sustainability

Review

Shark Fishing *vs.* Conservation: Analysis and Synthesis

Ila France Porcher [1,*] and Brian W. Darvell [2]

[1] Independent Researcher, Essaouira 44000, Morocco
[2] Dental Materials Science, University of Birmingham, Birmingham B5 7EG, UK; b.w.darvell@bham.ac.uk
* Correspondence: ilafranceporcher@protonmail.com

Abstract: The expanding shark fin market has resulted in intensive global shark fishing and with 90% of teleost fish stocks over-exploited, sharks have become the most lucrative target. As predators, they have high ecological value, are sensitive to fishing pressure, and are in decline, but the secretive nature of the fin trade and difficulties obtaining relevant data, obscure their true status. In consumer countries, shark fin is a luxury item and rich consumers pay high prices with little interest in sustainability or legal trade. Thus, market demand will continue to fuel the shark hunt and those accessible to fishing fleets are increasingly endangered. Current legal protections are not working, as exemplified by the case of the shortfin mako shark, and claims that sharks can be sustainably fished under these circumstances are shown to be misguided. In the interests of averting a catastrophic collapse across the planet's aquatic ecosystems, sharks and their habitats must be given effective protection. We recommend that all sharks, chimaeras, manta rays, devil rays, and rhino rays be protected from international trade through an immediate CITES Appendix I listing. However, a binding international agreement for the protection of biodiversity in general is what is needed.

Keywords: biodiversity conservation; sharks; shark fisheries; sustainable shark fishing; fisheries; shark fin trade

check for updates

Citation: Porcher, I.F.; Darvell, B.W. Shark Fishing *vs.* Conservation: Analysis and Synthesis. *Sustainability* **2022**, *14*, 9548. https://doi.org/10.3390/su14159548

Academic Editor: Francesco Tiralongo

Received: 30 June 2022
Accepted: 27 July 2022
Published: 3 August 2022

1. Introduction

Shark conservation has been the subject of numerous reports over many years, with arguments for and against action to limit the fishery. In the absence of a clear conclusion or consensus, we present a detailed and comprehensive data-driven analysis of the various aspects of the matter.

The growth of the market for shark fin soup, a fashionable, high-end Chinese dish, has resulted in intensive global shark fishing, but most of the catch is neither recorded nor managed [1–6]. With their low productivity, sharks have poor capacity to withstand fishing mortality [7] so their numbers are plummeting. In a rigorous global study in 2014, Dulvy *et al.* found one quarter of shark and ray species to be threatened with extinction as a result of overfishing in what could be called "a chronic accumulation of global marine extinction risk." In 2019 the UN Biodiversity Council [8] warned that more than one third of all known shark and ray species are facing the risk of extinction within the next few decades and named industrial fishing as the main reason for the loss of marine biodiversity. The latest report [9] found that more than three quarters of oceanic shark species are now threatened with extinction.

At the same time as the shark fin trade has expanded, some 90% of teleost fish stocks have become seriously depleted through decades of industrial overfishing [10]. As a result, due to the value of their fins, sharks became the most lucrative target, with the result that numerous fisheries around the world began to hunt them for the first time [3,11–14]. Pelagic sharks have been hardest hit [3,9,15]; earlier studies found that they provide most of the fins on the market [1,2,6]. More recently, Van Houtan *et al.* [16] found through modern barcoding and modelling techniques that coastal sharks now provide most of the fins on the market. However, all accessible sharks, from a wide variety of ecosystems, are caught to supply shark fin trade.

In 2013 Worm *et al.* [4] estimated the annual global catch and mortality of sharks, including both reported and unreported landings, discards, and shark finning (the practice whereby fins are cut from live sharks and the bodies dumped back in the sea), as being between 63 and 273 million sharks, depending on whether the tonnage was made up of larger or smaller sharks. Since reports for various regions in the world indicate that most sharks caught are immature [17–20], it is likely that the true number was closer to the higher estimate. Using three independent estimates, Worm *et al.* [4] found that the mortality of sharks as a group was between 6.4% and 7.9%, which exceeds the rebound rate of 4.9% for most shark species. They concluded that global shark mortality needed to be drastically reduced to avoid substantial damage to marine ecosystems and restore the ecological balance.

Jurisdictional issues, along with the difficulties of obtaining relevant data, have long obscured understanding of sharks' diversity and true numbers [21]. They range far from land and migrate across oceans, outside countries' Exclusive Economic Zones (EEZs), so their status is difficult for Regional Fisheries Management Organizations (RFMOs) to assess. In 2019, The International Union for Conservation of Nature (IUCN) [22] listed 198 data-deficient shark species out of the 494 assessed. RFMOs have placed higher priority on species with greater economic importance, so shark management in general has been low priority, poor, or entirely lacking [3,21–24].

In consumer countries, shark fin is a luxury item and there is little interest in sustainability or legal trade [25]. Rich consumers are willing to pay high prices while the will, oversight, and enforcement resources necessary to manage the trade are absent. Thus, market demand will continue to fuel the intensive search for more sharks, and the problem is likely to become greater as scarcity forces prices up [25].

The Food and Agriculture Organization of the United Nations (FAO) reported global shark fin imports between 2000 and 2011 as worth USD377.9 million per year; in 2011 the value of world exports was USD438.6 million [26]. Since then, the volume of the fins has declined as a result of overfishing [23] and the average annual value of imports globally between 2000 and 2016 was USD294 million annually [27].

Although it has been suggested that shark fishing could be made sustainable [28–30] the trends indicate that such is not the case. Increasing numbers of shark and ray species are found to be endangered or critically endangered and, given the nature of the shark fin trade, without intervention the situation will continue to decline. In the interests of averting a catastrophic collapse across the planet's diverse marine, riverine and estuarine ecosystems, sharks and their habitats must be given effective protection [8,9].

2. The Impact of Industrial Fishing

With approximately 2.9 million motorized fishing vessels hunting the global ocean, the footprint of industrial fishing exceeds other forms of food production [31]. Modern longliners, sea bottom and deep-sea trawling, and drifting fish aggregating devices (dFADs) are particularly lethal [32–36]. However, wild fisheries provide only 1.2% of global caloric production for human food consumption [31].

Large-scale fishing began in British and European waters with the development of steam-powered vessels in the 1870s. Increasingly, railroads connected fishing ports to towns in the interior so that the market developed as the fishing fleets grew and fished farther from shore [37]. After WWII, industrial fishing expanded enormously using long-distance factory fleets with processing capabilities such that they could stay at sea for months at a time. As a result, within a few decades, a global overfishing crisis developed and, in spite of great intensification of the fishing effort, the global catch began to dwindle in the late 1980s [38,39]. Pauly *et al.* warned that marine wildlife could not withstand targeted industrial hunting any more than terrestrial wildlife can, and recommended both that fishing effort be drastically reduced to rebuild the marine ecosystem, and that this be protected via a network of formal 'Marine Protected Areas' (MPAs) [39].

Sharks were always a substantial bycatch taken by longliners, drift nets, purse seine nets and bottom trawlers. In the Atlantic Ocean, longliners caught two or three sharks for every swordfish, and in the Gulf of Mexico and Pacific Ocean one shark was caught for every two yellowfin tuna [40]. They were mostly discarded as trash; official fisheries statistics recorded only landed shark catches [41,42].

By 2003, the global ocean had lost an estimated 90% of its predators, 80% within the first 15 years of industrial exploitation [7,17]. This suggests that by 1970, the baseline used by Pacoureau *et al.* [9] for their calculations of shark depletion, sharks were already severely depleted. Since then, the abundance of oceanic sharks has decreased by some 71%, while tropical sharks have declined by an average of 87% despite their more resilient life history [9]. This means that overall, only about 6% remain of the numbers present in 1950, and only about 3% in the case of tropical sharks.

Industrial fishing resulted in rapid and extreme declines in shark catches [7,17]. In the Pacific, for example, the catch of silky shark (*Carcharhinus falciformis*) decreased by some 92%, while in the Gulf of Mexico catches of the oceanic whitetip (*Carcharhinus longimanus*) fell by more than 99% [40]. Along the eastern shore of the United States of America (USA) huge declines were recorded: 87% for sandbar sharks (*Carcharhinus plumbeus*), 93% for the oceanic blacktip (*Carcharhinus limbatus*), 97% for tiger sharks (*Galeocerdo cuvier*), 98% for scalloped hammerheads (*Sphyrna lewini*), and more than 99% for bull (*Carcharhinus leucas*), dusky (*Carcharhinus obscurus*) and smooth hammerhead (*Sphyrna zygaena*) sharks [43]. Ecologically, they were functionally removed [44].

Over-exploitation and collapse of the porbeagle (*Lamna nasus*) population in the Northeast Atlantic in the 1960s led to intensive directed fishing in the Northwest Atlantic, where most of the virgin biomass was removed in just six years [3]. A similar situation is now ongoing for the spiny dogfish (*Squalus acanthias*) [42].

In the South China Sea, 109 species of sharks were recorded as being fished in the 1970s but only 18 are present in current market surveys. The market is now dominated by smaller species, of which 65% are under the age of sexual maturity [18]. Indonesia is the largest shark fishing country in the world and its annual catch exceeds 100,000 t per year from its 17,000 islands [25], yet what fishery management exists is not working due to loopholes in the regulations that facilitate IUU fishing and illegal trade [45]. Many shark species evolved in the diverse coral ecosystems of Southeast Asia, where now elasmobranchs are particularly overfished and threatened, yet no records have been kept so that the true extent of their losses is unknown [18]. In the Southwest Indian Ocean, devil ray abundance has declined by at least 85% in just 15 years [9].

Japan has operated some of the largest elasmobranch fisheries in the Northwest Pacific and was already trading shark fins with China more than 200 years ago. Japan's large trawl fisheries showed signs of being over-exploited before World War II, so in the Northwest Pacific shark exploitation may have peaked before the 1950s [40].

In the Mediterranean, trawl fishing led to the loss of 16 out of 31 species in the Tyrrhenian Sea, 6 out of 33 species in the Adriatic Sea, and half of the species in the Gulf of Lion since the 1950s [24]. The few records that have been kept indicate that hammerhead (*Sphyrnidae*), blue (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus)* porbeagle, and thresher sharks (*Alopias vulpinus*) declined between 96% and 99.99% relative to their former abundance [46]. Nine of the 16 shark species still landed in the Mediterranean are more threatened regionally than at the global level and between 53% and 71% are at risk of extinction [24].

Pelagic fisheries landings in Brazil recorded the disappearance of 14 species of *carcharhinids* between 1977 and 1994 [47].

Since the 1980s, the tuna industry has increasingly made use of dFADs, and half of all tuna are now caught using them [48]. These consist of floating platforms trailing lengths of netting to ensure that they move with the ocean currents, rather than being swept along by the wind. They maximize their catch by taking advantage of the tendency of tuna to shelter beneath floating objects. However, a variety of other marine animals, including the juveniles of oceanic whitetip and silky sharks, also use that shelter, and are therefore a major bycatch in those fisheries. Drifting FADs are left to drift, usually for several months between visits by the fishing fleet, which then uses purse seines to net the entire shoal of fish that has accumulated beneath them. In the Indian Ocean over 80% of the purse seine catch is now made using dFADs [36], and between 480,000 and 960,000 silky sharks, most of which are juveniles, are killed each year through entanglement in those trailing nets [35]. This mortality, from the Indian Ocean alone, is comparable in scale to the entire reported world fishing catch of 400,000 to 2,000,000 animals, the silky shark being second only to the blue shark for use in the fin trade [6]. Although some RFMOs are beginning to demand that dFADs must be non-entangling, the criteria for a non-entangling dFAD are still very weak. Many dFADs constructed to be non-entangling become entangling with the passage of time [49].

3. The Ecological Consequences

In pristine, unfished regions, sharks are abundant and diverse [40]. As highly successful top and middle predators, they survived the several mass, global extinctions and, through radial evolution, adapted to new ecological niches [50–52]. Thus, over the past 500 million years, they became deeply woven into the aquatic ecosystems of the planet. Industrial fishing has resulted in a large-scale ecological transformation, not only in terms of the size of individuals and the relative abundance of species, but also community biomass [17,21,40,43,53]. The removal of top predators causes alternating increases and declines in the abundance of lower levels on the food chain, an effect called a 'trophic cascade' [17]. However, due to the difficulties in studying marine ecosystems, particularly in deep waters, few such cases have been identified and little is known about the complex ecological roles played by sharks [9,21,43,44,54].

Food-web models suggest that large sharks are among the most strongly interacting species [55], and that their overfishing may have contributed to the degradation of the coral ecosystems in the Caribbean [56]. A 'removal' computer simulation conducted for the reef ecosystem of Floreana Island in the Galápagos Islands found that sharks were at the top of the trophic scale and that their loss caused a four-level trophic cascade [57]. Toothed cetaceans, sea lions, marine iguanas, and other mid-level predators were predicted to increase, which led directly to intensified predation on reef fish and a decline in their numbers. This in turn led to an increase in small benthic invertebrates. Other trophic cascades were also apparent. The removal of the sharks caused a rebalancing of the entire ecosystem.

In 2012, Nadon *et al.* [58] found that reef sharks were at some 3~10% of baseline abundance on coral reefs in the Pacific Ocean. Eight years later, MacNeil *et al.* [59] found that they are functionally extinct on 19% of coral reefs. The great white shark is now so rare around South Africa that sevengill sharks (*Notorynchus cepedianus*) are taking over its former hunting grounds [60].

The presence of large sharks also has a marked effect on the behaviour of prey species. The removal of tiger sharks so affected the evasion behaviour of dugongs and green sea turtles in Shark Bay, Australia, that the sea floor patterns of sea grass and its nutrient composition were significantly changed [44,61]. The removal of the large sharks is likely to have allowed multitudes of smaller species to move into the sunlit upper layers of the ocean during the daylight hours, whereas formerly they only migrated upwards at night [17].

Some elasmobranchs, including reef and tiger sharks, leave their ranges for a period of weeks when fishing begins [62,63] putting their communities [64,65] into disarray. The tendency to flee when some of their number are killed has been observed for both reef sharks in French Polynesia and tiger sharks in the Bahamas, including by local inhabitants [63,66], suggesting that it is a general reaction to fishing pressure.

The depletion of top predators, therefore, causes deep disruption in ecological communities that is widespread and long-lived [40,44]. Over more than seven decades, industrial shark removal has resulted in major shifts in biomass and size composition in all oceans [17,40,43]. The mean weight of blue sharks caught was 52 kg in the 1950s, but just 22 kg in the 1990s, while the species abundance fell to only 13% of that of the 1950s [17]. Along the Eastern coast of the USA, 11 species of large shark declined between 1970 and 2005, while catch rates for 14 small elasmobranch species increased from about 1% to some 26% per year [43,44]. Ten-fold declines in 12 large pelagic predators between 1950 and 2000 were noted in the Pacific Ocean at the same time that pelagic stingrays (*Dasyatis violacea*) and other smaller elasmobranchs increased some 10- to 100-fold [44]. In the North Sea, a rich ecosystem of elasmobranchs was changed to one consisting of a few small, productive species such as small spotted cat sharks (*Scyliorhinus canicula*) and small skates [40]. However, RFMOs do not take the ecological consequences of shark removal into account [53].

4. A Barrier to Shark Conservation

Following the release of the movie *Jaws* in June 1975, a wave of hatred for sharks swept the public, and, particularly in the USA, recreational fishermen went out to kill the perceived monsters en masse [67]. In the decades since, nature horror shows presenting sharks as dangerous man-eaters have continued in effect to justify the fishing and have raised a barrier against shark conservation [68–70]. Until recently, conservation was considered to be an unpopular subject for television audiences [71] so the extreme depletion of sharks received little publicity.

Shark science has been strongly influenced by fisheries [72] and most research on them has been through dissection or tagging, which distances researchers from the animal. Further, fear of sharks caused early researchers to refrain from observing them underwater [73], so that the complexity of shark behaviour has remained obscure. Researchers have been further misled by the prevailing idea that evolution produced a hierarchical or pyramidal structure of life forms, with humans on the top, making the elasmobranchs, which separated from our phylogenetic line 440,000,000 years ago [74,75], among the 'lowest' of animals. Many shark scientists consider them to be nothing more than a fisheries resource [30] and refer to them in anthropocentric terms. Research during the past two decades has shown them to be capable of complex cognition [76], yet there remains a strong bias against them.

Although public concern about their extreme depletion has grown in recent years [77], with many organizations and individuals promoting their conservation [78], they have not been granted effective protection.

5. The Uncertainties

In 2015, the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) analysed shortfin mako (*Isurus oxyrinchus*) stocks using the most complete data available. It found that due to missing information, untested indicators, and conflicts in the available data, an assessment was impossible to make [79].

Besides the difficulties in assessing the status of sharks due to their deep water habitats and vast ranges, most mortality is not recorded. Clarke *et al.* [1,2] studied the shark fin market in Hong Kong between 1999 and 2001, and at that time the shark mortality necessary to support the shark fin trade was four times what had been reported to the FAO (the only organization that keeps global fishing records). They found that about 1.7 million tonnes of sharks were being sacrificed for the vanity soup each year, but cautioned that these estimates were low and did not include shark mortality that did not produce fins (such as hooking mortality, post-release mortality, predatorial mortality during long-lining, and the killing of sharks by fishermen to reduce bait loss on future sets, as well as incidental, artisanal, and recreational catches and discards). Estimates based on recorded catches, therefore, underestimate the mortality that sharks are actually facing by about four times, and possibly much more.

Global studies have emphasized the problems inherent in assessing the status of sharks, providing detailed descriptions of the difficulties on every level [1–4,13,26]. For a shark fishery to be sustainable, it must be possible to determine not only what the shark fishing mortality is, but also the mortality that will produce maximum sustainable yield (MSY), yet in the case of sharks those reference points are often not known or are extremely uncertain [4,5,20,41,80]. Most shark hunting nations still do not keep species-specific catch records [1,2,6,26,81], and recorded catches are known to be inaccurate. Catch data from artisanal fisheries are generally ignored, but in many regions, they are significant [82]. In the Indian Ocean, for example, such fisheries are not required to report shark catch data, contributing to the underestimation of shark mortality [82]. These uncertainties are amplified by the vagueness and secrecy involved in the trade in shark products [26].

5.1. Illegal, Unreported, and Unregulated Fishing

Illegal, unreported, and unregulated (IUU) fishing takes about 20% of the world's fishing catch, and as much as 50% in some fisheries. It is valued at between $10 billion and $23.5 billion annually from 11 to 26 million tonnes of fish [83]. These losses contribute to the unreliability of stock assessments, and therefore to the danger of their collapse [84]. As top-valued animals, sharks are especially vulnerable: in all four tuna RFMOs, fishing vessels regularly retain valuable shark species, including oceanic whitetip, scalloped hammerhead, and silky sharks, in spite of retention bans [82].

IUU fishing includes fishing which directly contravenes laws, fishing conducted under the area of management of a RFMO in a manner that contravenes the conservation and management rules of that organization, and fishing outside of management areas in a manner that is not consistent with state responsibilities for the conservation of marine resources under international laws [84]. It is correlated with poor governance, resulting in a lack of management of fishing capacity and consequent overfishing [85]. With seafood in high demand, and the difficulties inherent in enforcing fisheries management, particularly on the high seas, IUU fishing is profitable. Globally, there has been a lack of political will to take the actions required to address it [85].

The United Nations Convention on the Law of the Sea (UNCLOS), the FAO Code of Conduct for Responsible Fisheries (CCRF), and the UN Fish Stocks Agreement (UNFSA), as well as a variety of other international codes of conduct, agreements and regulations, have been put in place for the purpose of ensuring that fishing activities are conducted responsibly. Their objectives include taking the precautionary approach to fisheries management, ensuring that bycatch and waste are minimized, that the marine environment is conserved to sustainable levels, and that the economic interests of coastal communities are taken into account. RFMOs, as well as the large seafood companies, are those in a position to ensure that these principles are respected [86]. However, compliance with these measures is poor. Many vessels intentionally violate laws on the virtually unmonitored high seas [85]. Without a strong, internationally binding High Seas Treaty there is almost no prosecution to be feared by fishing fleets for violations, even if detected.

For example, Taiwan has over 1100 flagged vessels fishing across all the oceans, and hundreds more Taiwanese-owned vessels are flagged to other countries. It is one of the world's largest distant-water fishing powers. It is a party to several RFMOs, including the Inter-American Tropical Tuna Commission (IATTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC), and the Western and Central Pacific Fisheries Commission (WCPFC). Yet Greenpeace [86] found that 50% of its ships practised shark finning, and 13% killed toothed cetaceans, such as dolphins and false killer whales, to use as shark bait or to sell. (The meat of dolphins is extremely attractive to sharks and stays on the hook better than fish meat.) Further, 92% of ships in the Taiwanese fleet committed human rights abuses. These included the withholding of wages, excessive overtime (20 h/day shifts), deception, physical violence, and passport confiscation, with no recourse to apply for justice. In spite of some improvements and efforts to legalize the Taiwanese fleet, continued violations are reported.

Taiwan is home to one of the top three tuna traders in the world, Fong Chun Formosa Fishery Co., Ltd., which recently purchased the American canned tuna company 'Bumble Bee', making it a major supplier of tuna to consumers in the USA [86]. It is a telling illustration of how successful and insidious is IUU fishing in today's market.

5.2. Other Markets

As well as the shark fin market, the increasing demand for a component of shark liver oil, squalene, is a prominent cause of shark mortality [87]. Squalene fishermen often extract the animal's liver and throw the body back into the ocean, which is called "shark livering." The scale of the shark liver oil market requires more than three million deep-sea sharks annually and targets species with large livers such as the Greenland shark (*Somniosus microcephalus*), the whale shark (*Rhincodon typus*), and deep-sea sharks including the gulper shark (*Centrophorus granulosus*), the leafscale gulper shark (*Centrophorus squamosus*) and the Portugese dogfish (*Centroscymnus coelolepis*). Even when they are caught in low numbers, deep-sea sharks are extremely vulnerable to fishing.

However, except in South Korea, there is no standard code designating shark liver oil or squalene, and countries do not declare their catches to the FAO. It is therefore impossible to analyse the global market in any detail [87]. Yet, shark meat and oil are now being used in everything from make-up to dogfood, particularly from blue, shortfin mako, and scalloped hammerhead (*Sphyrna lewini*) sharks [88]. Given the success of IUU fishing, threatened species easily find their way into the market.

5.3. Substituting Disappearing Species

The high diversity of shark species in the Hong Kong shark fin market indicates the likelihood that species more sensitive to fishing pressure are being replaced by others as their numbers become depleted. Such substitution could mask losses of declining species [6].

When landings of species complexes appear to remain stable, or even increase, in spite of intensive fishing, the declines or disappearance of the more sensitive members can go unnoticed while removal continues because overall yields are sustained by the more productive species in an unperceived target replacement [23]. Continued fishing pressure on such populations has often resulted in their total collapse [21,40]. Species replacement contributes to the uncertainties inherent in shark fisheries data [40]. Examples include the disappearance of three of the largest skate species from British waters, and steep declines in others, all while fishery reports on "skates and rays" claimed that the populations were stable [23].

The angel shark (*Squatina squatina*) was nearly fished to extinction in Europe. It was recorded and sold under the name 'monkfish', but as the catch dwindled, fishermen substituted anglerfish (*Lophius* spp.), sold under the same name [23]. Similarly, as many popular fish species have become critically depleted and scarce, sharks have been substituted, using a false label to sell them. In 2019 Hobbs *et al.* [89] used DNA Barcoding to identify species sold in the UK. Out of 79 tested samples of "fish and chips" sold as takeaways, 71 were spiny dogfish—almost 90%. They were labelled as 'rock eel', 'rock salmon', 'rock', or 'huss', thereby making it almost impossible for consumers to know that they were eating shark meat, and possibly the meat of a threatened species. The spiny dogfish is critically endangered in the Eastern North Atlantic [89]. These authors found that cheap fast-food outlets were the best places to disguise shark meat and sell it under a false name. Various species of dogfish have been sold under such names as well as 'flake' and 'rockfish' [90], presumably to disguise what might otherwise be seen as unpalatable.

In Brazil, where shark meat is considered to be low quality, it is sold under the name 'cação', for better consumer acceptance, as well as without labelling and at lower prices [13].

In Australia 'flake' is the name used for the meat of a wide variety of sharks, including the endangered school shark (*Galeorhinus galeus*), the endangered scalloped hammerhead, and the critically endangered whitefin swellshark *(Cephaloscyllium albipinnum).* According to the Australian Marine Conservation Society (AMCS), 'flake' is widely used for fish and chips, but less than 30% of fish and chips shops label the species being used correctly [91]. In their report, AMCS highlighted the fact that the most popular seafood in Australia exploits these endangered sharks, yet half of the consumers are not aware that they are eating shark when they buy 'flake' [91].

6. Shark Conservation Measures

The regulations intended to protect and manage sharks in recent decades [92] have been ineffective in stopping the decline in their numbers [9,23,25,93]. Listings by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) are proving inadequate in the face of the secretive shark fin trade [6,94]. Protection can only be gained one species at a time, while the shark fin market is indiscriminate, taking fins from essentially any species of shark or ray.

Once separated from the animal, it is difficult to determine from which species a fin has been taken, so enforcement is weak [1]. The morphological similarity of many shark species makes visual identification of detached fins sufficiently reliable for only a few species [25]. In spite of modern barcoding methods, identifying each fin is prohibitively slow and impractical. The existence of parallel legal and illegal markets undermines enforcement because it is not possible to separate legal from illegally caught fins due to complex trade patterns and consolidation by traders along the trade chain. Even if it were possible for customs' officials to identify each fin, in each shipment, at border crossings, there may be multiple fisheries operating in the area of origin, some legal, some not [25].

CITES listings are opposed by shark hunting nations because of the high commercial value of the fins [4]. To date, only 5 species of ray (sawfish) and not one species of shark has been listed under CITES' Appendix I in spite of their ongoing depletion and the acknowledged threat of extinction, though 14 species of shark and 27 species of ray, including the IUCN critically-endangered rhino rays, have been included under Appendix II.

However, an Appendix II CITES listing only requires a "Non-detrimental" finding to export fins from the listed species—it grants no protection from being fished in the first place. Since fins can be stockpiled until a "Non-detrimental" finding can be arranged, the loophole undermines the protection that was intended by the original CITES listing [95]. Further, shark hunting nations avoid granting protection to endangered sharks by claiming that they are not wildlife but species of commercial interest to fisheries [30,96].

The whale shark, for example, continues to decline in both abundance and size in spite of being protected by the Convention on the Conservation of Migratory Species of Wild Animals 2010 (CMS)—the 'Bonn Convention', CITES, and the Commonwealth Environment Protection and Biodiversity Conservation Act (EPBC) [93]. In 1999 it was listed on Appendix II of the CMS and on Appendix I in 2017 [97]. Similarly, the sand tiger shark (*Carcharias taurus*) in southern Australia has been protected from fishing since 1984, but due to the high rate of incidental hooking the population continues to decline [93].

In 2015, 52% of fins (by weight) analysed in the Hong Kong market were CITES-listed sharks [94]. In a later study, fins from 76 species of elasmobranchs were found being traded in Hong Kong, one third of which were considered to be threatened with extinction [6]. In 2017, a shipment of shark fins intercepted in Germany, en route from Mexico to Hong Kong, was found to include four species of CITES-listed sharks out of 11 [98]. Using barcoding methods in four shark fin markets on three continents [16] it was found that 47~60% of fins came from threatened and rare species and that 35~75% came from species classed as either threatened (CR, EN or VU) or 'data deficient' (DD) by the IUCN.

It is clear that an Appendix II listing for elasmobranchs is not sufficient to protect them [16].

6.1. Finning Bans and 'Fins Naturally Attached' Policies

Finning bans were thought to be a viable means to combat shark finning in the belief that they would result in a decline in shark mortality [11,99]. A fins-to-carcass ratio of 5% has generally been adopted (calculated as fins being 5% of the weight of the sharks on board the fishing vessel). This was intended to indicate that no sharks had been finned and discarded at sea. However, these ratios are almost impossible to verify, especially when fins have been dried or are frozen [26], and the legislation has not helped to improve data availability with respect to the true numbers and species of sharks being caught.

As a result, several jurisdictions introduced a 'fins naturally attached' (FNA) regulation that requires that fins cannot be cut off at sea but must be landed naturally attached to the carcass. This is now considered to be the only way to guarantee that finning did not occur [100], and to permit the true numbers, species, and size of the sharks caught to be reported accurately for the analysis of fishing-induced mortality.

The FNA policy has been an important improvement and is globally acknowledged as being the best practice [100–103]. It has been implemented in many countries and RFMOs including Costa Rica (2008), USA (2011), EU (2013), India (2013), Canada (2019), North East Atlantic Fisheries Commission (NEAFC) (2015), Northwest Atlantic Fisheries Organization (NAFO) (2017), and General Fisheries Commission for the Mediterranean (GFCM) (2018).

However, there is no strict FNA policy for vast regions of the high seas, including the Indian Ocean (IOTC), the Western Central Pacific (WCPFC), the Atlantic Ocean and adjacent seas (ICCAT), and the Eastern Pacific Ocean (IATTC). These authorities continue to allow the 5% rule, or other fins-to-carcass ratios, as sufficient proof that finning does not occur, so for most of the High Seas finning bans remain the only form of control on shark catches.

For the industry, fins-to-carcass ratios are easier to implement than an FNA policy or catch reductions, so many fisheries still strongly oppose their adoption. In spite of the very high rate of elasmobranch mortality, RFMOs have perceived the monitoring, assessment, and enforcement capacity required to manage shark fisheries as being prohibitively costly [4].

6.2. Shark Sanctuaries and Fishing Bans

The idea that the maximum sustainable yield should be taken for every possible species is by no means universal, even in maritime nations. French Polynesia, for example, wanted its sharks neither fished nor disturbed, and when companies from Asia began intensive shark removal throughout the vast archipelago of that island nation, the government responded by turning its entire EEZ, which is the size of Europe, into a shark sanctuary [60,104]. In the following years, this resulted in the complete recovery of the severely depleted populations of sharks. Other nations too, have become shark sanctuaries in response to the shark fin trade [104,105] as shown in Table 1.

Unfortunately, these sanctuaries are still limited to a few nations that have understood that the lifetime value of sharks is substantially better for their economies than the one-time revenues from shark fishing and the shark fin trade. However, enforcement is often poor due to a lack of sufficient surveillance and monitoring at sea and in the ports, while the prosecution and conviction of offenders are difficult.

In some cases, the laws are not strong enough to provide complete protection for sharks. In Egypt for example, shark fishing is only banned in part of the country, while others, including the Maldives, have not imposed strong enough measures to prohibit the retention of sharks caught as bycatch in other fisheries. In addition to a ban on shark fishing, the Bahamas enforces a trade ban on shark products, but other nations have not done so. National bans cannot be considered to be a guarantee of safety for sharks since they can be lifted again.

To date, no major shark fishing nation has taken effective steps to protect its sharks from being fished, with the exception of a few attempts to define Marine Protected Areas (MPAs). However, these are often too small to provide the required degree of protection. Fishing for pelagic sharks is often still allowed, as, for example, in most of the MPAs in the Azores.

Table 1. Nations that have banned shark fishing [105].

Year	Nation	Comments
2001	Congo-Brazzaville	Shark fishing banned
2004	Ecuador	Shark fishing banned, but only enforced around Galapagos
2006	French Polynesia	Shark sanctuary
2006	Egypt	Shark fishing banned up to 12 NM from shore in the Red Sea
2009	Palau	Shark sanctuary
2010	Maldives	Shark sanctuary
2011	Tokelau	Shark sanctuary
2011	Marshall Islands	Shark sanctuary
2011	Bahamas	Shark sanctuary
2011	Honduras	Shark sanctuary
2012	Cook Islands	Shark sanctuary
2013	Brunei	In EEZ; ban on trade of shark products
2013	New Caledonia	Shark fishing, transportation, trade, and consumption banned
2014	United Arab Emirates	Shark fishing of CITES listed sharks banned; other species banned between 1 February and 30 June. Imports and exports banned
2015	Federated States of Micronesia	Shark sanctuary
2015	Cayman Islands	Shark sanctuary
2015	Kiribati	Shark sanctuary
2015	Bonaire	Shark sanctuary
2015	Sabah	Shark sanctuary
2015	British Virgin Islands	Commercial shark fishing banned
2016	St Maarten	Shark sanctuary
2017	Dominican Republic	Shark sanctuary
2018	American Samoa	Shark sanctuary

6.3. The Fisheries Certification Standard for Sustainable Seafood

The Marine Stewardship Council (MSC), which awards its label to presumed sustainable fisheries, admits that finning still occurs in certified fisheries in spite of having been banned since 2012. Its Fisheries Certification Standard accepts the fins-to-carcass ratio with some degree of external validation as sufficient proof that finning is unlikely to have occurred. Conformity Assessment Bodies (CABs), which perform the assessment and certification of fisheries, are advised by MSC to consider only systematic finning or successful convictions as evidence for non-compliance with MSC's proclaimed zero-tolerance policy on finning [106–108]. No fishery has ever been deemed non-eligible for certification. The MSC has therefore been widely criticized, both by environmental organizations and civil society, for its failure to require that an FNA policy is in place as a prerequisite for certification.

The level of monitoring and surveillance that is accepted by certification agents is also insufficient. An observer level of only 5% is often considered a sufficient degree of external validation to prove that finning is not taking place in a fishery [107,108]. Environmental organizations, retailers, and even other fisheries, have therefore requested that both an FNA policy and a risk-based level of monitoring and surveillance of compliance must be introduced as essential [107,108]. (Risk-based monitoring requires that there be a greater level of surveillance and better external validation of compliance for those fisheries that have a higher risk of shark finning, while for lower-risk fisheries the burden of demonstrating compliance is reduced [108]).

7. The Shark Meat Problem

The use of finning bans and FNA policies have diverted attention from the central problem: the unsustainability of shark catches. Instead of reducing mortality, the resulting trend has been towards less detaching of the fins [99], while a surplus of low-value shark meat has been forced onto markets around the world [11,13,26]. Although only the fins are valuable, the whole shark has to be used. Thus, to a large extent, the shark fin market drives the market for shark meat.

In Costa Rica and other South and Central American countries, for example, sharks were considered undesirable and not used for food prior to the 1980s. Then the inflated price of shark fins resulted in sharks of many species, from a wide variety of habitats, being targeted for their fins alone. The subsequent FNA policies obligated fishermen to land fins attached to the bodies, and the shark fin industry put the surplus meat on the market for domestic consumption. Merchants pushed the meat onto local consumers, relying on the use of various other names to sell it. Now, Costa Ricans alone are consuming about 2000 tons of shark meat a year, and the situation is similar in many other countries [109].

In the USA, fishermen are applying powerful political pressure to be allowed to continue to fish sharks and profit from the shark fin trade, in spite of the global danger to sharks, even attempting to scare Americans with the threat of more shark attacks if they cannot kill the animals [110]. When Texas passed a law requiring that all dead sharks shipped through the state must have their fins naturally attached, meaning that fishermen could no longer sell the fins, the Western Gulf of Mexico shark fishery was effectively shut down in 2019 [110], a telling illustration of how the shark fin market drives shark fisheries.

Sharks are long-lived top and middle predators, and their meat has high levels of accumulated toxins. The Florida Fish and Wildlife Conservation Commission's (FWC) [111] fishing rules specify a minimum size of 54 inches for about half of the shark species caught. At the same time, the Florida Advisory on Fish Consumption [112] advises that no species of coastal shark longer than 43 inches should ever be eaten by anyone due to its high mercury content. Thus, fishermen are specifically advised to catch large sharks, which are the breeding females—mature female sharks of the species targeted are significantly larger than the males—yet at the same time they are considered too toxic to eat.

In parallel, the spiny dogfish fishery in the Northwest Atlantic is being expanded in spite of the finding that 32% of spiny dogfish exceed the United States Environmental Protection Agency (US EPA) recommended threshold level of 0.3 ppm of mercury [113] (US EPA, 2000), and concerns that the meat could have an adverse effect on consumers [114]. The Maine Seafood Guide [115] warns that dogfish meat

> "may contain amounts of mercury in excess of the recommendation of the USA Food and Drug Administration's (FDA) recommended limit".

It advises that

> "pregnant and nursing women, women who may get pregnant, and children under 8 years of age"

should not eat any shark, and others should eat no more than two such meals a month. Shark fins, especially the commonly traded species, are also found to contain high levels of toxins, including mercury and arsenic [116]. Shark fisheries are therefore targeting an animal that is both a potential risk to human health and globally threatened.

8. Sustainability in Shark Fisheries

Although the scale of illegal shark fishing is far greater than alleged sustainable shark fishing [25], Simpfendorfer and Dulvy [28] proposed that shark fishing become sustainable. They calculated that 8.7% of shark fishing was sustainable (although the calculation they used for this figure is not at all clear). The fisheries they counted as being managed and sustainable were a few in the USA, New Zealand, Australia, and Canada that have fished sharks and skates for meat [28]. However, the global markets for shark meat and fins historically have been separate, and relied on different species [26]. Hammerhead, oceanic whitetip (*Carcharhinus longimanus*) and blue sharks are preferred for shark fin soup whereas dogfish (*Squalus*), mako sharks (*Isurus*) and the school shark (*Galeorhinus galeus*) are preferred for meat [26]. However, since these fisheries are now being propped up economically by the value of the sharks' fins [29,117] their long-term viability is questionable [109].

Even in well-managed shark fisheries, ecosystem impacts are difficult to detect and evaluate, so they are ignored in stock assessments [40,53]. Most shark species are quite impossible to catch selectively [118], especially when using longline gear, so others will be caught as bycatch, including protected, endangered species [9,41].

8.1. The Spiny Dogfish

Among the managed shark fisheries considered to be sustainable, that of the spiny dogfish in the USA is considered by some to be a model [28]. It supplies more than 90% of the global trade in the species, the meat being sent to Europe while the fins go to Asia [117]. When decades of overfishing in the Northeast Atlantic caused a 95% decline, and finally the closure, of the European spiny dogfish fishery, the USA expanded its take in the Northwest Atlantic in the 1990s to fill the demand [117]. More than 95% of the sharks landed were mature females, the largest (and usually pregnant) dogfish [119]. The biomass of the female spawning stock declined by 75% as a result [117], and the fishery collapsed. However, in 2010 the US Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) declared the fishery rebuilt (meaning that dogfish numbers had increased), and since then has been working to expand it, considering it to be underutilized [77,120,121]. Spiny dogfish consume some of the same fishes that were depleted by fisheries on the eastern seaboard of the USA, and compete with cod for others. So when cod stocks were severely depleted, dogfish had less competition, and their numbers increased. The expansion of the dogfish fishery was therefore driven in part by the intention to eradicate this competition for fishermen, with the claim that getting rid of spiny dogfish would help restore balance to the ecosystem [121].

As a result, dogfish meat has been marketed in the Atlantic states as a replacement for teleost fish whose stocks have been badly depleted, including cod [122–124], even though it is known to be a potential danger to human health [114,121].

Using sharks as a replacement for depleted fish stocks is not a viable solution of that problem, for not only are sharks high on the food chain and of incalculable ecological importance, but shark productivity is also comparatively very low. Calls for restoration of the ecosystem, by permitting the overfished stocks of sharks to recover, have been made [10,39]. Dogfish are fished mostly by bottom gill-nets and trawlers [125], which is highly destructive to the sea floor and could in no way benefit the marine environment [32].

The dogfish fishery is also extremely wasteful. In 2018 commercial dogfish landings were estimated at 16.7 million pounds (7.6 Mt), while discards from commercial and recreational sources combined have remained at around 11 million pounds (5.0 Mt) each year over the last decade. In 2014 recreational discards alone totalled 8 million pounds (3.6 Mt) of shark [126].

Spiny dogfish are slow-growing, cold-water sharks whose numbers increased due to the removal of their predators and competitors. Nevertheless, such increases can be quickly reversed if intensive fishing continues because of the high sensitivity of elasmobranchs to any changes in survival rate [7,40]. The threat to sharks is clearly greater than that predicted by fisheries' assessments and local analyses may underestimate the risk of the collapse of global stocks [3]. Collapse is particularly likely when vulnerable stocks from just one region are expected to supply 90% of the world's demand [117], as is the case here.

The boom and bust pattern of spiny dogfish exploitation is typical of targeted elasmobranch fisheries. Rapidly increasing yields are followed by sudden and extreme declines in catch, which signify not only the fragility of the fishery, but also poor management [24]. USA Federal efforts to manage spiny dogfish have been ineffective, hampered by high bycatch and the defiance of scientific advice by the Atlantic states. The stock is currently assessed as 'Endangered' by IUCN (with a declining population trend) on the basis of past and continuing declines, persistent market demand, targeted fishing, increasing discards, and growing pressure to reopen fisheries [42]. Nevertheless, US Atlantic spiny dogfish meat, fished by trawlers, bottom gill-nets, and bottom longlines in the North West Atlantic, has been certified as sustainable since 2012 [127]. The history of the fishery suggests that it is not sustainable, and that it will not remain productive for long.

8.2. Sustainability in the Shark Fin Trade

Most species taken in the shark fin trade have never been known to support sustainably-managed fisheries [6]. However, Simpfendorfer and Dulvy [28] claimed that the mako and blue shark fisheries in the North and South Atlantic Ocean, and the blue shark fishery in the North Pacific Oceans, were among the 8.7% of sustainable shark fisheries mentioned above, even though they were unmanaged, the sharks are part of the global commons, and the fisheries serve the shark fin trade.

While the Northwest Atlantic Fisheries Organization (NAFO) and ICCAT are responsible for the management of fisheries in the Northwest Atlantic, ICCAT is responsible for the longline fisheries that catch most of the pelagic shark species [41]. ICCAT represents 52 contracting nations and groups, including the EU, that between them fish more than 127 million hooks each year in the North Atlantic. Their priority is tuna, swordfish, and billfish; sharks are of lesser concern. Member nations provide data of highly variable quality for their fisheries and there are also several major fishing nations working the North Atlantic that are not party to ICCAT and provide no shark catch data at all to anyone.

How any shark species could be managed sustainably under these conditions has not been defined by anyone anywhere. Indeed, Agrawal [128] established that it is in fact impossible to manage the global commons.

ICCAT has applied different standards for sharks than for tuna, swordfish, and billfish, which Campana [41] concluded meant that sharks were considered as a nuisance, not a concern. Until recently, there was no effort to measure or compensate for discards, discard mortality, or hooking mortality. Although it is now required that discards be reported, most contracting parties report very limited data on shark discards, if any.

The same tendency can be seen throughout the history of shark fishing [17,41,42]. The priority of the parties to the RFMOs is to maximize the profits of their own fisheries, and managing sharks can reduce those profits [41]. Even where possible, with few exceptions, RFMOs have not intervened as sharks have been increasingly overfished [5].

8.3. The Shortfin Mako

In a parallel with many other species, and as a result of industrial overfishing, the mean weight of the shortfin mako taken by longliners fell from 74 kg in the 1950s to just 38 kg in the 1990s [17]. This indicates how seriously the species has been affected by human predation. Like other cold water sharks, shortfin makos are slow growing and have a low reproductive rate, so they are especially vulnerable to overfishing. They are killed for sport as well as for their meat and fins, and have suffered high mortality throughout their range [40,129,130]. Shortfin makos have a greater landed value than blue sharks, and are retained after capture for use as meat [131].

Figure 1 shows the shortfin mako shark catches reported to ICCAT in the North and South Atlantic. For the last three years landings from the South Atlantic have exceeded those from the North, where the steady decline over the last 20 years is clear.

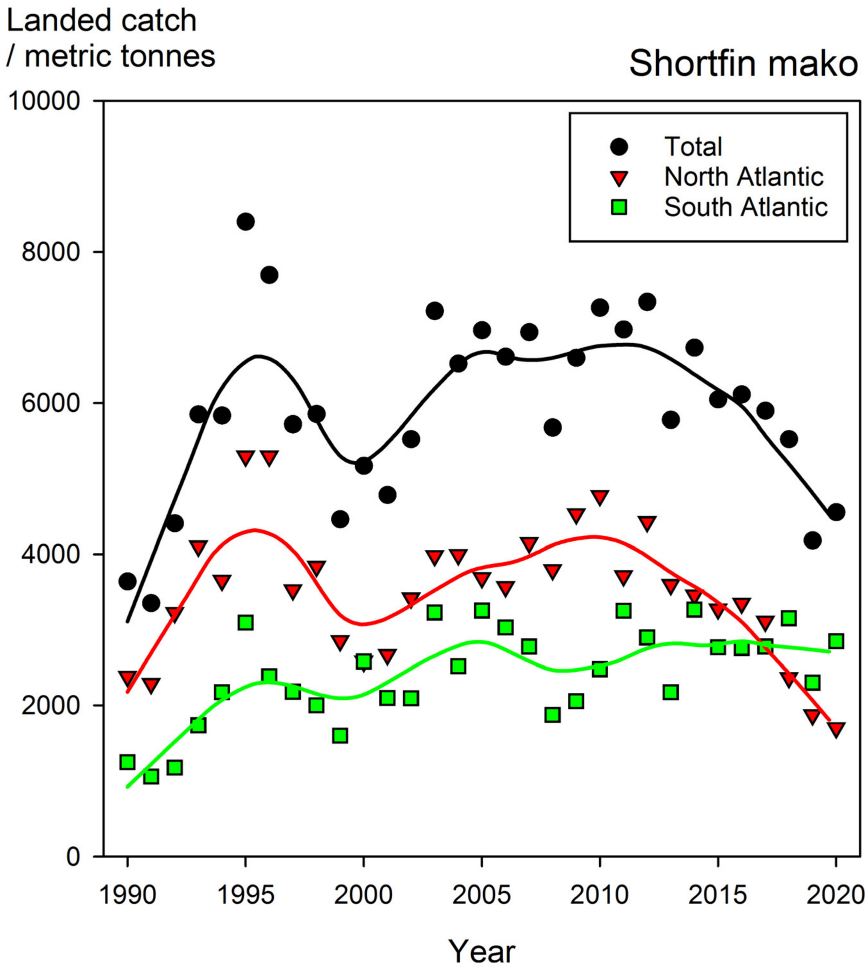

Figure 1. Landings of the shortfin mako shark, as reported to ICCAT. (Smoothed trend lines for eye-guidance).

The shortfin mako was assessed on the IUCN Red List in 2000 as being 'Near Threatened', reclassified as 'Vulnerable' in 2009, and in 2019 as 'Endangered' worldwide, with a decreasing population trend–this in less than 20 years because effective conservation actions were not taken. Finally, now in 2022, ICCAT is working on a management plan [132].

In the North Atlantic, an ICCAT stock assessment in 2017 showed a 90% probability that the stock was overfished, and that overfishing was occurring [133]. ICCAT noted that fisheries were removing mostly juveniles, but they were not catching mature females, meaning that replacement would not occur. This in turn means that the spawning stock size will keep declining for years even if fishing pressure is reduced. Based on a post-release mortality of 25%, ICCAT recommended a retention ban for live mako sharks, unless there was an observer on board (although how that helps is not clear), and that best handling practices be used prior to the release of live sharks [134].

In 2019, ICCAT updated the 2017 projections, noting that landings of blue and mako sharks had significantly decreased. It warned that shortfin mako status was so dire that even if all fishing was stopped immediately their numbers would continue to decline for the next 15 years, with a probability of only about 50% that the stock would be rebuilt by 2045. The probability that it would be rebuilt would not exceed 70% until 2070, some 50 years from now [20].

A CITES conference in August 2019 [135] found that the situation is the result of 30 years of intensive longline overfishing that removed a high proportion of the juveniles. Hence, as older females die, they will not be replaced by younger ones, indicating an impending population collapse. The situation is considered to be the same in the South

Atlantic [135]. CITES listed the shortfin mako in Appendix II, which is intended to protect species that are not under immediate threat of extinction but require extra protection. However, CITES also noted that since the species is threatened with extinction, it met the Appendix I criteria for full protection from international trade. CITES found that fisheries management measures under ICCAT would not halt its decline, and that no other RFMO limits mako catches, although the species is under the same threats globally [135].

The ICCAT 2017 recommendation for a retention ban [134] was to come into effect in 2019, but this was blocked by both the USA and the European Union (EU) [20], which chose to put short-term fishing interests before the need to protect the species. Their failure to respect the RFMO's scientific recommendations was in violation of UNFSA and UNCLOS regulations, which establish a clear duty to protect not only target species, but those caught as bycatch, as well as to refrain from the perpetration of actions which cause damage to the marine environment and threatened species. A duty to cooperate with other States in the conservation of living resources was also violated, which is particularly noteworthy given that both the EU and the USA have taken on the role of policing the rest of the world in terms of IUU fishing [14]. This detailed analysis indicates that both the USA and the EU are operating at some legal risk, *i.e.*, of being challenged for violating their own laws and therefore actually perpetrating IUU fishing as governments [14].

The EU is responsible, globally, for more recorded shark catches than any other polity because of the large catches of Spain, Portugal and France (India lies second [103]), while the USA is the fifth most prolific shark hunting nation [27] and boasts the biggest recreational shark fishery in the world [118].

Finally, in November, 2021, a retention ban was agreed upon, to start in 2022 and extend into 2023. A management plan will be launched, with the goal of achieving MSY by 2070 with a probability of between 60% and 70%. Total fishing mortality for the shortfin mako in the North Atlantic was set to a maximum of 250 t until new scientific advice is provided to the Commission [132].

However, Byrne *et al.* [129] found that mortality and post-release mortality of juvenile shortfin mako sharks is significantly higher than fisheries estimates in the North Atlantic. Capture often interrupts ram ventilation [136] and results in severe handling and hooking injuries [137]. Though best handling practices are recommended [20,134], it is unrealistic to expect exhausted fishing employees, often working in very poor conditions, to treat those large predators with care when they themselves are not being treated justly. Taiwan is a party to ICCAT, for example, and human rights violations were found on 92% of its ships [86]. The survival of the mako shark is more likely, therefore, to be dependent on the swift development of selective fishing gear, than on careful handling of the sharks prior to release.

8.4. The Blue Shark

With 90% of teleost stocks overfished [10], blue sharks are caught in increasing numbers around the world for their previously low-valued meat [13]. In Chile, for example, retention of blue sharks increased almost sixty-fold between 1999 and 2009 [23]. In the ICCAT area alone, reported landings of blue shark have increased by a factor of about six from 11,300 t in 1994 to 70,200 t in 2016 and 68,200 t in 2018. The blue shark makes up about 90% of the global catch of elasmobranchs [13] and provides more fins for the shark fin trade than any other species [2]. Fields *et al.* [6] estimated that between 34 and 64% of shark fins traded in Hong Kong are from the blue shark, but the chairman of the Hong Kong Marine Products Association, Ricky Leung Lak-kee, has stated that blue shark fins make up 60 to 80% of those consumed in Hong Kong [138].

Blue sharks dominate the bycatch of longline fisheries [15] and they are considered to be at high risk due to their distribution, which overlaps heavily fished regions [80]. Further, as oxygen minimum zones (OMZs) expand due to global warming, blue sharks may be shifting their distribution patterns into surface waters to avoid deeper, oxygen depleted waters [139]. Therefore, they are at even higher risk of being caught by surface longliners, who operate mostly above those OMZ depths [139].

Clarke *et al.* [11] found that blue sharks were already being taken at rates possibly exceeding the maximum sustainable yield (MSY) between October 1999 and March 2001. Since then, catch rates in the North Pacific have been estimated to be declining at 5% per year [97], which suggests that the catch volume is unsustainable. Most blue sharks caught in the Atlantic are juveniles [20], a strong sign of over-exploitation. Similarly, in Peru, of 11,166 blue and mako sharks caught in a longline fishery, 83.7% were sexually immature and under the legal minimum landing size [19]. In 2017, the blue shark was listed on Appendix II of the CMS [97].

In the USA and Canadian swordfish and tuna fisheries in the North Atlantic, blue shark discards approach 100% because blue shark meat has no commercial value in North America. Yet blue shark catches often exceed catches of the target species. Canada's North West Atlantic pelagic longline swordfish fishery, for example, reports catches of 20,000 swordfish and 100,000 blue sharks annually [140], indicating near total wastage. In the North Atlantic some 3 million blue sharks (~100,000 t) have been estimated to be discarded each year [41].

In the Atlantic Ocean, blue shark catches have steadily increased since the 1990s, from roughly 3000 t in 1990 to more than 73,000 t in 2011, an almost 25-fold increase over 30 years. Although the species is relatively productive, there is no evidence that such a take could be sustainable. Indeed, landings have begun to decline in the North, falling below the take in the South Atlantic for the first time in 2018 (Figure 2).

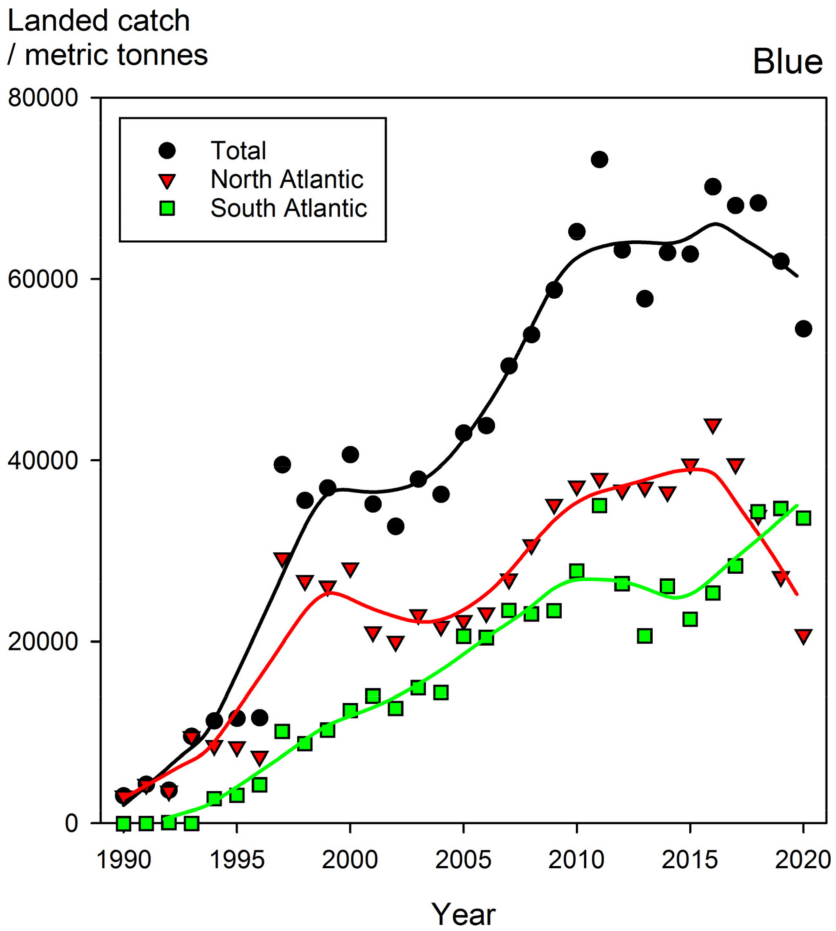

Figure 2. Landings of blue shark as reported to ICCAT. (Smoothed trend lines for eye-guidance.).

In 2019, ICCAT considered that the possibilities of blue sharks being overfished, and of overfishing occurring, could not be ruled out due to uncertainties in the data, and as a result established a total allowable catch limit (TAC) for blue sharks in both the North and South Atlantic for the first time [20].

The EU fleets are most heavily engaged in the targeting of blue sharks in the Atlantic, with Spain and Portugal responsible for some 80 or 90% of all catches there since 1997. As the third-ranking shark fin producer in the world, Spain exported 3409 t of shark fins to Southeast Asia each year between 2000 and 2011 [26]. The numbers of fins in Asian markets coming from the North Atlantic greatly exceed the reported catch [141], indicating that there is substantial unreported finning which is not being taken into account by ICCAT. The lucrative shark fin market provides strong motivation. Sharks whose fins have been cut off and then dumped, often still living, back into the sea, are not recorded because most western countries have banned the practice of shark finning. Campana [41] estimates that the actual numbers of blue sharks being killed are four times those reported.

Due to the lack of any reliable estimate of the numbers of discarded blue sharks, there is concern that the actual mortality may be much greater than that estimated [13]. Further, ICCAT's last blue shark assessment was made in 2015, and though another was planned for 2021, due to the COVID-19 pandemic and the low priority of the species, the assessment has been postponed until 2023 [142].

In the absence of any measure to prevent overfishing, or to ensure the rebuilding of overfished stocks, continued depletion appears inevitable. In 2020 the EU approved a proposal from the 2019 ICCAT meeting for an active management of shark stocks [143]. It remains to be seen what this will involve for blue sharks.

A further problem with the prediction of sustainability for the blue shark in the Atlantic Ocean [28] is that it is based on MSY, defined as the

> "current biomass being greater than that required to achieve MSY or current fishing mortality being less than that which will yield MSY". [28]

However, since MSY is estimated from actual landings it is not applicable to a largely discarded species [41]. Further, this method is no longer considered to be applicable to fisheries that are overfished and require stock rebuilding: spawning biomass first has to be restored, then the mortality from fishing must always be lower than mortality to maintain MSY [144].

Just two years after Simpfendorfer and Dulvy [28] claimed that the shortfin mako and blue shark fisheries in the North and South Atlantic Ocean were "bright spots of sustainable shark fishing," the unfolding trends indicated that they were wrong.

With the Atlantic Ocean being situated between the continents of Europe and America, in the heart of what is considered the civilized western world, one would expect it to receive the most exceptional management of fish and shark stocks. However, the above examination of the situation there clearly illustrates the failure of RFMO shark management.

9. Fishing Economics

The global fishing industry is currently propped up by an estimated US$35.4 billion in subsidies [145]. China provides the highest subsidy among nations, at 21% of the total, followed by the USA at 10%, and the Republic of Korea at 9%. These subsidies far exceed the profits from their fishing [146]. The only fishing fleets that are currently profitable are the longliners and purse-seiners which target the highest-valued marine animals: tuna and sharks [146]. Fully 54% are unprofitable, especially the largest fishing fleets. The current scale is enabled only by those large government subsidies [145,146]. For example, the diesel for the long-distance fishing fleets of the EU is paid for by subsidies, which allow them to go to the distant Indian Ocean and the Western and Central Pacific where, with their larger vessels and superior technology, they compete with the local fisheries for the remaining stocks of fish [145,146]. Deep-sea trawling, which is one of the most destructive fishing practices, is especially supported by subsidies, yet 32% of deep-sea trawling is unprofitable [33,34,145,146].

Evidently, high seas fishing activity would be completely transformed if subsidies were halted. For example, Spain, a top provider of blue shark fins to Asia, has its most profitable fisheries in the Western Indian Ocean, the Southeast Pacific, and the Southwest Pacific, far from its own EEZ. Many of its distant purse-seine fisheries would not be profitable without subsidies, and its high seas bottom trawling would be unprofitable everywhere without subsidies [146].

Global studies by the World Bank and FAO, *Sunken Billions* [147] and *Sunken Billions Revisited* [10], have reported that overfishing has resulted in a loss of about US$83 billion yearly. It found that fishing effort must be reduced to get the best economic result for solving the evolving global fisheries crisis. The fundamental reforms that are required must follow two parallel and simultaneous paths: (a) stock recovery, which would require giving depleted and over-exploited stocks a chance to recover, primarily by reducing fishing effort, and (b) restoring the integrity of the habitats on which the stocks depend (including mangroves, coral reefs, and seagrass beds).

This is the course of action which should be taken, as recommended 20 years ago by Pauly *et al.* [39]. However, the shark fin trade has made these top and middle predators valuable, so global fisheries are targeting them instead, despite their high ecological importance and the toxicity of both their fins and meat.

Clearly, shutting down a large proportion of the world's industrial fishing fleet will be disruptive and social unrest is predicted because millions of fishers will have to switch to other occupations. However, the fishing subsidies that have encouraged overfishing in the past could be used to help ease the social transition [8,10,39,147].

10. Fisheries Management

It has been known for decades that sharks are vulnerable to overfishing, *e.g.*, [118,148,149], are under high fishing pressure [4,7], of high ecological value [21,40], and that those accessible to commercial fishing fleets are threatened with global extinction [5,9]. One scientist after another has advised over many years that species-specific records are a necessary prelude to the possibility of the sustainable management of sharks, and that collecting data, especially in data-poor regions, should be a priority [15,21,93,150]. Since industrial fishing fleets operate over vast regions, and usually in international waters [31], the availability of accurate data, and international cooperation in its collection, is necessary on a global scale, for both the monitoring and management of elasmobranch catch and bycatch at the species-specific level [15,23].

Nevertheless, it was found in 2015 that of the top 10 shark fishing nations, only the USA had kept reasonable records, and only half had kept any records at all [15]. Lam and Sadovy de Mitcheson affirmed in 2011 [18] that at that time Chinese shark catch data were classified as state secrets and such data continue to be unavailable publicly. Thus, although China fishes more intensively than any other nation [146], its large shark catches have not been included in any fisheries' assessments.

10.1. The Impossibility of Establishing Global Sustainability

Sustainable shark fishing advocates broadcast the idea that sharks are being fished sustainably in spite of the established facts. In the USA, The Sustainable Shark Alliance (SSA) [151], a "coalition of shark fishermen and seafood dealers" advocates the *Sustainable Shark Fisheries and Trade Act* (SSFTA). Advertised as a "practical solution" that would allow American fishermen to continue to profit from the shark fin trade, SSFTA claims that it will create a

> "transparent certification program for countries seeking to import shark products into the United States,"

by requiring that they have

> "shark and ray management policies comparable to those under the U.S. Magnuson-Stevens Act".

This is supported by a variety of shark fisheries scientists [152,153], yet no one has described how all 1107 *Chondrichthyan* species (as well as all fish species) could be sustainably managed throughout the entire world.

The problems of such management would include:

- how the determination of what is a sustainable catch rate for every shark fishery in the world will be made
- how the baseline will be determined
- how management plans will be implemented
- how they will be funded
- how they will be enforced
- how RFMOs could be made to agree to base quotas and rules

Massive data collection projects would need to be organized–standardized, implemented, monitored, and funded on a global scale. Then, when laws are in place and enough data has been collected to determine what the sustainable catch rates might be, development and funding of fisheries management plans would need to be put in place, including staffing, training, and purchase of equipment. These are expensive to set up and operate. Expenses range from those for scientific advice and management, to enforcement, including monitoring, control, and surveillance; they can reach 14% of the value of landings [10]. Most of the cost is borne by the public sector, while the benefits are concentrated on the fishers [10,153].

All that is involved in SSFTA—putting American practices into play on a global scale—would need to be maintained long-term. Yet neither the necessary funds, nor an international organization that could create such a cooperative network, exist. It would require every country to keep politics, financial self-interest, corruption, and criminality, out of the process.

The refusals of the USA and the EU to follow ICCAT's recommendations for an immediate retention ban on shortfin mako in the North Atlantic in 2019 [20] provides an illustration of the willingness of states to ignore laws in the absence of a higher authority. It is also a telling example of how difficult it is to protect high-valued animals, no matter how large is the class of vertebrates involved, or how important they are ecologically.

The extent of surveillance and monitoring that would be required, as well as its cost, is also prohibitive, but essential to any claim to the sustainable management of all shark fisheries, and not just the official target species. Even 100% human observer coverage on all vessels would be insufficient to ensure that finning or illegal retention does not take place [86,154,155]. Due to the illegal character of the shark fin trade and the huge profits associated with it, observers have even been murdered [154]. Severe human rights abuses are a serious problem, especially on the long-distance fleets of WCPFC, including on MSC-certified fisheries vessels [86,154]. As is apparent from the shark fin industry, illegal, unreported, and unregulated activities tend to accompany the abuse of, and crimes against, humans [8]. Both authors have been threatened (BWD in Hong Kong, with violence by a shark fin trader at a public meeting, and IFP by a fisherman with death if he caught her alone at sea, during her ethological study of shark behaviour in French Polynesia).

In Asian consumer nations there is little government interest in regulating the shark fin market and the resources required to do so are simply not in place [25]. Shark fin consumers can afford to pay high prices for them and are quite unconcerned about sustainability.

The involvement of fisheries worldwide and the participation of criminal networks in a trade driven by high prices and rich customers, contrasted with the catastrophic, ongoing depletion of the animals supplying the fins [6,25], makes the current global hunt for sharks to supply the shark fin trade not only unsustainable but a severe threat to the health of global aquatic ecosystems.

Even the pressure from artisanal and subsistence fishing in remote regions, or shark netting programs to 'protect' beaches, can cause serious depletion of large coastal sharks [40]. Since the stocks of most elasmobranchs have collapsed, and in view of their low productivity, truly sustainable shark fishing would therefore now require the enforcement of near-zero shark mortality globally to allow both top predators and their small elasmobranch prey to recover [23,93]. Clearly this would not support even a tiny fraction of the shark fin trade.

10.2. The Concept of 'Sustainable Use'

The United Nations Convention on Biological Diversity (CBD) of 1992 [156] defines the sustainable "utilization of biodiversity" as

> "use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations (Article 2)". [156]

CITES was originally founded to limit industry destruction of biodiversity, and its Convention uses a biocentric set of values with regards to 'sustainable use' [157] in which biodiversity is considered to have an intrinsic value that must be preserved in a state of health. However, 'sustainable use' is often given a more anthropocentric set of values, in which human use has greater importance than the intrinsic value of biodiversity [157].

Fisheries law takes an anthropocentric position, being based on the concept of MSY without regard for ecosystem effects. The EU Common Fisheries Policy [158], for example, in part defined 'sustainable use' as: "exploitation of living aquatic resources that provides sustainable environmental, economic and social conditions". For comparison, the Magnuson-Stevens Act [159] (which regulates fisheries in the USA) defined the "optimum yield" from a fishery as the amount of fish that will provide "the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities" [159], while the rider: "and taking into account the protection of marine ecosystems" seems to receive little attention for *chondricthyans* in practice. "Optimum yield" "is prescribed on the basis of the maximum sustainable yield from the fishery". Benefit to industry, and by inference, humanity, is placed before the need to maintain ecosystems in good health. The lack of concern for biodiversity is especially evident in the case of highly uncertain shark assessments when the base values for calculating MSY are grossly inaccurate [41] and although up to 100% (in the case of blue sharks) of the catch may be discarded, MSY can only be calculated on actual landings.

As is evident in many ways in the treatment of fish and their environment, the fishing industry tends to view itself as the sole legitimate user, and in effect the owner, of living marine resources [160]. Fisheries science and management has focused on target populations and not the species caught as bycatch, resulting in ecological damage and extreme declines in abundance and biodiversity. Fisheries stock assessment scientists have traditionally worked in government laboratories for fisheries, with a narrow focus that dismissed conservation issues, even though their governments were signatories to binding conservation agreements [160]. This remained the case even after commercial fish stocks became depleted [160].

In political science, biodiversity interests are practically non-existent. In 2006, Agrawal and Ostrom [161] found that in the previous 20 years the top political science journals had published only one article that focused on biodiversity, out of more than 2000 papers. Further, in the top five political science departments in the USA, not a single faculty member counted biodiversity conservation among his or her interests [161].

This situation reveals an anthropocentric approach to the conservation of biodiversity in general and sharks in particular. It is aggravated by the territorial position taken by fisheries of ownership of the stocks, and the assumed right to take them no matter how depleted they become.

To most people, the idea of sharks being fished sustainably suggests that they and their environments are being kept in a state of health for future generations. However, this is far from being the case. In fisheries, 'sustainable use' is not being defended against 'unsustainable use', but it is being defended against the effective protection of sharks. This continues to be the case even though the species accessible to industrial fisheries are now threatened with extinction and therefore fulfill the criteria for the CITES Appendix I listing.

As well as being exemplified by the Sustainable Shark Alliance and its dogma, this position is evident in the many published pro-shark fishing papers in which anthropocentric terminology is used, shark depletion is described, and continued fishing is still promoted [9,28–30]. The sustainable use advocates fail to state when it would be time to stop using the 'resource'. The IUCN defines this situation as "Position 4", which is "deliberate misuse of the terminology of sustainable use". In fact, it has been noted that

> "[the phrase] *supporting sustainable use* can be used in order to justify any specific use, regardless of its sustainability. This will usually be used as a political or rhetorical strategy to defeat opposition to use . . . it has no biocentric rationale, and . . . it is not consistent with a conservation strategy. It will be motivated by anthropocentric reasons, to justify gaining the benefits of use to humans". [157]

According to IUCN policies, the actions that must be reduced are:

- the use of biodiversity and its components at unsustainable levels
- the use of components of biodiversity causing environmental damage
- consumption of anything that impacts unsustainably on biodiversity [157].

These are not being advocated for sharks by pro-sustainable shark fisheries' scientists.

10.3. Instinct Versus Science

The willingness of the fishing industry to pillage without regard for the health of the biosphere and the resulting ecological harm [39,53], the level of bycatch that has been treated as tolerable [15,40,162], and the readiness to put short-term financial interests first [14,20,29,42,121] illustrate its failure to take biodiversity into account, in spite of international agreements to the contrary.

Deep-sea trawlers, for example, 'mine' ecosystems in the knowledge that they will not recover [33,34]. Although the danger to marine life posed by abandoned ('ghost') fishing nets has long been recognized, for more than three decades the fishing industry has trailed nets to significant depths below dFADs, killing large numbers of sea turtles and sharks, which has been ignored by fisheries scientists and RFMOs alike [35,163]. Drifting FADs are regularly abandoned by the fleet that launched them. They are able to drift for as long as two years, can cover distances of more than 10,000 km [36], and badly damage the shore, especially delicate environments such as coral reefs and mangroves, when they beach [48]. Yet fish from such fisheries, as well as fish from those practicing shark finning and other highly wasteful and damaging pursuits, have been certified as "sustainable" by MSC, although the body claims to use a high standard in recommending only sustainable seafood to a trusting public. However, in practice, it is applying much lower industry standards for certification [164–167].

It has been 'scientifically' argued that fishermen should treat fish as they wish because they are predators and part of the food chain [168]. In contrast, our civilization prides itself on the idea that humanity uses reason in its decision-making, rather than following its instincts. Diggles *et al.* [168] have reminded us of the true situation: the world's fishermen are in the same position as any other predator that is in the process of eliminating its prey. With the human population as over-grown as it is, it has been known for decades that the moment would come in which no wild prey could sustain us [39,169].

We have the capacity to recognize the difference between instinctual drive and reasoned thought, yet reason (*i.e.*, science) is often rejected in negotiations. Territorial interests supervene and limit international cooperation [170], which carries over into the management of globally important species. Such barriers must be overcome, otherwise the current pattern of species depletion, extinction, and the unravelling of the planet's ecosystems will continue and accelerate, eventually to the severe detriment of humanity [8,171,172].

That one soup recipe, in just one of the world's many cultures, could have had such a serious effect on the status of as many species as are represented by the class of

Chondrichthyes is a telling indictment of the priorities of humanity. Participation in such a market is an ethical question [25]. The way the industrialized western nations have joined the hunt for sharks to profit from such a market highlights the need to address this facet of the problem.

11. Conclusions

The literature documents a global catastrophe of elasmobranch loss in which shark fishing is unmanageable and unsustainable. The current tendency to turn to fishing sharks because the shark fin trade has made them profitable, instead of concentrating on the recovery of the gravely depleted teleost fish stocks and their habitats (with the goal of long-term yields from healthy fish stocks in the future), is a dangerous course which should not be pursued. Sharks will go the way of the teleost fish, and much more quickly, if the current trend continues. No lessons have been learned from the demise of Grand Banks cod [173] and North Sea herring [174] it seems.

Given the market interplay of supply and demand, wherein the desire for money fuels the targeted hunt for sharks, and rich customers supply it, the way to stop their decline is to stop the shark fin trade itself, which could best be done through a ban on International trade [25]. Stopping demand, and addressing bycatch and IUU fishing, are key aspects of this [16].

11.1. Protection from International Trade

All sharks, manta rays, devil rays, rhino rays, and chimaeras, as well as their parts, require immediate protection. The illegal character and the high economic incentives associated with the shark fin trade heighten its danger for the increasingly depleted large predators supplying it, while the takes of shark liver oil, with at-sea processing, is of the same character [175,176]. The ineffectiveness of the measures taken to date, including CITES Appendix II listings, indicates that the protection afforded to accessible species must be significantly improved. Therefore, a CITES Appendix I listing should immediately be granted to provide the needed protection from international trade. The shark fin trade takes all fins, and therefore all should be listed. There is already a precedent in listing look-alike species as a counter to deception [177].

The claim that there is insufficient data to justify listings on Appendix I does not hold up in the face of the massive weight of evidence of over-depletion revealed by a study of the literature. It provides an alarming warning regarding what is occurring and lays out more than sufficient reason for that listing, especially given the impossibilities of assessing the status of sharks accurately or managing the global commons of the High Seas. Sharks must be treated as protected wildlife internationally, rather than as a 'resource' of interest to commercial fisheries. Critically, international cooperation is needed. A binding international treaty to protect sharks, as well as threatened biodiversity in general, should be the immediate goal [172].

Protection of sharks from international trade would benefit local communities that depend on the sea for their protein. In artisanal fisheries, the elasmobranch catch is generally fully-utilized [15]. With no shark exports, the market would remain local, and prices would not be jacked-up to export levels. Those in industrial nations, many of whom are already eating too much protein, will choose something else, including plant protein, if fish and shark meat is not on the menu.

A CITES I listing for sharks would greatly simplify management and policing by eliminating the need to identify illegally-caught species, or parts thereof, at border crossings, as well as the continuous demands for more species-specific information in the various regions as required by "Non-detrimental" findings in the case of Appendix II listings. Such species data is expensive, difficult, and too often impossible to obtain, while its absence delays action under current rules, and the trade continues. A telling example is the way ICCAT postponed the stock assessment of the blue shark, claiming that it lacked the time and resources to get the scientific information necessary to manage this important species [142].

Shark fin trade bans should be adopted as widely as possible. A trade ban is easier to enforce than fishing regulations, while taking away the enormous profit, and thereby the incentive, to catch sharks. For example, in the USA, the Shark Fin Trade Elimination Act has passed through Congress, and at this writing is awaiting passage in the Senate. Some 14 states have banned shark fins, and Florida has also passed an import ban on fins in 2020. There is a trade ban in Canada, requiring all shark fins to remain naturally-attached to the body of the animal for import and export. Political pressure is being applied to effect a trade ban in Europe [178].

Honest labelling of seafood products should be required for transparency and traceability. There would be a significant decrease in the 'demand' for shark meat if it were actually labelled as shark meat.

11.2. Fishing Effort Reduction

Fishing effort must be diminished by a large proportion to permit the damaged ecosystems of oceans, coral reefs, lagoons, mangroves, estuaries, rivers, lakes, and coastlines to recover [10,39]. All fishing subsidies must end. The money should be used instead to help fishermen switch to other occupations, including, for example, ecotourism or the planting of food crops, and to police the shores and reefs they once fished. Educating them to protect their damaged seacoast is an option that has been found to be highly successful [179–181]. Severe sanctions, including heavy fines and vessel seizures, should be levied on violators, and those revenues re-invested in policing and education. A radical change is needed to ensure that fishers can sell their catch at a fair price to make a living while neither overfishing nor damaging the environment. The installation and protection of MPAs helps to increase the abundance of fish in adjacent areas, which will ultimately help to secure income for them.

Deep sea fishing should be permanently banned, and fishing methods must be transformed in such a way that bycatch of non-target species is completely avoided. In the meantime, shark bycatch taken by longliners and trawlers should be reduced using available methods [9,15,182,183], and 'best handling' practices used as much as possible to ensure that the highest possible number of sharks survive mandatory release. The inevitable reduction in fishing efficiency and the increased costs thereby incurred will mean that consumers will have to pay higher prices to eat fish. Fish provide a high-quality protein, and a higher price would reflect more truly the value of such wild prey. A global shift towards selective fishing methods, and away from today's efficient, but unselective and destructive methods, must be an objective if we want the remaining biodiversity in our oceans to survive beyond this century [184,185].

In addition, at least 30% of the ocean should be set aside to recover as MPAs [186]. For pelagic species of sharks, large MPAs and no-take zones that include the High Seas are required for effective protection because most are highly migratory. There is a particularly urgent need for conservation and management measures at high-seas and coastal hotspots of shark space [80,187]. Designation of such MPAs should take the high degree of spatial overlap between sharks and industrial fishing vessels into consideration, especially in those areas that attract fish, because of their favourable productivity and temperature profiles [187,188]. Coastal MPAs must be managed effectively as no-take zones and large enough to encompass the ranges of the resident sharks, ensuring that they are protected at all times [189].

11.3. RFMO Policies

More scientific observers should be deployed by RFMOs [41,188]. However, given the increasing numbers of human rights violations, disappearances, and murder of observers [154], they should not be used for enforcement of regulations nor compliance monitoring. To effect this, there are now remote electronic monitoring tools available which are tamper-proof and can cover all activities on board. Monitoring of landings and transshipment activities needs to be mandatory, as well as positioning data via the Automatic Identification System (AIS) for all fishing vessels. The equipment should be installed in such a way that it cannot be switched off [190]. Implementation of a comprehensive monitoring and surveillance system combining both human observers and remote electronic monitoring should be a priority task for all RFMOs [191].

RFMOs should be required to respect human rights, and to address slavery, as well as unsafe and inhumane working conditions. At their own expense, they should be required to keep track of stocks through stock assessments by species and geographic region, update them regularly, and mandate catch limits. Landings should be monitored, and species-specific records kept. The pervasive problem of IUU fishing should be addressed globally, through all means available.

11.4. Cultural Change

Change can also come through cultural shifts. Such a change with respect to shark fin soup is already ongoing in China [25]. It needs to be strengthened there and in other shark fin consumer countries. Although demand is decreasing in China and Hong Kong, due to its lucrative nature it is growing in Thailand, Japan, and Malaysia [26]. Removing shark fin from menus and retail markets in consumer countries is of top priority [25].

11.5. True Sustainability

The sixth global mass extinction has been brought about by human activities [192] and marine biodiversity loss is largely the result of decades of over-exploitation by fisheries [193]. There must be a shift in attitude away from the idea that human expansion is the priority, above all other concerns, towards the management of the biosphere in the interests of sustainability, not of sharks alone (although they may be taken as key indicators), but to permit our civilization to continue on in good health. The domination by industry must end if the planet's aquatic ecosystems are to be saved from ecological collapse [8,172].

If history has taught us anything, no wild animal can withstand targeted industrial-scale hunting long term—not whales, not sea turtles, not fish, and certainly not sharks.

Author Contributions: Conceptualization, I.F.P.; methodology, I.F.P.; validation, B.W.D. and I.F.P.; investigation, I.F.P. and B.W.D.; writing—original draft preparation, I.F.P.; writing—review and editing, I.F.P. and B.W.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We thank Iris Ziegler for providing extensive information about the shark fishing industry. Many thanks to Alex Hofford and Keith DP Wilson for reading an early draft and making helpful suggestions. We are grateful to José I Castro, Randall Arauz, Mary O'Malley, and Stefanie Brendl for their insightful input on a variety of the political aspects of shark conservation.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

AMCS	Australian Marine Conservation Society
CAB	Conformity Assessment Body
CBD	United Nations Convention on Biological Diversity
CCRF FAO	Code of Conduct for Responsible Fisheries
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CREMA	Centro de Rescate de Especies Marinas Amenazada
DFAD	Drifting fish aggregating device
DNA	Deoxyribonucleic Acid
EEZ	Exclusive Economic Zone
EPBC	Commonwealth Environment Protection and Biodiversity Conservation Act
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FNA	Fins naturally attached
FWC	Florida Fish and Wildlife Conservation Commission
GFCM	General Fisheries Commission for the Mediterranean
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported, and unregulated
MPA	Marine protected area
MSC	Marine Stewardship Council
MSY	Maximum sustainable yield
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	North East Atlantic Fisheries Commission
NM	Nautical mile
NOAA	US Department of Commerce's National Oceanic and Atmospheric Administration
OED	Oxford English Dictionary
OMZ	Oxygen minimum zone
PADI	Professional Association of Diving Instructors
RFMO	Regional Fisheries Management Organization
SSA	Sustainable Shark Alliance
SSFTA	Sustainable Shark Fisheries and Trade Act
t	Metric tonne
TAC	Total allowable catch limit
UNCLOS	United Nations Convention on the Law of the Sea
UNFSA	UN Fish Stocks Agreement
US EPA	United States Environmental Protection Agency
USA	United States of America
USD	United States Dollar
WCPFC	Western and Central Pacific Fisheries Commission

References

1. Clarke, S.; Magnussen, J.E.; Abercrombie, D.L.; McAllister, M.; Shivji, M. Identification of shark species composition and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. *Conserv. Biol.* **2006**, *20*, 201–211. [CrossRef] [PubMed]
2. Clarke, S.; Murdoch, K.; McAllister, M.; Milner-Gulland, E.J.; Kirkwood, G.P.; Michielsens, C.; Agnew, D.J.; Pikitch, E.K.; Nakano, H.; Shivji, M.S. Global estimates of shark catches using trade records from commercial markets. *Ecol. Lett.* **2006**, *9*, 1115–1126. [CrossRef] [PubMed]
3. Dulvy, N.K.; Baum, J.K.; Clarke, S.; Compagno, L.J.V.; Cortés, E.; Domingo, A.; Fordham, S.; Fowler, S.; Francis, M.P.; Gibson, C.; et al. You can swim but you can't hide: The global status and conservation of oceanic pelagic sharks and rays. *Aquat. Conserv. Mar. Freshw. Ecosyst.* **2008**, *18*, 459–482. [CrossRef]

4. Worm, B.; Davis, B.; Kettemer, L.; Ward-Paige, C.A.; Chapman, D.; Heithaus, M.R.; Kessel, S.T.; Gruber, S.H. Global catches, exploitation rates, and rebuilding options for sharks. *Mar. Pol.* **2013**, *40*, 194–204. [CrossRef]
5. Dulvy, N.K.; Fowler, S.L.; Musick, J.A.; Cavanagh, R.D.; Kyne, P.M.; Harrison, L.R.; Carlson, J.K.; Davidson, L.N.; Fordham, S.V.; Francis, M.P.; et al. Extinction risk and conservation of the world's sharks and rays. *eLife* **2014**, *3*, e00590. [CrossRef]
6. Fields, A.T.; Fischer, G.A.; Shea, S.K.H.; Zhang, H.; Abercrombie, D.L.; Feldheim, K.A.; Babcock, E.A.; Chapman, D.D. Species composition of the international shark fin trade assessed through a retail-market survey in Hong Kong. *Conserv. Biol.* **2017**, *32*, 376–389. [CrossRef]
7. Myers, R.A.; Worm, B. Rapid worldwide depletion of predatory fish communities. *Nature* **2003**, *423*, 280–283. [CrossRef]
8. IPBES. *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*; IPBES Secretariat: Bonn, Germany, 2019. [CrossRef]
9. Pacoureau, N.; Rigby, C.L.; Kyne, P.M.; Sherley, R.B.; Winker, H.; Carlson, J.K.; Fordham, S.V.; Barreto, R.; Fernando, D.; Francis, M.P.; et al. Half a century of global decline in oceanic sharks and rays. *Nature* **2021**, *589*, 567–571. [CrossRef]
10. World Bank. *The Sunken Billions Revisited: Progress and Challenges in Global Marine Fisheries*; Environment and Sustainable Development Series; World Bank: Washington, DC, USA, 2017. [CrossRef]
11. Clarke, S.; Milner-Gulland, E.J.; Bjørndal, T. Social, economic and regulatory drivers of the shark fin trade. *Mar. Resour. Econ.* **2007**, *22*, 305–327. [CrossRef]
12. Hareide, N.R.; Carlson, J.; Clarke, M.; Clarke, S.; Ellis, J.; Fordham, S.; Fowler, S.; Pinho, M.; Raymakers, C.; Serena, F.; et al. European shark fisheries: A preliminary investigation into fisheries, conversion factors, trade products, markets and management measures. In Proceedings of the European Elasmobranch Association 2008, Lisbon, Portugal, 14–16 November 2008. Available online: www.iotc.org/documents/european-shark-fisheries-preliminary-investigation-fisheries-conversion-factors-trade/IOTC-2008-WPEB-INF04.pdf (accessed on 10 March 2021).
13. Da Silva, T.E.F.; Lessa, R.; Santana, F.M. Current knowledge on biology, fishing and conservation of the blue shark (*Prionace glauca*). *Neotrop. Biol. Conserv.* **2021**, *16*, 71–88. [CrossRef]
14. Rosello, M.; Vilata, J.; Belhabib, D. Atlantic shortfin mako: Chronicle of a death foretold? *Laws* **2021**, *10*, 52. [CrossRef]
15. Oliver, S.; Braccini, M.; Newman, S.J.; Harvey, E.S. Global patterns in the bycatch of sharks and rays. *Mar. Pol.* **2015**, *54*, 86–97. [CrossRef]
16. Van Houtan, K.S.; Gagné, T.O.; Reygondeau, G.; Tanaka, K.R.; Palumbi, S.R.; Jorgensen, S.J. Coastal sharks supply the global shark fin trade. *Biol. Lett.* **2020**, *16*, 20200609. [CrossRef] [PubMed]
17. Ward, P.; Myers, R.A. Shifts in open-ocean fish communities coinciding with the commencement of commercial fishing. *Ecology* **2005**, *86*, 835–847. [CrossRef]
18. Lam, V.Y.Y.; Sadovy de Mitcheson, Y. The sharks of South East Asia—Unknown, unmonitored and unmanaged. *Fish Fish.* **2011**, *12*, 51–74. [CrossRef]
19. Doherty, P.D.; Alfaro-Shigueto, J.; Hodgson, D.J.; Mangel, J.C.; Witt, M.J.; Godley, B.J. Big catch, little sharks: Insight into Peruvian small-scale longline fisheries. *Ecol. Evol.* **2014**, *4*, 2375–2383. [CrossRef]
20. ICCAT. International Commission for the Conservation of Atlantic Tunas Report of the Standing Committee on Research and Statistics (SCRS). In Proceedings of the Standing Committee on Research and Statistics (SCRS), Madrid, Spain, 30 September–4 October 2019. Available online: www.iccat.int/Documents/Meetings/Docs/2019/REPORTS/2019_SCRS_ENG.pdf (accessed on 22 April 2020).
21. Stevens, J.D.; Bonfil, R.; Dulvy, N.K.; Walker, P.A. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystem. *ICES J. Mar. Sci.* **2000**, *57*, 476–494. [CrossRef]
22. IUCN Red List. Available online: www.iucnredlist.org (accessed on 28 May 2022).
23. Davidson, L.N.K.; Krawchuk, M.A.; Dulvy, N.K. Why have global shark and ray landings declined: Improved management or overfishing? *Fish Fish.* **2016**, *17*, 438–458. [CrossRef]
24. Cashion, M.S.; Bailly, N.; Pauly, D. Official catch data under-represent shark and ray taxa caught in Mediterranean and Black Sea fisheries. *Mar. Pol.* **2019**, *105*, 1–9. [CrossRef]
25. Sadovy de Mitcheson, Y.; Andersson, A.A.; Hofford, A.; Law, C.S.W.; Hau, L.C.Y.; Pauly, D. Out of control means off the menu: The case for ceasing consumption of luxury products from highly vulnerable species when international trade cannot be adequately controlled; shark fin as a case study. *Mar. Pol.* **2018**, *98*, 115–120. [CrossRef]
26. Dent, F.; Clarke, S.C. *State of the Global Market for Shark Products. FAO Fisheries*; Technical Paper 590; FAO: Rome, Italy, 2015.
27. Okes, N.; Sant, G. *An Overview of Major Shark Traders, Catchers and Species*; TRAFFIC: Cambridge, UK, 2019. Available online: www.traffic.org/publications/reports/an-overview-of-major-shark-and-ray-catchers-traders-and-species (accessed on 28 May 2022).
28. Simpfendorfer, C.A.; Dulvy, N.K. Bright spots of sustainable shark fishing. *Curr. Biol.* **2017**, *27*, R97–R98. [CrossRef] [PubMed]
29. Shiffman, D.S.; Hueter, R.E. A United States shark fin ban would undermine sustainable shark fisheries. *Mar. Pol.* **2017**, *85*, 138–140. [CrossRef]
30. Shiffman, D.S.; Macdonald, C.C.; Wallace, S.S.; Dulvy, N.K. The role and value of science in shark conservation advocacy. *Sci. Rep.* **2021**, *11*, 16626. [CrossRef]
31. Kroodsma, D.A.; Mayorga, J.; Hochberg, T.; Miller, N.A.; Boerder, K.; Ferretti, F.; Wilson, A.; Bergman, B.; White, T.D.; Block, B.A.; et al. Tracking the global footprint of fisheries. *Science* **2018**, *359*, 904–908. [CrossRef] [PubMed]
32. Jones, J.B. Environmental impact of trawling on the seabed: A review. *N. Z. J. Mar.* **1992**, *26*, 59–67. [CrossRef]

33. Sumaila, R.U.; Rashid, K.; Ahmed, T.L.; Watson, R.; Tyedmers, P.; Pauly, D. Subsidies to high seas bottom trawl fleets and the sustainability of deep-sea demersal fish stocks. *Mar. Pol.* **2010**, *34*, 495–497. [CrossRef]
34. Norse, E.A.; Brooke, S.; Cheung, W.W.L.; Clark, M.R.; Ekeland, I.; Froese, R.; Gjerde, K.M.; Haedrich, R.L.; Heppell, S.S.; Morato, T.; et al. Sustainability of deep-sea fisheries. *Mar. Pol.* **2011**, *36*, 307–320. [CrossRef]
35. Filmalter, J.D.; Capello, M.; Deneubourg, J.; Cowley, P.D.; Dagorn, L. Looking behind the curtain: Quantifying massive shark mortality in fish aggregating devices. *Front. Ecol. Environ.* **2013**, *11*, 291–296. [CrossRef]
36. Hanich, Q.; Davis, R.; Holmes, G.; Amidjogbe, E.R.; Campbell, B. Drifting Fish Aggregating Devices (FADs) Deploying, Soaking and Setting—When Is a FAD 'Fishing'? *Int. J. Mar. Coast.* **2019**, *34*, 731–754. [CrossRef]
37. Blackford, M. A Tale of Two Fisheries: Fishing and Over-Fishing in American Waters. 2008. Available online: https://origins.osu.edu/article/tale-two-fisheries-fishing-and-over-fishing-american-waters?language_content_entity=en (accessed on 29 June 2022).
38. Jackson, J.B.C.; Berger, W.H.; Bjorndal, K.A.; Botsford, L.W.; Bourque, B.J.; Bradbury, R.H.; Cooke, R.; Erlandson, J.; Estes, J.A.; Hughes, T.P.; et al. Historical overfishing and the recent collapse of coastal ecosystems. *Science* **2001**, *293*, 629–638. [CrossRef] [PubMed]
39. Pauly, D.; Christensen, V.; Guénette, S.; Pitcher, T.J.; Sumaila, R.U.; Walters, C.J.; Watson, R.; Zeller, D. Towards sustainability in world fisheries. *Nature* **2002**, *418*, 689–695. [CrossRef] [PubMed]
40. Ferretti, F.; Worm, B.; Britten, G.L.; Heithaus, M.R.; Lotze, H.K. Patterns and ecosystem consequences of shark declines in the ocean. *Ecol. Lett.* **2010**, *13*, 1055–1071. [CrossRef] [PubMed]
41. Campana, S.E. Transboundary movements, unmonitored fishing mortality, and ineffective international fisheries management pose risks for pelagic sharks in the Northwest Atlantic. *Can. J. Fish. Aquat. Sci.* **2016**, *73*, 1599–1607. [CrossRef]
42. Fordham, S.; Fowler, S.L.; Coelho, R.P.; Goldman, K.; Francis, M.P. The IUCN Red List of Threatened Species: *Squalus acanthias*. *J. Fish. Biol.* **2016**. [CrossRef]
43. Myers, R.A.; Baum, J.K.; Shepherd, T.D.; Powers, S.P.; Peterson, C.H. Cascading effects of the loss of apex predatory sharks from a coastal ocean. *Science* **2007**, *315*, 1846–1850. [CrossRef] [PubMed]
44. Heithaus, M.R.; Frid, A.; Wirsing, A.J.; Worm, B. Predicting ecological consequences of marine top predator declines. *Trends Ecol. Evol.* **2008**, *23*, 202–210. [CrossRef] [PubMed]
45. Sulaiman, P.S.; Triharyuni, S. Shark fisheries management as a sustainable development implementation in Indonesia fishery sector. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *718*, 012069. [CrossRef]
46. Ferretti, F.; Myers, R.A.; Serena, F.; Lotze, H.K. Loss of large predatory sharks from the Mediterranean Sea. *Conserv. Biol.* **2008**, *22*, 952–964. [CrossRef]
47. Amorim, A.F.; Arfelli, C.A.; Fagundes, L. Pelagic elasmobranchs caught by longliners off Southern Brazil during 1974–1997: An overview. *Mar. Freshw. Res.* **1998**, *49*, 621–632. [CrossRef]
48. Balderson, S.D.; Martin, L.E.C. Environmental Impacts and Causation of 'Beached' Drifting Fish Aggregating Devices around Seychelles Islands: A Preliminary Report on Data Collected by Island Conservation Society. 2015. IOTC-2015-WPEB11-39. Available online: www.iotc.org/sites/default/files/documents/2015/09/IOTC-2015-WPEB11-39_-_FAD_beaching_Seychelles.pdf (accessed on 26 February 2022).
49. Wang, Y.; Zhou, C.; Xu, L.; Wan, R.; Shi, J.; Wang, X.; Tang, H.; Wang, L.; Yu, W.; Wang, K. Degradability evaluation for natural material fibre used on fish aggregation devices (FADs) in tuna purse seine fishery. *Aquacult. Fish.* **2020**, *6*, 376–381. [CrossRef]
50. Kriwet, J.; Benton, M.J. *Neoselachian* (*Chondrichthyes, Elasmobranchii*) diversity across the cretaceous-tertiary boundary. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2004**, *214*, 181–194. [CrossRef]
51. Kriwet, J.; Kiessling, W.; Klug, S. Diversification trajectories and evolutionary life-history traits in early sharks and batoids. *Proc. R. Soc. B.* **2009**, *276*, 945–951. [CrossRef] [PubMed]
52. Guinot, G.; Cavin, L. 'Fish' (*Actinopterygii* and *Elasmobranchii*) diversification patterns through deep time. *Biol. Rev.* **2016**, *91*, 950–981. [CrossRef] [PubMed]
53. Travis, J.; Coleman, F.C.; Auster, P.J.; Cury, P.M.; Estes, J.A.; Orensanz, J.; Peterson, C.H.; Power, M.E.; Steneck, R.S.; Wootton, T.J. Species interactions and fisheries management. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 581–584. [CrossRef] [PubMed]
54. Mumby, P.J.; Dahlgren, C.P.; Harborne, A.R.; Kappel, C.V.; Micheli, F.; Brumbaugh, D.R.; Holmes, K.E.; Mendes, J.M.; Broad, K.; Sanchirico, J.N.; et al. Fishing, trophic cascades, and the process of grazing on coral reefs. *Science* **2006**, *311*, 98–101. [CrossRef]
55. Freire, K.D.; Christensen, V.; Pauly, D. Description of the East Brazil Large Marine Ecosystem using a trophic model. *Scientia Marina.* **2008**, *72*, 477–491. [CrossRef]
56. Bascomte, J.; Melián, C.J.; Sala, E. Interaction strength combinations and the overfishing of a marine food web. *Proc. Natl. Acad. Sci. USA* **2005**, *102*, 5443–5447. [CrossRef]
57. Okey, T.A.; Banks, S.; Born, A.F.; Bustamante, R.H.; Calvopiña, M.; Edgar, G.J.; Espinoza, E.; MiguelFariña, J.; Garske, L.E.; Reck, G.K.; et al. A trophic model of a Galápagos subtidal rocky reef for evaluating fisheries and conservation strategies. *Ecol. Model.* **2004**, *172*, 383–401. [CrossRef]
58. Nadon, M.O.; Baum, J.K.; Williams, I.D.; McPherson, J.M.; Zgliczynski, B.J.; Richards, B.L.; Schroeder, R.E.; Brainard, R.E. Re-creating missing population baselines for Pacific reef sharks. *Conserv. Biol.* **2012**, *26*, 493–503. [CrossRef]
59. MacNeil, M.A.; Chapman, D.D.; Heupel, M.; Simpfendorfer, C.A.; Heithaus, M.; Meekan, M.; Harvey, E.; Goetze, J.; Kiszka, J.; Bond, M.E.; et al. Global status and conservation potential of reef sharks. *Nature* **2020**, *583*, 801–806. [CrossRef]

60. Hammerschlag, N.; Williams, L.; Fallows, M.; Fallows, C. Disappearance of white sharks leads to the novel emergence of an allopatric apex predator, the sevengill shark. *Sci. Rep.* **2019**, *9*, 1908. [CrossRef] [PubMed]
61. Heithaus, M.R.; Frid, A.; Wirsing, A.J.; Dill, L.M.; Fourqurean, J.W.; Burkholder, D.; Thomson, J.; Bejder, L. State-dependent risk-taking by green sea turtles mediates top-down effects of tiger shark intimidation in a marine ecosystem. *J. Anim. Ecol.* **2007**, *6*, 837–844. [CrossRef] [PubMed]
62. Porcher, I.F. *The Shark Sessions: My Sunset Rendezvous*; Strategic Book Publishing: Traverse City, MI, USA, 2010; pp. 317–320.
63. Porcher, I.F. *The True Nature of Sharks*; Independent: Chicago, IL, USA, 2017; p. 26.
64. Mourier, J.; Vercelloni, J.; Planes, S. Evidence of social communities in a spatially structured network of a free-ranging shark species. *Anim. Beh.* **2012**, *83*, 389–401. [CrossRef]
65. Papastamatiou, Y.P.; Bodey, T.W.; Caselle, J.E.; Bradley, D.; Freeman, R.; Friedlander, A.M.; Jacoby, D.M.P. Multiyear social stability and social information use in reef sharks with diel fission–fusion dynamics. *Proc. R. Soc. B.* **2020**, *287*, 20201063. [CrossRef] [PubMed]
66. Abernethy, J. Personal Communication during Interview. 2013. Available online: https://xray-mag.com/content/deep-trust-sharks (accessed on 29 July 2022).
67. Drumm, R. *the Slick of the Cricket*; BookSurge: Charleston, SC, USA, 1996.
68. Muter, B.A.; Gore, M.L.; Gledhill, K.S.; Lamont, C.; Huveneers, C. Australian and US news media portrayal of sharks and their conservation. *Cons. Biol.* **2013**, *27*, 187–196. [CrossRef]
69. Neff, C. The Jaws effect: How movie narratives are used to influence policy responses to shark bites in Western Australia. *Austral. J. Pol. Sci.* **2015**, *50*, 114–127. [CrossRef]
70. Le Busque, B.; Litchfield, C. Sharks on film: An analysis of how shark-human interactions are portrayed in films. *Hum. Dimens. Wildl.* **2021**, *27*, 193–199. [CrossRef]
71. Hasek, P. (Executive Producer and Senior Science Editor, Development & Production of 'Shark Week' for Discovery Channel, Silver Spring, MD, USA); Hasler, J. (Senior VP, Development & Production of 'Shark Week', Discovery Channel, Silver Spring, MD, USA). Personal communication during meeting with representatives of the Shark Group, 2010.
72. Castro, J.I. The origins and rise of shark biology in the 20th century. *Mar. Fish. Rev.* **2017**, *78*, 1433.
73. Gruber, H.; Myrberg, A.A. Approaches to the study of the behavior of sharks. *Integr. Comp. Biol.* **1977**, *17*, 471–486. [CrossRef]
74. Coates, M.I.; Finarelli, J.A.; Sansom, I.J.; Andreev, P.S.; Criswell, K.E.; Tietjen, K.; Rivers, M.L.; La Riviere, P.J. An early chondrichthyan and the evolutionary assembly of a shark body plan. *Proc. R. Soc. B.* **2018**, *285*, 20172418. [CrossRef]
75. Andreev, P.S.; Zhao, W.; Wang, N.Z.; Smith, M.M.; Li, Q.; Cui, X.; Zhu, M.; Sansom, I.J. Early Silurian chondrichthyans from the Tarim Basin (Xinjiang, China). *PLoS ONE.* **2020**, *15*, e0228589. [CrossRef] [PubMed]
76. Schluessel, V. Who would have thought that 'Jaws' also has brains? Cognitive functions in elasmobranchs. *Anim. Cogn.* **2015**, *18*, 19–37. [CrossRef] [PubMed]
77. Friedrich, L.A.; Jefferson, R.; Glegg, G. Public perceptions of sharks: Gathering support for shark conservation. *Mar. Pol.* **2014**, *47*, 1–7. [CrossRef]
78. PADI. 2011. Available online: www.diveagainstdebris.org/action/shark-awareness-campaign (accessed on 8 January 2022).
79. NOAA Fisheries. Shark Finning Report to Congress. 2016. Available online: https://repository.library.noaa.gov/view/noaa/17060 (accessed on 14 April 2020).
80. Queiroz, N.; Humphries, N.; Couto, A.; Vedor, M.; da Costa, I.; Sequeira, A.; Mucientes, G.; Santos, A.; Abascal, F.; Abercrombie, D.; et al. Global spatial risk assessment of sharks under the footprint of fisheries. *Nature* **2019**, *572*, 461–466. [CrossRef]
81. Musick, J.A.; Musick, S. *Sharks*; FAO Fisheries and Aquaculture Reviews and Studies; FAO: Rome, Italy, 2011; 13p. Available online: www.fao.org/fishery/docs/DOCUMENT/reviews%26studies/sharks.pdf (accessed on 28 May 2022).
82. DeBruyn, P. Report of the 23rd Session of the IOTC Scientific Committee. In Proceedings of the 23rd Session of the IOTC Scientific Committee, Video-Conference, 7–11 December 2020; IOTC–2020–SC23–R[E]. Available online: www.iotc.org/sites/default/files/documents/2021/01/IOTC-2020-SC23-RE.pdf (accessed on 14 May 2021).
83. Agnew, D.J.; Pearce, J.; Pramod, G.; Peatman, T.; Watson, R.; Beddington, J.R.; Pitcher, T.J. Estimating the worldwide extent of illegal fishing. *PLoS ONE* **2009**, *4*, e4570. [CrossRef] [PubMed]
84. Widjaja, S.; Long, T.; Wirajuda, H.; Van As, H.; Bergh, P.E.; Brett, A.; Copeland, D.; Fernandez, M.; Gusman, A.; Juwana, S.; et al. *Illegal, Unreported and Unregulated Fishing and Associated Drivers*; World Resources Institute: Washington, DC, USA, 2020. Available online: www.oceanpanel.org/iuu-fishing-and-associated-drivers (accessed on 9 April 2021).
85. Meere, F.; Lack, M. Assessment of Impacts of Illegal, Unreported and Unregulated (IUU) Fishing in the Asia-Pacific. Asia-Pacific Economic Cooperation Fisheries Working Group APEC#208-FS-01.5 2008. Available online: www.apec.org/publications/2008/11/assessment-of-impacts-of-illegal-unreported-and-unregulated-iuu-fishing-in-the-asiapacific (accessed on 28 May 2022).
86. Greenpeace. Choppy Waters: Forced Labour and Illegal Fishing in Taiwan's Distant Water Fisheries. 2020. Available online: www.greenpeace.org/southeastasia/publication/3690/choppy-waters-forced-labour-and-illegal-fishing-in-taiwans-distant-water-fisheries (accessed on 28 May 2022).
87. Chabrol, R.; Nouvian, C. The Hideous Price of Beauty. An Investigation into the Market of Deep-Sea Shark Liver Oil. *Bloom. Assoc.* 2012. Available online: www.bloomassociation.org/en/wp-content/uploads/2013/10/ENG_Squalene_4-pager.pdf (accessed on 4 June 2021).

88. Cardeñosa, D. Genetic identification of threatened shark species in pet food and beauty care products. *Conserv. Genet.* **2019**, *20*, 1383–1387. [CrossRef]
89. Hobbs, C.A.D.; Potts, R.W.A.; Bjerregaard, W.M.; Usher, J.; Griffiths, A.M. Using DNA barcoding to investigate patterns of species utilisation in UK shark products reveals threatened species on sale. *Sci. Rep.* **2019**, *9*, 1028. [CrossRef] [PubMed]
90. Oxford University. *OED Online: Oxford English Dictionary*; Oxford University Press: Oxford, UK. Available online: www.oed.com (accessed on 28 December 2021).
91. Guida, L. Why We Should #GiveFlakeABreak. *Aust. Mar. Conserv. Soc.* 2021. Available online: www.marineconservation.org.au/wp-content/uploads/2021/01/210120_Flake-Report-Full-Report.pdf (accessed on 18 April 2021).
92. FAO. Database of measures on conservation and management of sharks. In *Food and Agriculture Organization of the United Nation [online]*; FAO: Rome, Italy, 2022; Database Version 1-2022. Available online: www.fao.org/ipoa-sharks/database-of-measures/en# (accessed on 18 May 2022).
93. Ward-Paige, C.A.; Keith, D.M.; Worm, B.; Lotze, H.K. Recovery potential and conservation options for elasmobranchs. *J. Fish. Biol.* **2012**, *80*, 1844–1869. [CrossRef]
94. Cardeñosa, D.; Fields, A.T.; Babcock, E.A.; Zhang, H.; Feldheim, K.; Shea, S.K.H.; Fischer, G.A.; Chapman, D.D. CITES-listed sharks remain among the top species in the contemporary fin trade. *Conserv. Lett.* **2018**, *11*, e12457. [CrossRef]
95. CREMA. Costa Rica, Don't Export that Pile of Hammerhead Shark Fins. 2018. Available online: www.cremacr.org/en/policy-advocacy/campaigns/costa-rica-dont-export-that-stockpile-of-hammerhead-shark-fins/ (accessed on 10 March 2021).
96. Arauz, R. (Marine conservation policy advisor for Fins Attached Marine Research and Conservation, Costa Rica). Personal communication. 2021.
97. Convention on the Conservation of Migratory Species of Wild Animals. 2020. Available online: www.cms.int/en/species?field_species_class_tid=1857 (accessed on 19 August 2020).
98. Villate-Moreno, M.; Pollerspöck, J.; Kremer-Obrock, F.; Straube, N. Molecular analyses of confiscated shark fins reveal shortcomings of CITES implementations in Germany. *Conserv. Sci. Pract.* **2021**, *3*, e398. [CrossRef]
99. Clarke, S.C.; Harley, S.J.; Hoyle, S.D.; Rice, J.S. Population trends in Pacific Oceanic sharks and the utility of regulations on shark finning. *Conserv. Biol.* **2013**, *27*, 197–209. [CrossRef]
100. Cortés, E.; Neer, J.A. Preliminary reassessment of the validity of the 5% fin to carcass weight ratio for sharks. *Collect. Vol. Sci. Pap. ICCAT.* **2006**, *59*, 1025–1036.
101. Fischer, J.; Erikstein, K.; D'Offay, B.; Guggisberg, S.; Barone, M. Review of the Implementation of the International Plan of Action for the Conservation and Management of Sharks. In *FAO Fisheries and Aquaculture Circular*; FAO: Rome, Italy, 2012; No. 1076; p. 65. Available online: www.fao.org/3/i3036e/i3036e00.htm (accessed on 12 August 2020).
102. Biery, L.; Pauly, D. A global review of species specific shark fin to body mass ratios and relevant legislation. *J. Fish Biol.* **2012**, *80*, 1643–1677. [CrossRef]
103. India: Humane Society International/India. 'Fins Naturally Attached' Policy Adopted to Protect Sharks. 2013. Available online: www.hsi.org/news-media/fins_attached_india_082613/ (accessed on 5 January 2022).
104. Ward-Paige, C.A. A global overview of shark sanctuary regulations and their impact on shark fisheries. *Mar. Pol.* **2017**, *82*, 87–97. [CrossRef]
105. Animal Welfare Institute. International Shark Finning Bans and Policies. Available online: https://awionline.org/content/international-shark-finning-bans-and-policies (accessed on 21 July 2022).
106. Arauz, R. NGOs adverse MSC Sustainable Fisheries Certification granted to Western and Central Pacific Tuna Fishery. 2018. Available online: www.make-stewardship-count.org/ngos-adverse-msc-sustainable-fisheries-certification-granted-to-western-and-central-pacific-tuna-fishery (accessed on 28 December 2021).
107. Ziegler, I. Shark Finning—A Case Study Highlighting the Lack of Best Practice and Application of a Risk Based Need for Data "Combating Shark Finning, an IUU Fishing Activity that Severely Undermines Conservation Efforts" Transparency and Monitoring to Combat IUU in MSC Certified Fisheries. 2019. Available online: www.make-stewardship-count.org/wp-content/uploads/2020/01/Iris-Ziegler-Discussion-Paper-Shark-Finning.pdf (accessed on 12 August 2020).
108. Ziegler, A.H.; Millward, S.; Woodroffe, K.; Vail, C.; Guida, L.; Hofford, A.; Arauz, R. Analysis of the Marine Stewardship Council's Policy on Shark Finning and the Opportunity for Adoption of a 'Fins Naturally Attached' Policy in the MSC. Fisheries Standard Review. 2021. Available online: www.sharkproject.org/wp-content/uploads/2021/02/Analyis-of-the-Marine-Stewardship-Councils-policy-on-shark-finning-February-2021.pdf (accessed on 4 June 2021).
109. Porcher, I.F.; Darvell, B.W.; Cuny, G. Response to "A United States Shark Fin Ban Would Undermine Sustainable Shark Fisheries" Shiffman D.S.; Hueter, R.E. *Mar. Pol.* **2017**, *85*, 138–140, *Mar. Pol.* **2019**, *104*, 85–89. [CrossRef]
110. Gehan, S.M. Testimony of the Sustainable Shark Alliance before the House Subcommittee on Water, Oceans, and Wildlife. 26 March 2019. Available online: https://naturalresources.house.gov/imo/media/doc/Gehan%20Testimony%20WOW%20Leg%20Hrg%2003.26.19.pdf (accessed on 28 May 2022).
111. Florida Fish and Wildlife Conservation Commission. Available online: https://myfwc.com/fishing/saltwater/recreational/sharks/ (accessed on 14 April 2020).
112. Florida Department of Health Florida Advisory on Fish Consumption. Available online: www.floridahealth.gov/programs-and-services/prevention/healthy-weight/nutrition/seafood-consumption/_documents/fish-advisory-big-book2019.pdf (accessed on 17 April 2020).

113. Environmental Protection Agency, USA (US EPA). *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*, 3rd ed.; Volume 2, Risk Assessment and Fish Consumption Limits 2000; EPA-823-B-00-008; :U.S. Environmental Protection Agency, Office of Science and Technology, Office of Water: Washington, DC, USA, 2002. Available online: www.epa.gov/waterscience/fish/advice/volume2/index.html (accessed on 14 April 2020).
114. Taylor, D.L.; Kutil, N.J.; Malek, A.J.; Collie, J.S. Mercury bioaccumulation in cartilaginous fishes from southern new England coastal waters: Contamination from a trophic ecology and human health perspective. *Mar. Environ. Res.* **2014**, *99*, 20–33. [CrossRef] [PubMed]
115. Maine Seafood Guide; University of Maine: Orono, ME, USA. Available online: seagrant.umaine.edu/maine-seafood-guide (accessed on 14 April 2020).
116. Barcia, L.G.; Argiro, J.; Babcock, E.A.; Cai, Y.; Shea, S.K.H.; Chapman, D.D. Mercury and arsenic in processed fins from nine of the most traded shark species in the Hong Kong and China dried seafood markets: The potential health risks of shark fin soup. *Mar. Pol. Bull.* **2020**, *157*, 111281. [CrossRef]
117. Wiersma, J.; Carroll, M. An Economic Analysis of Spiny Dogfish: Historical Trends, Future Markets, and Implications for Management Action. Massachusetts Division of Marine Fisheries, Seafood Marketing Program. Available online: www.mass.gov/files/documents/2018/12/05/AnEconomicAnalysisofSpinyDogfish.pdf (accessed on 14 April 2020).
118. Walker, T.I. Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. *Mar. Freshw. Res.* **1998**, *49*, 553–572. [CrossRef]
119. Rago, P.J.; Sosebee, K.A.; Brodziak, J.K.; Murawski, S.A.; Anderson, E.D. Implications of recent increases in catches on the dynamics of Northwest Atlantic spiny dogfish (Squalus acanthias). *Fish. Res.* **1998**, *39*, 165–181. [CrossRef]
120. Witkin, T.; Dissanayake, S.T.; McClenachan, L. Opportunities and barriers for fisheries diversification: Consumer choice in New England. *Fish. Res.* **2015**, *168*, 56–62. [CrossRef]
121. St. Gelais, A.T.; Costa-Pierce, B.A. Mercury concentrations in Northwest Atlantic winter-caught, male spiny dogfish (*Squalus acanthias*): A geographic mercury comparison and risk-reward framework for human consumption. *Mar. Poll. Bull.* **2016**, *102*, 199–205. [CrossRef] [PubMed]
122. Goldfarb, B. Cod is Dead—Is Dogfish the Answer? Boston Newsmagazine. Available online: www.bostonmagazine.com/restaurants/2016/08/14/dogfish (accessed on 17 April 2020).
123. New York Post. Fish Sticks for millennials! Seafood Industry Rebrands 'Trash Fish'. Available online: https://nypost.com/2016/01/21/the-new-fish-sticks-for-millennials (accessed on 22 April 2020).
124. Kowacki, E.B. Can Dogfish Save Cape Cod Fisheries? Christian Science Monitor. Available online: www.csmonitor.com/Environment/2018/0820/Can-dogfish-save-Cape-Cod-fisheries (accessed on 27 April 2020).
125. NOAA Fisheries. Atlantic Spiny Dogfish. Available online: www.fisheries.noaa.gov/species/atlantic-spiny-dogfish (accessed on 6 May 2020).
126. Atlantic States Marine Fisheries Commission Spiny Dogfish. Available online: www.asmfc.org/species/spiny-dogfish (accessed on 17 April 2020).
127. Marine Stewardship Council. US Spiny Dogfish and Winter Skate. Available online: https://fisheries.msc.org/en/fisheries/us-atlantic-spiny-dogfish-and-winter-skate (accessed on 24 April 2020).
128. Agrawal, A. Common property institutions and sustainable governance of resources. *World Dev.* **2001**, *10*, 1649–1672. [CrossRef]
129. Byrne, M.E.; Cortés, E.; Jeremy, J.; Vaudo, J.J.; Harvey, G.C.M.; Sampson, M.; Wetherbee, B.M.; Shivji, M. Satellite telemetry reveals higher fishing mortality rates than previously estimated, suggesting overfishing of an apex marine predator. *Proc. R. Soc. B* **2017**, *284*, 20170658. [CrossRef] [PubMed]
130. Rigby, C.L.; Barreto, R.; Carlson, J.; Fernando, D.; Fordham, S.; Francis, M.P.; Jabado, R.; Liu, K.M.; Marshall, A.; Pacoureau, N.; et al. Isurus oxyrinchus. IUCN Red List Threat. Species. *Red List* **2019**, e.T39341A2903170. [CrossRef]
131. ICCAT. Summary Report by the Commission Chair. Doc. No. PLE_150_A/2020. Available online: www.iccat.int/com2020/ENG/PLE_150A_ENG.pdf (accessed on 9 March 2021).
132. ICCAT. ICCAT Press Release ICCAT Agreed a New Conservation Measure for the North Atlantic Shortfin Mako Shark. In Proceedings of the 27th Regular Meeting of the Commission, 23 November 2021. Available online: www.iccat.int/Documents/Meetings/COMM2021/PRESS_RELEASE_ENG.pdf (accessed on 4 December 2021).
133. ICCAT. Report of the Standing Committee on Research and Statistics (SCRS). In Proceedings of the Standing Committee on Research and Statistics (SCRS), Madrid, Spain, 2–6 October 2017. Available online: www.iccat.int/Documents/Meetings/Docs/2017_SCRS_REP_ENG.pdf (accessed on 12 January 2022).
134. ICCAT. Recommendation by ICCAT on the Conservation of the North Atlantic Stock of Shortfin Mako Caught in Association with ICCAT Fisheries. Rec. 17-08. Available online: www.iccat.int/Documents/Recs/compendiopdf-e/2017-08-e.pdf (accessed on 12 January 2022).
135. CITES. Supplementary Information on CITES COP 18 Proposal 42: Confirming that Shortfin and Longfin Mako Sharks Fully Meet the Criteria for Inclusion on CITES Appendix II. Paper presented at Eighteenth Meeting of the Conference of the Parties, Geneva, Switzerland, June 17–28; CoP18 Inf. 40, 1 and 6. Available online: https://cites.org/sites/default/files/eng/cop/18/inf/E-CoP18-Inf-040.pdf (accessed on 12 December 2021).

136. Wegner, N.C.; Lai, N.C.; Bull, K.B.; Graham, J.B. Oxygen utilization and the branchial pressure gradient during ram ventilation of the shortfin mako, *Isurus oxyrinchus:* Is lamnid shark-tuna convergence constrained by elasmobranch gill morphology? *J. Exp. Biol.* **2012**, *215*, 22–28. [CrossRef] [PubMed]
137. Campana, S.E.; Joyce, W.; Fowler, M.; Showell, M. Discards, hooking, and post-release mortality of porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), and blue shark (*Prionace glauca)* in the Canadian pelagic longline fishery. *ICES J. Mar. Sci.* **2016**, *73*, 520–528. [CrossRef]
138. Kao, E. Hong Kong Shark Fin Traders 'will be Hit Hard' by Proposal to Protect Blue Sharks. South China Morning Post. 2017. Available online: www.scmp.com/news/hong-kong/health-environment/article/2108502/hong-kong-shark-fin-traders-will-be-hit-hard (accessed on 14 April 2020).
139. Vedor, M.; Queiroz, N.; Mucientes, G. Climate-driven deoxygenation elevates fishing vulnerability for the ocean's widest ranging shark. *eLife* **2021**, *10*, e62508. [CrossRef]
140. Make Stewardship Count. Open Letter to MSC. Available online: www.make-stewardship-count.org/wp-content/uploads/2018/02/Open-Letter-to-MSC_FINAL_January-2018.pdf (accessed on 29 July 2022).
141. Clarke, S. Use of shark fin trade data to estimate historic total shark removals in the Atlantic Ocean. *Aquat. Living Resour.* **2008**, *21*, 373–381. [CrossRef]
142. ICCAT. Report of the Standing Committee on Research and Statistics (SCRS). In Proceedings of the Standing Committee on Research and Statistics (SCRS), Online, 27 September–2 October 2021. Available online: www.iccat.int/Documents/Meetings/Docs/2021/REPORTS/2021_SCRS_ENG.pdf (accessed on 4 December 2021).
143. European Union Plenary sitting. Recommendation on the Draft Council Decision on the Conclusion, on Behalf of the European Union, of the Protocol to Amend the International Convention for the Conservation of Atlantic Tunas (13447/2019—C9-0187/2019—2019/0225(NLE)) 27 April 2020. Available online: www.europarl.europa.eu/doceo/document/A-9-2020-0089_EN.pdf (accessed on 7 August 2020).
144. Tsikliras, A.C.; Froese, R. Maximum Sustainable Yield. In *Encyclopedia of Ecology*, 2nd ed.; Fath, B.D., Ed.; Elsevier: Oxford, UK, 2019; Volume 1, pp. 108–115.
145. Sumaila, R.U.; Ebrahim, N.; Schuhbauer, A.; Skerritt, D.; Li, Y.; Sik Kim, H.; Mallory, T.G.; Lam, V.W.L.; Pauly, D. Updated estimates and analysis of global fisheries subsidies. *Mar. Pol.* **2019**, *109*, 103695. [CrossRef]
146. Sala, E.; Mayorga, J.; Costello, C.; Kroodsma, D.; Palomares, M.L.D.; Pauly, D.; Sumaila, U.R.; Zeller, D. The economics of fishing the high seas. *Sci. Adv.* **2018**, *4*, eaat2504. [CrossRef]
147. Arnason, R.; Kelleher, K.; Willmann, R. *The Sunken Billions: The Economic Justification for Fisheries Reform*; Joint publication of the World Bank and the FAO; World Bank: Washington, DC, USA; FAO: Rome, Italy, 2008; ISBN 978-0-8213-7790-1.
148. Travis, W. *Shark For Sale*; Rand McNally: Chicago, IL, USA, 1961.
149. Castro, J.I.; Woodley, C.M.; Brudek, R.L. *A Preliminary Evaluation of Status of Shark Species*; FAO Fisheries Technical Paper; Food and Agriculture Organization: Rome, Italy, 1999.
150. Pauly, D.; Zeller, D. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. *Nat. Commun.* **2016**, *7*, 10244. [CrossRef] [PubMed]
151. Vaness, B. Sustainable Shark Alliance: Setting the Record Straight on Sharks for Ocean Week. Available online: www.accesswire.com/547715/Sustainable-Shark-Alliance-Setting-the-Record-Straight-on-Sharks-for-Ocean-Week (accessed on 10 January 2022).
152. Rutger, H. Sustainable Shark Trade Bill Offers Science Based Solutions for Overfishing. Mote Laboratories. 2018. Available online: https://mote.org/news/article/sustainable-shark-trade-bill-offers-science-based-solutions-for-overfishing (accessed on 10 January 2022).
153. Ferretti, F.; Jacoby, D.M.P.; Pfleger, M.O.; White, T.D.; Dent, F.; Micheli, F.; Rosenberg, A.A.; Crowder, L.B.; Block, B.A. Shark fin trade bans and sustainable shark fisheries. *Conserv. Lett.* **2020**, *13*, e12708. [CrossRef]
154. Human Rights at Sea. Fisheries Observer Deaths at Sea, Human Rights and the Role and Responsibilities of Fisheries Organisations. Available online: www.humanrightsatsea.org/2020/07/03/report-fisheries-observer-deaths-at-sea-human-rights-and-the-role-and-responsibilities-of-fisheries-organisations (accessed on 3 March 2021).
155. McVeigh, K.; Firdaus, F. 'Hold on Brother': Final Days of Doomed Crew on Chinese Shark Finning Boat. The Guardian 7 July 2020. Available online: www.theguardian.com/environment/2020/jul/07/hold-on-brother-final-days-of-doomed-crew-on-chinese-shark-finning-boat (accessed on 12 August 2020).
156. Convention on Biological Diversity (CBD). Available online: www.cbd.int/sustainable/introduction.shtml (accessed on 28 May 2022).
157. Cooney, R. Sustainable Use: Concepts, Ambiguities, Challenges. In Proceedings of the IUCN Species Survival Commission's Sustainable Use Specialist Group Strategic Planning Meeting, White Oak Plantation, Yulee, FL, USA, 10–13 July 2007. Available online: www.iucn.org/files/cooney-r-2007-sustainable-use-concepts-ambiguities-challenges (accessed on 28 May 2020).
158. EU Monitor Explanatory Memorandum to COM(2002)185—Conservation and Sustainable Exploitation of Fisheries Resources under the Common Fisheries Policy. Available online: www.eumonitor.eu/9353000/1/j4nvhdfdk3hydzq_j9vvik7m1c3gyxp/vi8rm2yv7ezh (accessed on 5 January 2022).
159. Magnuson-Stevens Fishery Conservation and Management Act (MSA) 16 USC Ch. 38: Fishery Conservation and Management. Available online: https://uscode.house.gov/view.xhtml?path=/prelim@title16/chapter38&edition=prelim (accessed on 28 May 2022).

160. Preikshot, D.; Pauly, D. Global Fisheries and Marine Conservation: Is Coexistence Possible. In *Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity?* Norse, E.A., Crowder, L.B., Eds.; Island Press: Washington, DC, USA, 2005; Chapter 11; pp. 185–197.
161. Agrawal, A.; Ostrom, E. Political science and conservation biology: A dialog of the deaf. *Conserv. Biol.* **2006**, *30*, 681–682. [CrossRef] [PubMed]
162. Harrington, J.M.; Myers, R.A.; Rosenberg, A.A. Wasted fishery resources: Discarded bycatch in the USA. *Fish Fish.* **2005**, *6*, 350–361. [CrossRef]
163. Stelfox, M.; Bulling, M.; Sweet, M. Untangling the origin of ghost gear within the Maldivian archipelago and its impact on olive ridley (*Lepidochelys olivacea*) populations. *Endang. Spec. Res.* **2019**, *40*, 309–320. [CrossRef]
164. Make Stewardship Count. Available online: www.make-stewardship-count.org (accessed on 28 May 2022).
165. Marine Stewardship Council. Echebastar Indian Ocean Purse Seine Skipjack Tuna. Available online: https://fisheries.msc.org/en/fisheries/echebastar-indian-ocean-purse-seine-skipjack-tuna (accessed on 10 March 2021).
166. Kearns, M. IPNLF: Tuna Fishery Certification 'Fatally Flawed'. Seafood Source. Available online: www.seafoodsource.com/news/environment-sustainability/ipnlf-tuna-fishery-certification-fatally-flawed (accessed on 24 April 2020).
167. Edwards, S. WWF Statement on MSC Certification of Spanish Purse Seine "Echebastar" Fishery in the Indian Ocean. Available online: https://wwf.panda.org/wwf_news/press_releases/?337217/WWF-Statement-on-MSC-certification-of-Spanish-Purse-Seine-Echebastar-Fishery-in-the-Indian-Ocean%C2%A0 (accessed on 29 June 2022).
168. Diggles, B.K.; Cooke, S.J.; Rose, J.D.; Sawynok, W. Ecology and welfare of aquatic animals in wild capture fisheries. *Rev. Fish. Biol. Fish.* **2011**, *21*, 739–765. [CrossRef]
169. Meadows, D.H.; Meadows, D.L.; Randers, J.; Behrens, W.W. *The Limits to Growth*; Universe Books: New York, NY, USA, 1972.
170. Lorenz, K. *Das Sogenannte Böse, Zur Naturgeschichte der Aggression*; Verlag Dr Borotha-Schoeler: Vienna, Austria, 1963.
171. Barry, G. Terrestrial ecosystem loss and biosphere collapse. *Manag. Environ. Qual.* **2014**, *25*, 542–563. [CrossRef]
172. Dasgupta, P. *The Economics of Biodiversity: The Dasgupta Review*; HM Treasury: London, UK, 2021. Available online: www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review (accessed on 29 June 2022).
173. Mason, F. The Newfoundland cod stock collapse: A review and analysis of social factors. *Electron. Green J.* **2002**, *1*. [CrossRef]
174. Dickey-Collas, M.; Nash, R.D.M.; Brunel, T.; van Damme, C.J.G.; Marshall, T.C.; Payne, M.R.; Corten, A.; Geffen, A.J.; Peck, M.A.; Hatfield, E.M.C.; et al. Lessons learned from stock collapse and recovery of North Sea herring: A review. *ICES J. Mar. Sci.* **2010**, *67*, 1875–1886. [CrossRef]
175. Sea Shepherd. Operation Sola Stella: Combatting Illegal Fishing in Liberia, West Africa. Available online: https://seashepherd.org/campaigns/iuu-fishing-africa/iuu-campaigns/sola-stella (accessed on 22 August 2020).
176. Sea Shepherd. Arrest of Poaching Vessel Shows Shark Liver Oil Production Could Drive Species to Extinction. Available online: www.seashepherdglobal.org/latest-news/shark-liver-oil-labiko2 (accessed on 4 June 2021).
177. Vincent, A.C.J.; Sadovy de Mitcheson, Y.; Fowler, S.L.; Lieberman, S. The role of CITES in the conservation of marine fishes subject to international trade. *Fish Fish.* **2013**, *15*, 563–592. [CrossRef]
178. Citizen's Initiative: Stop Finning EU. Available online: https://europa.eu/citizens-initiative/initiatives/details/2020/000001_en (accessed on 29 June 2022).
179. Alcala, A.C. Community-based coastal resource management in the Philippines: A case study. *Ocean. Coast. Manag.* **1998**, *38*, 179–186. [CrossRef]
180. Diegues, A.C. Marine Protected Areas and Artisanal Fisheries in Brazil. 2008. Available online: https://aquadocs.org/bitstream/handle/1834/19431/Samudra_mon2.pdf (accessed on 28 May 2022).
181. Espectato, L.N.; Monteclaro, H.M.; Arceo, H.O.; Catedrilla, L.C.; Baylon, C.C. Community perceptions on the role of inter-local government units alliance in coastal resource management: The case of Banate Bay alliance in Iloilo, Philippines. *Ocean. Coast. Manag.* **2022**, *219*, 106059. [CrossRef]
182. Kaplan, I.C.; Cox, S.P.; Kitchell, J.F. Circle hooks for Pacific longliners: Not a panacea for marlin and shark bycatch, but part of the solution. *Trans. Am. Fish. Soc.* **2007**, *136*, 392–401. [CrossRef]
183. Erickson, D.L.; Berkeley, S.A. Methods to reduce bycatch mortality in longline fisheries. In *Sharks of the Open Ocean: Biology, Fisheries and Conservation*; Camhi, M.D., Pikitch, E.K., Babcock, E.A., Eds.; Blackwell Publishing: Oxford, UK, 2008; pp. 462–471.
184. Reid, D.G.; Graham, N.; Suuronen, P.; He, P.; Pol, M. Implementing balanced harvesting: Practical challenges and other implications. *ICES J. Mar. Sci.* **2016**, *73*, 1690–1696. [CrossRef]
185. Zhou, S.; Kolding, J.; Garcia, S.M.; Plank, M.J.; Bundy, A.; Charles, A.; Hansen, A.; Heino, M.; Howell, D.; Jacobsen, N.S.; et al. Balanced harvest: Concept, policies, evidence, and management implications. *Rev. Fish. Biol. Fish.* **2019**, *29*, 711–733. [CrossRef]
186. O'Leary, B.C.; Winther-Janson, M.; Bainbridge, J.M.; Aitken, J.; Hawkins, J.P.; Roberts, C.M. Effective Coverage Targets for Ocean Protection. *Conserv. Lett.* **2016**, *9*, 398–404. [CrossRef]
187. Klimley, A.P.; Arauz, R.; Bessudo, S.; Chávez, E.J.; Chinacalle, N.; Espinoza, E.; Green, J.; Hearn, A.R.; Hoyos-Padilla, M.E.; Nalesso, E.; et al. Studies of the movement ecology of sharks justify the existence and expansion of marine protected areas in the Eastern Pacific Ocean. *Environ. Biol. Fish.* **2022**. [CrossRef]
188. Baum, J. Industrial fishing boats leave few safe havens for sharks on the high seas. *Nature* **2019**, *572*, 449–450. [CrossRef]
189. Dwyer, R.G.; Krueck, N.C.; Udyawer, V.; Heupel, M.R.; Chapman, D.; Pratt, H.L.; Garla, R.; Simpfendorfer, C.A. Individual and population benefits of marine reserves for reef sharks. *Curr. Biol.* **2020**, *30*, 480–489. [CrossRef]

190. Sumaila, R.U.; Zeller, D.; Hood, L.; Palomares, M.L.D.; Li, Y.; Pauly, D. Illicit trade in marine fish catch and its effects on ecosystems and people worldwide. *Sci. Adv.* **2020**, *6*, eaaz3801. [CrossRef] [PubMed]
191. Ewell, C.; Hocevar, J.; Mitchell, E.; Snowden, S.J. An evaluation of Regional Fisheries Management Organization at-sea compliance monitoring and observer programs. *Mar. Pol.* **2020**, *115*, 103842. [CrossRef]
192. Barnosky, A.; Matzke, N.; Tomiya, S.; Wogan, G.O.U.; Swartz, B.; Quental, T.B.; Marshall, C.; McGuire, J.L.; Lindsey, E.L.; Maguire, K.C.; et al. Has the Earth's sixth mass extinction already arrived? *Nature* **2011**, *471*, 51–57. [CrossRef] [PubMed]
193. Pievani, T. The sixth mass extinction: Anthropocene and the human impact on biodiversity. *Rend. Lincei* **2014**, *25*, 85–93. [CrossRef]