade monitoring, and/or it can be used in combination with population models to assess whether the resource is being harvested in a sustainable manner. The shark fin estimates generated in the preceding two chapters are well-suited for the first purpose, but without further manipulation cannot be utilized for the second purpose. This further manipulation involves establishing a linkage between the market-derived data and a particular population or set of populations based on explicit knowledge of product provenance. While this may be possible for some wildlife products, e.g. when there is a single market drawing from a population that is limited in distribution, customs data indicate the Hong Kong shark fin market was supplied by over 85 countries in 2000 (Hong Kong Government 2002). These customs data are not, however, capable of partitioning the Hong Kong auction data by source location due to the prevalence of shark fin trans-shipment which obscures the true product origin. The impacts of the shark fin trade on shark populations can thus only be assessed at the global level, and this requires that the estimates for the Hong Kong auctions be extrapolated to the global market.

This chapter first reviews and analyses Hong Kong customs data to derive a factor for extrapolating from the auction dataset to the Hong Kong trade as a whole. A second factor, necessary to extrapolate from the entire Hong Kong trade to a worldwide total, is then derived from national customs databases. Using these two factors, the estimates of shark numbers and whole weights calculated in Chapters 2 and 3 are extrapolated to a worldwide total and compared to existing estimates of shark landings from the United Nations Food and Agriculture Organization (FAO) and other fisheries management organizations. The final portion of this chapter uses simplified surplus production models applied to blue shark (*Prionace glauca*) to assess whether the number of this species utilized in the global shark fin trade is sustainable.

4.2 Supporting Analyses for Extrapolation of Auction-based Information to a Hong Kong Total

The best source of information on the quantity of shark fins imported to Hong Kong is the Hong Kong Special Administrative Region Government (HKSARG) customs databases. Declared imports and re-exports of shark fin within this database were analysed for the purpose of determining the total quantity of shark fins traded through Hong Kong. Once the total quantity of imports to Hong Kong is estimated, the proportion of this total represented by the auction data modelled in Chapters 2 and 3 can be calculated, and the modelling results can be extrapolated to represent all shark fins traded through Hong Kong.

A time series of imports was first compiled in order to determine the total quantity of shark fins imported during the period October 1999 to March 2001. Longer terms trends in imports are also examined for insights into potential biases in the statistics. One of the key issues in the analysis of shark fin customs data reported prior to 1998 is that in the older data sets there is no means of determining whether imported shark fins are raw (i.e. with cartilage) or processed (i.e. without cartilage). This is particularly important because fins are typically imported in raw form to Hong Kong, shipped across the border (re-exported) to Mainland China (the Mainland) for processing, and then re-imported to Hong Kong for wholesale or retail sale (Figure 4.1).

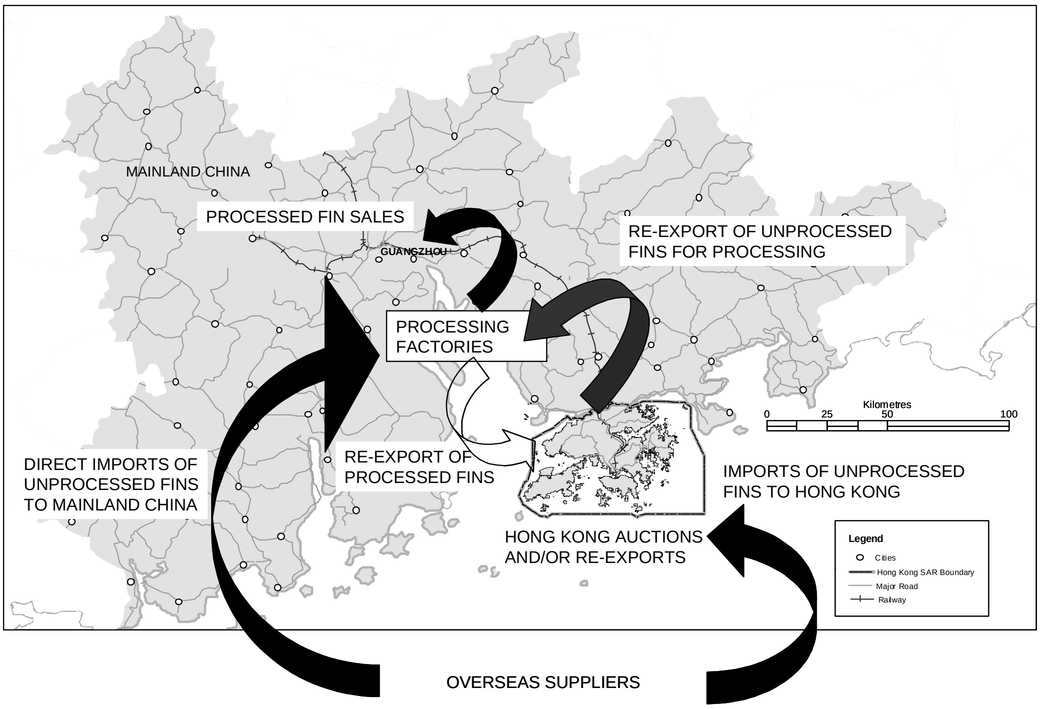

Figure 4.1 Schematic diagram of shark fin trade flows through Hong Kong and Mainland China.

Given that customs authorities, including those in Hong Kong, do not generally distinguish between imports and re-imports, if raw and processed shark fins are not classified under separate codes, a large number of fins imported to Hong Kong may be double counted (i.e. counted as imported in raw form and then again when imported in processed form). In 1998, Hong Kong instituted new commodity codes for shark fins which distinguish raw from processed fins on the basis of whether fin cartilage is present. This new system also maintains the separate reporting categories for dried and salted shark fins which existed in the previous system so that there are four commodity codes in all (Table 4.1).

Table 4.1 Commodity codes for shark fin as implemented by the Hong Kong Special Administrative Region Government in 1998 in accordance with the Harmonized Commodity Description and Coding System of the World Customs Organization (Hong Kong Government 2002).

Commodity Code	**Official Definition**	**Terminology used in this Study**
0305-5950	Sharks' fins with or without skin, with cartilage, dried whether or not salted but not smoked	Dried Unprocessed
0305-5960	Sharks' fins with or without skin, without cartilage, dried whether or not salted but not smoked	Dried Processed
0305-6930	Sharks' fins with or without skin, with cartilage, salted or in brine but not dried or smoked	Salted or in Brine (Frozen) Unprocessed
0305-6940	Sharks' fins with or without skin, without cartilage, salted or in brine but not dried or smoked	Salted or in Brine (Frozen) Processed

Total declared imports of unprocessed shark fins into Hong Kong between 1984 and 2001 are shown in Figure 4.2 (filled circles). Based on a previous study (Parry-Jones 1996), declared imports prior to 1998 are known to be inflated due to double counting of re-imported processed fins from Mainland China. Therefore, in Figure 4.2 all pre-1998 data (for dried, 'salted or in brine', and total imports) are also shown in adjusted form based on a method which assumes that all shark fins imported to Hong Kong from Mainland China are in processed form and thus subtracts these imported quantities from the total declared imports (Parry-Jones 1996). This adjustment is reasonable because Mainland China's reported capture production of sharks, skates and rays (in whole form) is only 200-400 mt in 1999 and 2000, and is zero or negligible in prior years (FISHSTAT 2002). Therefore, it is unlikely that Mainland China is producing substantial quantities of unprocessed shark fin. Furthermore, since 1998 when processed and unprocessed quantities began being declared separately, unprocessed shark fin originating in Mainland

China and imported to Hong Kong is reported to be an extremely small proportion of the trade (0.1 to 1.8% in 1998-2001 (Hong Kong Government 2002)).

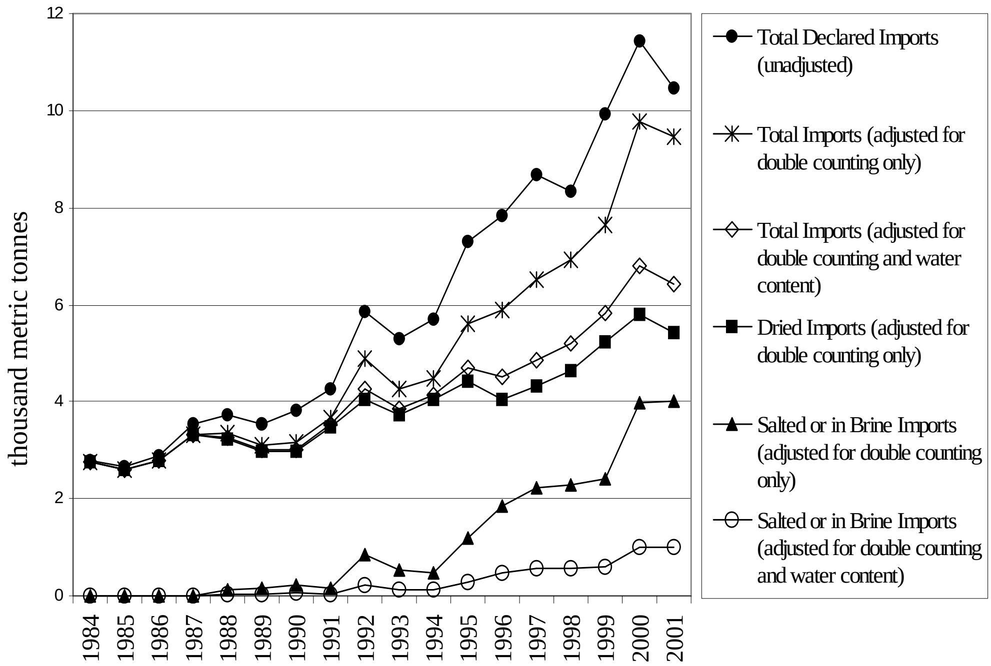

Figure 4.2 Imports to Hong Kong of dried, salted or in brine and total shark fins 1984-2001 in mt (Hong Kong Government 2002). Two corrections have been applied to the total declared import figures. First, all figures for dried and salted fins prior to 1998 have been adjusted for double-counting of re-imported (i.e. processed) fins as per Parry-Jones (1996) (■ and ▲series). Second, salted or in brine imports in all years have been adjusted for water content (○ series). The total imports without adjustment (●) are shown as well as the totals resulting from the adjustment for double counting alone (*), and for double counting in combination with adjustment for water content (◊).

Figure 4.2 also shows a second adjustment that is necessary to account for the fact that the 'salted or in brine' fins are believed to be in frozen form and thus should be normalized for water content. Anecdotal information from Hong Kong shark fin traders suggests that the weight of frozen fins will decrease by 70-80% when dried, thus a factor of 1 kg 'salted or in brine' (i.e. frozen) = 0.25 kg dried fins has been used to normalize the ‘salted or in brine’ data in Figure 4.2. Additional evidence for the adjustment factor is provided by the average declared values for unprocessed dried and unprocessed ‘salted or in brine fins’ since 1998 (Table 4.2). Although these declared value figures are expected to be somewhat unreliable as they summarize a variety of shark fin types from over 85 countries and declared values cannot be easily verified by customs agents, they suggest that the value of ‘salted or in brine’ fins is 21 to 36% of dried fins. This is broadly consistent with the assumption that 75% of the weight of ‘salted or in brine’ fins is due to water content.

Table 4.2 Average declared values (in United States dollars per kg, 1 USD=7.8 Hong Kong dollars) of unprocessed dried and ‘salted or in brine’ shark fins imported to Hong Kong, 1998-2001, and ratio of dried value to ‘salted or in brine’ value. Values are calculated using a weighted average: the total declared value of all shipments is summed over the year and divided by the total declared quantity of all shipments for that year.

Product Type	**1998**	**1999**	**2000**	**2001**
Dried	35.09	34.76	46.01	38.91
Salted (or in brine)	7.52	9.43	16.52	11.66
Dried : Salted	1:0.21	1:0.27	1:0.36	1:0.30

Examination of the total import series in Figure 4.2 reveals that quantities indicated by the unadjusted totals overestimate the traded volume by 60 to 70% each year as compared to the fully adjusted series. Similarly, the year-on-year rate of increase for the entire time period is estimated at 9.0% for the unadjusted series, but only 5.4% for the twice-adjusted series. The increasing proportion of ‘salted or in brine’ (i.e. frozen) imports, particularly since the mid-1990s, is responsible for this divergence and causes misleading patterns in the unadjusted totals. For example, the unadjusted totals suggest that shark fin imports declined in 1998 but this was actually due only to a slowing of the rate of increase for imports of ‘salted or in brine’ fins. In contrast, however, the decrease in unadjusted imports in 2001 represents a real contraction in the Hong Kong trade since it is also reflected in adjusted totals. Further exploration of market trends is presented in Chapter 5.

The adjusted total import figures described above can be used to estimate the proportion of shark fins entering Hong Kong that are auctioned. Modelling results in Chapter 2 were presented as metric tonnes of shark fin auctioned per year based on scaling the 18 month modelled period (October 1999 – March 2001) to a 12 month period. The model estimates of the quantity of all auctioned fins for the full 18 month period range from 1,662 to 1,871 mt with a mean of 1,764 mt. Summing the declared monthly imports of unprocessed shark fins to Hong Kong for the same 18 month period gives a total of 14,380 mt. This total does not need the correction for double counting (since the period of interest is post-1998), but does require correction for water content of 'salted or in brine' fins. Applying the adjustment factor of 1 kg frozen weight to 0.25 kg dry weight to the Hong Kong customs data gives a total of 10,002 mt of fins imported during the 18 month period. Applying this same correction factor to the estimated traded weight of auctioned fins over the 18 months, and then expressing this weight as a percentage of the total fins imported (as indicated by the customs data and adjusted above), suggests that auctioned fins represent 17.6% of Hong Kong imports based on the mean auctioned weight estimate. Using the 95% probability interval for the estimated traded weight of auctioned fins, the percentage is shown to vary from 17.1 to 18.2%. If the adjustment factor for salted or in brine fins is set at 0.2 for the lower bound and 0.3 for the upper bound, the estimate of total imports to Hong Kong changes, and the proportion of auctioned fins varies from 16.1 to 19.3% over the 95% probability interval.

This extrapolation assumes that the auctioned fins are representative of the shark fin market in Hong Kong as a whole. This assumption will not be valid if auctions preferentially focus on high-value fins in order to obtain the best price for these fins on the open market. Hong Kong shark fin traders are known to exhibit a preference for fins which contain longer, thicker and denser fin rays (Fong and Anderson 2000 and confirmed in this study), therefore it may be that larger fins of high-value species occur more frequently in the auction dataset. However, it has also been shown that some dealers prefer to structure their business to focus only on importing unprocessed fins from overseas and auctioning them in Hong Kong (Clarke 2002). It may be that these firms' inventory is representative of all shark fin imports to Hong Kong, and their choice to auction is simply a business decision to leave the export and processing of fins in Mainland China to other firms.

There is a clear bias toward larger fins in the size class distribution of auctioned fins (see Figure 2.17) but it is not possible to determine whether this bias is only present in the auction dataset or perhaps exists throughout the shark fin trade due to, for example, preferential targeting of larger sharks for fin production. Without access to descriptive data on shark fin sizes and types across the breadth of the Hong Kong trade, it is not possible to conclusively address this issue within this study. Therefore, of necessity, the auction data is assumed to be representative of all shark fin imports to Hong Kong. If, however, small fins are under-represented in the auction data, it is likely that the true number of sharks utilised in the trade would be higher, and the true biomass of sharks utilised in the trade would be lower, than estimated in this analysis.

4.3 Supporting Analyses for Extrapolation of Hong Kong Estimates to Represent the Global Trade

4.3.1 The Global Shark Fin Trade as Characterized by the FAO Database

The only global database containing information on the shark fin trade is the FAO FISHSTAT Commodities Production and Trade database which compiles national governments' official statistics on production, imports, exports and re-exports (FISHSTAT 2002). According to FAO, global import totals for shark fin between 1996 and 2000, the latest available data, exhibit a decrease from a high of 7,046 mt in 1997 to 4,630 mt in 1998, and subsequently increase to 5,242 mt in 2000 (Table 4.3). These global figures, which presumably include both unprocessed and processed shark fin would, by definition, be expected to equal or exceed the total Hong shark fin import figures. However, the uncorrected Hong Kong total (processed and unprocessed) shark fin imports exceed the FAO global imports by large amounts (1.1 to 2.2 times greater) (Table 4.3). The substantial decrease in Hong Kong quantities reported to FAO from 1998 onward may be due to Hong Kong's modification of commodity codes in 1998. The discrepancy between the Hong Kong Government's and the FAO data for Hong Kong has been reported to FAO and will be corrected in the next issue of the database later this year (S. Vannuccini, pers. comm., 12 December 2002).

Another, less apparent, issue in the FAO shark fin data is that the total is highly dependent on the contribution of Mainland China. In each year shown in Table 4.3, Mainland China contributes the largest quantities to global imports, ranging from 62% to 91% of the total. The FAO-reported figures for Mainland China correspond exactly to those reported in the People's Republic of China national customs database for the same period (Anon. 1997a, Anon. 1998a, Anon. 1999a, Anon. 2000a, Anon. 2001a), however,

Table 4.3 FAO Commodity Production and Trade statistics for Hong Kong, Mainland China and global imports, 1996-2000, and Hong Kong total (processed and unprocessed) imports as recorded by the Hong Kong Government.

	1996	**1997**	**1998**	**1999**	**2000**
Data according to FAO					
Hong Kong Imports	1,850	2,211	13	14	23
Mainland China Imports	4,363	4,389	4,236	4,062	4,646
TOTAL IMPORTS	7,010	7,046	4,630	4,584	5,242
Data according to Hong Kong Government					
Hong Kong Imports (unadjusted)	7,846	8,670	8,323	9,935	11,451

as the next section will demonstrate, the figures from Mainland China are likely to be gross underestimates of the actual volume of the trade. Given this, and observing that the FAO-reported Hong Kong quantities are much lower than figures in Hong Kong's own database, the FAO dataset underestimates world trade in shark fins through deflated figures for the world's two largest participants at a minimum. Use of the FAO figures to characterize quantities and trends in the global shark fin trade may therefore lead to false conclusions.

4.3.2 Under-representation of the Shark Fin Trade in People's Republic of China Databases

In order to assess the extent of potential under-reporting of the shark fin trade in Mainland China, re-exports from Hong Kong to Mainland China were compared to Mainland China imports from Hong Kong (i.e. the northbound trade, grey arrow in Figure

4.1), and the exports / re-exports from Mainland China to Hong Kong were compared to the Hong Kong imports from Mainland China (i.e. the southbound trade, clear arrow in Figure 4.1). The premise underlying this comparison is that the higher the reported quantity, the more accurately that quantity reflects the true volume of trade. In this respect, Hong Kong, as a duty free port, would appear to have an advantage over other locations in compiling trade statistics as there would be little incentive to minimize declared quantities to reduce tariffs.

Since the Mainland China databases do not distinguish between any of the different forms of shark fins recorded by the Hong Kong classification system, Hong Kong dried and 'salted or in brine', processed and unprocessed, declared quantities were agglomerated (Table 4.4). In the northbound trade, Hong Kong annual re-export figures exceed Mainland China annual import figures by 38 to 140 times during 1996-2000. In contrast, figures for the southbound trend (i.e. from Mainland China to Hong Kong) demonstrate a close agreement.

Table 4.4 Comparison between Mainland China and Hong Kong recorded trade in shark fin, 1996-2000 (mt).

	1996	**1997**	**1998**	**1999**	**2000**
Northbound Trade					
Hong Kong Re-exports to the Mainland	4,797	5,163	5,630	6,167	7,701
Mainland Imports from Hong Kong	125	59	46	45	55
Mainland Reported Quantity : Hong Kong Reported Quantity	1:38	1:88	1:122	1:137	1:140
Southbound Trade					
Mainland Exports to Hong Kong	2,053	2,242	1,930	1,853	1,907
Hong Kong Imports from the Mainland	1,992	2,251	2,002	2,076	2,443
Mainland Reported Quantity : Hong Kong Reported Quantity	1:0.97	1:1.00	1:1.04	1:1.12	1:1.28

An explanation for the disparity in agreement between northbound and southbound trade statistics is hypothesized to lie in the import conditions and customs duties of Mainland China. Goods imported to Mainland China for the sole purpose of processing are exempt from tariffs as long as the finished, processed materials are re-exported. According to Parry-Jones (1996) the system fixes the required re-export weight for shark fins at 30-50% of the imported unprocessed weight; interviews with traders in this study suggest the percentage is 35%. It appears that if imports are designated in one of these tariff-free categories they are not recorded as imports. This would explain why the reported Mainland China import quantities are extremely low in comparison to the Hong Kong re-export figures in the northbound trade, and why there would be close agreement in the figures for the southbound trade in which tariffs do not apply. If this hypothesis is correct, the quantity reported in the southbound trade, by both jurisdictions, should be approximately 35% by weight of the northbound trade as reported by Hong Kong. Table 4.5 shows the actual quantities and reveals some support for this hypothesis.

Table 4.5 Comparison between declared Hong Kong re-exports (northbound trade) and the average of Hong Kong's and the Mainland China's declared southbound trade. All figures in mt.

	1996	**1997**	**1998**	**1999**	**2000**
Hong Kong declared Re-exports to the Mainland (northbound)	4,797	5,163	5,529	6,097	7,615
Average of PRC declared exports to Hong Kong and Hong Kong declared imports from the Mainland (southbound)	2,022	2,246	1,966	1,964	2,175
Percentage Return to Hong Kong (expect ≈35%)	42%	44%	36%	32%	28%

The under reporting of shark fin imported from Hong Kong in the Mainland China customs statistics, and subsequently reported to FAO, does not necessarily have major implications for quantifying the global trade. This is because these shark fins have theoretically already been counted in the Hong Kong customs system and would thus be double-counted if also recorded as imports in Mainland China. However, in this particular case, the fins appear to have indeed been counted in Hong Kong but somehow not reported correctly to FAO (see preceding section). Furthermore, it is not clear whether this type of under reporting in the Mainland system extends to other countries' imports and if so whether the countries importing fins to the Mainland accurately record their own shark fin trade statistics and accurately report them to FAO. For example, in 2000 Japan reported exporting 15 mt of shark fin to Mainland China, while Mainland China reported receiving 1,847 mt of imports from Japan. In the FAO database Japan reports exporting / re-exporting a total of 242 mt to all countries in 2000. It thus appears that Japan is under reporting its exports, but Mainland China may also be under reporting its imports from Japan as it does for Hong Kong. The uncertainty surrounding this issue has potentially serious implications for global tallies, particularly if continued economic liberalization in Mainland China results in increasing quantities of shark fins bypassing Hong Kong in the future.

4.3.3 Alternative Estimate of the Global Trade in Shark Fins

As described above, there are strong reasons to doubt the FAO estimate of the global shark fin trade, since traded quantities in both Hong Kong and Mainland China, believed to be the world's largest parties to the shark fin trade, and as well as possibly Japan, are likely to be inaccurately represented. In order to provide a more realistic basis for extrapolation of Hong Kong quantities to global totals, an alternative estimate of the world trade in shark fins, based on unprocessed fins, was constructed for 1996-2000 using appropriately adjusted national customs databases.

The approach first required obtaining customs data for Hong Kong, Mainland China and Singapore, which were assumed to represent the major shark fin entrepôts. For these countries it was assumed that all shark fins were imported, since they report no substantial catch of sharks (FISHSTAT 2002). Imports were tallied for each country excluding imports from the other two to avoid double counting of fins. Customs data were also obtained for Taiwan and Japan which are major shark fishing nations as well as shark fin consumer markets (see Section 1.3.1). For these countries, imports were tallied in the same manner as for the entrepôts (i.e. subtracting the other countries' shares), but exports were also included to account for excess domestic production entering the trade. Domestic consumption in Taiwan and Japan, which by definition is part of the world market for shark fin, is not reflected in customs datasets, nor in any other available databases, and thus unfortunately cannot be incorporated into this analysis.

The compilation began with customs statistics from Hong Kong (Hong Kong Government 2002) which were corrected for water content of frozen fins using the best estimate of the adjustment factor (i.e. 1 kg frozen = 0.25 kg dried) and corrected for double counting using the method in Parry-Jones (1996) for the years 1996-1997. The Hong Kong estimate shown in Table 4.6 represents total adjusted imports of unprocessed shark fin minus adjusted unprocessed imports from Mainland China and Singapore. Any unprocessed fins passing from Mainland China or Singapore to Hong Kong should be recorded first as imports in Mainland China and Singapore, therefore they must be excluded from the Hong Kong estimates to avoid double counting. For this reason, the Hong Kong estimates in Table 4.6 would not be expected to correspond to figures given in previous sections of this chapter.

The next step required tallying Mainland China data on the total reported imports from all countries except Hong Kong and Singapore (Anon. 1997a, Anon. 1998a, Anon. 1999a, Anon. 2000a, Anon. 2001a). Although some fins imported by the Mainland may be in frozen form this could not be quantified, thus no adjustment was made. The Mainland customs system also does not distinguish between processed and unprocessed shark fins, therefore all quantities were assumed to be unprocessed.

Singapore statistics separate unprocessed from processed shark fins (Anon. 1997b, Anon. 1998b, Anon. 1999b, Anon. 2000b, Anon. 2001b). The Singapore figures presented in Table 4.6 are total imports of unprocessed fins, excluding those from Hong Kong and Mainland China. No adjustment for frozen fins was possible given the commodity codes.

A different approach was taken for Taiwan and Japan as they are both producers and consumers of shark fin. It was assumed that these countries are not entrepôts and would not trans-ship unprocessed shark fins. Therefore any imports are assumed to be destined for internal use and not subject to double counting unless they were imported from one of the entrepôts. Similarly, all exports are assumed to be products of domestic production (or national fleets) and also not double counted unless they were exported to one of the entrepôts.

Taiwan estimates presented in Table 4.6 are total reported dried imports except those from the entrepôts of Hong Kong, Mainland China and Singapore, plus 0.25*frozen shark fin imports excluding frozen imports from the same entrepôts (Anon. 1997c, Anon. 1998c, Anon. 1999c, Anon. 2000c, Anon. 2001c). For reasons discussed below, imports from Japan were counted if present. Under Taiwan's commodity coding system it is not possible to determine whether the reported quantities are processed or unprocessed, thus they were assumed to be unprocessed. Exports were tallied by excluding exports to Hong Kong, Mainland China and Singapore, since such exports should be recorded as imports in each of the entrepôts' customs databases.

Japan does not maintain a commodity code for imports of shark fin (Anon. 1997d, Anon. 1998d, Anon. 1999d, Anon. 2000d, Anon. 2001d). Therefore, any exported production from Taiwan to Japan was retained in the Taiwan database and would be not be double-counted as imports to Japan. Japan does use a distinct code for shark fin exports, but since Japan's exports to Hong Kong, Mainland China, Singapore and Taiwan should be recorded in these receiving countries' import databases, only Japan's exports to other countries were tallied (Table 4.6). As Japan's data do not specify whether the shark fins are processed or unprocessed, all quantities were assumed to be unprocessed.

Table 4.6 Alternative estimate of the world trade in unprocessed shark fins (mt) based on the major markets for shark fin. Hong Kong, Mainland China and Singapore figures include imports only, whereas estimates for Taiwan and Japan are tallies of imports and exports (see text for rationale and methods). All figures have been adjusted for double counting and water content as appropriate and where possible.

Country	**1996**	**1997**	**1998**	**1999**	**2000**
Hong Kong	4,061	4,414	4,086	4,489	5,501
Mainland China	3,889	3,941	3,893	3,645	3,960
Singapore	786	606	444	596	520
Taiwan	5	31	62	69	156
Japan	10	23	0.3	1	1
Total of the above National Estimates	8,751	9,015	8,485	8,800	10,138
Hong Kong Percentage of Total	46%	49%	48%	51%	54%

The estimates of the total quantity of shark fins traded per annum from 1996 to 2000 range from 8,485 to 10,138 mt. These estimates are believed to be underestimates due to several assumptions in the analysis. Firstly, only trade in the largest shark fin markets was included and the actual global trade total would undoubtedly be higher. Secondly, for customs systems which do not distinguish between processed and unprocessed fins, such as Mainland China, Singapore and Japan, this analysis assumed the declared weights were unprocessed fins. If, however, the declared weights were actually processed fins, the equivalent unprocessed weight could be on the order of three or more times higher (Parry-Jones 1996). Thirdly, shark fins passing through customs systems are often under reported to minimize tariffs and many shipments are thought to bypass the official recordkeeping system by using unofficial, or illegal, trade routes (Clarke 2002, TRAFFIC 1996). Finally, shark fins produced and consumed within a single country (i.e. domestic consumption) are not recorded in trade statistics and are therefore excluded from this estimate.

Biases leading to overestimation may also be present in the database, but these influences are expected to be minimal compared to those under estimation biases discussed above. The main concern in this regard is the assumption in the Mainland China, Singapore and Japan databases that unspecified fins were dried rather than frozen. If substantial quantities were indeed frozen, the actual quantity of shark fins in those shipments would be over estimated by a factor of four.

The estimate of Hong Kong's share of the world market ranges from 46 to 54% with a mean value of 50% for all years combined (Table 4.6). This estimate is undoubtedly also affected, to an unknown extent, by the potential over and under estimation biases discussed above. In particular, excluding domestic production and consumption from the estimate may serve to underplay the role of countries like Taiwan and Japan in the shark fin trade and over-emphasize the importance of Hong Kong. Another consideration is Hong Kong's status as a duty free port. If quantities are less likely to be under reported in

Hong Kong, this may result in higher figures for Hong Kong relative to other countries, and create an upward bias in the estimate of Hong Kong's percentage of the world trade.

To explore this issue, an analysis comparing Hong Kong's declared quantities of shark fin with those of its main trading partners was conducted. This analysis revealed that the only major discrepancy in declared quantities was that of Mainland China imports from Hong Kong (Figure 4.3, 'Out, Mainland') which has been identified in Section 4.3.2 and accounted for in the alternative estimate methodology above. A pattern of slight under reporting of imports was also identified for Taiwan (Figure 4.3, 'Out, Taiwan') and may be a result of 42% tariffs levied on goods imported into Taiwan by foreign-registered vessels (Watts 2001). This discrepancy is unlikely to unduly bias the estimate of Hong Kong's share of the trade since the extent of Taiwan's identified under-reporting is small, as is the calculated contribution to world trade by Taiwan.

It is acknowledged that there remain a number of important shortcomings of this estimate of the quantity of shark fin traded worldwide and the market share of Hong Kong. However, in order to draw conclusions within the context of the global shark fin trade, it is necessary to derive an extrapolation factor relating Hong Kong's traded quantities to the total volume of the world trade. Based on thorough review and analysis of all existing information, the mean value of the alternative estimates for 1996-2000 presented in Table 4.6, i.e. 50%, appears to be the most reasonable extrapolation factor. Hong Kong's market share has been demonstrated to range from 46 to 54% (Table 4.6), but due to potential over and under estimation biases in the datasets used to construct this estimate, it is possible that the true value may lie beyond this range. Although it would be desirable, there is no basis for quantifying most of these biases, and it is therefore impractical to define a more appropriate range of values for extrapolation.

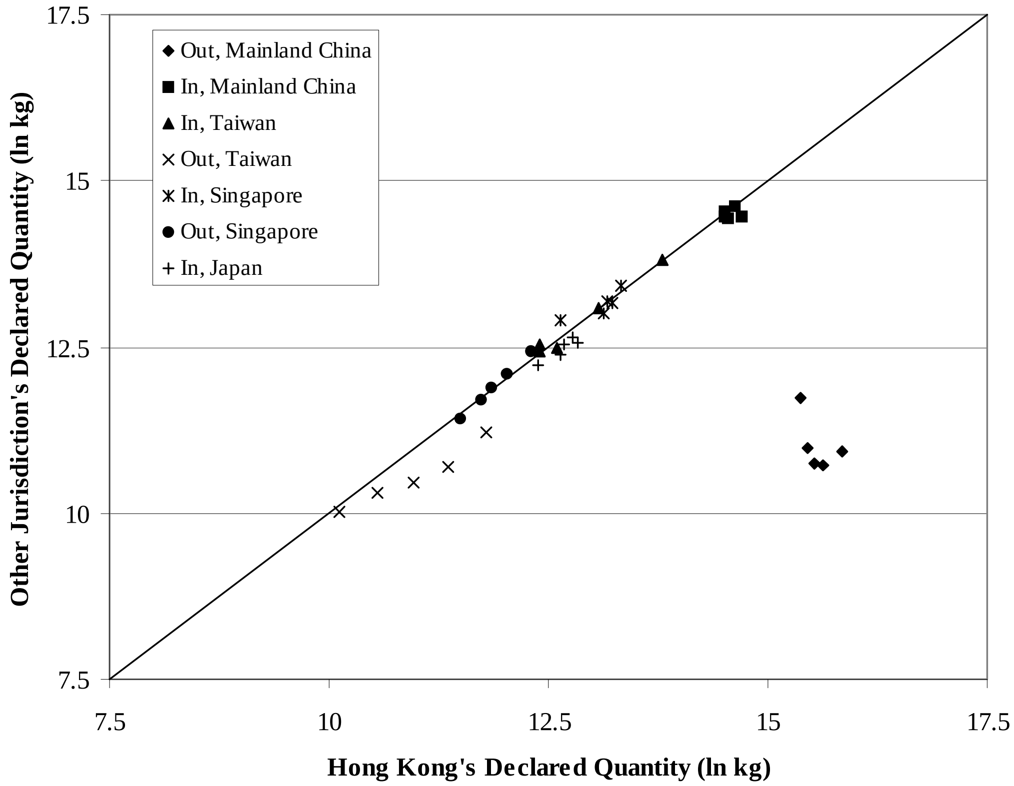

Figure 4.3 Pair wise comparison between the natural logarithms of quantities of shark fins declared in Hong Kong versus quantities declared by Mainland China, Taiwan, Singapore and Japan. Each point represents the Hong Kong declared quantity (independent axis) and the quantity declared by the trading partner (dependent axis). Each data series consists of shipments exported from Hong Kong ('Out') or imported to Hong Kong ('In') with points representing the years 1996 through 2000. There is only one series for Japan ('In') as Japan does not record imports of shark fin. The diagonal line represents the expected position of each point assuming that both trading partners report the same quantity of shark fins.

4.4 Extrapolation of Number and Whole Weight of Sharks to Global Totals

4.4.1 Definition of Extrapolation Factors

The estimates of the number and whole weight of sharks utilized per year presented in Chapter 2 are derived from the eleven studied shark types in the auction dataset. In order to convert these estimates to more meaningful figures, they must first be extrapolated to the entire volume of auctioned fins including unstudied shark types; then extrapolated to the entire volume of fins imported to Hong Kong; and finally extrapolated to the quantity of fins traded worldwide.

As discussed in Chapter 2, the need to extrapolate numbers and whole weights from studied shark types to unstudied shark types to produce estimates for the entire auction dataset derives from an inability to specify fin conversion factors for unknown shark types (Section 2.5.1). Due to the lack of appropriate information for shark types not examined in this study, extrapolation by weight from studied to unstudied shark types assumes that the fin sizes and shapes represented in the eleven studied shark types are representative of the unstudied shark types. The rationale for use of the final two extrapolation factors is given above in Sections 4.2 and 4.3.3, respectively.

Composite base, low and high factors for extrapolating number or biomass quantities by fin position (*P*) were defined according to the following equation:

$$P = \frac{Q + Q\left(\frac{U}{1-U}\right)}{A \cdot G} \qquad \text{(Eq. 4.1)}$$

where *Q* represents the estimate of the quantity (number or biomass) to be extrapolated,

U is the estimate of the fraction of unstudied sharks in the auction dataset, *A* is the estimate of the fraction of auctioned fins within the total imports to Hong Kong, and

G is the estimate of Hong Kong's share of the global trade.

Similarly, base, low and high factors for extrapolating numbers or biomass quantities by species (*S*) were calculated, using the same variable definitions, as follows:

$$S = \frac{Q}{A \cdot G} \qquad \text{(Eq. 4.2)}$$

The difference between Equations 4.1 and 4.2 derives from the fact that species-specific extrapolations do not need to include the extrapolation to unstudied shark types, as it is assumed that all fins from studied species are included in the quantity totals for those species (see Section 3.4.3 for a discussion of this issue). The values of *U*, *A* and *G* for the base, low and high factors are derived from the preceding discussion and given in Table 4.7.

Table 4.7 Input data (*U*, *A*, and *G*) for calculation of fin position-based and species-based extrapolation factors (*P* and *S*) as given in Equations 4.1 and 4.2.

	Fraction of unstudied sharks within auction dataset (*U*)	Fraction of total Hong Kong imports that are auctioned (*A*)	Fraction of global trade imported to Hong Kong (*G*)	Factor for fin position-based extrapolations (*P*)	Factor for species-based extrapolations (*S*)
Source	Table 2.8	Section 4.2	Section 4.3.3	Equation 4.1	Equation 4.2
Base	0.5406	0.176	0.50	Q x 24.7358	Q x 11.3636
Low	0.5177	0.193	0.54	Q x 19.8944	Q x 9.5951
High	0.5626	0.161	0.46	Q x 30.8700	Q x 13.5026

These extrapolation factors are applied to total (i.e. fin position-based) and species-based figures for number of sharks in Section 4.4.2 and for biomass in Section 4.4.3 below.

4.4.2 Estimate of Numbers of Sharks and Comparison to Fishery Databases

Total (fin position-based) and species-based extrapolations of shark numbers given in Chapters 2 and 3 to worldwide totals using the base, low and high extrapolation factors given in Section 4.4.1 are presented in Table 4.8. The high variance associated with dorsal fin-based estimates was noted in Chapter 2 and is apparent again here. Caudal fin variance, which was also highlighted in Chapter 2, is even higher. This results in large values at the upper end of the probability interval due to small estimates of individual fin weights divided into total traded weight to obtain the number of sharks. Based on precision and other considerations, the pectoral-based results may best represent the true probability interval for the number of sharks utilized in the shark fin trade worldwide, i.e. between 17 and 89 million. Higher estimates for dorsal and caudal fins are known to be influenced by uncertainty in conversion factors but cannot be wholly dismissed. Therefore, stochastic summing of all three fin positions was conducted and resulted in median estimates ranging from 52 to 81 million, and 95% probability intervals of 27 to 247 million.

It is difficult to compare these total (fin position-based) or species-based estimates to shark fishery monitoring databases for at least two reasons. As discussed in Chapter 1, there are very few datasets which contain information on shark catches *per se* and the majority of these do not contain data by genus or species. Furthermore, most fisheries landings data, including those compiled by FAO, are presented in terms of landed weight (or biomass) rather than number of individuals. The shark catch statistics published by the International Commission for the Conservation of Atlantic Tunas (ICCAT) is one of the only readily available catch datasets that refer to shark numbers (ICCAT 2001). No data are available for 2000, but reported shark catches for 1995-1999 range between 31,000 and 99,000 sharks per year, which is only a tiny fraction of the estimates in Table 4.8. Discrepancies between the ICCAT data and the estimates would be expected because the ICCAT data only pertain to shark catches in the Atlantic, and perhaps also because they derive from fisheries in which sharks are not the main target species. In the latter case it is likely that any finned sharks (i.e. those whose carcass is discarded at sea) are not recorded in the ICCAT database. As similar issues would apply to comparisons with most other catch statistics, further comparisons of this type were not pursued.

The popular press often quotes shark experts as claiming that 30-100 million sharks are killed each year (e.g. Lemonick 1997). After considerable enquiry, the basis for this calculation remains nebulous (possibly Bonfil 1994), but it is nevertheless generally in the same range as the median estimates in Table 4.8.

Table 4.8 Estimates of the number of sharks (in millions) utilized per year in the shark fin trade worldwide. See Section 4.4.1 for definition of Base, Low, and High extrapolation factors. The quantities extrapolated for total (fin position-based) estimates are given in Table 2.15, and for species-based estimates in Table 3.6. The first number given in each cell is based on the median shown in each table, and the figures in parentheses are based on the lower and upper 95% probability intervals shown in each table.

Estimate	**Low Extrapolation Factor**	**Base Extrapolation Factor**	**High Extrapolation Factor**
Total (Fin Position-based) Extrapolations			
Based on Dorsal Fins	38.6 (16.1 to 189.9)	48.0 (20.0 to 236.0)	59.8 (25.0 to 294.6)
Based on Pectoral Fins	28.8 (17.4 to 57.1)	35.8 (21.6 to 71.0)	44.7 (27.0 to 88.6)
Based on Caudal Fins	70.5 (27.4 to 395.7)	87.6 (34.1 to 492.0)	109.3 (42.5 to 614.0)
Based on Mean of All Fin Positions	51.9 (26.9 to 159.1)	64.5 (33.4 to 197.8)	80.5 (41.7 to 246.9)
Species-based Extrapolations (all fin positions combined)			
Blue (*Prionace glauca*)	11.2 (3.4 to 53.2)	13.3 (4.0 to 63.0)	15.8 (4.8 to 74.9)
Shortfin mako (*Isurus oxyrinchus*)	0.6 (0.3 to 1.7)	0.7 (0.3 to 2.0)	0.9 (0.4 to 2.4)
Silky (*Carcharhinus falciformis*)	1.1 (0.4 to 6.3)	1.3 (0.5 to 7.5)	1.5 (0.6 to 8.9)
Dusky (*Carcharhinus obscurus*)	0.3 (0.2 to 0.7)	0.4 (0.2 to 0.8)	0.4 (0.2 to 1.0)
Sandbar (*Carcharhinus plumbeus*)	0.8 (0.4 to 2.1)	1.0 (0.5 to 2.5)	1.1 (0.6 to 3.0)
Tiger (*Galeocerdo cuvier*)	0.03 (0.02 to 0.14)	0.04 (0.02 to 0.17)	0.05 (0.02 to 0.20)
Hammerheads (*Sphyrna* spp.)	2.0 (0.7 to 10.0)	2.4 (0.8 to 11.9)	2.9 (1.0 to 14.1)
Great Hammerhead (*Sphyrna mokarran*)	0.3 (0.2 to 1.2)	0.4 (0.2 to 1.4)	0.5 (0.3 to 1.6)
Threshers (*Alopias* spp.)	1.1 (0.5 to 4.8)	1.3 (0.6 to 5.6)	1.5 (0.7 to 6.7)
Bull (*Carcharhinus leucas*)	0.5 (0.3 to 0.9)	0.6 (0.4 to 1.1)	0.7 (0.4 to 1.3)
Oceanic Whitetip (*Carcharhinus longimanus*)	0.5 (0.3 to 2.7)	0.6 (0.3 to 3.2)	0.8 (0.4 to 3.8)

4.4.3 Estimate of Biomass of Sharks and Comparison to Fishery Databases

Total (fin position-based) and species-based extrapolations of shark biomass given in Chapters 2 and 3 to worldwide totals based on the base, low and high extrapolation factors are presented in Table 4.9. Due to the considerably greater uncertainty involved in the additional conversion steps required to estimate shark biomass, the nine scenarios' estimates of the total shark biomass utilized by the world shark fin trade show a wider range of variability than the estimates of numbers. Median values lie between approximately 1.1 and to 2.3 million mt per year worldwide while upper limits of 95% probability intervals are more than double these median estimates for all scenarios. High variance in dorsal fin estimates is again apparent and again linked to large variances in conversion factors and high traded quantities in the estimates for blue shark. The under estimation in earlier steps of the conversion factors for caudal fins is not as pronounced in the results for numbers of sharks. This may be due to low estimates of individual fin weights, leading to low estimates of shark weights, which are then combined with higher numbers as shown in Table 4.8, to produce mid-range estimates[1]. As discussed above for estimates of shark numbers, a higher credence may be placed on pectoral fin-based estimates and thus the shark biomass represented by the global shark fin trade per year is most likely to be on the order of 0.5 to 4.5 million metric tonnes. Estimates based on a stochastic simulation of all fin types and all three extrapolation factors result in medians ranging from 1.4 to 2.2 million metric tonnes, with 95% probability intervals of 0.6 to 4.9 million metric tonnes.

[1] In other words, when the total traded weight of caudal fins is divided by a small single fin weight, the result is a large estimate of the number of sharks present. In contrast, small single fin weights lead to low whole shark biomass estimates. When these low biomass estimates for a single shark are multiplied by a large number of sharks, the result is a mid-range value.

Table 4.9 Estimates of the biomass (in thousand mt) of sharks utilized per year in the shark fin trade worldwide. See Section 4.4.1 for definition of Base, Low, and High extrapolation factors. The quantities extrapolated for total (fin position-based) shark estimates are given in Table 2.21, and for species-based estimates in Table 3.6. The first number given in each cell is based on the median shown in each table, and the figures in parentheses are based on the lower and upper 95% probability intervals shown in each table.

Estimate	Low Extrapolation Factor	Base Extrapolation Factor	High Extrapolation Factor
Total (Fin Position-based) Shark Extrapolations			
Based on Dorsal Fins	1,464 (449 to 5,533)	1,820 (558 to 6,879)	2,271 (696 to 8,585)
Based on Pectoral Fins	1,206 (494 to 2,916)	1,499 (615 to 3,626)	1,871 (767 to 4,525)
Based on Caudal Fins	1,115 (374 to 3,340)	1,386 (466 to 4,153)	1,730 (581 to 5,183)
Based on Mean of All Fin Positions	1,386 (658 to 3,151)	1,724 (819 to 3,918)	2,151 (1,022 to 4,890)
Species-based Extrapolations			
Blue (*Prionace glauca*)	245 (94 to 722)	290 (111 to 856)	344 (132 to 1,017)
Shortfin mako (*Isurus oxyrinchus*)	39 (14 to 112)	46 (17 to 133)	54 (20 to 158)
Silky (*Carcharhinus falciformis*)	44 (18 to 111)	52 (22 to 132)	62 (26 to 157)
Dusky (*Carcharhinus obscurus*)	14 (7 to 32)	17 (8 to 38)	20 (10 to 45)
Sandbar (*Carcharhinus plumbeus*)	31 (14 to 71)	37 (17 to 84)	44 (20 to 100)
Tiger (*Galeocerdo cuvier*)	1.2 (0.5 to 3.4)	1.4 (0.6 to 4.1)	1.7 (0.7 to 4.8)
Hammerheads (*Sphyrna* spp.)	58 (24 to 154)	69 (29 to 183)	82 (34 to 217)
Great Hammerhead (*Sphyrna mokarran*)	23 (10 to 61)	27 (12 to 72)	32 (14 to 86)
Threshers (*Alopias* spp.)	44 (16 to 128)	52 (19 to 151)	62 (22 to 180)
Bull (*Carcharhinus leucas*)	28 (13 to 67)	33 (15 to 80)	39 (18 to 95)
Oceanic Whitetip (*Carcharhinus longimanus*)	14 (6 to 39)	17 (7 to 47)	20 (8 to 55)

Although there are a greater number of datasets available with which to compare these biomass estimates, most of these datasets are fishery-specific and thus will not provide the global figures necessary for meaningful comparisons. One exception is the FAO Capture Production database which compiles data in metric tonnes for all major fishing nations (FISHSTAT 2002). The database indicates that in 2000 the capture production for ‘sharks, rays and chimaeras’ totalled 828,364 mt. It is difficult to separate sharks from other elasmobranchs in the data due to large quantities (370,187 mt) reported in the undifferentiated ‘sharks, skates, rays, etc. not elsewhere indicated (nei)’ category (Figure 4.4).

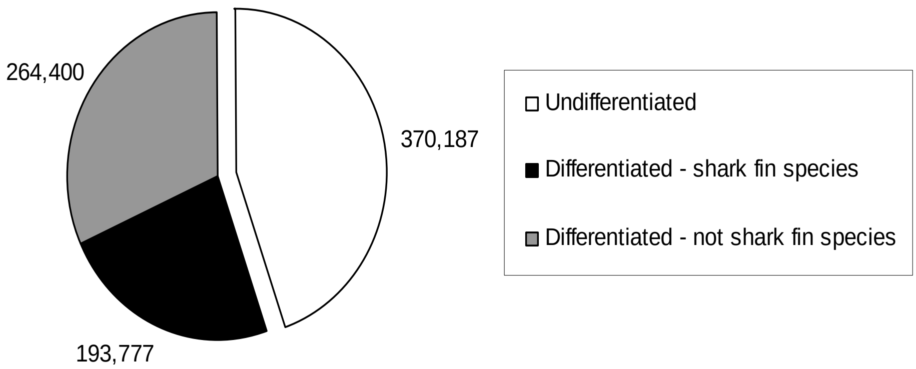

Figure 4.4 FAO Capture Production for 2000 (FISHSTAT 2002) showing quantity (mt) of sharks, rays and chimaeras reported in undifferentiated and differentiated categories. The differentiated category has been separated based on whether the reported ‘species’ is used in the shark fin trade.

Of the data that are differentiated, 193,777 mt (42.3%) are ‘species’ (or types) that are used or potentially used in the shark fin trade. These ‘species’ were designated to include all shark species as well as guitarfish and sawfish (Rose 1996); all other ‘species’, including skates, rays and chimaeras were excluded. Applying the percentages in the differentiated capture production to the undifferentiated capture production suggests that 42.3% of the undifferentiated capture production, or 156,589 mt, may be used in the shark fin trade. Therefore, the total FAO capture production that can be considered to support the shark fin trade is 350,366 mt (i.e. 193,777 mt + 156,589 mt).

These adjusted data from FAO represent only approximately one half to one tenth of estimates based on the world shark fin trade (Table 4.9). This is not surprising since some of the shark data reported to FAO are known to be aggregated at higher taxonomic levels (e.g. 'marine fishes, not elsewhere indicated'), such that sharks may be represented in the database but are not always identifiable as sharks (Shotton 1999a). This would be expected to suppress the FAO shark total and increase the differential when compared to the trade-based estimate. In addition, if sharks are finned and the carcass is discarded at sea, whole biomass would not be expected to be reported to FAO, further reducing the FAO estimate. Given these difficulties in constructing comparisons to FAO shark data in general, species-specific comparisons were not attempted. However, the following section uses a stock assessment approach to contextualize the trade-based estimates of number and biomass for one species.

4.5 Assessment of the Sustainability of Current Trade Levels

4.5.1 Introduction

Beyond providing a benchmark for monitoring the world trade in shark fins, it is desirable to use the figures presented above to evaluate whether shark populations can continue to support the trade at existing levels. This type of assessment represents the final step in a framework which aims to use trade data to evaluate the sustainability of current exploitation levels and thereby inform resource management. In order to achieve this final step a comparison must be made between the number or biomass of sharks utilized by the shark fin trade and a fisheries reference point (Caddy and Mahon 1995, Caddy 1999) expressed in absolute, rather than relative, number or biomass of sharks, such as maximum sustainable yield (MSY). Most such reference points derive from fisheries management plans or stock assessments conducted on a regional or stock-specific basis, however, it has proved impossible to partition shark fin trade figures by region, or to establish linkages between particular populations and specific quantities in trade. For this reason, this study requires reference points that are global in scope or that can be extrapolated to represent global conditions. Furthermore, as discussed in Section 1.3.2, different shark species exhibit distinct responses to exploitation and it is therefore essential to apply reference points on a species-specific basis.

Conducting a global level assessment imposes certain constraints on the interpretation of the results. For example, it is acknowledged that in reality catches and production may vary from one population to another. Therefore, if the utilization at the global level is found to be less than MSY, it does not necessarily imply that the catch for all regional populations is less than each population's MSY. In the opposite case, that is if the global utilization is found to be higher than the global MSY, this suggests that catch exceeds MSY for at least one but not necessarily all populations of the species of interest. Due to these constraints, this type of global-level assessment acts as a preliminary indicator of sustainability, and must be complemented by regional or population level assessments before policy recommendations can be formulated.

4.5.2 Identification of Reference Points

A literature review was conducted to establish whether regional or global estimates of number- or biomass-based reference points were available for any of the shark species analysed in this study. Due to the lack of management attention and species-specific catch data for sharks in previous years (see Chapter 1), few such studies have been conducted. Many studies analysing the catch per unit effort of sharks were identified (Matsunaga and Nakano 1999, Nakano 2002, Simpendorfer et al. 2002, Cortés 2002b, Hoey et al. 2002, Baum et al. 2003) but this type of analysis only documents trends in shark catches without providing estimates of what might constitute a sustainable catch or necessarily reflecting the status of the population. Other published or publicly available studies included a limited number of shark stock assessments (Kleiber et al. 2001, McAllister et al. 2001, Cortés et al. 2002), all of which discuss MSY, and a paper on the effects of the high seas drift net and longline fisheries in the north Pacific which provided minimum estimates of the blue shark (*Prionace glauca*) population (Nakano and Watanabe 1991). These four studies form two pairs: Nakano and Watanabe (1991) and Kleiber et al. (2001) assess the North Pacific population of blue sharks, whereas McAllister et al. (2001) and Cortés et al. (2002) assess the large coastal shark populations of the western Atlantic and Gulf Mexico with specific estimates for sandbar (*Carcharhinus plumbeus*), blacktip (*Carcharhinus limbatus*), and a complex of other sharks.

Since none of the identified studies were conducted on a global basis, all would require extrapolation of the reference points to cover the entire habitat of the species of interest. Developing an algorithm for extrapolating MSY based on temperature, salinity, depth, substrate and other factors (e.g. Luo et al. (2001)) was considered to be beyond the scope of this study. A two-dimensional area-based MSY extrapolation was envisaged but in coastal areas, marked habitat heterogeneity, as well as seasonal variability, present additional difficulties for implementation of this approach.

To avoid these problems, this assessment was limited to pelagic species, and therefore, due to data limitations, to blue sharks, which are widely and continuously distributed in all world oceans (Compagno 1984). For this reason, estimates of MSY per unit area from one part of the blue shark habitat should provide a suitable approximation of MSY over a broader area of known blue shark habitat, assuming that all populations have similar values for MSY per unit area. Specifically, variation in the factors contributing to MSY, for example, reproductive rates, natural mortality and fishing selectivity, may be observed from one population to another, but this assessment assumes that the MSY per unit area is fairly represented by one value over the entire range of blue shark habitat.

Since the assessments of both Kleiber et al. (2001) and Nakano and Watanabe (1991) are only applicable to the North Pacific blue shark population, an illustrative example of an extrapolation methodology was produced by calculating the total area of blue shark habitat in the world ocean and dividing this figure by the area of blue shark habitat in the North Pacific to derive an extrapolation factor. Based on published data on blue shark ranges (Nakano and Seki 2003, Compagno 1984) blue shark habitat was defined as the area between 50ºN and 50ºS latitude worldwide and extending to the coastline in each ocean basin. The North Pacific was defined as the subset of this area north of the equator and bounded by the western coast of North and Central America to the west, and the eastern coast of Asia to the Straits of Malacca to the east (Figure 4.5). Although blue sharks are more sparsely distributed in tropical waters (i.e. from 0^o to 10^o on either side of the equator), the calculations in Kleiber et al. (2001) and Nakano and Watanabe (1991) are based on the entire area of the North Pacific (as defined above) and thus this reduced abundance in tropical areas is accounted for in the extrapolations. Using an equal area projection in ArcView 3.2 geographic information system software, the area of the North Pacific habitat was calculated as 75,347 thousand km^2, and the area of the world ocean habitat was calculated as 287,836 thousand km^2. The extrapolation factor was therefore set at 3.82.

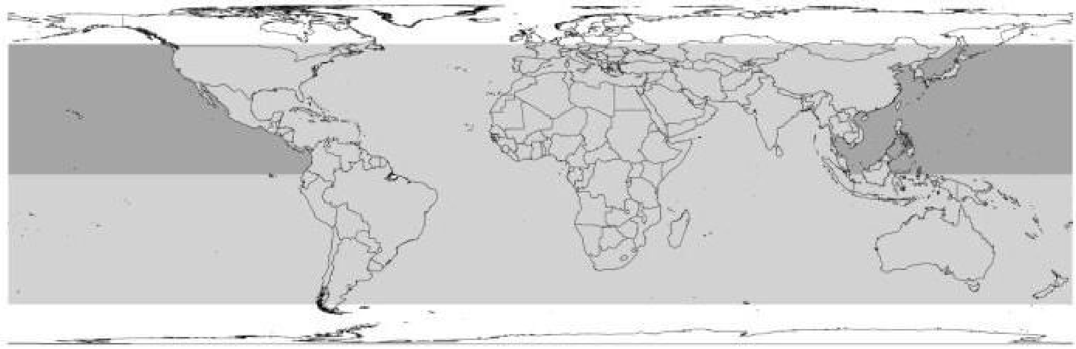

Figure 4.5 Assumed area of blue shark habitat in the North Pacific (dark shading) and worldwide (light shading excluding land forms).

4.5.3 Estimates of Global Maximum Sustainable Yield for Blue Sharks

The study by Kleiber et al. (2001) presents an MSY for blue sharks in the North Pacific relative to the average catches recorded between 1993 and 1998 using an age-structured model. Their model is based on blue shark catch series from 10 fleets operating in the North Pacific from the 1970s through the 1990s. To calculate MSY, abundance at age, recruitment, natural mortality and fishing mortality at age from a population dynamics model (Multifan-CL) were used in conjunction with a Beverton-Holt stock-recruitment relationship. The average catches are given as 1.1 million sharks per year, and the MSY was estimated to range from 1.7 to 3.0 times this amount, therefore the blue shark MSY for the North Pacific is expected to lie between 1.9 and 3.3 million sharks. The authors state their assumptions were ‘conservative, or pessimistic’, and that traditional assessment procedures could well produce MSY estimates at or exceeding the upper limit of their calculated ranges. Applying the area extrapolation factor of 3.82, the estimated MSY for blue shark worldwide ranges from 7.2 to 12.6 million.

As it was not possible to understand all the assumptions and sensitivities of the model used in the Kleiber et al. (2001) assessment from the available documentation, data provided in Nakano and Watanabe (1991) was used to calculate a comparative MSY for the same North Pacific area. The details of these cross-check calculations are provided in Appendix 3. Although the Nakano and Watanabe (1991) study is based on an time series of data extending only up until 1988, and a number of assumptions are required in order to calculate an MSY from their data, this exercise serves as a comparison to the Kleiber et al. (2001) MSY values and an example of a methodology for linking trade-based estimates of the numbers of organisms utilized with stock assessment studies.

The low and high estimates of blue shark MSY from the Kleiber et al. (2001) study in number, as well as the results of the MSY cross-check calculations based on the Nakano and Watanabe (1991) study are presented in Table 4.10. Kleiber et al. (2001) estimate global MSY within the range of 7 to 13 million blue sharks per year. The estimates from the surplus production form of the cross-checking calculations are higher and indicate an annual MSY of 13 to 21 million blue sharks per year (Appendix 3).

Table 4.10 Summary of low and high estimates for blue shark MSY in millions of sharks for the North Pacific and the world ocean based on a stock assessment (Kleiber et al. 2001) and cross-check calculations (based on Nakano and Watanabe (1991)).

	Low Estimate		High Estimate	
	North Pacific	Global	North Pacific	Global
Number (millions of sharks)				
Kleiber et al. (2001) (do not provide a global estimate)	1.9	7.2	3.3	12.6
Appendix 3 surplus production based calculations	3.4	13.0	5.6	21.4

Differences between the cross-check results and those of Kleiber et al. (2001) may be due to the different catch series and catch periods, model structure, and/or assumptions about parameter values and ranges. Based on this comparison the results of Kleiber et al. (2001) appear plausible, thus if the global extrapolation is validly applied, the global MSY values for blue shark are postulated to lie in the range from 7 to 13 million sharks per year, with limited evidence for global MSY values as high as 21 million (Table 4.10).

Cross-checking the results from Kleiber et al. (2001) against a North Pacific blue shark population estimate from 1988 may be ignoring important changes in blue shark catchability and fishing effort that have occurred in the intervening period. In particular, the United Nations ban on small-mesh drift nets in 1992 caused a decrease in fishing mortality on the smaller age classes (ages 2-3) of blue shark (H. Nakano, personal communication) possibly changing the age structure of the population. With the growth of the shark fin trade in the 1990s, fishing effort for sharks is also likely to have changed. The effects of potential increased targeting (or retention or finning) of sharks, could, however, be offset by a reproductive or competitive advantage for blue shark over other sharks at high fishing mortalities. Despite likely changes in circumstances since 1988, reference points derived from Kleiber et al. (2001), based on data through 1998, and the 1988-based cross-check calculations both produce results of the same order of magnitude with nearly overlapping ranges of MSY values.

4.5.4 Comparison of Reference Point Estimates to Trade-Based Estimates

The objective of estimating the global MSYs was to compare them to the number of blue sharks utilized in the shark fin trade worldwide. The global shark fin trade estimates presented in Table 4.8 indicate that between 3 and 75 million blue sharks are represented each year based on all examined scenarios. The upper range of these figures exceeds the range of MSY estimates (7 to 13 million) approximated by the Kleiber et al. (2001) study (as extrapolated) by a considerable margin. However, the upper ranges of the trade-based estimates are believed to be influenced by high, and possibly anomalous, estimates of blue shark numbers based on uncertain fin conversion factors (see Chapter 2 for full discussion). Using medians for the base, low and high extrapolation scenarios, trade-based estimates for blue shark range from 11 to 16 million sharks per year. These estimates also lie at or above the MSY estimates of 7 to 13 million by Kleiber et al. (2001) but below those estimated by the surplus production cross-check calculation. The results from this evaluation suggest that blue sharks are being harvested at rates close to the MSY level but the possibilities of over or under exploitation cannot be eliminated on the basis of available information.

4.6 Conclusions

This chapter has explored methods for relating the characteristics of the Hong Kong shark fin auctions to the global shark fin trade. Using national customs data for Hong Kong, as well as several other key shark fin trading countries, the proportion of the trade passing through the Hong Kong auctions was calculated and used to develop a number of extrapolation factors. These were then applied to calculate the number and biomass of sharks represented in the global trade. The total number of sharks represented is believed to lie within the interval of approximately 17 to 89 million per year. Similar estimates in biomass varied from 0.5 to 4.5 million mt per year. In comparison, shark capture production (in biomass) reported to FAO in 2000 represents only one half to one tenth of these trade-based estimates. The lower FAO figures may be a reflection of non-reporting, aggregation of shark catch data at higher taxonomic levels where it cannot be distinguished, and/or shark finning.

Comparison of these trade-derived estimates to fisheries management reference points was limited by the availability of shark stock assessment studies. As it was considered that an area-based extrapolation of MSY would be most suitable for pelagic sharks, MSY estimates were only available from one study (Kleiber et al. 2001). Simple surplus production methods were used to cross-check this study's MSY estimate for blue shark in the North Pacific and provide an example of a methodology for linking stock assessment studies with trade assessments. These MSY estimates were then extrapolated to the world ocean by area. When contrasted with the shark fin trade-based estimates, the MSY in number of sharks (7 to 13 million based on Kleiber et al. (2001) and 13 to 21 million based on surplus production cross-check calculations) overlapped the range of median trade-based estimates (11 to 16 million) but was substantially lower than the highest trade-based estimates (75 million sharks). This finding suggests that blue sharks are being exploited at rates that are close to MSY, or possibly exceeding MSY if the true exploitation rates lie near the high end estimates.

These findings do not allow us to dismiss the idea that blue sharks are being harvested sustainably on a global level. However, if any regional populations of blue shark have considerably lower values for MSY per unit area or are being fished more intensively than indicated in the global assessment, these populations could be overexploited. Furthermore, the assessment presented here for blue shark (*Prionace glauca*) applies only to this species and is not indicative of any other species present in the trade. Blue shark is known to be one of the most productive and resilient of shark species (Cortés 2002a, Smith et al. 1998) and of all the sharks present in the fin trade it is perhaps the most likely to be utilized within biologically sustainable limits. Lacking stock assessments for some of the rarer and less productive sharks present in the trade, it is not possible to infer whether these species are over-fished and whether their rarity is a reflection of their depleted status.

Conclusions regarding the sustainable or unsustainable use of other species, and thus of the shark fin trade as whole, cannot be drawn until a broader suite of appropriate fishery reference points have been developed. As more shark stock assessments are produced, the trade-based estimates provided by this study for the ten additional studied species can be compared to provide insights into the impacts of the shark fin trade on these sharks. Although uncertainty in the estimates presented in this chapter is inevitable given the limited amount and quality of the data, the strength of the approach lies in its ability to recognize, and in many cases account for uncertainty, and to be updated as better data become available. Improved datasets may also provide opportunities for an even more rigorous treatment of uncertainty in some steps. In addition to the specific findings, the extrapolation methodology introduced here highlights the strengths and weaknesses of the information at each step and thus can serve as a multi-tiered trade monitoring framework for sharks and other traded wildlife.