Seattle Journal of Environmental Law

Volume 5 | Issue 1 Article 15

5-31-2015

Can Sharks be Saved? A Global Plan of Action for Shark Conservation in the Regime of the Convention on Migratory Species

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Shark populations throughout the world are at grave risk; some species have declined by 95 percent. The most recent IUCN (International Union for the Conservation of Nature) assessment by the Shark Specialist Group (SSG) found that one-fourth of shark and ray species face the prospect of extinction. This article proposes an engagement plan to accelerate efforts by states and international organizations to conserve and protect sharks worldwide.

Sharks are found throughout all of the world's oceans, and collectively they occupy an indispensable niche as apex predators at the top of the ocean trophic ecosystem. These fish function as an important part of the system of checks and balances in the seas, helping maintain the delicate equilibrium among species. As a result of anthropogenic activities, however, sharks face intense pressure to survive. Overfishing, finning, and bycatch pose the greatest threats.

The Convention on the Conservation of Migratory Species of Wild Animals (CMS)[1] *adopted a Memorandum of Understanding on the*

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1. Convention on the Conservation of Migratory Species of Wild Animals, June 23, 1979, 1651 U.N.T.S 355 (entered into force Nov. 1, 1983).

Conservation of Migratory Sharks (Sharks MoU) in 2010. This group seeks to specifically focus on seven shark populations that migrate globally, posing unique challenges for protection. As the apex predators of the oceans, sharks consume high levels of biomass to support their populations. As a result, their populations are relatively small and, therefore, even minor disturbances to their populations radiate and can have profound impacts. This creates a potential tragedy of the commons situation: as populations are decimated in certain areas of the globe, it impacts other regions and leaves fewer resources for everyone. The CMS Shark MoU seeks to protect seven specific species that would be served by a global group of signatories, which are countries that sign an agreement to work together to enforce policies that will aid population recovery. The signatory states first met in 2012, and there are significant challenges to overcome if the MoU is to serve as an effective instrument for the protection of sharks. This article proposes an engagement plan to accelerate these efforts to fashion a sustainable shark protection regime.

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I. INTRODUCTION

Sharks range throughout the oceans of the world. In order to effectively manage their populations and improve conservation efforts, a global partnership among nations will be necessary. The Shark Memorandum of Understanding (MoU), under the umbrella of Convention on Migratory Species (CMS), is the one of the few groups that exists as a global instrument dedicated for shark conservation. The reason this partnership is so important is because some sharks are highly migratory, traveling thousands of miles per year through the high seas and in the 200 nautical mile (nm) exclusive economic zones (EEZs) of numerous states.[2]

Perhaps the more concerning trends are those that we have not yet studied or lack the data for comparison. Without reliable baseline information, it is difficult to determine population dynamics, species trends, and ultimately, to develop an effective recovery plan.

Through the international cooperation of the CMS Shark MoU, scientists and policy makers have an opportunity to combine scientific knowledge to inform global regulations that will aid shark recovery. Though other committees and groups have been formed to protect sharks, their efforts are not focused only on sharks. The Convention on the International Trade in Endangered Species (CITES),[3] for example, lists specific shark species in Appendix II, including basking, whale, great white, porbeagle, hammerheard, oceanic whitetip, and manta rays. All

2. SARAH FOWLER, THE CONSERVATION STATUS OF MIGRATORY SHARKS 14 (2014), *available at* http://www.cms.int/sites/default/files/publication/The%20Conservation%20Status%20of%20Migratory%20Sharks.pdf.
3. Convention on the International Trade in Endangered Species (CITES), March 3, 1973, 993 U.N.T.S 243 (entered into force July 1, 1975).

sawfish species are also listed in Appendix I. These species are considered to be at risk because they are valued for their fins and meat, or have been historically exploited.

Regional Fisheries Management Organizations (RFMOs) exist to regulate catch on a larger scale. These instruments do not focus on sharks, but instead center their efforts on management of tuna and tuna-related fisheries.[4] Because of the high level of shark bycatch associated with fishing operations, however, it is important for CMS to develop a closer relationship with RFMOs in order to better monitor and reduce bycatch of sharks during tuna fishing. Furthermore, many coastal states regulate fishing in their EEZ, including the management of bycatch. Some countries have individual laws regulating shark catch specifically.[5] Such laws typically detail how sharks may be landed, and in areas where finning is common, some countries established additional regulations specifying that the fins must be "naturally attached" when brought to shore or have placed a complete ban on any shark fishing, or the sale of shark products.[6] This Engagement Plan seeks to combine the state of scientific knowledge about shark ecology and conservation trends with legal and policy tools to create a more effective approach to preserving shark populations worldwide. First, it is essential to attract a greater number of signatories to the Shark MoU of the CMS, especially from key nations that are involved in direct and indirect taking of sharks. Second, our understanding of shark ecology is limited; more studies on shark reproductive biology, migration patterns, and population trends need to be completed to better inform decision makers. Without a combination of research and cooperation among nations, sharks will likely fall victim to the tragedy of the commons. This CMS Shark MoU Engagement Plan is proposed as a first step toward implementing the MoU, and is aimed at preservation and conservation of seven critical species.

II. THE CASE FOR ACTION

Shark conservation is a global problem. When considering highly migratory shark species, we must not only think of ourselves as citizens of our state, but of the globe. To manage and maintain shark populations at a stable level, international cooperation among nations will be necessary,

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4. Merry D. Camhi et al., *Domestic and international management for pelagic sharks*, *in* SHARKS OF THE OPEN OCEAN: BIOLOGY, FISHERIES AND CONSERVATION 428 (Merry Camhi et al. eds., 2008).
5. FOWLER, *supra* note 2, at 1, 15.
6. C. A. Ward-Paige, et al., *Recovery potential and conservation options for elasmobranchs*, 80 JOURNAL OF FISH BIOLOGY 1844-1869 (2012), *available at* http://wormlab.biology.dal.ca/publication/view/ward-paige-ca-keith-d-worm-b-lotze-hk-2012-recovery-potential-and-conservation-options-for-elasmobranchs/.

with agreed upon catch limits. To accomplish this goal, more countries would have to sign the CMS Shark MoU, and carry out its principles and vision.

Biologically, there are three common factors across these shark species reproductively that make them especially vulnerable to overfishing and slow population recovery. Though each shark species is unique, there is a general trend that holds between each of the species currently listed in the MoU.

1. Slow growth, and late sexual maturity after many years
2. Long gestation periods of up to 2-3 years
3. Many species do not produce many pups at one time.

These factors mean that the overfishing, which has intensified in recent years as a result of the high demand for shark fins, is causing sharks to be overfished. Therefore, some key pieces of information would be (1) where they mate, (2) if and how they aggregate, and (3) where nursery sites are (which is known in some cases, but not all). Determining these critical sites would aid the policy-making for these species, and is a continuing goal for shark researchers. Beyond simply the difficulty in looking at reproductive biology, there are many basic truths about sharks that are unknown and hard to determine, from accurate metabolic rates to social structure. This information would also aid in policy-related decisions.

Though many similarities can be drawn among the seven species under the CMS MoU, there are some distinct differences between them, and they should not be treated uniformly if we want to provide them the greatest amount of aid. Therefore, as each issue is presented, it will be considered broadly, then considered for each species individually if it is an applicable concern. In addition, the nations that are critical for each species are presented with a rationale for their listing. For example, many Asian countries are listed as key signatories that the CMS Shark MoU still stands to gain, such as China, Taiwan, Indonesia, Japan, South Korea, Thailand, Singapore, or Vietnam. However, without their support, as some of the major importers, fishers, trade hubs, and consumers are among these nations, the policies and great ideas can fall flat, and the tragedy of the commons can take hold. Therefore, it is essential that the key signatories join the MoU in order to best implement new policies for these sharks.

III. SPECIES AT RISK

A. White Shark

The White Shark (*Carcharodon carcharias*) is a large predatory shark reaching up to seven meters in length,[7] and is characterized by its countershaded body and keen senses, and is a very efficient predator with a complex social structure.[8] It also possesses a liver that makes up 30 percent of its total weight, which aids with buoyancy, provides backup energy storage, and allows it to undergo migrations that span thousands of miles across the globe.[9]

Because of its extensive migration and threatened status, the white shark has already been listed in CMS Appendix I and II, and is covered by the MoU as well. Species listed in CMS Appendix I are strictly protected, and the taking of this species is prohibited.

The White Shark is also listed on the IUCN Red List as Vulnerable, and in CITES Appendix II. The CITES listing regulates the international trade of white shark parts, but does not prohibit taking or national trade.[10] Presently, they are still taken as bycatch or get caught in beach meshing and drum line programs. Also, illegal game fishing is frequently reported. However, white shark populations were recently found to be higher than previously thought.[11]

B. Basking Shark

Basking Sharks (*Cetorhinus maximus*) are a species with a long history of overexploitation, and have been a commercially important species since the late 1700s. As the second largest fish in the sea, they are an imposing animal, and reach up to 12.27 meters in length.[12] Their bodies are fueled simply by zooplankton and other small invertebrates, which they catch using gill rakers as they filter feed. They are often seen slowly cruising near the surface of the water at a top speed of only 3.7 kmh, literally basking in the sun. Their leisurely swim patterns and unaggressive

7. Craig R. McClain et al., *Sizing ocean giants: patterns of intraspecific size variation in marine megafauna*, 3 PEERJ 10.7717, at 28 (2015).
8. Emilio Sperone et al., *Social interactions among bait-attracted white sharks at Dyer Island (South Africa)*, 6 MARINE BIOLOGY RESEARCH no. 4, at 412 (2010).
9. Theagarten Lingham-Soliar, *Caudal fin allometry in the white shark Carcharodon carcharias: implications for locomotory performance and ecology*, 92 NATURWISSENSCHAFTEN no. 5, at 235 (2005).
10. Mahmood S Shivji et al., *Genetic profiling reveals illegal international trade in fins of the great white shark, Carcharodon carcharias*, 6 CONSERVATION GENETICS 1038 (2005), *available at* http://link.springer.com/article/10.1007%2Fs10592-005-9082-9#page-2.
11. George H. Burgess et al., *A re-evaluation of the size of the white shark (Carcharodon carcharias) population off California, USA*, 9 PLOS ONE no. 6, at e98078 (2014).
12. McClain et al., *supra* note 7, at 27.

nature, however, made them into an easy target for fishers who wanted their liver oil.[13]

With livers comprising up to 25 percent of their body, and at up to 1,000 pounds, this was a highly lucrative business, with the oil being used for lamp oil, medicine, and cosmetics. This was also the only commercially valuable part of the shark at the time, so once they harvested the liver, the rest was typically thrown back. The only other part that was generally used was their skin, which was made into leather, and later, in the 1980s to 2003, they were also finned.[14]

Not only were basking sharks hunted for their oil, but also because they were so often caught in the fishing nets, they were simply slaughtered because they were also considered a nuisance. These two factors combined to produce a boom and bust basking shark fishing industry. In the late 1700s to mid-1800s, they were fished until they dwindled in number at about 1,000 sharks a year.[15] By the 1940s they had recovered in numbers, and the fishing resumed, continuing until 1975 in the Northeast Atlantic. In these years alone, over 12,000 sharks were landed, and their populations have not since recovered.[16] The last basking shark fishery closed in 2003 in Norway, and overfishing is no longer considered the main threat.[17] Additionally, bycatch, boat strikes, and strandings remain threats to basking sharks. These sharks are especially prone to bycatch because of their behavior of floating near the surface, which is also the origin of their common name, as they appear to bask. This causes them to be frequently entangled in nets, and were historically considered a nuisance. This "basking" behavior also makes it possible for them to get hit by boats easily, as they are close to the surface of the water, and can then be subsequently stranded accidentally.[18]

C. Shortfin Mako Shark

The Shortfin Mako Shark (*Isurus oxyrinchus*) is a large predatory fish that lives throughout the tropical and temperate oceans at depths of up to 150 meters, reaching up to 4.45 meters in length.[19] These sharks migrate great distances annually, and can travel at a maximum speed of 74 kmh, making them the fastest shark.[20] This is as a result of their hydrodynamic

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13. SCOTT WALLACE & BRIAN GISBORNE, BASKING SHARKS: THE SLAUGHTER OF BC'S GENTLE GIANTS TRANSMONTANUS 1-96 (2006).
14. *Id.*
15. *Id.*
16. *Id.*
17. *Id.*
18. *Id.*
19. John G. Casey & and Nancy E. Kohler, *Tagging studies on the Shortfin Mako Shark (Isurus oxyrinchus) in the Western North Atlantic*, 45 MARINE AND FRESHWATER RESEARCH no. 1, at 51 (1992).
20. Id.

body shape, and beyond making them a highly successful predator, it also means that they can migrate large distances at great speed.[21]

These swift predators are integral to their ecosystems, consuming large quantities of teleosts, cephalopods, and in some areas, elasmobranchs. They eat up to 2 kg/day, or 3 percent of their body weight.[22] Their fast metabolism is also in part attributed to the fact they are endothermic, and, as a result, generally do not inhabit waters below 16ºC.[23] They are able to inhabit colder waters through highly efficient heat exchange in their body, which puts their internal body temperature a few degrees above that of the surrounding water. The species is susceptible to being caught as bycatch in pelagic longlines, driftnets, and gillnets.[24] As a result of their vulnerability to bycatch, their populations are in sharp decline. While in some areas these sharks are protected, there are many gaps where the CMS Shark MoU can play an important role. There are a few RFMOs that help manage shortfin mako sharks, including the General Fisheries Commission for the Mediterranean (GFCM), which prohibits catch of the species, and the International Commission of the Conservation of Atlantic Tunas (ICCAT), which encourages stock assessment.[25]

D. Longfin Mako Shark

The scientific name of the Longfin Mako Shark (*Isurus paucus*) says it all. The species' name, *paucus*, means few. In fact, beyond simply being a rare species, it was not distinguished from the shortfin mako until 1966.[26] It differs in appearance by the shape of its head and fins, which are both broader and less pointed. Due to its relatively recent appearance in shark literature and the difficulty in differentiating it from its cousin, the shortfin mako, there is relatively little formal research on this species by scientists and few observations by fishermen so it is hard to make an assessment on its stock.[27] Its distribution range is slowly becoming more known but more research is needed.[28] It is presumed by its similar body shape and

21. *Id.*
22. J.D. Stevens*, Biological observations on sharks caught by sport fisherman of New South Wale*s, 35 MARINE AND FRESHWATER RESEARCH no. 5, at 573, 578 (1984). G. Cliff et al., *Sharks caught in the protective gill nets off Natal, South Africa. 3. The shortfin mako shark Isurus oxyrinchus (Rafinesque)*, 9 SOUTH AFRICAN JOURNAL OF MARINE SCIENCE no. 1, at 115, 117 (1990).
23. John D Stevens, *The biology and ecology of the shortfin mako shark, Isurus oxyrinchus*, *in* SHARKS OF THE OPEN OCEAN: BIOLOGY, FISHERIES AND CONSERVATION 87 (Merry Camhi et al. eds., 2008).
24. *Id.*
25. *See* GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN, www.gfcm.org/ (last visited Spring 2015). *See also* ICCAT: INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS, https://www.iccat.int/en/ (last visited Spring 2015).
26. DARIO GUITART MANDAY, NUEVO NOMBRE PARA UNA ESPECIE DE TIBURON DEL GENERO ISURUS: (ELASMOBRANCHII: ISURIDAE) DE AGUAS CUBANAS 1,4 (1966).
27. SHARKS OF THE OPEN OCEAN: BIOLOGY, FISHERIES AND CONSERVATION 406 (Merry Camhi et al. eds., 2008).
28. G. Mucientes et al., *Short communication Updated distribution range of longfin mako Isurus paucus (Lamniformes: Lamnidae) in the North Atlantic*, 29 JOURNAL OF APPLIED ICHTHYOLOGY no. 5, at 1163-1165 (2013).

distribution that it has a relatively similar lifestyle to the shortfin mako, living in deeper offshore waters, but more research is needed to confirm basic facts about this diminishing species.

E. Whale Shark

As the largest fish inhabiting the ocean today, whale sharks (*Rhincodon typus*) have been studied for many years. Surprisingly, however, little is known about them. At up to 18.8 meters in length,[29] these animals filter feed many tons of gallons of water to find tiny crustaceans and other small invertebrates. Their migratory nature is thought to correspond with currents and food aggregations,[30] with some tagged individuals travelling 13,000 meters in thirty-seven months[31] across the tropical and warm temperate seas. Interestingly, the pattern on the back of the whale shark is like a fingerprint, and is unique for each individual. As a result, an astronomy algorithm normally used to analyze star patterns was adapted to identify single whale sharks.[32] This method aims to identify and track individuals across the globe, providing specific information about various sharks and their migrations, in addition to the global whale shark identification database.

Unfortunately, whale sharks have been hunted in large numbers in the recent past. It is estimated that in a single Chinese butchery 600 whale sharks were processed each year to manufacture supplement pills and skincare products, which were exported to other nations. Though illegal, this hunting is likely still occurring, but it is hard to estimate the catch levels.[33]

F. Porbeagle

The porbeagle (*Lamna nasus*) is unique among the seven MoU species as the only amphitemperate shark, meaning it is absent from the tropics. The species inhabit the oceans between 30-70^{o}N and 30-50^{o}S

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29. McClain et al., *supra* note 7, at 24.
30. Steven G. Wilson et al., *The seasonal aggregation of whale sharks at Ningaloo Reef, Western Australia: currents, migrations and the El Nino/Southern Oscillation*, 61 ENVIRONMENTAL BIOLOGY OF FISHES, no. 1, at 1, 6 (2001). Eugenie Clark & Diane R. Nelson. *Young whale sharks, Rhincodon typus, feeding on a copepod bloom near La Paz, Mexico*, 50 ENVIRONMENTAL BIOLOGY OF FISHES no. 1, at 63, 65 (1997).
31. Scott A. Eckert & Brent S. Stewart, *Telemetry and satellite tracking of whale sharks, Rhincodon typus, in the Sea of Cortez, Mexico, and the north Pacific Ocean*, 60 ENVIRONMENTAL BIOLOGY OF FISHES no. 1-3, at 299, 303 (2001).
32. Zaven. Arzoumanian et al., *An astronomical pattern-matching algorithm for computer-aided identification of whale sharks Rhincodon typus*, 42 JOURNAL OF APPLIED ECOLOGY no. 6, at 999, 1006 (2005).
33. Jane J. Lee, *Slaughterhouse Said to Process "Horrifying" Number of Whale Sharks Annually*, NAT'L GEO., Jan. 30, 2014, http://news.nationalgeographic.com/news/2014/01/140129-whale-shark-endangered-cites-ocean-animals-conservation/.

latitude exclusively.[34] Though these sharks undergo long seasonal migrations each year, the two different hemisphere populations are probably genetically distinct and remain separate. Like other lamnids, it is endothermic and uses efficient heat exchange to keep its body temperature elevated above that of the water specifically in the eyes and brain so that the nervous system can still function under rapid temperature changes.[35] This opportunistic feeder reaches sizes up to three meters,[36] and due to its strong, swift nature, is a prized game fish, though often mistaken for a mako.[37] Though capable of injuring people, this shark is not generally considered a threat to humans. The CMS Shark MoU could help this species by implementing global quotas, and bycatch limits specifically targeting countries where this animal is found, because it is only located in colder waters.

G. Spiny Dogfish

In many ways, the Spiny Dogfish (*Squalus acanthias*) is the outlier of the CMS Shark MoU species. Only the northern hemisphere populations are listed on the MoU. This unique position, however, means that the species needs special attention and requires a different approach than the others. Only particular countries are in the protected range of this species, meaning only signatories in the Northern Hemisphere would be impacted by policy decisions made about this particular shark. Therefore, it would be beneficial to have a targeted group responsible for this species.

This small shark, at up to 1.6 meters in length,[38] is easily distinguishable by the spines off the back of its dorsal fins, which it can use to defend itself if attacked. They favor temperate waters, and travel in large packs, segregating themselves by length and gender.[39] As one of the formerly most abundant sharks on the globe, spiny dogfish were so heavily fished for their meat and fins that they have experienced 95 percent declines in European waters.[40] The decline is especially devastating for this species because it is perhaps one of the latest maturing sharks at thirty-

34. Malcolm P. Francis et al., *The Biology and Ecology of the Porbeagle Shark, Lamna nasus*, *in* SHARKS OF THE OPEN OCEAN: BIOLOGY, FISHERIES AND CONSERVATION 105, 107 (Merry Camhi et al. eds., 2008).
35. Barbara A. Block & Francis G. Carey, *Warm brain and eye temperatures in sharks*, 156 JOURNAL OF COMPARATIVE PHYSIOLOGY B no. 2, at 229, 230 (1985).
36. Francis et al., *supra* note 34, at 105.
37. *Id*.
38. Archontia Chatzispyrou & Persefoni Megalofonou, *Sexual maturity, fecundity and embryonic development of the spiny dogfish, Squalus acanthias, in the eastern Mediterranean Sea*, 85 JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM no. 5, at 1155-1161 (2005).
39. Mariano Koen Alonso et al., *Fishery and ontogenetic driven changes in the diet of the spiny dogfish, Squalus acanthias, in Patagonian waters, Argentina*, 63.ENVIRONMENTAL BIOLOGY OF FISHES no. 2, at 193-202 (2002).
40. *Squalus acanthias*, THE IUCN RED LIST OF THREATENED SPECIES, http://www.iucnredlist.org/details/44168/0 (last visited Spring 2015).

two years of age, and relatively little is known about its reproduction.[41] Therefore, the likelihood is very low that these depleted populations will recover without aid from policymakers. In contrast with the sharks under the MoU that mature at a relatively younger age, the signatories would have to establish very strict catch limits, as there are two main parts of the population that need protection: (1) the oldest and reproductively mature population over thirty-two years of age, and (2) the youngest population that will serve as a foothold to establish future groups of spiny dogfish. Though taking any would certainly be detrimental with the level of decline, it is unlikely that signatories would agree to completely suspend fishing for this species. While this strategy would certainly serve to benefit the other species as well, spiny dogfish would stand to benefit the most, as they will recover very slowly due to the length of time needed for young dogfish to mature. In addition, the current decimation of younger populations currently will not slow up for many years due to the lag time in-between birth to reproductive maturity.

IV. OVERALL OBJECTIVES

In order to effectively implement the goals of the CMS Shark MoU, there are some basic pieces of information that should be gathered and steps that can be taken. The following suggestions would greatly improve the conservation of these sharks.

- Learn more about the reproductive biology of each shark to shape the future conservation plans.
- Gather and globally harmonize data on a species-specific level about direct catch, bycatch, and the amount of those species brought to shore, or landings data, in order to assess the status and monitor trends in shark species.[42]
- Bio-logging of a greater population of sharks to learn more about their migratory patterns, activity levels, and seasonal distribution in order to determine critical sites.
- Take measures to mitigate incidental bycatch and to bring target fisheries down to sustainable levels.

41. Ian G. Taylor & Vincent F. Gallucci, *Unconfounding the effects of climate and density dependence using 60 years of data on spiny dogfish (Squalus acanthias)*, 66 CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES no. 3, at 351, 355 (2009).

42. Catch is direct catch. Bycatch is indirect, such as taking the species while intending to catch another. Landings mean the amount of the species actually brought to shore. These three separate categories impact each other. *See* IVOR CLUCAS, A STUDY OF THE OPTIONS FOR UTILIZATION OF BYCATCH AND DISCARDS FROM MARINE CAPTURE FISHERS, FAO FISHERIES CIRC. NO. 928 (Oct. 19970, *available at* http://www.fao.org/docrep/w6602e/w6602E00.htm.

- Attract signatories to the CMS Shark MoU, especially with efforts targeted toward key countries that can have the greatest impact on conservation and recovery of highly migratory shark populations.

V. KEY SIGNATORIES

Because these species are migratory, they can benefit from virtually any state that signs and implements the CMS Shark MoU. There are several key countries, however, that could have an outsized impact on conservation. Table 1 displays the states that would now be instrumental to moving the CMS Shark MoU forward based on potential nursery and migratory zones, trading, and fishing of sharks. The countries that are already a part of the MoU are highlighted in blue, and the critical migratory zones are in red.

In determining the states in this table and the designations, there are some biases that should be noted. This table was determined in part using data from fisheries or tagging studies, meaning they are biased to areas where fishing takes place and for which catch data are being reported. In addition, countries with major shark research institutes would have more data and would, as a result, be more likely to be selected. Therefore, there may be many important countries that are not represented in this table. The designations are simply based on available data, with nursery grounds often presumed in areas where the smallest sharks have been caught or observed, aggregation zones where most sharks are seen or caught, and migratory paths from tagging studies and confirmed sightings. It should be noted that due to the lack of definitive studies, these designations are educated guesses, and there are many more studies that should be completed in order to confirm the present hypotheses and find more of these zones. In addition, because pregnant females or pups are so rarely sighted, it is often the case that they overlap with aggregation zones, because there is a higher level of overall observations in these areas. The economically important zones were determined by the 2013 Traffic Report, and 2014 CMS Shark MoU Report.[43]

43. Victoria Mundy-Taylor & Crook Vicky Crook, Into the deep: Implementing CITES measures for commercially-valuable sharks and manta rays, Report prepared for the European Commission 106 (2013), *available at* http://ec.europa.eu/environment/cites/pdf/reports/traffic_pub_fisheries15.pdf. FOWLER, *supra* note 2, at 1, 14.

Nations[44]	Nursery Ground	Aggregation or Mating Zone[45]	Economic Reasons
Argentina		Porbeagle	Top fisher[4] (5)
Australia	Great White	Great White, Shortfin Mako, Longfin Mako, Whale	Top fisher (23)
Bahamas			
Brazil		Great White, Basking	Top fisher (13)
Canada	Porbeagle	Great White, Basking, Shortfin Mako, Spiny Dogfish	Top fisher (21)
Chile		Basking, Spiny Dogfish	Major product exporter & importer
China			Major importer
Colombia			
Costa Rica			Major exporter and importer
Cuba		Longfin Mako	
Denmark		Basking, Porbeagle	
Djibouti	Whale		
Dominican Republic	Longfin Mako		
France		Porbeagle	Top fisher (11)
Hong Kong			Major trade hub
Iceland		Basking	
India		Whale	Top fisher (2)
Indonesia			Top fisher (1)
Iran			Top fisher (18)
Japan	Basking	Great White, Shortfin Mako, Porbeagle	Top fisher (10)
South Korea			Top fisher (20)
Madagascar			
Malaysia			Top fisher (9)
Mediterranean Sea Nations[46]	Great White, Shortfin Mako, Porbeagle	Great White, Basking, Porbeagle	
Mexico	Great White, Basking, Shortfin Mako	Shortfin Mako, Basking, Whale	Top fisher (6)
Morocco	Basking		
Mozambique			
New Zealand	Shortfin Mako	Great White, Shortfin Mako, Porbeagle, Spiny Dogfish	Top fisher (15)
Nicaragua			
Nigeria			Top fisher (17)
Norway		Basking, Porbeagle	
Pakistan			Top fisher (8)
Panama			Major trade hub
Peru			Top fisher (22)
Portugal	Basking	Basking, Longfin Mako	Top fisher (16)
Senegal			Top fisher (25)
Singapore			Major trade hub
South Africa		Great White, Porbeagle	Major trade hub
Spain			Top fisher (3)
Sri Lanka	Whale		Top fisher (14)
Sweden		Porbeagle	
Taiwan			Top fisher (4)
Thailand			Top fisher (12)
UAE			Major trade hub
United Kingdom	Basking, Porbeagle	Basking, Porbeagle	Top fisher (19)
United States	Great White, Basking, Shortfin Mako, Longfin Mako, Porbeagle, Whale	Great White, Shortfin Mako, Longfin Mako, Spiny Dogfish	Top fisher (7)
Uruguay		Porbeagle	Major trade hub
Venezuela			Top fisher (26)
Vietnam			
Yemen			Top fisher (24)

44. Shark MoU signatories in Blue.
45. Critical migratory hotspots in Red.
46. Turkey, Syria, Lebanon, Israel, Egypt, Libya, Malta, Tunisia, Algeria, Morocco, Spain, France, Monaco, Italy, Greece, Palestina (Gaza Strip), Albania, Montenegro, Bosnia, Herzegovina, Croatia, and Slovenia. Top fishers from Johanne Fischer et al., Review of the Implementation of the International Plan of Action for the Conservation and Management of Sharks, FAO FISHERIES AND AQUACULTURE CIRCULAR no. 1076, at 1, 64 (2012).

Table 1: Key Signatories for the CMS Shark MoU

VI. LINES OF ACTION

A. Develop Greater Knowledge of Shark Ecology

1. Tag and track

Understanding the migration patterns, aggregation areas, and population dynamics of any species is a key to creating an effective and impactful conservation plan but, unfortunately, these are incredibly difficult to definitively determine. Bio-tagging gives scientists and policy makers a chance to understand their behaviors and movements throughout the globe, and also by season. This information would be key in allowing us to determine possible nursery grounds, aggregation zones, or typical migration paths.

Ideally, sharks would be tagged with both accelerometers and satellite tags, providing depth, speed, orientation, and location data, as well as behavioral information.[47] It should be noted though, that at the present time, some sharks would be too small for these tags because their fin wouldn't be large enough to support the float package, which must be recovered in order to download accelerometer data. Perhaps a modified package could be engineered. Despite the differences in technology, this does not diminish the value of the information learned from older tagging studies. In the future, however, attaching tags that will provide the most information possible is ideal.

2. Reproductive biology

Beyond simply tracking sharks and looking at their migratory patterns, it is important to understand why they travel to various locations, especially for reproductive purposes. Some species of sharks do not necessarily reproduce annually, and have long gestation periods, often lasting longer than a year, which produces relatively low numbers of offspring. These traits are associated with k-selected species, which channel more energy into fewer offspring. They also grow slowly and become sexually mature only in their teens. Though this is not the case with every shark, it is clear from the data (Table 2) that it is certainly a factor that needs to be considered when creating policy. These traits produce a perfect storm for these species to become easily overexploited

47. Nicholas M. Whitney et al., *Identifying shark mating behaviour using three-dimensional acceleration loggers*, 10 ENDANGERED SPECIES RESEARCH no. 2, at 71, 74 (2010).

by the fishing industry because their populations take a long time to recover.

Shark Species	Age of Maturity (yrs)	Gestation Period (months)	Litter Size	Lifespan (yrs)
Great White[48]	M: 8-13; F: 9-23	12-18	2-17	70
Basking[49]	M: 12-16; F: 16-20	31.2-42	6	~50
Whale[50]	30	Unknown	300 (birthed over time)	70-100
Shortfin Mako[51]	M: 7; F:19	15-18	Avg 12, Max 25	11.5-17 (oldest measured), 45 estimated
Longfin Mako[52]	Unknown	Unknown	2-4	Unknown
Porbeagle[53]	M: 8 F:13	8-9	1-6, Avg 4	>26
Spiny Dogfish[54]	32	18-24	2-17, Avg 6-7	>80

48. Great White: Francis et al., *supra* note 34. Sabine Wintner & Geremy Cliff, *Age and growth determination of the white shark, Carcharodon carcharias, from the east coast of South Africa*, 97 FISHERY BULLETIN no. 1, at 153, 157 (1999).Gregory Cailliet et al., *Preliminary studies on the age and growth of the white shark, Carcharodon carcharias, using vertebral bands*, 9 SOUTHERN CALIFORNIA ACADEMY OF SCIENCES 49, 55 (1985). Malcolm Francis, *Observations on a pregnant white shark with a review of reproductive biology*, *in* THE BIOLOGY OF THE WHITE SHARK, *CARCHARODON CARCHARIAS* (A.P. Klimley & D.G. Ainley eds., 1996). Barry Bruce, *The Biology of the white shark (Carcharodon carcharias)*, *in* SHARKS OF THE OPEN OCEAN: BIOLOGY, FISHERIES AND CONSERVATION 13, 69, 70 (Merry D. Camhi et al. eds., 2008). Li Ling Hamady et al., *Vertebral Bomb Radiocarbon Suggests Extreme Longevity in White Sharks*, PLOS ONE 1, 4(2014).

49. COSEWIC, COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA, COSEWIC ASSESSMENT AND STATUS REPORT ON THE BASKING SHARK CETORHINUS MAXIMUS, ATLANTIC POPULATION, IN CANADA 1, 14 (2009).

50. AUSTRALIAN GOVERNMENT, DEP'T OF THE ENVIRONMENT AND HERITAGE, WHALE SHARK (RHINCODON TYPUS) ISSUES PAPER 1, 4 (2005). Shoou-Jeng Joung et al., *The whale shark, Rhincodon tyupus, is a livebearer: 300 embryos found in one 'megamamma' supreme*, 46 ENVIRONMENTAL BIOLOGY OF FISHES 219, 220 (1996).

51. Shortfin Mako: S.D.H. Bishop et al., *Age, growth, maturity, longevity and natural mortality of the shortfin mako shark (Isurus oxyrinchus) in New Zealand waters*, 57 MARINE AND FRESHWATER RESEARCH 143, 150 (2006). H.F. Mollet et al., *Reproductive biology of the female shortfin mako, Isurus oxyrinchus Rafinesque, 1810, with comments on the embryonic development of lamnoids*, 98 FISHERY BULLETIN 299, 303 (2000). Harold Pratt Jr. & John G. Casey, *Age and growth of the shortfin mako, Isurus oxyrinchus, using four methods*, 40 CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES no. 11, at 1944, 1949 (1983). GREGOR M. CAILLIET ET AL. PRELIMINARY STUDIES ON THE AGE AND GROWTH OF BLUE, PRIONACE GLAUCA, COMMON THRESHER, ALOPIAS VULPINUS, AND SHORTFIN MAKO, ISURUS OXYRINCHUS, SHARKS FROM CALIFORNIA WATERS 179, 184 (1983).

52. Longfin Mako: Franklin Snelson et al., *The reproductive biology of pelagic elasmobranchs*, *in* SHARKS OF THE OPEN OCEAN: BIOLOGY, FISHERIES AND CONSERVATION 24, 30 (Merry Camhi et al. eds., 2008). DARIO GUITART MANDAY, LAS PESQUERIAS PELAGICO-OCEANICAS DE CORTO RADIO DE ACCION EN LA REGION NOROCCIDENTAL DE CUBA. ACADEMIA DE CIENCIAS DE CUBA, INSTITUTO DE OCEANOLOGÍA (1975). R. Grant Gilmore, *Observations on the embryos of the longfin mako, Isurus paucus, and the bigeye thresher, Alopias superciliosus.* 1983 *COPEIA* no. 2, at 375, 379 (1983).

53. Porbeagle: Christopher F. Jensen et al., *The reproductive biology of the porbeagle shark (Lamna nasus) in the western North Atlantic Ocean*, 100 FISHERY BULLETIN no.4, at 727, 729 (2002). Malcolm P. Francis & J.D. Stevens, *Reproduction, embryonic development, and growth of the porbeagle shark, Lamna nasus, in the southwest Pacific Ocean*, 98 FISHERY BULLETIN no. 1, at 41, 50 (2000). Lisa J. Natanson et al., *Validated age and growth of the porbeagle shark (Lamna nasus) in the western North Atlantic Ocean*, 100 FISHERY BULLETIN no. 2, at 266, 274 (2002). Steven E. Campana et al., *Population dynamics of the porbeagle in the northwest Atlantic Ocean*, 22 NORTH AMERICAN JOURNAL OF FISHERIES MANAGEMENT no. 1, at 106, 111 (2002).

54. Spiny dogfish: K.S. Ketchen, *Size at maturity, fecundity, and embryonic growth of the spiny dogfish (Squalus acanthias) in British Columbia waters*, 29 JOURNAL OF THE FISHERIES BOARD OF CANADA no. 12, at 1717, 1718 (1972). Thomas S. Jones & Karl I. Ugland, *Reproduction of female spiny dogfish, Squalus acanthias, in the Oslofjord*, 99 FISHERY BULLETIN-NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION 685, 686 (2001). Taylor & Gallucci,

3. Genetic studies

Genetic studies not only give us an insight into the genetic diversity between the subpopulations of sharks in different oceans, but can also give us an indication of how various populations mix. In conjunction with tagging studies, it can help provide a more complete picture as to how sharks move and mingle throughout the globe. Genetic studies, however, are hard to perform because it is difficult to get good samples. Genetic studies have been done on some of the MoU sharks to track their incidence in international fish markets because they are often found in pieces and otherwise nearly impossible to identify.[55] In that case, genetic studies would be the only way to determine the species and provide a method for assessing the extent of finning in various species.

B. Determine and Reduce Direct and Indirect Catch

1. Direct Catch

Finning is the practice of catching a shark out at sea, removing the fins, and throwing the rest of the animal back to sea, sometimes while still alive. This practice, beyond simply being wasteful, puts sharks at extreme risk, because it is possible to take back the equivalent of many more animals if you only harvest 2-5 percent of the overall weight. Historically, and to this day, fins have been thought of as an aphrodisiac. Shark fin soup is considered a display of wealth and a culinary delicacy in some Asian cultures, especially China. As a result of this cultural practice, an estimated 38 million sharks fins are sold each year to fill this demand because it is such a lucrative business.[56] Initial steps are being made to curb this practice, with China recently outlawing shark fin soup at official banquets, but overall the dish is still rampantly popular. Due to difficulty in identifying what species sharks fins originate from except using trade records[57] and genetic analyses,[58] it is hard to determine which sharks are being taken, and at what rate.

In addition to being finned, shortfin and longfin mako sharks, porbeagles, and spiny dogfish are currently direct fishing targets, through

supra note 41, at 351, 355. Gordon A. McFarlane & Jacquelynne R. King, *Migration patterns of spiny dogfish (Squalus acanthias) in the North Pacific Ocean*, 101 FISHERY BULLETIN no. 2, at 358, 361 (2003).

55. Mahmood Shivji et al., *Genetic identification of pelagic shark body parts for conservation and trade monitoring*, 16 CONSERVATION BIOLOGY no. 4, at 1036-1044 (2002).

56. Nicholas K., Dulvy et al., *You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays*, 18 AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS no. 5, at 459-482 (2008).

57. Shelley C. Clarke, et al., *Global estimates of shark catches using trade records from commercial markets* 9 ECOLOGY LETTERS no. 10, at 1115-1126 (2006).

58. Shivji, et al., *supra* note 55, at 1036-1047.

both commercial and recreational fishing. Mako sharks, both shortfin and longfin, are a common target of game fishing, due to their high energy acrobatic antics when hooked, and are the subject of lucrative fishing tournaments. Beyond simply recreational fishing, they are also commercially fished, with some smaller operations in California and Spain, but in comparison to the level of bycatch, the numbers are relatively low. Reports show that there were 65,795 shortfin and longfin makos caught commercially and recreationally since 1986 in the United States alone.[59] The concerning part is that the sharks in some of these drift net and longline fisheries are catching nearly 90 percent immature sharks,[60] depleting the population of potentially reproductive individuals down the line. Porbeagle sharks and spiny dogfish, which are considered valuable in terms of their meat, are also the target of direct fisheries. Porbeagles, given their limited range, are fished directly in both hemispheres, particularly in the Atlantic on pelagic longlines,[61] but in comparison to the levels at which they were historically fished, it is a relatively low level now. As a highly valuable shark in terms of their fins and their meat, they have been under pressure from overfishing since the 1930s, and in the southern hemisphere, their catch rates are relatively undocumented and unknown except for New Zealand, posing a threat to that likely genetically distinct group.

The spiny dogfish, among the seven MoU shark species, comes from a unique standpoint. As one of the formerly most abundant sharks, their numbers are in a steep decline.[62] Unlike other shark species, they were widely fished recently, whereas others had already undergone a boom and bust in terms of their fisheries, as shark populations were overfished and the operations were forced to shut down. Recently, however, spiny dogfish populations have been heavily fished for their meat and sold to European markets.[63] As a result, the spiny dogfish stocks in EU waters are at critically low levels, and a zero catch limit was set in these waters in 2011. According to the FAO (Food and Agriculture Organization), the reported catch between 2000-2009 was between 13,800 and 31,700 tons.[64] Interestingly, in 2010, spiny dogfish stocks in the eastern Atlantic were considered rebuilt by NOAA, and the fishing limits were greatly increased,

59. Julia K. Baum et al., *Collapse and conservation of shark populations in the Northwest Atlantic*, 299 SCIENCE no. 5605, at 389-392 (2003).
60. David B., Holts et al., *Pelagic shark fisheries along the west coast of the United States and Baja California, Mexico*, 39 FISHERIES RESEARCH no 2, at 115-117 (1998).
61. J. A. GAULD, RECORDS OF PORBEAGLES LANDED IN SCOTLAND WITH OBSERVATIONS ON THE BIOLOGY, DISTRIBUTION AND EXPLOITATION OF THE SPECIES (SCOTTISH FISHERIES RESEARCH REPORT) 1, 7 (1989), *available at* http://www.gov.scot/Uploads/Documents/No%2045.pdf.
62. *Squalus acanthias*, THE IUCN RED LIST OF THREATENED SPECIES, *supra* note 40.
63. *Id*.
64. FAO, FAOYB, FISHERY AND AQUACULTURE STATISTICS 2009 (2011).

implying that European stocks were much more depleted and are in much greater danger.[65]

Great white, basking, and whale sharks are no longer directly fished in large numbers, but because they were once historically targeted, they still face the impacts from these operations. That is not to say that illegal operations that still target these species do not exist, but from an overall standpoint, the greatest threat to their populations in terms of fishing volume has passed, both recreationally or commercially. In fact, a common theme among shark fishing operations is the incidence of boom and bust patterns, as mentioned with the porbeagles. Whale sharks were even hunted directly by harpoon and set nets in Asia,[66] which was legal until 1998 in the Philippines, 2001 in India, and 2007 in Taiwan. Despite being illegal, direct hunting still occurs, posing a threat to the populations. In addition to being commercially hunted for fins, liver oil, and skin, basking sharks ruined so much fishing gear that there was actually an eradication program created from 1945-1970 that sought to kill as many as possible, using both harpoons and even a cleaver attached to the front of a ship.[67]

Great white sharks have also been the targets of purposeful eradication programs, mainly through shark culling. Shark culling is the act of specifically killing larger or more mature sharks to remove them from the population. The rationale for eradication is to protect swimmers and beachgoers from shark attacks. Recently, in late 2013, this was proposed in Australia, and went into effect in early 2014. It is clear where this idea originated from: fear. Several people have been killed in the past few years, and in order to reassure the general public of their safety, they feel this is a good solution. In practice, however, it is simply removing sexually mature individuals from the already dwindling population. Without proper management, the dwindling great white population, which may number as few as 3,500, could fall victim to the tragedy of the commons.[68] Without the cooperation and enforcement of many nations, these important animals could easily become extinct.

65. Andrea Dell'Apa et al., *The Magnuson–Stevens act (1976) and its reauthorizations: Failure or success for the implementation of fishery sustainability and management in the US?* 36 MARINE POLICY no. 3, at 673-680 (2012).
66. Che-Tsimg Chen et al., *Preliminary report on Taiwan's whale shark fishery*, 17 TRAFFIC BULLETIN no. 1, at 57 (1997).
67. WALLACE & GISBORNE, *supra* note 13.
68. Ian Sample, *Great white shark is more endangered than tiger, claims scientist*, THE GUARDIAN, Feb. 19, 2010, http://www.theguardian.com/environment/2010/feb/19/great-white-shark-endangered-tiger.

2. Indirect Catch

It has been estimated that 50 percent of the global catch of chondrichthyans is through bycatch, and this statistic indicates a vast amount of sharks that are unaccounted for and unmanaged.[69] Commercial fishery nets are the main source of this rampant level of accidental catch, and with a large variety of net types that are highly efficient at catching different types of fish, sharks inevitably also get tangled up, especially when the target fish are their prey. Sharks are highly susceptible to becoming bycatch because they not only inhabit the same areas and hunt many popular fish, but also use shore areas to pup, forage, and migrate. In addition, their curiosity often draws them close to nets and lines, which can trap them.[70]

Shark bycatch is relatively common, but often goes unreported, which is why the CMS Shark MoU would benefit greatly from a partnership with the sixteen RFMOs, which could help monitor and manage bycatch levels. Presently, RFMO management measures include basking, spiny dogfish, great white, and porbeagle sharks, but only one RFMO includes each one, rather than all sixteen. Also, some sharks become indirect targets, as mako sharks are considered desirable bycatch of tuna and swordfish fisheries, placing further stress on these species.

a) Great White Shark

Great white sharks are highly curious top predators of the seas, and their immense repertoire of large prey and frequent hunts cause them to encounter nets, which sometimes make them bycatch. The most frequent type of net they get entangled in are gillnets, but in addition to commercial fishery accidental take, they also get caught in the nets which protect beaches in Kwazalu-Natal, South Africa, Hong Kong, and Australia.[71] These are an attempt to protect and reassure beachgoers, but end up simply drowning or killing sharks rather than protecting people. The sharks can swim around the nets, and if anything, they probably raise interest for the sharks in the coastline, meaning the apparatus actually may create more problems. In addition, many other harmless species end up drowning in the nets as well.[72] Instead, the development of deterrent devices rather than physical barriers would be a good alternative measure. Perhaps through

69. J.D. Stevens et al., *The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems*, 57 ICES JOURNAL OF MARINE SCIENCE no. 3, at 476, 488 (2000).
70. *Id*.
71. Geremy Cliff & Sheldon FJ Dudley, *Reducing the environmental impact of shark-control programs: a case study from KwaZulu-Natal, South Africa*, 62 MARINE AND FRESHWATER RESEARCH no. 6, at 700, 707 (2011).
72. Martin Krogh & Dennis Reid, *Bycatch in the protective shark meshing programme off south-eastern New South Wales, Australia*, 77 BIOLOGICAL CONSERVATION no. 2-3, at 219, 224 (1996).

scent, magnets, electric current, or other methods, we could simply dissuade them from approaching the shore, rather than killing them.

b) Basking Shark

Historically, basking sharks have often gotten caught and strangled by cod and salmon nets, and have been viewed as a nuisance to fishers, and were even the target of an eradication program. Typically spotted as slow-moving surface dwellers, basking sharks are especially susceptible to trammel nets, which hang in layers vertically from the surface of the water.[73] However, studies suggest that basking sharks tend to hang near the surface only in the spring and summer, but go down to depths of about 250 meters in the winter, hanging around the continental shelf.[74] Therefore, using nets that target fish at greater depths to avoid this basking behavior will not completely solve the problem in the winter, but would help in the summer and spring. In order to avoid the sharks when fishing, perhaps setting regulations that change with season would be advantageous. Reducing the number of the surface trammel nets temporarily in spring and summer, then trawls in the winter, would help reduce interactions. But in order to create a net that will not catch basking sharks year-round, it may be best to focus on mid-water regions, which basking sharks do not seem to inhabit. Another tactic could be to track zooplankton aggregations in order to predict basking shark movements, and temporarily suspend or cautiously proceed with fishing operations in those areas to reduce bycatch.

c) Shortfin Mako Shark

Shortfin mako sharks would benefit from improved monitoring and management of bycatch as this species is an extremely common bycatch. According to catch reports, they are extremely common bycatch, with numbers estimated at up to 12,500 metric tons caught by longline fishers along in a year (Stevens 2000).[75] They are not only caught accidentally, but are also usually retained because of the high quality of their meat and fins. They are caught in Japanese longlines by the thousands,[76] which stresses the overall population. The CMS Shark MoU can serve as a vehicle for change for this species by having signatories agree to change

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73. WALLACE & GISBORNE, *supra* note 13, at 1-96.
74. M.P. Francis, and C. Duffy, *Distribution, seasonal abundance and bycatch of basking sharks (Cetorhinus maximus) in New Zealand, with observations on their winter habitat*, 140 MARINE BIOLOGY no. 4, at 831, 835 (2002).
75. Francis & Stevens, *supra* note 53, at 41, 50.
76. J.D. Stevens, *Blue and mako shark bycatch in the Japanese longline fishery off south-eastern Australia*, 43 MARINE AND FRESHWATER RESEARCH no. 1, at 227, 231 (1992).

the way that they fish for this species, using lines that lower bycatch, and making it illegal to keep them as non-target species.

d) Longfin Mako Shark

While longfin mako sharks have not been as well-studied as the closely-related shortfin makos, this shark species would benefit from better monitoring and management that it would receive under the CMS Shark MoU. It is unclear exactly how many longfin mako sharks are caught annually because they are rarer and are extremely similar in apperance to their shortfin cousins, which makes them historically understudied. But, given the startlingly high bycatch levels of the shortfin mako and other highly migratory species, it is very likely that that the rate of bycatch is not sustainable and needs further investigation. The CMS Shark MoU could serve as a platform to lower catch levels of both the shortfin and long fin makos. This could be achieved through agreements on longline fishing in particular, and again, not allowing them to be taken if they are not the target catch.

e) Whale Shark

Whale sharks could benefit greatly from bycatch management targeted in regions where it is still an issue. Because whale sharks often cruise along the surface and move relatively slowly, they sometimes get tangled in set nets intended for other fish, and have been recorded as bycatch in Taiwan.[77] In this case, the sharks are then kept and sold for the meat, since it is a highly valuable shark. In European purse seine fisheries in the Atlantic, there was a very low incidence of whale shark bycatch, with only seventeen accidental captures between 2003-2007, all of which were released alive.[78] The CMS Shark MoU could help whale sharks by having signatories in regions of the world where this is still an issue meet with the countries that have mitigated bycatch, and talk about how to continue to lessen indirect catch.

f) Porbeagle

The porbeagle would benefit from the better monitoring and management that it would receive under the CMS Shark MoU, as this species has almost been driven to extinction in some regions due to bycatch and direct fishing. The porbeagle is considered to be extremely

77. Che-Tsimg Chen et al, *supra* note 66, at 1, 57.
78. Monin Justin Amandè, et al., *Bycatch of the European purse seine tuna fishery in the Atlantic Ocean for the 2003-2007 period*, 23 AQUATIC LIVING RESOURCES no. 4, at 353, 357 (2010).

valuable in terms of its meat and fins, and if taken as bycatch, it is often kept, putting extra pressure on this species. The highest levels of bycatch in the northern hemisphere are from bottom trawls, hand lines, and gillnets,[79] and in the southern hemisphere, tuna longlines in the South Pacific and Indian Oceans account for the bulk of the recorded bycatch, but comparatively, there is much less information.[80] The combination of bycatch and direct fishing has essentially driven these sharks to the point of extinction in the Mediterranean, as only a handful have even been sighted in the past few decades in this area.[81] This shark could benefit greatly from the CMS Shark MoU because there need to be agreements made between signatories to return accidental catch of this species and to help mitigate bycatch, or this species will continue to drop greatly in numbers.

g) Spiny Dogfish

The spiny dogfish could benefit further from the monitoring and management associated with the CMS Shark MoU, as these sharks are commonly taken as bycatch. However, out of the MoU sharks, spiny dogfish are probably the most likely to survive if thrown back, and in a trawl study were found to have a 29 percent mortality rate,[82] which is much lower than the usual estimation of 50 percent in fisheries.[83] At the same time, there is still a high incidence of bycatch, and in the United States: 7400-47300 metric tons were discarded from 1989-2005.[84] Through the CMS Shark MoU, signatories could have a dialogue on the best practice when it comes to spiny dogfish, their return if caught as bycatch, and how to utilize those discarded.

C. Develop a recovery plan

By estimating how many sharks are caught each year, and learning more about their biology, it is possible for conservationists to determine how long it will take for a species to recover and reach a population level

79. J.A. GAULD, *supra* note 61, at 1,7.
80. Malcolm P. Francis et al., *Pelagic shark bycatch in the New Zealand tuna longline fishery*, 52 MARINE AND FRESHWATER RESEARCH no. 2, at 165, 173 (2001).
81. Francesco Ferretti et al., *Loss of Large Predatory Sharks from the Mediterranean Sea*, 22 CONSERVATION BIOLOGY no. 4, at 952, 959 (2008).
82. John W Mandelman & Marianne A. Farrington, *The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (Squalus acanthias)*, 83 FISHERIES RESEARCH no. 2-3, at 238, 242 (2007).
83. NORTHEAST FISHERIES SCIENCE CENTER (NEFSC), 37TH NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP (37TH SAW), ADVISORY REPORT (NORTHEAST FISHERIES SCIENCE CENTER REFERENCE DOCUMENT 03-17) 1, 19 (2003), *available at* http://www.nefsc.noaa.gov/publications/crd/crd0317/saw37advrpt.pdf.
84. NORTHEAST FISHERIES SCIENCE CENTER (NEFSC), REPORT OF THE 43RD NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP (43RD SAW), STOCK ASSESSMENT REVIEW COMMITTEE (SARC) CONSENSUS SUMMARY OF ASSESSMENTS (NORTHEAST FISH. SCI. CENT. REF. DOC. 06-25) 1, 18 (2006).

where the sharks can easily reproduce and continue to increase in number. But as a k-selected species with low reproductive output, late reproductive maturity, and long gestation periods, it likely would take decades of protection to rebuild populations to sustainable levels. One survey, for example, estimates there are only 3,500 individual Great Whites in all the world's oceans.[85] Because of their low numbers and reproductive traits, it would be decades for many of these shark species to even partially recover.

These biological traits, along with the anthropogenic pressures, only increase the importance for conservation and a committed group of signatories for the CMS Shark MoU. Generating a recovery plan for each species in order to supervise these species would be highly advantageous because it would provide direction and goals for the populations to reach as we work to improve the status of these species. Without a concrete plan and set of policies, it is simply too easy for these important animals to fall victim to the tragedy of the commons.

D. Monitoring and Review

The CMS Shark MoU is in a unique position to join many different EEZs and create a network of concerned nations for these highly migratory shark species. Given the large distribution of these sharks and array of pressures they face, a multifaceted recovery plan will be necessary, with periodic checks in order to maintain an effective committee. Above all else, more scientific studies are required for these species. The more we know about their reproductive biology and movements, the more we can aid them. In the long run, designating and protecting important reproductive zones, creating partnerships with fisheries to monitor bycatch rates, designing new fishing gear, and doing more population surveys will be key to success. The bottom line is that in many cases, we know very little about these species, and only by discovering more about these animals we truly act to protect them.

Guiding each shark species toward recovery will require an evaluation of the successful completion of the lines of action over increments of time, along with the cooperation of other management organizations and scientists. Because parties to the MoU meet every three years, there is ample time to pursue additional state parties. An updated list of target nations can be generated based on new data, and a revision of catch rates based on new scientific studies can be incorporated into the effort. In addition to pursuing new signatories, the CMS Shark MoU should also seek the assistance of RFMOs, FAO, CITES, NGOs, and local

85. Sample, *supra* note 68.

groups in coastal and port states. Partnerships with these organizations could provide more accurate bycatch data and help form a more vigilant base of supporters to protect sharks and uphold CMS Shark MoU policies. Beyond cooperation with other groups, the MoU should also consider creating standardized or graduated sanctions imposed upon violators of the policies. With the cooperation and enforcement of conservation plans by a network of signatories, it is possible to protect and save these important ocean dwellers.

VII. CONCLUSION

The CMS Shark MoU can unify a critical mass of states to conserve these critical ocean predators. Only through the cooperation of many nations, along with other groups, such as RFMOs, will it be possible to truly protect these highly migratory species, as we aim to not only set limits and generate policy, but also learn more about the biology and overall movements of these sharks.

In order to aid these seven shark species, the CMS Shark MoU should use the lines of action set out in the plan in order to allow the biology to help dictate appropriate policy. The lines of action dictate that the sharks can be helped by discovering more about shark ecology, determining ways to reduce direct and indirect catch, developing a recovery plan, and monitoring and reviewing the shark populations over time. Despite the great strides being made in shark research with the advent of accelerometers, satellite tags, and genetic work, there is still a lack of data to implement more effective policies. Even with all the biological information available, the most important part of this process is to attract commitments and recruit key signatories to the MoU. Without the cooperation of these States, even the most informed and extensive conservation plans will be undermined by illegal, unreported, and unregulated (IUU) fishing.

At first glance, the next logical steps in shark conservation and protection may seem very simple: gain more signatories, set catch limits, and improve national policies, and in doing so, provide space for the recovery of sharks over time. But there is more than meets the eye. At the root of this issue, and generally of any threat to the natural environment, is poverty, ignorance, and overpopulation. Because of lack of knowledge about predatory behavior and ecosystem dynamics, fishermen will continue to hunt every last shark, especially when it is a matter of their livelihood. In the end, establishing a level of respect and appreciation for sharks and the invaluable purpose they serve in the ocean may yield the biggest revolution in shark policy, though sadly, this goal is impossible when stacked against the concerns faced by subsistence fishermen or the drive for economic gain. Meanwhile, highly migratory shark species are highly susceptible to the tragedy of the commons, which is why we must fight harder to protect them.