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# A global review of species-specific shark-fin-to-body-mass ratios and relevant legislation

L. Biery* and D. Pauly

*The University of British Columbia Fisheries Centre, Sea Around Us Project, 2202 Main Mall, Vancouver, BC, V6T 1Z4 Canada*

In this review, shark-fin-to-body-mass ratios, which have been legislated by several countries as a means of regulating and monitoring shark fisheries, have been compiled and reviewed. Observed and legislated wet-fin-mass-to-round-mass ($M_{fw}$:$M_r$) ratios have been collected for 50 species and eight countries. Wet to dry-fin mass conversion factors have also been reviewed. Existing shark fishery legislation was compiled by political entity and regional fishery management organizations (RFMO). The mean observed $M_{fw}$:$M_r$ ratio for all species was 3·0%, but actual fin to body-mass ratios varied considerably by species and location. Species-specific mean ratios ranged from 1·1 to 10·9%, and estimated mean ratios ranged from 1·5 to 6·1% by country, depending on fin-cutting practices and the mix of exploited species. The mean conversion factor for wet to dry-fin mass was 0·43. Shark-related legislation was found to exist in 37 countries and the 22 maritime members of the European Union, and shark-related regulations have been designated by nine RFMOs. Results suggest that currently regulated ratios may not be appropriate for all species and fin-cutting practices, and regulations based on generalized ratios for all sharks may be inadequate. Alternative policies may be necessary for the effective management of global shark fisheries. © 2012 The Authors
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Key words: elasmobranch; finning; laws; policies and regulations; RFMO.

## INTRODUCTION

Over 400 species of sharks exist globally, inhabiting all of the world's oceans and acting as important apex predators in some marine ecosystems (Last & Stevens, 2009). During the early 1900s, a demand existed for many shark products, including liver oil, hides, fins, meat, teeth and jaws (Beaumariage, 1968; Kreuzer & Ahmed, 1978). Since the 1980s, much of the demand for shark products has shifted to fins, and shark populations have experienced rapid decline as a result of the increasing consumption of shark-fin soup in China and other economically expanding Asian countries (Rose, 1996; Mejuto & Garcia-Cortés, 2004). Because shark fins are highly coveted as a delicacy in China, they are more valuable than other shark products including meat, cartilage, oil, skins, jaws and teeth (Hareide *et al*., 2007). To feed the demand for valuable fins, shark finning, the act of removing fins at sea and discarding the remainder of the shark carcass, is practised both legally and illegally in

*Author to whom correspondence should be addressed. Tel.: +1 604 822 2731; email: l.biery@fisheries.ubc.ca



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fisheries worldwide (Cortés & Neer, 2006). Finning allows vessels to store fins more efficiently than if they were to retain entire carcasses, thus maximizing profit (Hareide *et al*., 2007). The removal of fins during processing on land is not considered shark finning (Fowler & Séret, 2010).

Sharks tend to grow slowly, reach maturity at a large size and late age and have low fecundity, all traits which make them especially sensitive to overfishing (Hoenig & Gruber, 1990). The IUCN Red List currently lists 141 shark species as critically endangered, endangered, vulnerable or near threatened (IUCN, 2011). The wasteful practice of shark finning, which fails to utilize sharks to their full potential as a natural resource, contributes to the overharvesting and resulting decline of many of these species (IUCN, 2003). Furthermore, shark finning makes catch monitoring difficult because shark bodies are not present to be counted or weighed, and these figures are challenging to estimate based solely on the quantity of fins landed. The resulting lack of accurate catch data makes effective shark fishery management troublesome, because fishing pressure is not well understood and is therefore commonly underestimated (Jacquet *et al*., 2008). The biomass of sharks caught worldwide may be three to four times higher than statistics assembled by the United Nations Food and Agriculture Organization (FAO) suggest (Clarke *et al*., 2006).

Globally, steps are being taken to improve the effectiveness of shark management strategies and introduce them where they do not yet exist, but challenges still remain. An International Plan of Action for the Conservation and Management of Sharks was adopted by the FAO Committee on Fisheries in 1999, but so far none of its elements have been implemented successfully (Lack & Sant, 2011). Some nations have realized the need for more rigorous management of shark fisheries, and have adopted a country-specific National Plan of Action for the Conservation and Management of Sharks or established other regulations which limit or ban shark finning (Cortés & Neer, 2006). The U.S. Shark Finning Prohibition Act, passed in 2000, prohibited the landing of fins without the corresponding mass in shark carcasses, and the U.S. Shark Conservation Act of 2010 added the requirement that all sharks must be brought to the port with fins attached. Additional countries have also instated laws that require sharks to be landed with fins naturally attached (Hindmarsh, 2007). Fins-attached regulations are helpful from an ecological perspective, but due to the low value of shark meat and the rigidity of shark fins, fishers often think that it is impractical to store bodies on-board vessels with fins attached (Hareide *et al*., 2007).

As a compromise, some countries permit fishers to remove fins from bodies at sea for separate storage if the bodies are kept and the mass of fins on board a vessel corresponds, *via* a pre-established fin-to-body-mass ratio, to the mass of carcasses present. The European Union requires most vessels to land sharks with fins attached, but special fishing permits can be issued which allow certain vessels to separate fins from carcasses at sea as long as ratio requirements are met, a common practice among Spanish and Portuguese longline vessels (Fowler & Séret, 2010). This type of regulation made the establishment of standard fin-to-body-mass ratios necessary to confirm that landed fins correspond to the shark carcasses present on board (Cortés & Neer, 2006). The U.S. Fishery Management Plan for Sharks of the Atlantic Ocean proposed a 5% wet-fin-to-dressed-carcass-mass ($M_{fw}$:$M_d$) ratio, which was based on an independent examination of 12 individual sandbar sharks *Carcharhinus plumbeus* (Nardo 1827) (NMFS, 1993). This ratio was later validated by a study of 27 000 sharks by the U.S. Commercial Shark Fishery Observer Programme, which found a

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mean ratio of 4·9% for 28 shark species. The 5% ratio was officially adopted by the European Union in 2003, but the regulation specifies a wet-fin-to-round-(or total)-mass ($M_{fw}$:$M_r$) ratio instead of a $M_{fw}$:$M_d$ ratio where fins and head have already been removed, so the validity of the ratio is undermined and it may allow fishers to fin extra sharks (Hareide *et al*., 2007; Ariz *et al*., 2008). Similar ratio-based regulations have been implemented in additional countries, and by some regional fishery management organizations (RFMO).

The 5% $M_{fw}$:$M_r$ ratio may not be a realistic mean for all shark species and fishing fleets, as numerous data sources show considerable variation in ratios between species and locations. Accurate ratios for each species are essential to monitor total catches (Cortés & Neer, 2006; Ariz *et al*., 2008). If regulated ratios are set at levels higher than observed ratios, a loophole is created which allows fishers to harvest more fins than correspond to the number of carcasses on board while still meeting mass-ratio requirements. Ratio-based regulations also provide an opportunity for high-grading, the practice of mixing carcasses and fins from different animals to maximize profit (Hareide *et al*., 2007). Even if species-specific ratios were to be regulated, observers would need to be capable of identifying carcasses by species with or without fins, as well as the species of fins without carcasses, which is a difficult task that makes this type of enforcement particularly challenging to implement (Fowler & Séret, 2010). Variation in ratios between species is probably due to anatomical differences, while ratio differences between locations are probably attributed to fin-cutting practices and typical fin-set composition, which vary between regions. Most countries harvest the primary fin set, which consists of the most valuable fins, including the first dorsal, two pectoral and lower caudal fins, but some countries harvest secondary fins as well (Cortés & Neer, 2006) (Fig. 1).

During processing, and sometimes prior to landing, fins may be dried in preparation for trade (Anderson & Hudha, 1993). Fins are typically rinsed in salt water, and then spread out on mats or tables to dry for 4–7 days, depending on various factors including fin cut, fin size and weather (Anderson & Hudha, 1993). The drying

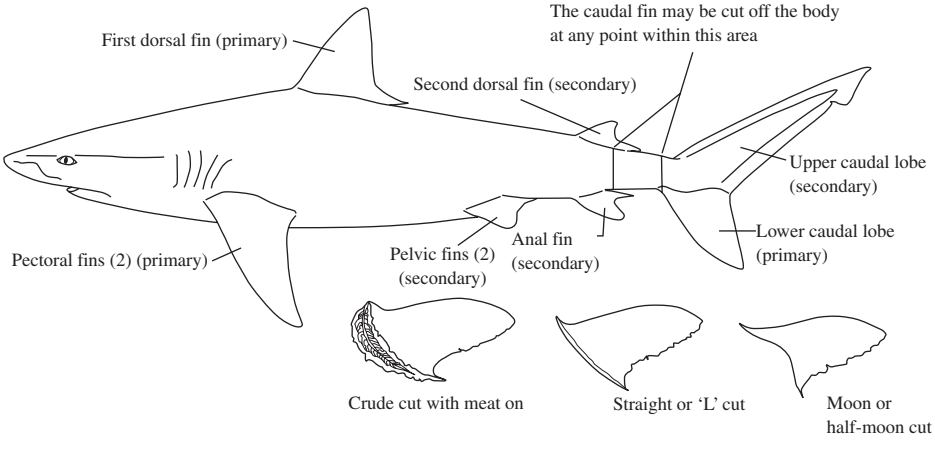


FIG. 1. Diagram of whole shark with primary and secondary fin sets labelled. Three common fin cuts are illustrated (Figure modified from Anderson & Hudha, 1993; S. Fowler in Cortés & Neer, 2006; Hareide *et al*., 2007).

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process results in a loss of water, and although one anecdotal conversion factor is insufficient for use in regulating shark fisheries, the mass of frozen fins has been described anecdotally to decrease by 70–80% when dried (Clarke, 2003). Such a conversion factor can be applied to estimate the wet mass of dried fins, making it possible to enforce $M_{fw}$:$M_r$ ratio regulations even when fins are landed dry.

In this paper, current regulations have been compiled globally by country and RFMO and classified into five categories to provide an overview of existing legislation. $M_{fw}$:$M_r$ ratios from independent and government sources were compiled and examined by species and location, and wet-to-dry-fin-mass conversion factors were collected and reviewed. Data were extracted from scientific literature, reports, government regulations and unpublished sources. The legitimacy of the 5% ratio has been reviewed and recommendations were made to adopt a policy that requires fishers to land sharks with fins attached to promote the more effective management of global shark fisheries.

## MATERIALS AND METHODS

### GLOBAL SHARK FISHERY LEGISLATION AND REGULATIONS

Legislation and regulations related to shark fisheries have been collected and compiled from legal documents and secondary literature sources for countries and RFMOs. The countries and RFMOs have been classified into one or more of the following categories based on existing legislation and regulations: shark sanctuary (an area where shark fishing has been entirely prohibited), area where sharks must be landed with fins attached, area where fin-to-body-mass ratio-based regulations have been implemented, area where shark product trade regulations exist or other.

### REVIEW OF OBSERVED WET-FIN-TO-ROUND-MASS RATIOS AND WET-TO-DRY-FIN-MASS CONVERSION FACTORS

Literature including scientific papers and reports, NGO reports, private government studies and unpublished sources relating to observed shark-fin-to-body-mass ratios has been reviewed and a database was compiled of mean observed $M_{fw}$:$M_r$ ratios. Mean $M_{fw}$:$M_r$ ratios were extracted from a total of 17 sources for 50 species and 12 countries. Observed sample size $n$ and mean $M_{fw}$:$M_r$ ratio values were recorded by species and fishing vessel country, and available fin set and finning practice descriptions were noted. In cases where $n$ was unavailable, sample size was assumed to be 1. The S.D., S.E. and range values were recorded when provided. Observed, legislated and anecdotal wet-fin-to-dry-fin-mass conversion factors were compiled from 10 sources.

For one species, spiny dogfish *Squalus suckleyi* (Girard 1855), the $M_{fw}$:$M_r$ ratio was estimated by the authors based on fish specimens sampled from the British Columbia coast in July 2011.

### DATA ANALYSIS

Mean $M_{fw}$:$M_r$ ratio values for each individual species and for countries with three or more species represented were weighted by species sample size $n$ and overall mean values calculated. Missing sample sizes were assigned a value of $n = 1$. Missing S.D. ($s$) values were calculated from available S.E. ($q$) values using $s = q(\sqrt{n})$. In cases where only range was available, rough estimates of S.D. were obtained from $s \approx r(d^{-1})$, where $r$ is equal to the range and $d$ is a variable dependent on sample size $n$ (Sokal & Rohlf, 1995; Montgomery,

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2005). Missing $d$ values were estimated using log-linear interpolation based on $d$ values for different values of $n$ (Sokal & Rohlf, 1995; Montgomery, 2005).

The combined S.D. was calculated for each species using the equation for pooled sample variance: $s_p^2 = \{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 \ldots\}(N - k)^{-1}$, where $n$ is equal to sample size, $s_p$ is the pooled S.D., $s_1^2$, $s_2^2$ ... are the $s$ values for each individual sample, $N$ is equal to $\sum n$ and $k$ equals the number of individual samples being combined (Kleinbaum *et al.*, 1998). Mean $M_{fw}$:$M_r$ values for each family and genus were calculated without being weighted by species, where $n$ represents the number of species included within each genus or family.

Dry-to-wet-fin conversion factors were calculated based on available data from eight sources so that $M_{fd} = CM_{fw}$, where $M_{fd}$ is the mass of dry fins, $C$ is the conversion factor and $M_{fw}$ is the mass of wet fins. In cases where both wet-fin-to-total-body-mass ($M_{fw}$:$M_r$) and dry-fin-to-total-body-mass ($M_{fd}$:$M_r$) ratios were available, the $M_{fd}$:$M_r$ ratios were divided by the $M_{fw}$:$M_r$ ratios to obtain $C$ values. Where both wet and dry masses were provided for individual samples, dry mass was divided by wet mass to calculate $C$. The S.D. was estimated for each source using $s \approx r(d^{-1})$ as described above and $q = s[(\sqrt{n})^{-1}]$ was used to calculate S.E. Combined S.D. were calculated using the formula for pooled-sample variance.

## RESULTS

### EXISTING SHARK FISHERY LEGISLATION AND REGULATIONS

Regulations were found to exist in 37 countries and the European Union (E.U.), which includes 22 maritime countries (Appendix). Additionally, legislation was pending in Taiwan and the U.S. states of California and Oregon at the time of publication. Five countries were classified as shark sanctuaries; 17 countries, the U.S. state of Alaska and the European Union were classified as areas where sharks must be landed with fins attached; eight countries and the European Union have implemented ratio-based shark regulations and seven countries and three U.S. states have passed legislation to regulate the trade of shark products (note that individual countries may be classified into multiple categories).

Nine RFMOs have designated shark-related regulations; eight RFMOs follow the 5% ratio, although whether the ratio is based on wet-fin-to-dressed-carcass mass or wet-fin-to-round mass is unspecified, and the entire area covered by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has been classified as a shark sanctuary.

### MEAN OBSERVED FIN-TO-BODY-MASS RATIOS AND WET-TO-DRY-FIN-MASS CONVERSION FACTORS

By species, mean shark $M_{fw}$:$M_r$ ratios were found to range from 1·06% for nervous shark *Carcharhinus cautus* (Whitley 1945) to 10·90% for smalltooth sawfish *Pristis pectinata* Latham 1794 (Table I). When ordered by genus, mean ratios ranged from 1·34% for the genus *Carcharias* to 10·90% for the genus *Pristis* (Table II), and by family ranged from 1·34% for members of the family Odontaspididae to 5·40% for members of the family Ginglymostomatidae (Table III). Of those reviewed, 42 of 50 species, 19 of 24 genera and 11 of 13 families had mean $M_{fw}$:$M_r$ ratios lower than the 5% ratio regulated by many countries. Mean country ratios ranged from 1·52% in Australia to 6·06% in Portugal (Table IV). Descriptions of finning practices varied

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TABLE I. Mean ± S.E. wet-fin-to-round-mass ($M_{fw}$:$M_r$) ratios by shark species, for species with available data, ranked from lowest to highest

| Species | Common name | *n* | Mean ± S.E. ($M_{fw}$:$M_r$) ratio | Sources[a] |
|---|---|---|---|---|
| *Carcharhinus cautus* | Nervous shark | 1 | 1·06 ± 0·00 | 16 |
| *Carcharhinus signatus* | Night shark | 2 | 1·30 ± 0·16 | 3 |
| *Carcharhinus taurus* | Sand tiger shark | 1 | 1·34 ± 0·00 | 3 |
| *Carcharhinus dussumieri* | Whitecheek shark | 18 | 1·35 ± 0·06 | 16 |
| *Carcharhinus perezii* | Caribbean reef shark | 2 | 1·37 ± 0·16 | 3 |
| *Galeocerdo cuvier* | Tiger shark | 48 | 1·41 ± 0·06 | 3, 4, 7 |
| *Carcharhinus sorrah* | Spottail shark | 31 | 1·42 ± 0·04 | 1, 16 |
| *Carcharhinus amblyrhynchoides* | Graceful shark | 13 | 1·47 ± 0·06 | 16 |
| *Scymnodon ringens* | Knifetooth dogfish | 9 | 1·50 ± 0·06 | 16 |
| *Carcharhinus tilstoni* | Australian blacktip shark | 50 | 1·53 ± 0·03 | 16 |
| *Carcharhinus melanopterus* | Blacktip reef shark | 36 | 1·59 ± 0·04 | 1, 16 |
| *Carcharhinus amboinensis* | Pigeye shark | 6 | 1·68 ± 0·10 | 16 |
| *Mustelus canis* | Smooth dogfish | 6 | 1·69 ± 0·31 | 4 |
| *Squalus suckleyi* | Spiny dogfish | 9 | 1·69 ± 0·01 | 17 |
| *Carcharhinus acronotus* | Blacknose shark | 27 | 1·71 ± 0·09 | 3, 4 |
| *Carcharhinus fitzroyensis* | Creek whaler shark | 14 | 1·71 ± 0·07 | 16 |
| *Carcharhinus obscurus* | Dusky shark | 6 | 1·80 ± 0·13 | 3, 4 |
| *Rhizoprionodon terraenovae* | Atlantic sharpnose shark | 45 | 1·81 ± 0·04 | 3, 4 |
| *Rhizoprionodon acutus* | Milk shark | 1 | 1·92 ± 0·00 | 16 |
| *Sphyrna mokarran* | Great hammerhead shark | 11 | 1·96 ± 0·25 | 3, 4, 16 |
| *Carcharhinus altimus* | Bignose shark | 11 | 1·98 ± 0·15 | 3, 4 |
| *Centroscymnus coelolepis* | Portuguese dogfish | 10 | 2·00 ± 0·13 | 10 |
| *Alopias vulpinus* | Thresher shark | 10 | 2·06 ± 0·05 | 3, 4 |
| *Sphyrna lewini* | Scalloped hammerhead | 81 | 2·13 ± 0·05 | 2, 3, 4 |
| *Carcharhinus limbatus* | Blacktip shark | 70 | 2·18 ± 0·08 | 3, 4, 7 |
| *Lamna nasus*[b] | Porbeagle shark | 620 | 2·20 ± 0·02 | 3, 5 |
| *Carcharhinus brevipinna* | Spinner shark | 58 | 2·27 ± 0·12 | 3, 4 |
| *Negaprion brevirostris* | Lemon shark | 1 | 2·30 ± 0·00 | 3 |
| *Sphyrna tiburo* | Bonnethead shark | 76 | 2·46 ± 0·06 | 3, 4 |
| *Eusphyra blochii* | Winghead shark | 10 | 2·47 ± 0·16 | 7, 16 |
| *Dalatias licha* | Kitefin shark | 1 | 2·50 ± 0·00 | 7 |
| *Carcharhinus plumbeus* | Sandbar shark | 103 | 2·52 ± 0·04 | 3, 4 |
| *Isurus oxyrinchus*[b] | Shortfin mako shark | 265 | 3·14 ± 0·04 | 2, 4, 8, 15 |
| *Centroscyllium fabricii* | Black dogfish | 10 | 3·40 ± 0·16 | 10 |
| *Loxodon macrorhinus* | Sliteye shark | 175 | 3·69 ± 0·04 | 9 |
| *Carcharhinus albimarginatus* | Silvertip shark | 4 | 3·48 ± 0·27 | 1, 3 |

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TABLE I. Continued

| Species | Common name | *n* | Mean ± S.E. ($M_{fw}$:$M_r$) ratio | Sources[a] |
|---|---|---|---|---|
| *Centrophorus squamosus* | Leafscale gulper shark | 10 | 3·80 ± 0·09 | 10 |
| *Carcharhinus amblyrhynchos* | Grey reef shark | 3 | 4·00 ± 0·31 | 1 |
| *Centroselachus crepidater* | Longnose velvet dogfish | 10 | 4·00 ± 0·13 | 10 |
| *Carcharhinus falciformis* | Silky shark | 324 | 4·46 ± 0·03 | 1, 2, 3, 4, 6, 7, 11, 13 |
| *Galeorhinus galeus* | Soupfin shark | 1 | 4·50 ± 0·00 | 7 |
| *Mustelus antarcticus* | White-spotted gummy shark | 1 | 4·50 ± 0·00 | 7 |
| Legislated ratio (E.U. and Canada) | — | — | 5·00 | — |
| *Carcharhinus brachyurus* | Bronze whaler | 1 | 5·10 ± 0·00 | 7 |
| *Deania calcea* | Birdbeak dogfish | 10 | 5·40 ± 0·25 | 10 |
| *Nebrius ferrugineus* | Tawny nurse shark | 3 | 5·40 ± 0·31 | 1 |
| *Prionace glauca*[b] | Blue shark | 3959 | 5·65 ± 0·02 | 2, 3, 4, 6, 7, 11, 12, 13, 15 |
| *Negaprion acutidens* | Sicklefin lemon shark | 1 | 5·70 ± 0·00 | 1 |
| *Sphyrna zygaena* | Smooth hammerhead | 127 | 5·74 ± 0·04 | 3, 13 |
| *Carcharhinus longimanus* | Oceanic whitetip shark | 225 | 7·34 ± 0·06 | 1, 2, 6, 7, 11, 13 |
| *Pristis pectinata* | Smalltooth sawfish | 1 | 10·90 ± 0·00 | 14 |

*n*, sample size.

[a]1, Anderson & Hudha (1993); 2, Ariz *et al*. (2008); 3, NMFS (1993); 4, Cortés & Neer (2006); 5, Cortés & Neer (2006); 6, Dai *et al*. (2006); 7, Gordievskaya (1973); 8, A. Hore (pers. comm.); 9, F. Humber (pers. comm.); 10, Kjerstad *et al*. (2003); 11, Mejuto & Garcia-Cortés (2004); 12, Neves dos Santos & Garcia (2005); 13, Neves dos Santos & Garcia (2008); 14, Pauly (2006); 15, Petersen *et al*. (2007); 16, Rose *et al*. (2001); 17, Pers. obs.

[b]In New Zealand, the legislated wet-fin-to-round-mass ratio is 2·22 for *Lamna nasus*, 1·70 for *Isurus oxyrinchus* and 1·50 for *Prionace glauca*.

by country (Table V). The mean ± S.E. wet mass to dry fin mass conversion factor was 0·43 ± 0·01 for all sources (Table VI).

## DISCUSSION

Progress has been made in recent years to protect sharks through international partnerships and the creation and implementation of shark-related legislation (Fig. 2). On a global scale, however, the majority of countries remain unregulated. Because many shark species are highly migratory and move between countries and RFMO areas, it is important for additional countries and organizations to adopt legislation to

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TABLE II. Mean ± S.E. wet-fin-to-round-mass ($M_{fw}$:$M_r$) ratios by shark genus, ranked from lowest to highest. The total number of species within each genus is given and the number of species included from each genus ($n$)

| Genus | $n$ | Total species | Mean ± S.E. ($M_{fw}$:$M_r$) ratio | Sources[a] |
|---|---|---|---|---|
| *Carcharias* | 1 | 2 | 1·34 ± 0·00 | 3 |
| *Galeocerdo* | 1 | 1 | 1·41 ± 0·00 | 3, 4, 7 |
| *Scymnodon* | 1 | 2 | 1·50 ± 0·00 | 16 |
| *Squalus* | 1 | 26 | 1·69 ± 0·00 | 17 |
| *Rhizoprionodon* | 2 | 7 | 1·87 ± 0·06 | 3, 4, 16 |
| *Centroscymnus* | 1 | 5 | 2·00 ± 0·00 | 10 |
| *Alopias* | 1 | 3 | 2·06 ± 0·00 | 3, 4 |
| *Lamna* | 1 | 2 | 2·20 ± 0·00 | 3, 5 |
| *Carcharhinus* | 21 | 31 | 2·44 ± 0·35 | 1, 2, 3, 4, 7, 11, 13, 16 |
| *Eusphyra* | 1 | 1 | 2·47 ± 0·00 | 7, 16 |
| *Dalatias* | 1 | 1 | 2·50 ± 0·00 | 7 |
| *Sphyrna* | 4 | 8 | 3·07 ± 0·90 | 2, 3, 4, 13, 16 |
| *Mustelus* | 2 | 27 | 3·10 ± 1·41 | 4, 6, 7 |
| *Isurus* | 1 | 2 | 3·14 ± 0·00 | 2, 3, 4, 8, 15 |
| *Centroscyllium* | 1 | 7 | 3·40 ± 0·00 | 10 |
| *Loxodon* | 1 | 1 | 3·69 ± 0·00 | 9 |
| *Centrophorus* | 1 | 14 | 3·80 ± 0·00 | 10 |
| *Centroselachus* | 1 | 1 | 4·00 ± 0·00 | 10 |
| *Negaprion* | 2 | 2 | 4·00 ± 1·70 | 1, 3 |
| *Galeorhinus* | 1 | 1 | 4·50 ± 0·00 | 7 |
| Legislated ratio (E.U. and Canada) | — | — | 5·00 | — |
| *Deania* | 1 | 4 | 5·40 ± 0·00 | 10 |
| *Nebrius* | 1 | 1 | 5·40 ± 0·00 | 1 |
| *Prionace* | 1 | 1 | 5·65 ± 0·00 | 2, 3, 4, 6, 7, 11, 12, 13, 15 |
| *Pristis* | 1 | 6 | 10·90 ± 0·00 | 14 |

[a]1, Anderson & Hudha (1993); 2, Ariz *et al*. (2008); 3, NMFS (1993); 4, Cortés & Neer (2006); 5, Cortés & Neer (2006); 6, Dai *et al*. (2006); 7, Gordievskaya (1973); 8, A. Hore (pers. comm.); 9, F. Humber (pers. comm.); 10, Kjerstad *et al*. (2003); 11, Mejuto & Garcia-Cortés (2004); 12, Neves dos Santos & Garcia (2005); 13, Neves dos Santos & Garcia (2008); 14, Pauly (2006); 15, Petersen *et al*. (2007); 16, Rose *et al*. (2001); 17, Pers. obs.

prohibit finning over a larger geographical range. The Convention on Migratory Species (CMS) agreed to a Memorandum of Understanding (MoU) on the Conservation of Migratory Sharks in 2009, which is aimed at improving international collaboration relating to the protection of sharks, but the MoU is non-binding and not all shark-fishing countries are CMS members (Lack & Sant, 2011).

A number of RFMOs have existing regulations to prevent finning, but guidelines, including the 5% ratio, are often vague and poorly enforced. Eight RFMOs require members to adhere to the 5% ratio-based regulation, but none of the organizations specify whether enforcement should be based on a fin-to-round-mass ratio or a fin-to-dressed-carcass-mass ratio (Hindmarsh, 2007). The organizations also fail to specify whether the ratio should be based on the mass of dry or wet fins (Hindmarsh, 2007).

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TABLE III. Mean ± S.E. wet-fin-to-round-mass ($M_{fw}$:$M_r$) ratios by shark family, ranked from lowest to highest. The total number of genera within each family is given and the number of species included from each family ($n$)

| Family | $n$ | Total genera | Mean ± S.E. ($M_{fw}$:$M_r$) ratio | Sources[a] |
|---|---|---|---|---|
| Odontaspididae | 1 | 4 | 1·34 ± 0·00 | 3 |
| Squalidae | 1 | 29 | 1·59 ± 0·00 | 17 |
| Alopiidae | 1 | 3 | 2·06 ± 0·00 | 3, 4 |
| Somniosidae | 3 | 19 | 2·50 ± 0·76 | 10 |
| Dalatiidae | 1 | 10 | 2·50 ± 0·00 | 7,10 |
| Carcharhinidae | 28 | 53 | 2·64 ± 0·31 | 1, 2, 3, 4, 6, 7, 11, 12, 13, 15, 9 |
| Lamnidae | 2 | 5 | 2·67 ± 0·47 | 2, 3, 4, 5, 8, 15 |
| Sphyrnidae | 5 | 9 | 2·95 ± 0·70 | 2, 3, 4, 7, 13, 16 |
| Etmopteridae | 1 | 45 | 3·40 ± 0·00 | 10 |
| Triakidae | 3 | 45 | 3·56 ± 0·94 | 4, 7 |
| Centrophoridae | 2 | 18 | 4·60 ± 0·80 | 10 |
| Legislated ratio (E.U. and Canada) | — | — | 5·00 | — |
| Ginglymostomatidae | 1 | 3 | 5·40 ± 0·00 | 1 |
| Pristidae | 1 | 7 | 10·90 ± 0·00 | 14 |

[a]1, Anderson & Hudha (1993); 2, Ariz *et al*. (2008); 3, NMFS (1993); 4, Cortés & Neer (2006); 5, Cortés & Neer (2006); 6, Dai *et al*. (2006); 7, Gordievskaya (1973); 8, A. Hore (pers. comm.); 9, F. Humber (pers. comm.); 10, Kjerstad *et al*. (2003); 11, Mejuto & Garcia-Cortés (2004); 12, Neves dos Santos & Garcia (2005); 13, Neves dos Santos & Garcia (2008); 14, Pauly (2006); 15, Petersen *et al*. (2007); 16, Rose *et al*. (2001); 17, Pers. obs.

Despite their existence, laws and regulations are rapidly changing and are not always effectively enforced by countries and RFMOs. The E.U. is currently re-evaluating its shark policy and may switch to a different interpretation of the 5% ratio or an all fins-attached policy in the near future (E.U., 2010). Enforcement can be challenging due to confusion, time constraints and lack of resources. Laws or regulations that require sharks to be landed with fins attached make monitoring and species-specific data collection comparatively easy, but fin-to-body-mass ratios are more difficult to enforce because it can be difficult for observers to identify individual species, especially when carcasses are without fins or *vice versa* (Hareide *et al*., 2007). Like most regulations, those that are ratio-based are most accurately enforced by observers at landing sites, which is not always a viable option due to economic and time constraints. European Union vessels are allowed to land or trans-ship shark fins separately from carcasses, so logbooks are used for monitoring and are less reliable than observations made at landing sites (Hareide *et al*., 2007). Very few RFMOs require members to provide yearly reports on their adherence to regulations (Hindmarsh, 2007).

Results suggest that considerable differences in wet-fin-to-round-mass ratios exist between species, genera, families and countries. Variation in fin-to-round-mass ratios can be attributed to a number of factors, including differences in species morphology, fin-cutting practices and fin sets. Each shark species has distinct anatomical features,

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TABLE IV. Mean ± S.E. wet-fin-to-round-mass ($M_{fw}$:$M_r$) ratios of sharks by country, ranked from lowest to highest, and $n$, the total number of individual sharks

| Country[a] | $n$ | Number of species represented | Mean ± S.E. ($M_{fw}$:$M_r$) ratio | Sources[b] |
|---|---|---|---|---|
| Australia | 186 | 15 | 1·52 ± 0·02 | 15 |
| U.S.A. | 752 | 37 | 2·03 ± 0·02 | 3, 4 |
| Norway | 50 | 5 | 3·72 ± 0·07 | 9 |
| Maldives | 21 | 8 | 4·28 ± 0·12 | 1 |
| Legislated ratio (E.U. and Canada) | — | — | 5·00 | — |
| Israel | 10 | 10 | 4·55 ± 0·00 | 7 |
| Spain | 3884 | 9 | 5·62 ± 0·02 | 2, 10 |
| China | 25 | 3 | 5·78 ± 0·17 | 6 |
| Portugal | 739 | 5 | 6·06 ± 0·02 | 11, 12 |

[a]Only those countries with three or more species represented are listed in this table.

[b]1, Anderson & Hudha (1993); 2, Ariz *et al*. (2008); 3, NMFS (1993); 4, Cortés & Neer (2006); 5, Cortés & Neer (2006); 6, Dai *et al*. (2006); 7, Gordievskaya (1973); 8, A. Hore (pers. comm.); 9, Kjerstad *et al*. (2003); 10, Mejuto & Garcia-Cortés (2004); 11, Neves dos Santos & Garcia (2005); 12, Neves dos Santos & Garcia (2008); 13, Pauly (2006); 14, Petersen *et al*. (2007); 15, Rose *et al*. (2001).

with fins varying in size, shape and thickness (Hindmarsh, 2007). The deviation in $M_{fw}$:$M_r$ ratios between species can be partially attributed to these morphological differences (Hindmarsh, 2007).

The combination of shark fins harvested from each individual shark also varies by country and vessel (Hareide *et al*., 2007). The majority of fisheries discard all but the primary fin set, which includes only the first dorsal, two pectoral and lower caudal fins (Hareide *et al*., 2007). Others, including some European fisheries, also retain the remaining fins and the upper caudal, which are commonly referred to as the secondary fin set (Hareide *et al*., 2007). Differences in fin set preference between countries may account somewhat for the particularly high ratios observed in European countries, but the additional mass of the secondary fin set is not believed to increase the overall ratio enough to completely explain the pattern (Hareide *et al*., 2007).

Fin-cutting procedures are also a major factor in the variation in overall fin-to-round-mass-ratios between countries (Table V). Some countries, including the Maldives and E.U. members, typically use a crude cut (Fig. 1), which leaves a significant amount of meat attached to the fin and increases the overall $M_{fw}$:$M_r$ ratio (Anderson & Hudha, 1993; Hareide *et al*., 2007; Ariz *et al*., 2008). This practice may account for the relatively high ratios observed in these countries. In some fleets, the shark belly is frequently used as bait before catches are landed, which may also increase $M_{fw}$:$M_r$ ratios (Neves dos Santos & Garcia, 2008). Other countries use a straight cut or a half-moon cut, which leave less meat attached, resulting in lower ratios. These differences make the application of an all-encompassing ratio challenging and unreliable (Ariz *et al*., 2008). Additionally, many studies lack a clear definition of fin sets and fin-cutting practices, making it difficult to pinpoint the exact reason for discrepancies between fin ratios for individuals of the same species harvested in separate locations (Hindmarsh, 2007).

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TABLE V. Descriptions of shark-finning practices by country

| Country | Description | Source |
|---|---|---|
| China | A set of shark fins includes a dorsal fin, a caudal fin and a pair of pectoral fins. | Dai *et al.* (2006) |
| Europe (Portugal) | All fins (first and second dorsal, pectorals, anal, pelvic and caudal) from each specimen were separately weighted (wet weight)... Their extraction was done with a knife, following fishermens' current practices, near the base of each fin with a minimum of muscle quantity. | Neves dos Santos & Garcia (2005) |
| Europe (Spain) | Commercial fins are defined as the combination of fins that fishermen retain for commercial purposes in each vessel or fleet. For European fleets, this consists of all fins, including the whole tail. However, this criterion is not followed by all fleets trading in shark fins. | Ariz *et al.* (2008) |
| Europe (Spain) | The general criteria for cutting the fins in the Spanish fleet is trying to obtain the maximal profitable use of the body as fin meat. The caudal, first dorsal and pectoral fins at least are used, but in some cases other fins are also taken, as pelvic fins. | Mejuto & Garcia-Cortés (2004) |
| Europe (Spain) | The complete caudal, first dorsal and both pectoral fins are always used. Pelvic fins may also be taken. As would be expected, the cutting points of the fins could produce some variability, especially with regard to the complete caudal fin used in this fleet, which should be detected by the variability of the ratios obtained among the boats sampled. | Mejuto *et al.* (2009) |
| Maldives | Four fins are normally taken: first dorsal, both pectorals and the lower caudal lobe. The second dorsal, pelvics and anal may be taken from large sharks, or those species with particularly large fin sets (*e.g.* the Lemon shark *Negaprion acutidens*). The dorsal and pectoral fins are normally round cut, often with considerable flesh attached. The lower caudal lobe and sometimes the other fins are straight cut. Buyers in Male' trim the meat from the dried fins. Fins are exported straight or L-cut. | Anderson & Hudha (1993) |
| New Zealand | The data give the weight of fins that are removed for the shark fin trade (*i.e.* they do not include the upper lobe of the tail, or the small second dorsal and anal fins, which is consistent with commercial practice). | A. Hore (pers. comm.) |

TABLE V. Continued

| Country | Description | Source |
|---|---|---|
| New Zealand | Dried fins, in all cases of blue, mako and porbeagle sharks, mean the state in which the head, body and all internal organs, other than pectoral fins, dorsal fins and the lower lobe of the caudal fin have been discarded and the pectoral fins, dorsal fin and the lower lobe of the caudal fin have been rendered into a dried form. . . | Anon (2004) |
| Pacific shark fisheries | Most crew know, for example, that the usual practice is to retain for sale the dorsal, two pectorals and lower caudal fins, strung together as a set. While some newer crew might think that they will get paid more by weight if they leave some meat on the fin, they quickly learn that discriminating buyers deduct for such practices. | McCoy & Ishihara (1999) |
| Peru | Removal of lower caudal fin lobe only. | Hareide *et al.* (2007) |
| South Africa | The fins exported from South Africa . . . include the dorsal fin, pectoral fins, ventral flaps and the caudal fin. | Ariz *et al.* (2008) |
| South Africa | The sets of fins for export from South Africa include the dorsal fin, both pectoral fins, ventral flaps and the caudal fin. The dorsal fin is considered the most valuable and buyers will not accept any excess flesh. Therefore, it is cut with a straight cut. Pectoral fins, on the other hand, are cut in a half-moon shape to max the flesh on the fin and hence increase the weight. Anal fins are prepared by first removing a piece of flesh including the anal fin and the claspers in a male. In some species (*e.g.* blue sharks), processing frequently involves the removal of the belly flaps. The caudal fin is cut at the pre-caudal pit and therefore includes considerable flesh. | Petersen *et al.* (2007) |
| U.S.A. | . . .fin weight refers to the wet weight of the primary fin set, which included the dorsal fin, both pectoral fins and the lower lobe of the caudal fin. | Cortés & Neer (2006) |

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TABLE VI. Mean ± S.E. shark wet-to-dry-fin-mass conversion factors by study

| Study | *n* | Conversion factor Mean ± S.E. | Methods/remarks |
|---|---|---|---|
| Anderson & Hudha (1993) | 1 | 0·460 ± 0·000 | Conversion factor provided in text, based on 18 sharks of mixed species. |
| Anon (2004) | 3 | 0·410 ± 0·006 | Calculated from legislated wet-fin-to-round-mass and dry-fin-to-round-mass conversion factors for *Prionace glauca*, *Isurus oxyrinchus* and *Lamna nasus*. |
| Rose *et al.* (2001) | 14 | 0·450 ± 0·013 | Calculated from observed wet-fin-to-round-mass ratios and dry-fin-to-round-mass ratios for 12 shark species. |
| NMFS (1993) | 3 | 0·400 ± 0·069 | Calculated from observed wet-fin-to-round-mass ratios and dry-fin-to-round-mass ratios for *Prionace glauca*, *Isurus oxyrinchus* and *Sphyrna zygaena.* |
| Clarke (2003) | 1 | 0·250 ± 0·000 | 'Anecdotal information from Hong Kong shark fin traders suggests that the mass 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...' (p. 164) |
| P. Horvat (pers. comm.) | 1 | 0·460 ± 0·000 | Calculated from legislated frozen or fresh-fin-to-trunk-mass and dry-fin-to-trunk-mass ratios. |
| Fong (1999) | 28 | 0·590 ± 0·004 | Calculated from the wet mass and dry mass of individual dorsal, pectoral and caudal fins from *Carcharhinus limbatus.* |
| S. Clarke (pers. comm.) | 1 | 0·400 ± 0·000 | 'An Australian fin trader once insisted to me that the figure should be more like 0·4 but he did not have any data to back it up so I went with what the Hong Kong traders told me (0·25).' |
| Mean conversion factor | 52 | 0·430 ± 0·011 | |

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FIG. 2. Number of political entities implementing shark-fishery-related legislation since 1980. Legislation is classified into the following four categories: (1) that which stipulates that sharks be landed with fins attached (—), (2) that which implements fin-to-body-mass-ratio-based regulations (—), (3) that which specifies trade regulations (.....) and (4) that which creates a shark sanctuary (an area where shark fishing is entirely prohibited) (- - -). The 22 maritime E.U. members are included for years in which E.U.-wide legislation is instated, and individual U.S. states are included where state-specific legislation exists.

Wet-to-dry-fin-mass conversion factors vary considerably between sources, but not between species or countries. Variation between sources may be attributed to differences in drying procedures and the remaining moisture content of dried fins.

From a scientific standpoint, it would be logical to introduce species-specific ratio-based legislation, but from a management perspective, enforcing such complex regulations is not feasible. Changing market preferences can cause finning practices to change quickly, which would require frequent ratio revisions (Hareide *et al*., 2007). Enforcement of such ratios would require independent observers to ensure that fishers comply with regulations and identify species correctly, which is a costly obligation (Hindmarsh, 2007). Also, fin-to-body-mass ratio data are sparse for numerous species, and many existing ratios have been calculated from very small sample sizes (Hareide *et al*., 2007). Developing accurate species-specific ratios would require the collection of a large quantity of additional, standardized data (Hindmarsh, 2007).

Regulations that ban the removal of fins from the carcass and require sharks to be landed with fins naturally attached may be a more reasonable solution to current regulatory challenges (E.U., 2010). A fins-attached policy would eliminate shark finning and prevent the practice of high-grading when enforced throughout legal shark fisheries (Hareide *et al*., 2007). It would also make the development of species-specific ratios unnecessary, make enforcement more straightforward by eliminating the need for observers to identify the species of carcasses without fins and *vice versa* and improve the accuracy and ease of data collection for fisheries

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management use (Hareide *et al*., 2007). Although both ratio-based regulations and fins-attached regulations aim to support the responsible use of sharks as a natural resource, regulations that require sharks to be landed with fins attached would be more effective based on the fact that they would prevent high-grading and therefore allow catch composition to be monitored with a higher level of certainty (Hareide *et al*., 2007).

## CONCLUSIONS

Numerous shark species are being depleted by intense fishing pressure, so it is crucial that protective measures be implemented quickly and effectively. A need exists to increase the specificity and geographical coverage of shark-related legislation to prevent the practice of finning and provide protection through measures like shark sanctuaries and trade regulations. To date, only a small percentage of countries have implemented regulations to protect sharks, and the 5% fin-to-body-mass ratio used for the majority of current regulations is inadequate and inappropriate for most species. Countries that currently enforce a 5% ratio should switch to a fins-attached policy. Due to the highly migratory nature of many shark species, it will also be necessary for additional countries to implement and enforce this type of regulation to make anti-shark finning measures more effective. Although some countries have made great strides in improving shark protection measures, in many cases it is unclear whether or not regulations are being enforced sufficiently. Countries with existing legislation must take steps to enhance the accuracy and scope of enforcement efforts.

The generalized 5% ratio used in many of the existing regulations presents a dangerous loophole, which provides an opportunity for fishers to land extra sharks without consequences. To eliminate this loophole and make ratio-based regulations effective, ratios should be species and fleet-specific and must be adequately enforced, which is not a practical solution due to high-grading and the difficulties associated with accurate species identification.

Additionally, it would be difficult to establish a standardized wet-to-dry-fin-mass conversion factor for instances when fins are dried at sea before landing due to the variation in drying practices. The mean wet-to-dry-fin-mass conversion factor presented in this paper is mainly calculated from literature where $M_{fw}$:$M_r$ and $M_{fd}$:$M_r$ ratios were provided, but the drying process was unexplained. Factors such as temperature, humidity and length of time can affect conversion factors considerably and would be nearly impossible to standardize outside a laboratory.

Due to the complications presented by the development and enforcement of species and fleet-specific regulations, finning bans which require that sharks be landed with fins attached are ideal. When sharks are landed with fins attached, it is easier for trained observers at landing sites to record the number, mass and species of sharks landed, making data collection and monitoring more straightforward and accurate.

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APPENDIX. Shark-related legislation and regulations listed in alphabetical order by country and in yearly order by regional fishery management organizations (RFMO). Countries are classified into the following categories based on the nature of each regulation: SS, shark sanctuary (an area where shark fishing is entirely prohibited; FA, area where sharks must be landed with fins attached; RB, area where fin to body mass ratio-based regulations have been implemented; TR, area where shark product trade regulations exist; O, or other. Countries with a National Plan of Action (NPOA) for sharks are indicated with a 'Y' for yes, 'N' for no. An 'N' in the NPOA column indicates an unspecified NPOA status

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Argentina | 2009 | Law No. 24.922 | Argentina waters | Finning activities, described as the removal of shark fins and disposal of remaining body, are prohibited. Sharks larger than 160 cm in length must be returned to the ocean. | Y | FA | Consejo Federal Pesquero (2009) |
| Australia | — | — | Commonwealth–federal waters; ranges from 3–200 miles (4·8 to 321·9 km) offshore | Finning is not allowed in any tuna or billfish longline fishery, or in any Commonwealth fishery taking sharks. Fins must be landed attached, and additional regulations apply in some states or territories. Finning has been banned in six state and Northern Territory waters to 3 miles (4.8 km), including: Queensland in 2002, New South Wales in 1999, Victoria in 1972, Tasmania in 2001, Western Australia in 2000 and Northern Territory. See details below. | Y | FA, RB | Camhi *et al.* (2009) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Australia (Northern Territory) | 2003 | Northern Territory Licence Owners Licence Conditions | Northern Territory waters | A person may not discard a shark with its fins removed unless (1) there has been an interaction with a marine organism (such as lice) which reduces the value of the product to the point that it cannot be utilized for sale or (2) the product cannot be used for sale due to mechanical or on-board processing error. Discards must be logged. Fresh or frozen fin mass is to be no more than 6·5% of trunk mass... Shark fin ratios to be reviewed annually. | Y | RB | P. Horvat (pers. comm.), T. Beatty (pers. comm.) |
| Australia (Western Australia) | 1995 | Fish Resources Management Regulations 1995, Regulation 16 | Western Australia's (WA) temperate demersal gillnet and demersal longline fisheries off WA's west and south coasts | A master of a fishing boat must not have on the boat any shark or ray other than a whole shark or ray unless every part of the shark or ray (other than disposable parts – *i.e.* head, tail and parts removed during gutting) are on the boat together; and the only parts that have been removed from the shark or ray are one or more of the fins. | Y | RB | P. Horvat (pers. comm.) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Australia (Western Australia) | — | Western Australia Fishery Licence Conditions 16 and 17 | Western Australia's temperate demersal gillnet and demersal longline fisheries off WA's West and South coasts | (16) Sharks taken in the zone must not be finned, but may have their fins removed with both the fins and trunk retained on board... (17) When fishing in the northern zone, all shark products on board or brought onto land from the fishing boat must conform to the following mass ratios: total landed mass of fins does not exceed 11% of the total mass of shark fillets, cartilage, liver, head and upper tail or if not filleted, total landed mass of fins must not exceed 5·5% of the total mass of shark products. | Y | RB | P. Horvat (pers. comm.) |
| Bahamas | 2011 | — | Bahamas waters | Shark fishing is prohibited, and a ban is in place on the sale, import and export of shark products. | N | SS | Anon (2011*b*) |
| Bahamas | 1990 | Statute 244.22 | Bahamas EEZ | Statute 244.22 prohibits longline fishing in the EEZ, thought to be responsible for healthy local shark populations. | N | O | Commonwealth of the Bahamas (1993) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Brazil | 1998 | Portaria N° 121/98 | Waters under national jurisdiction | Prohibits the discard of shark carcasses which have had fins removed. Fins being transported or landed must be proportional to the mass of withheld shark carcasses on board. The total fin mass may not exceed 5% of the total mass of shark carcasses, and all fins must be weighed upon landing (none may be retained on board from previous travels). | N | RB | Anon (1998) |
| Canada | 1994 | Canada's National Plan of Action for the Conservation and Management of Sharks Section 2.1.1 | Atlantic and Pacific Ocean waters | Shark finning is banned. This applies to Canadian fisheries waters and Canadian licensed vessels fishing outside the EEZ. Moreover, the trade and sale of fins must be in appropriate proportion to the quantity of carcasses landed (5% of dressed carcass mass). | Y | RB | DFO (2007) |
| Toronto | 2011 | — | Toronto | Pending: a ban on the consumption and sale of shark fins. | N | TR | Heilbron (2011) |
| Cape Verde | 2005 | — | Cape Verde waters | Finning is prohibited throughout EEZ. | Y | FA | Camhi *et al.* (2009) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Cayman Islands (U.K.) | 2007 | — | — | Fins must be attached upon landing, permits are required for transporting fins after landing and transshipping of fins while at sea is forbidden. | N | FA | Camhi *et al.* (2009) |
| Chile | 2011 | — | Chilean waters | All sharks must be landed with fins naturally attached. | N | FA | Cranor (2011) |
| Costa Rica | 2006 | Article 40, Costa Rican Fishery Law | Costa Rican (CR) waters, applies to all CR vessels and vessels unloading in CR ports | Article 40 of the Costa Rican Fishery Law requires all shark fins to be landed attached in natural form, and not tied on. | N | FA | Anon (2006) |
| Ecuador | 2004 | — | Ecuador and Galapagos waters | Shark finning is prohibited. Targeted fishing for sharks is banned, and by-catch should be fully utilized. A ban on the trade of shark fins was overturned in 2007. | Y | FA | Camhi *et al.* (2009), Jacquet *et al.* (2008) |
| Egypt | 2006 | — | Egyptian waters in the Red Sea, to 12 miles (19·3 km) offshore | Fishing for sharks is prohibited in Egypt's territorial waters in the Red Sea [to 12 miles (19·3 km) offshore]. | N | SS | Camhi *et al.* (2009) |
| El Salvador | 2006 | — | El Salvador (ES) waters, all ES vessels | Fins should be at least a quarter attached to the carcass. | N | FA | Camhi *et al.* (2009) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| European Union (E.U.) (27 members states) | 2003 | — | E.U. waters and vessels | Fins should be landed attached to the carcass. Special fishing permits can be obtained which allow fins to be landed or transshipped separately from carcasses, but in no case shall the theoretical mass of the fins exceed 5% of the live mass of the shark catch. | N | FA, RB | E.U. (2003), Camhi *et al.* (2009) |
| Spain | 2002 | — | Spanish waters and vessels | Same as E.U., but enacted earlier. | N | FA, RB | Camhi *et al.* (2009) |
| Fiji | 2011 | — | Fiji waters | Pending: a ban on the trade of shark fin and other shark products, which will not prohibit locals from consuming shark meat. | N | TR | Anon (2011*c*) |
| French Polynesia | 2006 | — | French Polynesian waters | Finning is forbidden. Trade in shark parts and products is prohibited (except for shortfin mako). | N | FA, TR | Camhi *et al.* (2009) |
| Galapagos Islands (Ecuador) | 2004 | — | Galapagos waters | Same as Ecuador. | N | FA | Camhi *et al.* (2009), Jacquet *et al.* (2008) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Gambia | 2004 | — | Gambian territorial waters | A finning ban exists in territorial waters. Sharks landed in Gambian waters must be landed on Gambian soil. | Y | FA | Diop & Dossa (2011) |
| Guam | 2011 | Bill No. 44-31 | Guam waters | It is against the law for any person to possess, sell, take, purchase, barter, transport, export or import, offer for sale or distribute shark fins, alive or dead. | N | TR | Guam Legislature (2011) |
| Guinea | 2009 | — | Guinean territorial waters | A finning ban exists in all territorial waters. A fishing ban exists for seven critically threatened species of sharks and rays. The fees associated with obtaining a shark fishing licence were increased substantially in 2005. | Y | FA, O | Diop & Dossa (2011) |
| Guinea-Bissau | — | — | — | A ban on shark fishing is in place for marine protected areas. | Y | O | Diop & Dossa (2011) |
| Honduras | 2010 | — | Honduran waters | A moratorium has been enacted on all shark fishing. | N | SS | Anon (2010*b*) |
| Israel | 1980 | — | Israeli waters | Sharks are protected in Israeli waters, all shark fishing and finning are illegal. | N | SS | Camhi *et al.* (2009) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Japan | 2008 | — | Japanese vessels except far seas and those landing outside Japan's waters | All Japanese vessels (excluding far seas and those outside of Japanese waters) are required to land all parts of the shark. Heading, gutting and skinning are allowed. | Y | O | Camhi *et al.* (2009) |
| Malaysia | — | — | — | — | Y | — | FAO (2011) |
| Maldives | 2009 | Law 5/87, Clause 10 | 12 miles (19·3 km) from atoll rim of all atolls in the Maldives | A ban exists on any fishery targeted at the killing, capturing or extraction of any shark species inside and within 12 miles (19·3 km) from the outer atoll rim of all Maldivian atolls. | N | O | Anon (2009) |
| Marshall Islands | 2011 | — | — | A moratorium has been put in place on the trade in and export of shark fins until effective regulatory measures can be implemented. | N | TR | Johnson (2011) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Mauritania | — | — | — | A minimum landing size of 60 cm is specified for houndsharks, shark finning is prohibited in the Banc d'Arguin National Park and a ban exists on tuna seiners and longline surface boats fishing for basking shark *Cetorhinus maximus*, great white shark *Carcharodon carcharias*, sand tiger shark *Carcharias taurus* and tope shark *Galeorhinus galeus*. | Y | O | Diop & Dossa (2011) |
| Mexico | 2007 | — | Mexican waters and vessels | A finning ban applies to sharks caught intentionally or as by-catch. Carcasses of landed sharks must be present on board. Plans have been announced to declare a moratorium on shark fishing beginning in 2012. | Y | FA | Camhi *et al.* (2009), Gronewald (2011) |
| Namibia | — | — | Territorial waters | Namibian law prohibits the discarding of biological materials in territorial waters, which does not specify, but includes shark fins. | N | O | Camhi *et al.* (2009) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| New Zealand | 2004 | — | NZ vessels | Legislated conversion factors are applied to landed fins and carcasses to ensure that fin mass corresponds to carcass mass. | N | RB | Anon (2004) |
| Nicaragua | 2005 | — | Nicaragua waters | Finning is prohibited, mass of fins shall not exceed 5% of total carcass mass on board. If fins are exported, exporters must show proof that meat was also sold. | N | RB, TR | Camhi *et al.* (2009) |
| Commonwealth of the Northern Marianas | 2011 | HR 17-94 (Public Law No. 17-27) | Commonwealth of the Northern Marianas | HR 17-94 prohibits any person from possessing, selling, offering for sale, trading or distributing shark fins in the Commonwealth of the Northern Marianas Islands. | N | TR | Commonwealth of the Northern Mariana Islands (2010) |
| Oman | Before 1999 | — | — | Waste of shark parts is forbidden at sea and on land. Fins must remain attached to carcasses, and permits must be obtained to handle all sharks and shark parts. | N | FA | Camhi *et al.* (2009) |
| Palau | 2003 | — | Palau waters | Palau is a shark sanctuary: all commercial fishing is banned in its waters. All incidentally caught sharks (dead or alive) must be released. | N | SS | Black (2009), Camhi *et al.* (2009) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| Panama | 2006 | — | Panamanian waters | Sharks must be landed with fins attached by at least a quarter of the fin to body union. Vessels with outboard motors <60 hp may land fins separately, but fins must not weigh >5% of landed meat. Fin trade requires certificate of origin. | N | FA, RB | Camhi *et al.* (2009) |
| Senegal | — | — | — | — | Y | — | Diop & Dossa (2011) |
| Seychelles | 2006 | — | Seychellois vessels 24 m or less, all foreign vessels | Finning is banned; mass of fins must not exceed 5% of landed dressed carcass mass. | Y | RB | Camhi *et al.* (2009) |
| Sierra Leone | — | — | — | Shark fishing licences are required, a ban on finning is in place and an export tax is applied to shark products. | Y | FA, TR | Diop & Dossa (2011) |
| South Africa | 1998 | — | South African waters and vessels | Finning is banned; fins can be separated from carcasses if the fin to dressed carcass mass ratio does not exceed 8% for domestic vessels and 5% for foreign vessels. | N | RB | Camhi *et al.* (2009) |
| Taiwan | 2011 | — | — | Pending: sharks must be landed with fins attached. | Y | FA | Anon (2011*a*) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| U.K. | 2009 | — | — | Sharks must be landed with fins attached. | Y | FA | McKie (2009) |
| U.S.A. | 2000 | HR 5461 | U.S. waters and vessels | H.R. 5461 prohibits removal of shark fins without the corresponding carcass. | Y | RB | United States Congress (2000) |
| U.S.A. | 2010 | HR 81 | U.S. waters and vessels | H.R. 81 prohibits finning at sea and the possession, transfer and landing of fins not naturally attached to the shark carcass. | Y | FA | United States Congress (2010) |
| U.S.A. (Alaska) | 2010 | 5 AAC 28.084 (c) | Alaskan waters | Any person that retains any species of shark as by-catch and sells or retains any species of shark must sell or utilize the whole shark. Harvested sharks must have fins, head and tail attached when sold. Utilize is defined as the use of the flesh of the shark for human consumption, for reduction to meal, for production of food for animals or fish, for bait or for scientific, display or educational purposes. | N | FA | Anon (2010*a*) |
| U.S.A. (California) | 2011 | AB 376 | State of California | Pending: it is unlawful to possess, sell, offer for sale, trade or distribute a shark fin. | N | TR | California Assembly (2011) |

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Appendix. Continued

| Location | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| U.S.A. (Florida) | 2011 | — | Florida | The killing of tiger sharks *Galeocerdo cuvier*, great hammerheads *Sphyrna mokarran*, scalloped hammerheads *Sphyrna lewini* and smooth hammerheads *Sphyrna zygaena* is prohibited. | | O | Fleshler (2011) |
| U.S.A. (Hawaii) | 2010 | SB 2169 | State of Hawaii | It shall be unlawful for any person to possess, sell, offer for sale, trade or distribute shark fins. | N | TR | Hawaii Legislature (2010) |
| U.S.A. (Oregon) | 2011 | HB 2838 | State of Oregon | A person may not possess, sell, offer for sale, trade or distribute shark fins in the state of Oregon. | N | TR | Oregon Legislative Assembly (2011) |
| U.S.A. (Washington) | 2011 | SB 5688 | State of Washington | It is unlawful to sell, offer for sale, purchase, offer to purchase or otherwise exchange a shark fin or shark-fin derivative product. The preparation or processing of shark fins and shark-fin derivative products is also prohibited. | N | TR | Washington Senate (2011) |
| Uruguay | — | — | — | — | Y | — | FAO (2011) |


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Appendix. Continued

| RFMO | Year | Law | Area | Description | NPOA (Y–A) | Type | Source |
|---|---|---|---|---|---|---|---|
| International Commission for the Conservation of Atlantic Tunas (ICCAT) | 2004 | Rec. 04-10 | Atlantic Ocean, Mediterranean Sea, Gulf of Mexico waters | Full utilization is required (only head, skin and guts may be discarded); landed fins are not to exceed 5% of landed shark mass; encourages, but does not require, live release of incidentally caught shark. | N | RB | ICCAT (2004), Camhi *et al.* (2009) |
| Inter-American Tropical Tuna Commission (IATTC) | 2005 | Resolution C-05-03 | Eastern Pacific Ocean waters | Same as ICCAT. | N | RB | IATTC (2005), Camhi *et al.* (2009) |
| Indian Ocean Tuna Commission (IOTC) | 2005 | Resolution 05/05 | Indian Ocean waters | Same as ICCAT. | N | RB | IOTC (2010), Camhi *et al.* (2009) |
| North Atlantic Fisheries Organization (NAFO) | 2005 | Article 17 | North-west Atlantic Ocean waters | Same as ICCAT. | N | RB | NAFO (2011), Camhi *et al.* (2009) |

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Appendix. Continued

| RFMO | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| General Fisheries Commission of the Mediterranean (GFCM) | 2006 | GFCM/2006/8 (B) | Mediterranean Sea waters | Same as ICCAT. | N | RB | GFCM (2006), Camhi *et al.* (2009) |
| Western and Central Pacific Fisheries Commission (WCPFC) | 2006 (mandatory in 2008) | Conservation and Management Measure 2006-05 | Western and central Pacific Ocean waters | Similar to ICCAT, but full utilization is required to the point of first landing or transshipment. Fins can be landed and transshipped separately. | N | RB | WCPF (2006), Camhi *et al.* (2009) |
| Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) | 2006 | Conservation Measure 32-18 (2006) | Antarctic waters | Directed fishing on shark species is prohibited in the convention area for purposes other than scientific research. Any by-catch of shark, especially juveniles and gravid females, taken accidentally in other fisheries should be released alive if possible. | N | SS | CCAMLR (2006) |

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Appendix. Continued

| RFMO | Year | Law | Area | Description | NPOA (Y–N) | Type | Source |
|---|---|---|---|---|---|---|---|
| South East Atlantic Fisheries Commission (SEAFO) | 2006 | — | South-east Atlantic Ocean waters | Same as ICCAT. | N | RB | Camhi *et al.* (2009) |
| North East Atlantic Fisheries Commission (NEAFC) | 2007 | — | North-east Atlantic Ocean waters | Same as ICCAT. | N | RB | Camhi *et al.* (2009) |

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