2017 Shark Finning Report to Congress

NOAA FISHERIES

REPORT TO CONGRESS

2017 Shark Finning Report

Developed pursuant to: Shark Finning Prohibition Act (Public Law 106-557)

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Introduction

This report describes the efforts of the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) during calendar year 2016 to implement the 2000 Shark Finning Prohibition Act and more recent shark conservation legislation. The 2000 Shark Finning Prohibition Act amended the Magnuson-Stevens Fishery Conservation and Management Act (MSA) to prohibit the practice of shark finning by any person under U.S. jurisdiction.

The 2000 Shark Finning Prohibition Act requires NMFS to promulgate regulations to implement its provisions, initiate discussion with other nations to develop international agreements on shark finning and data collection, provide Congress with annual reports describing efforts to carry out the Shark Finning Prohibition Act, and establish research programs.

Background and Context

Great Hammerhead (Sphryna mokarran) Shark. Photo: NOAA

Sharks are among the ocean's top predators and vital to the natural balance of marine ecosystems. They are also a valuable recreational species and food source. The practice of shark finning and shark bycatch in some fisheries can affect the status of shark stocks and the sustainability of their exploitation in world fisheries. When the Shark Finning Prohibition Act became law, in 2000, global shark catches reported to the Food and Agriculture Organization of the United Nations (FAO) had tripled since 1950, reaching an all-time high of 888,000 tons. Since then, the United States has implemented several measures, and has some of the strongest shark management measures, both domestically and internationally. Since 2000, there has been a continuing decrease in global shark catches, to 767,000 tons in 2016.[1] The most recent FAO report (2017) reported global imports of shark fins were approximately 13,000 mt in 2015, the most recent year data are available, and the lowest volume since 2011.[2] In 2015, the average value of global shark fin imports increased to $15,411/mt, and the average value of exports increased to $12,548/mt. Hong Kong was the largest importer and Thailand the largest exporter of shark fins in 2015. In response to continued concerns about shark populations internationally, many countries have banned shark fishing in their waters in favor of promoting tourism opportunities. In addition, many other nations have adopted finning bans, including: Bahamas, Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Maldives, Nicaragua, Palau, Panama, and Taiwan.

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[1] Food and Agriculture Organization of the United Nations, FishStatJ database, www.fao.org
[2] Food and Agriculture Organization of the United Nations, FishStatJ database, www.fao.org

Domestic

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Shark Finning Prohibition Act and the Shark Conservation Act, is the Federal law governing the conservation and management of Federal fisheries in the United States. The suite of conservation and management measures required of all Federal fisheries under the MSA makes the United States a leader in the sustainable management of domestic shark fisheries. Shark fisheries are valuable contributors to the U.S. economy. In 2016, U.S. fishermen landed over 32 million pounds of sharks, valued at over $8 million.[3] In 2016, five out of 37 U.S. shark stocks or stock complexes (13.5 percent) were listed as subject to overfishing and seven shark stocks (19 percent) were listed as overfished. Fifteen stocks or stock complexes (40.5 percent) had an unknown overfishing status and 20 shark stocks or stock complexes (54 percent) had an unknown overfished status. Ten stocks or stock complexes (27 percent) were neither subject to overfishing nor overfished. (Table 1, Page 9).

In the United States, shark finning has been prohibited since 2000. In 2008, NOAA implemented even more stringent regulations to require all Atlantic sharks to be landed with all fins naturally attached, to facilitate species identification and reporting and improve the enforceability of existing shark management measures, including the finning ban. In 2011, President Obama signed the Shark Conservation Act of 2010, which amended the High Seas Driftnet Fishing Moratorium Protection Act and the 2000 Shark Finning Prohibition Act provisions of the MSA to further improve domestic and international shark conservation measures, including additional measures against shark finning. In addition, as of 2016, many U.S. States and territories have passed laws addressing the possession, sale, trade, or distribution of shark fins, including Hawaii (2010), California (2011), Oregon (2011), Washington (2011), the Commonwealth of the Northern Mariana Islands (2011), Guam (2011), American Samoa (2012), Illinois (2012), Maryland (2013), Delaware (2013), New York (2013), Massachusetts (2014), Rhode Island (2016), and Texas (2016).

Domestically, the Shark Conservation Act states that it is illegal "…to remove any of the fins of a shark (including the tail) at sea; to have custody, control, or possession of any such fin aboard a fishing vessel unless it is naturally attached to the corresponding carcass; to transfer any such fin from one vessel to another vessel at sea, or to receive any such fin in such transfer, without the fin naturally attached to the corresponding carcass; or to land any such fin that is not naturally attached to the corresponding carcass, or to land any shark carcass without such fins naturally attached." These provisions improved the United States' ability to enforce shark finning prohibitions in domestic shark fisheries. The Shark Conservation Act also created an exception for smooth dogfish (*Mutelis canis*) in the Atlantic "…if the individual holds a valid State commercial fishing license, unless the total weight of smooth dogfish fins landed or found on board a vessel to which this subsection applies exceeds 12 percent of the total weight of smooth dogfish carcasses landed or found on board."

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[3] Commercial Fishery Statistics Database, https://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index

International

In 1998, the United States participated in the development of and endorsed the FAO International Plan of Action (IPOA) for the Conservation and Management of Sharks (IPOA-Sharks), which is voluntary. The IPOA-Sharks encourages all FAO members to adopt a corresponding National Plan of Action if their vessels conduct directed fisheries for sharks or if their vessels regularly catch sharks in non-directed fisheries. Consistent with the IPOA-Sharks, the United States developed a National Plan of Action for the Conservation and Management of Sharks in February 2001 and updated it in 2014. Many other FAO members have developed national plans of action, and several regional plans of action have been developed. In addition to meeting the statutory requirement of the Shark Finning Prohibition Act, this annual Report to Congress serves as a periodic update of information called for in both the International and National Plans of Action for sharks.

In addition, the Shark Conservation Act amended the High Seas Driftnet Fishing Moratorium Protection Act in two important ways. First, it requires the Secretary of Commerce to identify a nation if fishing vessels of that nation have been engaged in fishing activities or practices in waters beyond any national jurisdiction that target or incidentally catch sharks and if that nation has not adopted a regulatory program to provide for the conservation of sharks, including measures to prohibit removal of any of the fins of a shark (including the tail) and discarding the carcass of the shark at sea, that is comparable to that of the United States, taking into account different conditions. Second, it directs the United States to urge international fishery management organizations to which the United States is a member to adopt shark conservation measures, including measures to prohibit removal of any of the fins of a shark (including the tail) and discarding the carcass of the shark at sea. It also directs the United States to enter into international agreements that require measures for the conservation of sharks that are comparable to those of the United States, taking into account different conditions. These approaches, along with our strong domestic shark fishery management, have made the United States a leader in the conservation and management of sharks globally.

In response to continuing issues regarding illegal, unreported, and unregulated (IUU) fishing or seafood fraud, NMFS published a final rule on December 9, 2016, creating the Seafood Import Monitoring Program (81 FR 88975). This final rule established permitting, reporting, and recordkeeping procedures relating to the importation of certain fish and fish products, including sharks, identified as being at particular risk of IUU fishing or seafood fraud. This program provides additional protections for the sustainability of sharks. It is the first phase of a risk-based traceability program that requires the importer of record to provide and report key data from the point of harvest to the point of entry into U.S. commerce.

2016 Accomplishments in Response to Requirements of the Shark Finning Prohibition Act

Section 6 of the Shark Finning Prohibition Act requires the Secretary of Commerce, in consultation with the Secretary of State, to provide to Congress an annual report describing efforts to carry out the Act. Report requirements are:

1. Include a list that identifies nations whose vessels conduct shark finning and detail the extent of the international trade in shark fins, including estimates of value and information on harvesting, landings, or transshipment of shark fins.
2. Describe and evaluate the progress taken to carry out this Act.
3. Set forth a plan of action to adopt international measures for the conservation of sharks.
4. Include recommendations for measures to ensure that the actions of the United States are consistent with national, international, and regional obligations relating to shark populations, including those listed under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

NMFS' 2016 accomplishments to carry out the Act are discussed below. An appendix including detailed information on U.S. shark management and enforcement (Section 1), imports and exports of shark fins (Section 2), international shark efforts (Section 3), 2016 NOAA research on sharks (Section 4), ongoing NOAA shark research (Section 5), and references (Section 6) has been posted online.

A copy of this report and the appendix are available online at:
https://www.fisheries.noaa.gov/national/laws-and-policies/shark-conservation-act

International Participation in Shark Finning and Trade

Data on the international trade of shark fins are available from the FAO, and data on U.S. imports and exports of shark fins are available from the U.S. Census Bureau (as provided by U.S. Customs and Border Protection). It is important to note that, due to the complexity of the shark fin trade, fins are not necessarily harvested by the same country from which they are exported. During 2016, shark fins were imported through the following U.S. Customs and Border Protection districts: Los Angeles, Miami, and New York. In 2016, countries of origin were China, Hong Kong, the Netherlands, and New Zealand (see Table 2.1.1 in Section 2 of the appendix). The mean value of U.S. imports per metric ton has somewhat stabilized with a mean of $12,000/mt in 2016, the same mean value seen in 2015 and 2013. The majority of shark fins exported in 2016 were sent from the United States to Hong Kong, with smaller amounts going to China (Table 2.2.1). The mean value of U.S. exports per metric ton has generally declined since 2012, but average value increased to $71,000/mt in 2016 compared to $57,000/mt in 2015. Detailed information regarding imports and exports of shark fins can be found in Section 2 of the appendix associated with this report.

U.S. Progress Implementing the Shark Finning Prohibition Act

Satellite Tags Being Attached to a Bull Shark by NOAA Scientists. Photo: NOAA

Sharks in Federal waters are managed under 11 fishery management plans under the authority of the MSA. The New England, Mid-Atlantic, Pacific, North Pacific, and Western Pacific fishery management councils have developed 10 of those plans. The Secretary of Commerce has developed the fishery management plan for oceanic sharks and other highly migratory species of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea as required by the MSA. All recent shark-related management, enforcement, international, and research activities in support of the Shark Finning Prohibition Act are summarized in the appendix.

During calendar year 2016, shark-related research took place at all six NOAA regional fisheries science centers and included research on data collection, stock assessments, biological information, incidental catch reduction, and post-release survival.

Major management actions took place both domestically and internationally in 2016. Domestically, NMFS published a proposed rule for Amendment 5b to the 2006 Consolidated Atlantic Highly Migratory Species (HMS) Fishery Management Plan (FMP) to consider management measures to end overfishing of dusky sharks and to rebuild the stock (October 18, 2016; 81 FR 71672). Draft Amendment 5b considered new permit requirements, gear modifications, education, and outreach.

In June 2016, NMFS published a final rule to implement domestic provisions of the Shark Conservation Act. The final rule prohibits the removal of shark fins at sea; the possession, transfer, and landing of shark fins that are not naturally attached to the corresponding carcass; and the landing of shark carcasses without the corresponding fins naturally attached (June 29, 2016; 81 FR 42285). With the publication of the final rule, the Shark Conservation Act has been fully implemented.

NMFS also issued negative 12-month findings for separate petitions to list porbeagle sharks, common thresher sharks, bigeye thresher sharks, and smooth hammerhead sharks as threatened or endangered under the Endangered Species Act (ESA). Based on the best scientific and commercial information available and after taking into account efforts being made to protect these species, NMFS determined that these species do not warrant listing. In 2016, NMFS issued both a positive 90-day review and a proposed rule to list oceanic whitetip sharks as threatened under the ESA, based on the best scientific and commercial information available and taking into account efforts being made to protect the species (81 FR 96304). The comment period for this proposed rule closed on March 29, 2017. In addition, violations of the Shark Finning Prohibition Act, and noncompliance with regulations designed to protect sharks, were detected, investigated, and referred for administrative prosecution in the Pacific Islands and West Coast Enforcement

Divisions. Details on specific shark management, enforcement, and education activities can be found in Section 1 of the appendix, and information on 2016 shark research activities can be found in Sections 4 and 5 of the appendix.

Plans to Adopt International Measures for Shark Conservation and U.S. Consistency with National, International, and Regional Obligations

NMFS continues to work with the Department of State to promote the development of international agreements consistent with the Shark Finning Prohibition Act. The United States brings forward recommendations through bilateral, multilateral, and regional efforts. As agreements are developed, the United States implements those agreements.

Illegal Shark Fins Sorted for Species Identification. Photo: NOAA

Throughout 2016, NMFS participated in meetings of international regional fishery management organizations. At many of these meetings, the U.S. delegations supported or introduced proposals to strengthen international shark management. International 2016 actions included supporting projects aimed at assisting other governments with training and tools to improve implementation of the CITES shark and ray listings that were adopted at the 16th meeting of the Conference of the Parties to CITES (CoP16) in 2013. These efforts include the continued support of a collaborative project to equip and train Ecuadorian officials in standard genetic techniques to identify shark products in trade. Southeast and Northeast Fisheries Science Center scientists continued collaborations with scientists from several nations as part of the International Commission for the Conservation of Atlantic Tunas (ICCAT) Shark Research and Data Collection Program. These activities included several projects on shortfin makos with Japan, Uruguay, and Portugal dealing with population genetics, age and growth dynamics, as well as two projects using archival satellite tags to determine post-release mortality and stock boundaries, movement patterns, and habitat use. During 2016, ICCAT's Shark Species Group also held a meeting in preparation for the 2017 shortfin mako stock assessment.

At the 90th meeting of the Inter-American Tropical Tuna Commission (IATTC), in July 2016, IATTC adopted two new resolutions on sharks. First, IATTC adopted Resolution C-16-06 (*Conservation Measures for Shark Species with Special Emphasis on Silky Shark (Carcharhinus falciformis), for the years 2017, 2018, and 2019*). Resolution C-16-06 includes fishing restrictions for silky shark on purse seine and longline vessels in the eastern Pacific Ocean (EPO). Second, IATTC adopted Resolution C-16-05 (*Management of Shark Species*), which was a U.S.-sponsored proposal. Resolution C-16-05 includes requirements for safe release procedures for sharks on purse seine vessels and prohibits gear on longline vessels that target sharks in the EPO.

The U.S. delegations to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) and its Shark Working Group (SHARKWG) worked on a new benchmark stock assessment for blue sharks that will be completed in mid-2017. The goals for the new stock assessment are to update the time-series data and develop an age-structured model. Working with Mexican collaborators at Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Southwest Fisheries Science Center scientists conducted the first bilateral stock assessment of common thresher sharks along the west coast of North America[4], which was completed in 2016. However, concerns about the reproductive parameters used in the stock assessment led to the recommendation to update the stock assessment using parameters from the Atlantic until a revised study could be conducted for the Northeast Pacific.

The Western and Central Pacific Fisheries Commission agreed to begin development of a comprehensive approach to shark and ray management, with a view to adopting a new conservation and management measure in 2018. Detailed information on international shark-related efforts during 2016 is provided in Section 3 of the appendix. References and internet sources used to compile this report can be found in Section 6 of the appendix.

Table 1

Status of Shark Stocks and Stock Complexes in U.S. Fisheries as of December 31, 2016

Fishery Management Council (FMC)	Fishery Management Plan (FMP) or Fishery Ecosystem Plan (FEP)	Stock or Stock Complex	Overfishing	Overfished
New England FMC & Mid-Atlantic FMC	Spiny Dogfish FMP	Spiny dogfish – Atlantic coast	No	No
NMFS Highly Migratory Species Management Division	Consolidated Atlantic Highly Migratory Species FMP	Atlantic large coastal shark complex*	Unknown	Unknown
		Atlantic pelagic shark complex**	Unknown	Unknown
		Atlantic sharpnose shark-Atlantic	No	No
		Atlantic sharpnose shark- Gulf of Mexico	No	No
		Blacknose shark – Atlantic	Yes	Yes
		Blacknose shark – Gulf of Mexico	Unknown	Unknown
		Blacktip shark – Gulf of Mexico	No	No
		Blacktip shark – Atlantic	Unknown	Unknown
		Blue shark – Atlantic and Gulf of Mexico	No	No
		Bonnethead – Atlantic	Unknown	Unknown
		Bonnethead – Gulf of Mexico	Unknown	Unknown
		Dusky shark – Atlantic and Gulf of Mexico	Yes	Yes
		Finetooth shark – Atlantic and Gulf of Mexico	No	No

[4] Teo, S., Rodriquez, E., Sosa-Nishizaki, O. (In Review) Status of Common Thresher Shark along the West Coast of North America. NMFS Tech Memo. NOAA-TM-NMFS-SWFSC-557.

Status of Shark Stocks and Stock Complexes in U.S. Fisheries as of December 31, 2016				
Fishery Management Council (FMC)	**Fishery Management Plan (FMP) or Fishery Ecosystem Plan (FEP)**	**Stock or Stock Complex**	**Overfishing**	**Overfished**
		Porbeagle – Atlantic and Gulf of Mexico	No	Yes
		Sandbar shark – Atlantic and Gulf of Mexico	No	Yes
		Scalloped hammerhead shark – Atlantic and Gulf of Mexico	Yes	Yes
		Shortfin mako – North Atlantic	No	No
		Smoothhound shark complex – Gulf of Mexico	No	No
		Smooth dogfish – Atlantic	No	No
Pacific FMC	Pacific Coast Groundfish FMP	Leopard shark – Pacific Coast	No	Unknown
		Spiny dogfish – Pacific Coast	No	Unknown
		Soupfin (Tope) – Pacific Coast	No	Unknown
Pacific FMC & Western Pacific FMC	U.S. West Coast Fisheries for Highly Migratory Species & Pacific Pelagic FEP	Thresher shark – North Pacific	Unknown	Unknown
		Shortfin mako shark – North Pacific	Unknown	Unknown
		Blue shark – North Pacific	No	No
Western Pacific FMC	FEP for Pelagic Fisheries of the Western Pacific Region (Pacific Pelagic FEP)	Longfin mako shark – North Pacific	Unknown	Unknown
		Oceanic whitetip shark – Tropical Pacific	Yes	Yes
		Salmon shark – North Pacific	Unknown	Unknown
		Silky shark – Tropical Pacific	Yes	Yes
Western Pacific FMC	American Samoa FEP	American Samoa Coral Reef Ecosystem Multi-Species Complex	Unknown	Unknown
Western Pacific FMC	Mariana Archipelago FEP	Guam Coral Reef Ecosystem Multi-Species Complex	Unknown	Unknown
		Northern Mariana Islands Coral Reef Ecosystem Multi-Species Complex	Unknown	Unknown
Western Pacific FMC	Pacific Remote Islands Areas FEP	Pacific Island Remote Areas Coral Reef Ecosystem Multi-Species Complex	Unknown	Unknown
North Pacific FMC	Gulf of Alaska Groundfish FMP	Gulf of Alaska Shark Complex	No	Unknown
North Pacific FMC	Bering Sea/Aleutian Islands Groundfish FMP	Bering Sea/Aleutian Islands Shark Complex	No	Unknown
Western Pacific FMC	Hawaiian Archipelago FEP	Hawaiian Archipelago Coral Reef Ecosystem Multi-Species Complex	Unknown	Unknown

Status of Shark Stocks and Stock Complexes in U.S. Fisheries as of December 31, 2016				
Fishery Management Council (FMC)	**Fishery Management Plan (FMP) or Fishery Ecosystem Plan (FEP)**	**Stock or Stock Complex**	**Overfishing**	**Overfished**
Totals:			5 “yes” 17 “no” 15 “unknown”	7 “yes” 10 “no” 20 “unknown”

* LCS complex assessed in 2006. Since then, species-specific assessments have been performed only on individual species.

** Pelagic sharks are now being assessed individually. The only pelagic sharks that have not had a species-specific assessment are common thresher and oceanic whitetip sharks.

2017 Shark Finning Report to Congress
Appendix

Pursuant to the

Shark Finning Prohibition Act

(Public Law 106-557)

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

Prepared by the
National Marine Fisheries Service

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Section 1: Management and Enforcement

1.1 Management Authority in the United States

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) provides the legal authority for fisheries conservation and management in Federal waters and requires the National Marine Fisheries Service (NMFS) and the eight regional fishery management councils to take specific actions. State agencies and interstate fishery management commissions are bound by State regulators and, in the Atlantic region, by the Atlantic Coast Fisheries Cooperative Management Act.

Development of fishery management plans (FMPs) is the responsibility of one or more of the eight regional fishery management councils, established under the MSA, as well as, the responsibility of the Secretary of Commerce in the case of Atlantic highly migratory species. Since 1990, shark fishery management in Federal waters of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, excluding spiny dogfish, has been the responsibility of the Secretary of Commerce. Spiny dogfish in the Atlantic Ocean are managed by the New England Fishery Management Council (NEFMC) and the Mid-Atlantic Fishery Management Council (MAFMC). In the Pacific, three regional councils are responsible for developing fishery management plans for sharks: The Pacific Fishery Management Council (PFMC), the North Pacific Fishery Management Council (NPFMC), and the Western Pacific Fishery Management Council (WPFMC). The PFMC's area of jurisdiction is the exclusive economic zone (EEZ) off California, Oregon, and Washington; the NPFMC covers Federal waters off Alaska, including the Gulf of Alaska and the Bering Sea/Aleutian Islands; and the WPFMC's jurisdiction covers Federal waters around Hawaii, Guam, American Samoa, the Northern Mariana Islands, and other U.S. non-self-governing insular areas of the Pacific.

In general, waters under the jurisdiction of the individual States extend from the shoreline out to 3 miles (9 nautical miles off Texas, the west coast of Florida, and Puerto Rico); while U.S. waters under Federal management continue from the seaward boundary of each of the coastal States out to 200 nautical miles offshore except where intercepted by the EEZ of another nation. Management of elasmobranchs in State waters usually falls under the authority of State regulatory agencies, which are typically the marine division of the State fish and wildlife departments. Each State develops and enforces its own fishing regulations for waters under its jurisdiction, though federally permitted commercial fishermen in the Atlantic are required to follow Federal regulations regardless of where they are fishing, as a condition of the permit. While States set fishery regulations in their own waters, they are encouraged to adopt compatible regulations between State and Federal jurisdictions. Many coastal States promulgate regulations for shark fishing in State waters that complement or are more restrictive than Federal shark regulations for the U.S. EEZ. Given that many shark nursery areas are located in waters under State jurisdiction, States play a critical role in effective shark conservation and management.

Cooperative management of the fisheries that occur in the jurisdiction of two or more States and Federal waters may be coordinated by an interstate fishery management commission. These commissions are interstate compacts that work closely with NMFS. Three interstate commissions exist: the Pacific States Marine Fisheries Commission (PSMFC), the Atlantic States Marine Fisheries Commission (ASMFC), and the Gulf States Marine Fisheries Commission (GSMFC). The Atlantic Coast Fisheries Cooperative Management Act (ACFCMA) established a special management program between NMFS, the Atlantic coast States, and the ASMFC. Under this legislation, Atlantic States must comply with the management measures approved by this Commission, or risk a Federally-mandated closure by NMFS of the subject fishery (50 CFR part 697).

The Shark Conservation Act of 2010

In January 2011, the President signed the Shark Conservation Act of 2010 (Pub. L. 111-348). This legislation requires that all sharks, except smooth dogfish (*Mustelus canis*), landed from federal waters in the United States be landed with their fins and tail naturally attached to the carcass. Smooth dogfish fins can be removed at sea in certain instances. Additionally, the Shark Conservation Act required the Secretary of Commerce to identify foreign nations that catch sharks in waters beyond any national jurisdiction and that have not adopted a regulatory program for the conservation of sharks that is comparable to that of the United States. NMFS addressed the requirements of the Shark Conservation Act through three separate rulemakings. Two of these rulemakings address domestic provisions of the Shark Conservation Act. A third rule, finalized in 2013, amended the identification and certification procedures under the High Seas Driftnet Fishing Moratorium Protection Act and amended the definition of illegal, unreported, and unregulated (IUU) fishing. All three rulemakings are summarized below.

On January 16, 2013, NMFS published a final rule that set forth identification and certification procedures to implement provisions of the Shark Conservation Act, which amended the High Seas Driftnet Fishing Moratorium Protection Act (Moratorium Protection Act), to address shark conservation in areas beyond any national jurisdiction (78 FR 3338). Under this rule, NMFS will identify nations based on IUU fishing or bycatch of protected living marine resources, and foreign nations with fishing vessels that have been engaged in fishing activities that target or incidentally catch sharks in waters beyond any national jurisdiction, if that nation has not adopted a regulatory program comparable to that of the United States. This rule became effective on January 16, 2013.

On November 24, 2015, NMFS published a final rule regarding the smooth dogfish-specific provisions of the Shark Conservation Act (80 FR 73128). This rule allows fishermen to remove the fins of smooth dogfish at sea if the following criteria are met: 1) 25 percent of retained catch on board the vessel must be smooth dogfish; 2) Federally-permitted smooth dogfish fishermen must possess a State commercial fishing license that allows fishing for smooth dogfish; 3) the vessel is located between the shore and 50 nm and is along the Atlantic Coast (Maine through the east coast of Florida); and 4) the fin-to-carcass ratio does not exceed 12 percent. This rule became effective on March 15, 2016.

On June 29, 2016, NMFS published a final rule that prohibits any person from removing any of the fins of a shark at sea, possessing shark fins on board a fishing vessel unless they are naturally attached to the corresponding carcass, transferring or receiving fins from one vessel to another at sea unless the fins are naturally attached to the corresponding carcass, landing shark fins unless they are naturally attached to the corresponding carcass, or landing shark carcasses without their fins naturally attached (81 FR 42285). This prohibition noted the limited exception for smooth dogfish as implemented in the November 25, 2015 final rule. This rule became effective on July 29, 2016.

1.2 2016 Conservation and Management Actions in the Atlantic Ocean

Atlantic Highly Migratory Species Management

In 1993, the Highly Migratory Species (HMS) Management Division began managing Atlantic sharks, except spiny dogfish, with the publication of the 1993 FMP for Sharks of the Atlantic Ocean. In 1999, NMFS revised the 1993 FMP and published the 1999 FMP for Atlantic tunas, swordfish, and sharks (1999 FMP). The 1999 FMP, among other things, prohibited the practice of shark finning for species managed under the FMP. In 2006, the 1999 FMP for Sharks of the Atlantic Ocean was replaced with the final Consolidated Atlantic HMS FMP, which consolidated management of all Atlantic HMS under one plan, reviewed current information on shark essential fish habitat, required shark dealers to attend shark identification workshops, and included measures to address overfishing of finetooth sharks (71 FR 58058). The 2006 Consolidated Atlantic HMS FMP also strengthened enforcement of the prohibition on shark finning by requiring the second dorsal and anal fin to remain on shark carcasses through landing. The 2006 Consolidated Atlantic HMS FMP manages several species of sharks.

As noted above, the Shark Conservation Act of 2010 expanded the requirement to land sharks with fins naturally attached to nearly all sharks caught in the U.S. EEZ. However, the Act also included an exception for smooth dogfish, which are managed by the Atlantic HMS Management Division. The smooth dogfish exception of the Act states that the fins-attached requirement does "not apply to an individual engaged in commercial fishing for smooth dogfish (*Mustelus canis*)," under limited circumstances.

Table 1.2.1 lists the species in each species complex and management group. The 2008–2016 annual commercial shark landings are shown in Table 1.2.2, separated by species group. A more detailed breakdown of 2016 commercial shark landings relative to the 2016 quotas are shown in Tables 1.2.3, 1.2.4, and 1.2.5. Table 1.2.3 shows 2016 commercial shark landings for species and species groups with a Gulf of Mexico-specific quota. Table 1.2.4 shows 2016 commercial shark landings for species and species groups with an Atlantic-specific quota. Finally, Table 1.2.5 shows 2016 commercial shark landings for species and species groups without region-specific quotas.

Table 1.2.1 U.S. Atlantic shark management units, shark species for which retention is prohibited, and data-collection-only species.

Sharks in the Consolidated Atlantic HMS FMP			
Large Coastal Sharks (LCS)		Small Coastal Sharks (SCS)	
Aggregated LCS Management Group		**Non-Blacknose SCS Management Group**	
Spinner	*Carcharhinus brevipinna*	Finetooth	*Carcharhinus isodon*
Silky*	*Carcharhinus falciformis*	Atlantic sharpnose	*Rhizoprionodon terraenovae*
Bull	*Carcharhinus leucas*	Bonnethead	*Sphyrna tiburo*
Blacktip***	*Carcharhinus limbatus*	**Blacknose Sharks**	

Sandbar**	*Carcharhinus plumbeus*
Tiger	*Galeocerdo cuvier*
Nurse	*Ginglymostoma cirratum*
Lemon	*Negaprion brevirostris*
Hammerhead Shark Management Group	
Scalloped hammerhead	*Sphyrna lewini*
Great hammerhead	*Sphyrna mokarran*
Smooth hammerhead	*Sphyrna zygaena*

Blacknose	*Carcharhinus acronotus*
Pelagic Sharks	
Pelagic Sharks other than Porbeagle or Blue	
Common thresher	*Alopias vulpinus*
Oceanic whitetip	*Carcharhinus longimanus*
Shortfin mako	*Isurus oxyrinchus*
Porbeagle Sharks	
Porbeagle	*Lamna nasus*
Blue Sharks	
Blue	*Prionace glauca*
Smoothhound Sharks	
Smooth dogfish****	*Mustelus canis*
Florida smoothhound	*Mustelus norrisi*
Gulf smoothhound	*Mustelus sinusmexicanus*

Prohibited Species			
Bignose	*Carcharhinus altimus*	Bigeye thresher	*Alopias superciliosus*
Galapagos	*Carcharhinus galapagensis*	Narrowtooth	*Carcharhinus brachyurus*
Dusky	*Carcharhinus obscurus*	Caribbean reef	*Carcharhinus perezii*
Night	*Carcharhinus signatus*	Smalltail	*Carcharhinus porosus*
Sand tiger	*Carcharias taurus*	Sevengill	*Heptranchias perlo*
White	*Carcharodon carcharias*	Sixgill	*Hexanchus griseus*
Basking	*Cetorhinus maximus*	Bigeye sixgill	*Hexanchus nakamurai*
Bigeye sand tiger	*Odontaspis noronhai*	Longfin mako	*Isurus paucus*
Whale	*Rhincodon typus*	Caribbean sharpnose	*Rhizoprionodon porosus*
		Atlantic angel	*Squatina dumeril*
Deepwater and Other Species (Data Collection Only)			
Iceland catshark	*Apristurus laurussoni*	Green lanternshark	*Etmopterus virens*
Smallfin catshark	*Apristurus parvipinnis*	Marbled catshark	*Galeus arae*
Deepwater catshark	*Apristurus profundorum*	Cookiecutter shark	*Isistius brasiliensis*
Broadgill catshark	*Apristurus riveri*	Bigtooth cookiecutter	*Isistius plutodus*
Japanese gulper shark	*Centrophorus acus*	American sawshark	*Pristiophorus schroederi*
Gulper shark	*Centrophorus granulosus*	Blotched catshark	*Scyliorhinus meadi*
Little gulper shark	*Centrophorus uyato*	Chain dogfish	*Scyliorhinus retifer*
Portuguese shark	*Centroscymnus coelolepis*	Dwarf catshark	*Scyliorhinus torrei*
Kitefin shark	*Dalatias licha*	Smallmouth velvet dogfish	*Scymnodon obscures*
Flatnose gulper shark	*Deania profundorum*		
Bramble shark	*Echinorhinus brucus*	Greenland shark	*Somniosus microcephalus*
Lined lanternshark	*Etmopterus bullisi*	Pygmy shark	*Squaliolus laticaudus*
Broadband dogfish	*Etmopterus gracilispinnis*	Roughskin spiny dogfish	*Squalus asper*
Caribbean lanternshark	*Etmopterus hillianus*		
Great lanternshark	*Etmopterus princeps*	Blainville's dogfish	*Squalus blainvillei*
Smooth lanternshark	*Etmopterus pusillus*	Cuban dogfish	*Squalus cubensis*
Fringefin lanternshark	*Etmopterus schultzi*		

*Not allowed for recreational harvest.
**Can only be harvested within a shark research fishery, and not allowed for recreational harvest.
***Blacktip shark is part of its own management group in the Gulf of Mexico Region.
**** Smooth dogfish is the only smoothhound species in the Atlantic Region.

Table 1.2.2 Commercial landings for Atlantic large coastal, small coastal, pelagic, and smoothhound sharks in metric tons dressed weight, 2008–2016. Source: Cortés pers. comm. (2008-2012) and HMS eDealer database (2013-2016).

Commercial Shark Landings (mt)									
Species Group	2008	2009	2010	2011	2012	2013	2014	2015	2016
Large Coastal Sharks	618	686	711	666	656	639	566	774	581
Small Coastal Sharks	283	303	162	267	302	201	197	251	169
Pelagic Sharks	106	91	141	141	142	117	163	98	109
Smoothhound Sharks*	*	*	*	*	*	*	*	*	318
Total	**1,007**	**1,080**	**1,014**	**1,074**	**1,100**	**957**	**926**	**1,123**	**1,177**

Data changes from previous year's table are due to updated information.
* Smoothhound sharks were not federally managed until 2016 and landings reports were not required. Thus, landings data before 2016 are incomplete.

Table 1.2.3 Landings estimates from the Gulf of Mexico region in metric tons (mt) and pounds (lb) dressed weight (dw) for the 2016 Atlantic shark commercial fisheries; Includes any landings south and west 25° 20.4' N. long. Landings are based on dealer data provided through the HMS eDealer database.

2016 Gulf of Mexico Landings Estimates				
Sub-Region	Shark Management Group	2016 Quota	Estimated Landings in 2016	% of 2016 Quota
Eastern Gulf of Mexico (East of 88° W. lat. only)	Blacktip	28.9 mt dw (63,189 lb dw)	20.2 mt dw (44,482 lb dw)	70%
	Aggregated Large Coastal (quota linked to Hammerhead)	85.5 mt dw (188,593 lb dw)	56.4 mt dw (124,355 lb dw)	66%
	Hammerhead (quota linked to Agg. LCS)	13.4 mt dw (29,421 lb dw)	6.5 mt dw (14,348 lb dw)	49%
Western	Blacktip	266.5 mt dw (587,396 lb dw)	165.7 mt dw (365,268 lb dw)	62%

2016 Gulf of Mexico Landings Estimates				
Sub-Region	Shark Management Group	2016 Quota	Estimated Landings in 2016	% of 2016 Quota
Gulf of Mexico (West of 88° W. lat. only)	Aggregated Large Coastal (quota linked to Hammerhead)	72.0 mt dw (158,724 lb dw)	66.1 mt dw (145,624 lb dw)	92%
	Hammerhead (quota linked to Agg. LCS)	11.9 mt dw (26,301 lb dw)	16.8 mt dw (37,133 lb dw)	141%
N/A	Non-Blacknose Small Coastal	107.3 mt dw (236,603 lb dw)	73.8 mt dw (162,785 lb dw)	69%
	Smoothhound	336.4 mt dw (741,627 lb dw)	0 mt dw (0 lb dw)	0%

Table 1.2.4 Landings estimates from the Atlantic region in metric tons (mt) and pounds (lb) dressed weight (dw) for the 2016 Atlantic shark commercial fisheries; Includes any landings north of 25° 20.4' N. lat. Landings are based on dealer data provided through the HMS eDealer database.

2016 Atlantic Region Landings Estimates			
Shark Management Group	**2016 Quota**	**Estimated Landings in 2016**	**% of 2016 Quota**
Aggregated Large Coastal (quota linked to Hammerhead)	168.9 mt dw (372,552 lb dw)	162.0 mt dw (357,078 lb dw)	96%
Hammerhead (quota linked to Agg. Large Coastal)	27.1 mt dw (59,736 lb dw)	14.0 mt dw (30,900 lb dw)	52%
Non-Blacknose Small Coastal (quota linked to Blacknose south of 34° N. lat. only)	264.1 mt dw (582,333 lb dw)	83.1 mt dw (183,225 lb dw)	31%
Blacknose (South of 34° N. lat. only)	15.7 mt dw (34,653 lb dw)	12.2 mt dw (26,842 lb dw)	77%

2016 Atlantic Region Landings Estimates			
Shark Management Group	**2016 Quota**	**Estimated Landings in 2016**	**% of 2016 Quota**
Smoothhound	1,201.7 mt dw (2,647,725 lb dw)	318.3 mt dw (701,727 lb dw)	27%

[1] NMFS reduced the retention limit for the commercial aggregated LCS and hammerhead shark management groups in the Atlantic region for directed shark limited access permit holders from 45 LCS other than sandbar sharks per vessel per trip to 25 LCS other than sandbar sharks per vessel per trip on October 19, 2016.

Table 1.2.5 Landings estimates for quotas without a region in metric tons (mt) and pounds (lb) dressed weight (dw) for the 2016 Atlantic shark commercial fisheries. Landings are based on dealer data provided through the HMS eDealer database.

2016 Landings Estimates for Quotas without Regions			
Shark Management Group	2016 Quota	Estimated Landings in 2016	% of 2016 Quota
Shark Research Fishery (Aggregated LCS)	50.0 mt dw (110,230 lb dw)	19.4 mt dw (42,725 lb dw)	39%
Shark Research Fishery (Sandbar only)	90.7 mt dw (199,943 lb dw)	52.2 mt dw (115,034 lb dw)	58%
Blue	273.0 mt dw (601,856 lb dw)	0.3 mt dw (607 lb dw)	0%
Porbeagle	1.7 mt dw (3,748 lb dw)	0 mt dw (0 lb dw)	0%
Pelagic Sharks Other Than Porbeagle or Blue	488.0 mt dw (1,075,856 lb dw)	108.4 mt dw (239,048 lb dw)	22%

Shark Stock Assessments and Overfishing/Overfished Status

An updated assessment of dusky sharks was conducted in 2016 under the Southeast Data, Assessment, and Review (SEDAR) process (update assessment to SEDAR 21). The assessment and an addendum concluded that the Atlantic and Gulf of Mexico stock of dusky sharks continues to be overfished, and overfishing is still occurring despite a substantial reduction in the level of overfishing since the previous stock assessment was conducted in 2011 (81 FR 69043; October 5, 2016). Additional details are provided in section 4.

Observer Coverage

Since 2002, observer coverage has been mandatory for selected bottom longline and gillnet vessels to monitor catch and bycatch in the shark fishery and compliance with the 2000 Shark Finning Prohibition Act and requirements under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). The data collected through the observer program is critical for monitoring takes and estimating mortality of protected sea turtles, seabirds, marine mammals, Atlantic sturgeon, and smalltooth sawfish. Data obtained through the observer program are also vital for conducting stock assessments of sharks and for use in the development of fishery management measures for Atlantic sharks. Gillnet observer coverage is also necessary to comply with the requirements of the 2007 Atlantic Large Whale Take Reduction Plan (ALWTRP) (72 FR 34632, June 25, 2007; 72 FR 57104, Oct. 5, 2007).

Atlantic Shark Endangered Species Act Updates

NMFS received a petition from Wild Earth Guardians (WEG) dated January 20, 2010, requesting to list porbeagle sharks (*Lamna nasus*) throughout their entire range, or as Northwest Atlantic, Northeast Atlantic, and Mediterranean Distinct Population Segments (DPS) under the ESA, as well as designate critical habitat for the species. NMFS also received a petition from the Humane Society of the United States (HSUS), dated January 21, 2010, requesting to list a Northwest Atlantic DPS of porbeagle sharks as endangered in the North Atlantic under the ESA. Information contained in the petitions focused on the species' imperilment due to historical and continued overfishing; modification of habitat through pollution, climate change, and ocean acidification; failure of regulatory mechanisms; and low productivity of the species. On July 12, 2010, we published a 90-day finding in the Federal Register (75 FR 39656) stating that neither petition presented substantial information indicating that listing porbeagle sharks may be warranted. Accordingly, a status review of the species was not initiated. In August 2011, the petitioners filed complaints in the U.S. District Court for the District of Columbia challenging our denial of the petitions (Case 1:11–cv–01414–BJR, *Humane Society of the United States v. Blank et al.*). On November 14, 2014, the court published a Memorandum Opinion vacating the 2010 90-day finding for porbeagle shark, and ordering NMFS to prepare a new 90-day finding. The court entered final judgment on December 12, 2014. On March 27, 2015, NMFS reopended the 90-day finding and published a request soliciting scientific and commercial data and other information relevant to the status of porbeagle sharks worldwide (80 FR 16356). NMFS completed another comprehensive status review for porbeagle sharks and issued a 12-month findings on August 1, 2016 (81 FR 50463). Based on the best scientific and commercial information available and taking into account ongoing efforts to protect these species, NMFS has determined that porbeagle sharks do not warrant listing at this time. This review identified two DPSs—North Atlantic and Southern Hemisphere—of porbeagle sharks and concluded that neither is currently in danger of extinction throughout all or a significant portion of its range or likely to become so in the foreseeable future. The review also concluded that the species itself is not in danger of extinction throughout all or a significant portion of its range or likely to become so in the foreseeable future.

On September 21, 2015, NMFS received a petition from Defenders of Wildlife to list the oceanic whitetip shark (*Carcharhinus longimanus*) as threatened or endangered under the ESA throughout its entire range, or, as an alternative, to list two DPSs of the oceanic whitetip shark as threatened or endangered. On January 12, 2016, NMFS issued a positive 90-day finding for the oceanic whitetip shark (81 FR 1376), announcing that the petition presented substantial scientific or commercial information indicating the petitioned action of listing the species may be warranted range wide, and explaining the basis for those findings. Subsequently, NMFS published a proposed rule on December 29, 2016, proposing to list oceanic whitetip sharks as threatened, based on the best scientific and commercial information available and taking into account efforts being made to protect the species (81 FR 96304). The comment period for this proposed rule closed on March 29, 2017.

On August 26, 2014, NMFS received a petition from Friends of Animals to list the common thresher shark (*Alopias vulpinus*) as threatened or endangered under the ESA throughout its entire range, or, as an alternative, to list 6 DPSs of the common thresher shark as threatened or endangered, and designate critical habitat. On April 27, 2015, NMFS received a separate petition from Defenders of Wildlife to list the bigeye thresher shark (*Alopias superciliosus*) as threatened or endangered throughout its range, or, as an alternative, to list any identified DPSs, should we find they exist, as threatened or endangered species. NMFS found that the petitioned actions may be warranted for both species; on March 3, 2015, and August 11, 2015, positive 90-day findings were published for the common thresher (80 FR 11379) and bigeye thresher (80 FR 48061), respectively, announcing that the petitions presented substantial scientific or commercial information indicating the petitioned actions of listing each species may be warranted, and explaining the basis for those findings. NMFS completed comprehensive status reviews under the ESA for the two species of thresher shark in response to the petitions to list those species and on April 1, 2016, published a 12-month finding that neither common thresher nor bigeye thresher sharks is currently in danger of extinction throughout all or a significant portion of its range nor likely to become so within the foreseeable future (81 FR 18979). Based on the best scientific and commercial information available and after taking into account efforts being made to protect these species, NMFS determined that the common thresher and bigeye thresher do not warrant listing.

On April 27, 2015, NMFS received a petition from Defenders of Wildlife to list the smooth hammerhead shark (*Sphyrna zygaena*) as threatened or endangered under the ESA throughout its entire range, or, as an alternative, to list any identified DPSs threatened or endangered. On August 11, 2015, NMFS published a positive 90-day finding (80 FR 48053) announcing that the petition presented substantial scientific or commercial information indicating the petitioned action of listing the species may be warranted and explained the basis for that finding. On June 28, 2016, NMFS announced a 12-month finding that the species does not warrant listing at this time (81 FR 41934). The Agency concluded that the smooth hammerhead sharks are not in danger of extinction throughout all or a significant portion of its range and are not likely to become so within the foreseeable future.

Shark Management by the Regional Fishery Management Councils and States

The Mid-Atlantic and New England Fishery Management Councils and NMFS manage spiny dogfish (*Squalus acanthias),* the only shark species managed by the Regional Fishery Management Councils in Federal waters off the Atlantic Coast, and the largest volume shark fishery in the U.S. These Councils manage spiny dogfish fisheries under the 2000 Spiny Dogfish FMP. The Atlantic States Marine Fisheries Commission manages the fishery with complementary measures in state waters. Spiny dogfish products landed in the United States are almost entirely exported to Europe (meat) and Asia (fins). Most product is landed whole. In 2016, the commercial quota for spiny dogfish was 39 million pounds (2016 fishing year), landings totaled more than 26.3 million pounds, and were valued at more than $5.3 million ($0.20 per pound). Spiny dogfish was not subject to overfishing and was above its biomass target in 2016.

1.3 Current Management of Sharks in the Pacific Ocean

Pacific Fishery Management Council (PFMC)

The PFMC's area of jurisdiction is Federal waters off the coasts of California, Oregon, and Washington. The PFMC and NMFS manage sharks under the 2004 U.S. West Coast HMS Fisheries FMP and the Pacific Coast Groundfish FMP, which was approved in 1982 and most recently amended in 2010. Species included under the West Coast HMS FMP are the common thresher and shortfin mako (sharks commercially valued but not primarily targeted in the West Coast–based fisheries), as well as blue sharks (Table 1.3.1). Amendment 2 to the West Coast HMS FMP and its supporting regulations (76 FR 56327; Sept. 13, 2011) reclassified bigeye thresher and pelagic thresher sharks as ecosystem component species that do not require management. The West Coast HMS FMP also designates three shark species as prohibited (Table 1.3.1). If intercepted during HMS fishing operations, these species—great white, megamouth, and basking sharks—must be released immediately, unless other provisions for their disposition are established consistent with State and Federal regulations.

Table 1.3.1 Shark species in the West Coast Highly Migratory Species Fishery Management Plan.

West Coast Highly Migratory Species FMP		
Group	Common name	Scientific name
Sharks Listed as Management Unit Species	Common thresher Shortfin mako Blue shark	*Alopias vulpinus* *Isurus oxyrinchus* *Prionace glauca*
Sharks Included in the FMP as Ecosystem Component Species	Pelagic thresher Bigeye thresher	*Alopias pelagicus* *Alopias superciliosus*
Prohibited Species	Great white Basking shark Megamouth	*Carcharodon carcharias* *Cetorhinus maximus* *Megachasma pelagios*

Sharks within the West Coast HMS FMP are managed to achieve optimum yield (OY) set at a precautionary level of 75 percent of maximum sustainable yield (MSY). The precautionary approach is meant to prevent localized depletion of these vulnerable species. Blue, thresher and shortfin mako sharks are managed under the West Coast HMS FMP, and while blue and common thresher sharks are not overfished, the status of the shortfin mako sharks is still uncertain. The FMP proposed annual harvest guidelines for common thresher and shortfin mako sharks given the level of exploitation in HMS fisheries at the time the FMP was adopted (e.g., large mesh drift gillnet), and accounting for the uncertainty about catch in Mexico of these straddling stocks. High exploitation rates and their impact on HMS shark stocks, if not checked, could take decades to correct given the vulnerable life history characteristics of the species.

In 2016, the ISC SHARKWG prepared data to conduct a new benchmark assessment of blue sharks in the North Pacific in 2017. The objective was to update the time-series data from the 2014 assessment through 2015, review the latest biological research, and develop an age-structured model to provide conservation advice to managers at the WCPFC. Participants from Japan, Taiwan, Korea, Mexico, Canada, IATTC, and the U.S. contributed data and/or analytical work. The SHARKWG developed two assessment models for consideration at the March 2017 working group meeting in La Jolla. The first was an age-based statistical catch-at-length model developed with Stock Synthesis (SS) (Carvalho *et al.* 2017), and the second was a Bayesian state-space surplus production (BSP) model (Kai *et al.* 2017). The SHARKWG will provide the results of both approaches to the ISC Plenary in July 2017, and if accepted by the Plenary, the assessment will be presented to the WCPFC Science Committee as the basis for conservation and management advice.

In 2015, the Southwest Fisheries Science Center, in collaboration with Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), initiated the first bilateral Northeast Pacific common thresher shark stock assessment. This assessment used reproductive parameters estimated by Smith et al. (2008) for the Northeast Pacific. However, given the dramatic differences in estimates of age at first reproduction for females for the Atlantic and Pacific Oceans (216 cm FL versus 160 cm FL respectively) SWFSC scientists reexamined the data and specimens used by Smith in her study. In 2016, due to concerns about the species ID and other inconsistencies, it was determined that additional analyses and samples would be needed to provide a validated estimate. In the interim it was recommended that the stock assessment be rerun in 2017 using reproductive parameters for common thresher sharks in the Atlantic Ocean.

The Pacific Coast Groundfish FMP, last amended in 2015, includes three shark species: leopard, soupfin, and spiny dogfish, in the groundfish management unit (Table 1.3.2). These shark species are mainly caught incidentally in groundfish fisheries and discarded at sea. In 2013, spiny dogfish were not overfished, but the status was unknown for soupfin and leopard sharks. As part of the PFMC’s biennial specifications process for 2015-16, soupfin shark was reclassified as an Ecosystem Component species, as it is not targeted, is not subject to overfishing or being overfished in the absence of conservation measures, and is not generally retained for sale or personal use. A separate overfishing limit (OFL) and annual catch limit (ACL) were also established for spiny dogfish, beginning in 2015. From 2006 through 2010, NMFS managed spiny dogfish using two-month cumulative trip limits for both open access and limited entry fisheries. Since 2011, most of the limited-entry trawl fishery for groundfish has been managed under an individual quota program, in which vessels are held accountable for their total catch of all species managed with quota shares. However, landings of spiny dogfish by trawlers continue to be managed through a cumulative trip limit, now of 1-month duration. Landing limits for non-trawl vessels remain at two months.

Table 1.3.2 Shark species in the groundfish management unit of the Pacific Coast Groundfish Fishery Management Plan.

Pacific Coast Groundfish FMP	
Sharks Listed as Management Unit Species	
Common name	Scientific name
Soupfin shark (Tope) Spiny dogfish Leopard shark	*Galeorhinus galeus* *Squalus suckleyi* *Triakis semifasciata*

Shark catch data are obtained from commercial landings receipts, observer programs, and recreational fishery surveys. Landings data for the U.S. West Coast are submitted by the States to the Pacific Fisheries Information Network (PacFIN) and Recreational Fisheries Information Network (RecFIN) data repositories. Table 1.3.3 shows commercial shark landings for the West Coast from 2006 to 2016. Estimates of commercial discards, as well as catch in the at-sea hake fishery, are developed by the West Coast Groundfish Observer Program, at the NMFS Northwest Fisheries Science Center. Additional recreational data collection and estimation of recreational catch are also conducted by NMFS. Data from all of these sources are used for monitoring and management by the PFMC. Recreational shark fishing, primarily for common thresher and shortfin mako shark, is popular among anglers seasonally in Southern California waters. Data collected formerly through the Marine Recreational Fisheries Statistics Survey (MRFSS) and now through the California Recreational Fisheries Survey (CRFS) is used as the best available information regarding shark catch and effort in Southern California Waters.

Table 1.3.3 Commercial Shark landings (round weight equivalent in metric tons) for California, Oregon, and Washington, 2006–2016. Source: PacFIN Database, data for the Pacific Fishery Management Council area extracted using the “Explorer” tool on November 24, 2017.

	Commercial Shark Landings (mt) for California, Oregon, and Washington										
Species Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Bigeye thresher shark	4	5	6	7	1	1	<1	1	1	1	1
Blue shark	<1	10	<1	1	<1	<1	<1	<1	0	1	<1
Brown catshark	--	--	--	--	11	4	14	1	1	8	5
Common thresher shark	160	204	147	107	96	76	70	66	40	57	49
Leopard shark	11	11	3	2	3	2	3	1	3	4	6
Pacific angel shark	15	8	12	12	9	10	10	11	8	14	19
Pelagic thresher shark	<1	2	<1	<1	<1	--	1	6	6	3	<1
Shortfin mako	45	44	35	29	21	19	27	30	24	20	30
Soupfin shark	30	17	8	5	3	3	2	1	2	3	6
Spiny dogfish	394	425	638	264	230	409	215	160	228	395	301

Other shark	4	2	2	2	3	1	2	1	2	6	1
Unspecified shark	5	5	2	2	20	4	3	2	4	7	4
Total	**668**	**733**	**853**	**431**	**397**	**528**	**357**	**274**	**319**	**518**	**422**

[A]This extraction includes all commercial landings, in West Coast U.S. ports, of sharks caught in areas managed by the PFMC. This is a change from some prior years, in which West Coast landings of sharks caught in Alaska, Canada, and Puget Sound were included (via the use of PacFIN Report #307). This summary does not include estimates of commercial discards or any recreational catch.
Data changes from previous year's table are due to updated information.

North Pacific Fishery Management Council (NPFMC)

The NPFMC and NMFS manage fisheries in Federal waters off Alaska. Eleven shark species are found in the Alaskan waters (Table 1.3.4; Goldman 2012). NMFS monitors shark catch in season for Pacific sleeper, salmon, and spiny dogfish sharks and the remaining species of sharks are grouped into the "other/unidentified sharks". Pacific sleeper, salmon, and spiny dogfish sharks are taken incidentally in Federal groundfish fisheries, while the other eight species are very rarely taken in any sport or commercial fishery.

Table 1.3.4 North Pacific shark species.

North Pacific shark species	
Common name	Scientific name
Pacific sleeper shark	*Somniosus pacificus*
Salmon shark	*Lamna ditropis*
Spiny dogfish shark	*Squalus suckleyi*
Brown cat shark	*Apristurus brunneus*
Basking shark	*Cetorhinus maximus*
Sixgill shark	*Hexanchus griseus*
Blue shark	*Prionace glauca*
Pacific angel shark	*Squatina californica*
White shark	*Carcharodon carcharias*
Common thresher shark	*Alopias vulpinus*
Soupfin shark	*Galeorhinus glaeus*

In Federal waters, sharks are currently in a "bycatch only" status, which prohibits directed fishing for the species. In the Bering Sea/Aleutian Islands (BSAI), most of the shark incidental catch occurs in the midwater trawl pollock fishery and in the hook-and-line fisheries for sablefish, Greenland turbot, and Pacific cod along the outer continental shelf and upper slope areas. In the Gulf of Alaska (GOA), most of the shark incidental catch occurs in the midwater trawl pollock fishery, non-pelagic trawl fisheries, and hook-and-line Pacific cod, sablefish, and halibut fisheries. The most recent estimates of the incidental catch of sharks in the BSAI and GOA are from 2016. These data are included in Chapter 20 in the 2016 BSAI and GOA Stock Assessment and Fishery Evaluation (SAFE) reports and the NMFS catch accounting system. Estimates of the incidental catch of sharks in the groundfish fisheries from 2006 through 2016 have ranged from 523 to 2,180 mt in the GOA and from 61 to 688 mt in the BSAI (Table 1.3.5). Very few sharks incidentally taken in the groundfish fisheries in the GOA and BSAI are retained. There has been no effort targeting sharks in the BSAI or GOA since 2006.

Table 1.3.5 Incidental catch and utilization (in metric tons) of sharks in the Gulf of Alaska and Bering Sea/Aleutian Islands commercial groundfish fisheries, 2006-2016.
(Values are rounded to nearest metric ton)
Source: NMFS Catch Accounting System Data

Incidental Catch of Sharks (mt) - Gulf of Alaska											
Species	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Spiny dogfish	1,188	797	533	1,653	404	485	458	2,076	1,323	957	1,848
Pacific sleeper shark	252	295	66	56	168	27	142	95	72	71	78
Salmon shark	34	141	7	9	107	7	50	3	145	371	80
Unidentified shark	83	107	12	24	9	5	10	6	6	17	7
Total	**1,557**	**1,340**	**618**	**1,742**	**688**	**523**	**661**	**2,180**	**1,546**	**1416**	**2,014**
% Retained	4.2	3.4	6.8	3.3	5.7	2.8	2.6	0.6	0.9	1.4	0.7
Incidental Catch of Sharks (mt) - Bering Sea/Aleutian Islands											
Spiny dogfish	7	3	17	20	15	8	20	23	52	33	41
Pacific sleeper shark	313	257	127	51	28	48	47	65	63	62	80
Salmon shark	63	44	41	71	12	47	26	23	52	33	41
Unidentified shark	305	28	7	10	6	5	3	1	2	3	1
Total	**688**	**332**	**192**	**152**	**61**	**107**	**96**	**113**	**136**	**107**	**127**
% Retained	3.9	9.8	6.7	4.1	6.3	6.4	3.6	2.0	3	2.2	4

Data changes from previous year's table are due to updated information.

In October 2010, NMFS issued a final rule to implement Amendments 95 and 96 to the BSAI FMP and Amendment 87 to the GOA FMP (75 FR 61639) to comply with statutory requirements for annual catch limits and accountability measures (under National Standard 1), and to rebuild overfished stocks. NMFS specified the NPFMC recommended overfishing levels (OFLs), acceptable biological catch (ABCs), and total allowable catch (TAC) amounts. Due to conservation concerns, the final rules to implement groundfish harvest specifications in the BSAI and GOA in 2016 and 2017 prohibited directed fishing for sharks in both management areas. In other groundfish fisheries open to directed fishing, the retention of sharks taken as incidental catch is limited to no more than 20 percent of the aggregated amount of sharks, skates, octopuses, and sculpins in the BSAI, and 20 percent of the aggregated amount of sharks, octopuses, squids, and sculpins in the GOA.

At its December 2015 meeting, the NPFMC recommended OFLs, ABCs, and TACs for sharks in both the BSAI and GOA for the 2016 and 2017 fishing years. The GOA TAC was based in large part on the natural mortality and biomass estimates for spiny dogfish combined with an average historical catch (1997-2007) of other shark species, while the BSAI TAC was set at a value of 130 metric tons (mt), substantially less than that recommended ABC, which was based on historical maximum catch (1997-2007) of all the shark species. Table 1.3.5 lists the recent historical catch of sharks in the BSAI and GOA. In 2016, the BSAI TAC was 130 mt, and catch was 127 mt. The 2016 GOA TAC was 4,514 mt, and catch was 1,414 mt. The most recent assessments for sharks are in Chapter 20 to the 2016 SAFE reports for the BSAI and GOA, which is currently available online.

The shark complexes in the BSAI and GOA are assessed biennially, with update only assessments in the off years, to coincide with the availability of new survey data. Thus, the most recent BSAI SAFE report was completed in 2016 and the most recent GOA SAFE report was completed in 2015. In the BSAI, NMFS conducts surveys annually in the Eastern Bering Sea shelf and triennially along the deeper slope area in the BSAI for all groundfish, including sharks. In the GOA, NMFS conducts surveys biennially for groundfish, including sharks. The most recent surveys were conducted in 2016 on the BSAI slope and 2016 on the shelf and in 2015 in the GOA, with the results incorporated into the SAFE reports for sharks.

The North Pacific Observer Program was restructured in 2013. As a result, observers are now deployed on smaller vessels and vessels fishing in the Pacific halibut Individual Fishing Quota fishery, which were previously unobserved. Details of the restructuring are provided in Faunce et al. (2014). The restructuring in essences created a new time series of catch, which more accurately reflects catch of sharks in both the GOA and BSAI. Analyses are ongoing to determine the overall impact of the new catch time series and how it effects the stock assessments.

Commercial shark fishing in State waters
State of Alaska regulation 5 AAC 28.084 prohibits directed commercial fishing of sharks statewide unless a commissioners permit is issued (5 AAC 28.379). In 2006, one commissioners permit was issued for a spiny dogfish permit fishery in the Cook Inlet area, this fishery was not successful. Sharks taken incidentally to commercial groundfish and salmon fisheries may be retained and sold provided that the fish are fully utilized as described in 5 AAC 28.084. In the Southeast, the State limits the amount of incidentally taken sharks that may be retained (5AAC 28.174 (1) and (2)). In addition, in the East Yakutat Section and the Icy Bay Subdistrict salmon gillnetters may retain all spiny dogfish taken as bycatch during salmon gillnet operations (5AAC 28.174 (3)). Since 2014, in Prince William Sound and Cook Inlet, an emergency order is issued annually which sets bycatch limits in the halibut, directed groundfish, and drift or set gillnet (herring or salmon) fisheries. Participants in these fisheries may retain 15 percent shark species in aggregate, which includes spiny dogfish, of the round weight of their target species. All sharks landed must be recorded on an ADF&G fish ticket.

Western Pacific Fishery Management Council (WPFMC)
The WPFMC's area of jurisdiction includes the EEZ around Hawaii, American Samoa, Guam, the Northern Mariana Islands, and the Pacific Remote Islands Areas (PRIA). The Western Pacific Fishery Management Council and NMFS conserve and manage sharks through five fishery ecosystem plans. The WPFMC's Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region identifies nine sharks as management unit species (Table 1.3.6). Five species of coastal sharks are listed in the fishery ecosystem plans for American Samoa, Hawaii, the Mariana Archipelago, and the Pacific Remote Islands Areas (Table 1.3.7) as currently harvested.

The longline fisheries in the western Pacific, mostly in Hawaii and American Samoa, landed the vast majority of the sharks. Shark landings (estimated whole weight) by the Hawaii-based longline fisheries peaked at about 2,870 mt in 1999, largely due to the finning of blue sharks, which is now prohibited. A State of Hawaii law prohibiting landing shark fins without an associated carcass was passed in mid-2000 (Hawaii Revised Statutes 188.40-5). Shark landings decreased by almost 50 percent to 1,450 mt in 2000. With the subsequent enactment of the Federal Shark Finning Prohibition Act, shark landings since 2001 have been less than 200 mt (Table 1.3.8). Landings in 2016 were approximately 75 mt. Today, sharks are marketed as fresh shark fillets and steaks in Hawaii supermarkets and restaurants and are also exported to the U.S. mainland.

Table 1.3.6 Sharks in the management unit of the Fishery Ecosystem Plan for Western Pacific Pelagic Fisheries (as amended December 2009).

Western Pacific Pelagic Fisheries FEP	
Common name	Scientific name
Common thresher shark	*Alopias vulpinus*
Pelagic thresher shark	*Alopias pelagicus*
Bigeye thresher shark	*Alopias superciliosus*
Silky shark	*Carcharhinus falciformis*
Oceanic whitetip shark	*Carcharhinus longimanus*
Shortfin mako shark	*Isurus oxyrinchus*
Longfin mako shark	*Isurus paucus*
Salmon shark	*Lamna ditropis*
Blue shark	*Prionace glauca*

Table 1.3.7 Coastal sharks listed as management unit species and designated as currently harvested coral reef taxa in the four Western Pacific Fishery Ecosystem Plans. Other coastal sharks in the management unit of the FEP belonging to the families Carcharhinidae and Sphyrnidae are designated as potentially harvested coral reef taxa.

Western Pacific Fishery Ecosystem Plans					
Sharks Listed as Management Unit Species and Designated as Currently Harvested Coral Reef Taxa					
Common Name	Scientific Name	American Samoa FEP	Hawaii FEP	Marianas FEP	PRIA FEP
Silvertip shark	*Carcharhinus albimarginatus*	X	-	X	X
Grey reef shark	*Carcharhinus amblyrhynchos*	X	X	X	X

Galapagos shark	*Carcharhinus galapagenis*	X	X	X	X
Blacktip reef shark	*Carcharhinus melanopterus*	X	X	X	X
Whitetip reef shark	*Triaenodon obesus*	X	X	X	X

The American Samoa longline fishery lands a small amount of sharks compared to Hawaii's longline fisheries (Table 1.3.8). The pattern of shark landings by the American Samoa longline fishery was similar to shark landings by the Hawaii-based longline fisheries and has remained low since 2011. The decline in shark landings by the American Samoa longline fishery is attributed to the Shark Finning Prohibition Act.

Table 1.3.8 Shark landings (in metric tons) from the Hawaii-based and American Samoa-based pelagic longline fisheries, 2007–2016.
Source: Pacific Islands Fisheries Science Center, Fisheries Research and Monitoring Division.

	Species	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hawaii-based Longline Fisheries	Blue shark	11	6	8	10	9	16	19	2	1	1	1
	Mako shark	95	127	130	119	92	65	69	52	53	59	70
	Thresher shark	33	44	42	31	17	19	14	6	7	7	4
	Misc. shark	11	8	5	6	4	3	2	0	0	0	0
	Total shark landings	**151**	**186**	**186**	**166**	**122**	**102**	**104**	**60**	**61**	**67**	**75**
American Samoa	Total shark landings	**1**	**2**	**1**	**1**	**2**	**4**	**4**	**1**	**1**	**1**	**1**

ESA listing petitions

In 2014, Friends of Animals petitioned NMFS to list the common thresher shark under the ESA. In 2015, Defenders of Wildlife petitioned NMFS to list the smooth hammerhead, oceanic whitetip shark, and the bigeye thresher shark under the ESA. Following review of the status of these species, NMFS determined that listing smooth hammerhead, common and bigeye thresher sharks under the ESA was not warranted. On December 29, 2016, NMFS proposed to list the oceanic whitetip shark as a threatened species (81 FR 96304).

Protected Species Workshop Trainings

Western Pacific longline fishing vessel owners and captains are required to complete annual training on protected species. In 2016, SFD staff included content on regulations regarding oceanic whitetip shark, silky shark, and whale sharks into these training workshops. These regulations include prohibiting the retention of oceanic whitetip and silky sharks, and requirements to release these sharks, by longline vessels while fishing in the Convention Area of the Western and Central Pacific Fisheries Commission (WCPFC). For more information on these regulations, see Section 3.2 Regional Efforts.

1.4 NOAA Enforcement of the Shark Finning Prohibition Act

The NMFS Office of Law Enforcement (OLE) has responsibility for enforcing the Shark Finning Prohibition Act (SFPA) of 2000 and implementing regulations. During 2016, violations of the SFPA and noncompliance with regulations to protect sharks have been investigated in the Pacific Islands, West Coast, Northeast and Southeast Enforcement Divisions. Violations which were investigated included finning by U.S. domestic fishing vessels and the illegal importation of shark fins.

- In November of 2016, a NMFS enforcement officer responded to a complaint from the Hawaii Observer Program concerning a pelagic longline fishing vessel, wherein the crew reportedly removed the fins from a short finned mako shark prior to landing. The assigned federal fishing vessel observer detected the violation after rechecking the contents of the vessel's ice hold and discovered that the previously intact short finned mako shark that he had measured, subsequently had its head, dorsal and pectoral fins removed while the vessel was still at sea. The investigating officer determined that a member of the crew had completely removed the animal's fins in apparent violation. A Summary Settlement Offer (SSO) was issued to the vessel master in the amount of $1,000 for landing a shark carcass without the fins naturally attached. The SSO was accepted, and paid by the vessel owner.

- While performing an offload inspection of a commercial fishing vessel in Point Pleasant, New Jersey in August of 2016, a NMFS enforcement officer observed the landing of six (6) thresher sharks and four (4) blacktip sharks without their corresponding heads, tails or fins attached. Further investigation disclosed that one of the reported thresher sharks was actually a spinner shark, and that all sharks had been harvested in state waters of New Jersey. The shark finning violation was forwarded to the New Jersey Department of Environmental Protection's Bureau of Law Enforcement for further action. Additional detected federal violations included fishing for Atlantic Sharks in the EEZ without a federal permit and failing to comply in accurate and timely reporting of fishing vessel trip reports. A written warning was issued to the vessel operator by NMFS OLE.

- On May 21, 2016 a NMFS OLE special agent was notified by a SEATAC airport cargo employee of a trans-shipment thought to contain shark fins. Inspection by OLE revealed 27 out of 41 sacks (approx. 695 lbs.) labeled as dried fish maw in fact contained dried shark fins and were not recorded on the airway bill accompanying the shipment, and the shark fins were seized. The claimants (the shipper, the import company, and the issuing carrier's agent) forfeited the product to the United States.

- In April of 2016, Louisiana Department of Wildlife and Fisheries officers were conducting a federal fisheries patrol pursuant to an agreement under NMFS OLE's Cooperative Enforcement Program in the Gulf of Mexico. During the patrol, they conducted a boarding of a recreational fishing vessel in federal waters. While conducting an inspection of the vessel, eleven (11) shark fins without corresponding carcasses were discovered in addition to 94 closed season red snapper, 40 of which were undersized. The vessel operator was issued a Notice of Violation and Assessment (NOVA) administrative penalty in the final, settled amount of $10,800 that was paid by the respondent.

- During an inspection of a HMS longline fishing vessel by a U.S. Coast Guard boarding team in San Pedro, California, four (4) detached shark fins without a corresponding carcass were found on the vessel during offloading. A NMFS special agent issued a SSO in the amount of $2,000 to the vessel master that was accepted and paid in March of 2016.

- On February 27, 2016, Louisiana Department of Wildlife and Fisheries officers were conducting a federal fisheries patrol pursuant to an agreement under the NMFS OLE's Cooperative Enforcement Program. During the patrol, they conducted a boarding and inspection of a commercial fishing vessel registered in Florida. The vessel master was found to be in possession of nineteen (19) large coastal sharks with no fins attached. Moreover, a search of the vessel failed to produce any corresponding fins. A case package was subsequently prepared by a NMFS OLE special agent and was forwarded to the NOAA Office of General Counsel – Enforcement Section (GCES) for prosecution. A NOVA administrative penalty was issued by GCES, and the vessel master paid $9,000 in a final settlement agreement with NMFS.

- Also in February of 2016, NMFS enforcement personnel participated in joint boarding investigations with U.S. Customs and Border Protection (CBP), U.S. Homeland Security Investigations (HSI) and the U.S. Coast Guard (USCG) in Honolulu, Hawaii. During the boarding and inspection of a Hawaii pelagic longline limited entry fishing vessel, six (6) shark fins without corresponding carcasses were discovered onboard. The shark fins were found stored in a chest freezer in a passageway of the vessel. No corresponding carcasses were located onboard and fin specific species identification proved to be difficult. Due to a prior violation by this vessel for finning sharks in 2015, an investigative case package was prepared, and forwarded to the NOAA GCES, for further disposition and potential administrative prosecution.

1.5 Education and Outreach

The U.S. National Plan of Action for the Conservation and Management of Sharks states that each U.S. management entity (i.e., NMFS, Regional Fishery Management Councils, Interstate Marine Fisheries Commissions, and States) should cooperate with regard to education and outreach activities associated with shark conservation and management. As part of the effort to implement the U.S. National Plan of Action, NMFS, OLE, and other U.S. shark management entities have completed the following actions:

- In October of 2016, NMFS enforcement officers attended a shark identification training workshop in Somerville, MA where they conducted education and outreach with participants. The training was attended by Federally-permitted HMS dealers and Massachusetts Environmental Police officers.

- In September of 2016, NMFS enforcement officers conducted a multi-agency saturation operation focused on the Shark and Tuna Tournament in Newburyport, MA. Prior to the start of the tournament, the officers provided a presentation at the captains meeting to inform participants of recent changes to the HMS regulations. Over 36 inspections were conducted and regulatory compliance was very high.

- During June 2016, NMFS enforcement officers provided education and outreach to approximately 200 fishermen at the 30th Annual Star Island Shark Tournament in Montauk, NY. The officers assisted vessel owners with obtaining HMS permits and provided compliance information regarding HMS shark fishing regulations.

- To facilitate identification of Atlantic sharks, the HMS Management Division requires that all Federal Atlantic shark dealers attend a mandatory Atlantic Shark Identification Workshop at least once every three years. These free, monthly workshops provide hands-on training to help identify both processed and whole sharks to the species level. State and Federal fish and wildlife law enforcement officers also frequently attend these workshops, which are conducted throughout the entire Atlantic and Gulf of Mexico coasts. A total of 23 Atlantic Shark Identification Workshops were held in 2016.

- The Greater Atlantic Regional Fisheries Office (GARFO) and the Northeast Fisheries Science Center (NEFSC) work together to provide the public with information about shark and skate species found in the Northwest Atlantic Ocean. This includes collaborating and coordinating media interviews with shark experts to highlight recent research as well as offering updated information about shark-related (i.e., spiny dogfish and skates) management actions.

- Staff from NMFS NEFSC attend Northeast U.S. recreational shark fishing tournaments, captains meetings, and local sport fishing shows to inform participants on current shark management regulations and discuss and answer questions on current research. Annually, the NEFSC tagging booklet is updated, detailing tagging and recapture instructions, catch and release guidelines, research results, length and weight information, management regulations, and contact websites and telephone numbers. This booklet along with tags and identification guides and placards are made available to the fishing public and is also mailed to NMFS Cooperative Shark Tagging Program participants. Feedback is given to tournament officials on historic tournament landings to encourage further shark conservation measures and to facilitate better catch and release practices.

- NEFSC staff developed a summary of safe release practices for sharks which was added to the standard packet of information sent to new CSTP taggers and is included when current taggers request more tags. This was in response to the rise in U.S. land based shark fishing and the need for clearer angler education.

- NEFSC staff presented a Shark Ecology Lecture in a MOOC (Massive Open Online Course) on shark age and growth that was filmed for Cornell University and aired in June of 2016.

- Dr. John Carlson continues to work with NOAA Public affairs providing information to the media and the public, as needed, regarding shark attacks and sharks and their interactions with people.

- SEFSC staff continue to support NOAA's Teacher at Sea program by hosting teachers aboard the annual shark survey. Two teachers participated in the survey in 2016, and 21 teachers have participated in the shark survey since 2000. Staff also attended the NOAA Heritage Day in Silver Spring, MD to talk to the public in person as well as through an interview with the Washington Post about sharks and NOAA's work.

- Dr. Cindy Tribuzio (AFSC) helped organize and participated in a shark outreach event in cooperation with The Gills Club at the Alaska Sea Life Center.

- The NMFS Office of Communications coordinates a national Shark Week campaign to which each Region and Science Center can contribute.

- SWFSC staff organize and participate in two annual events that include shark outreach including the Day at the Docks and the Fred Hall Fishing Show.

Section 2: Imports and Exports of Shark Fins

The summaries of annual U.S. imports and exports of shark fins in Tables 2.1.1 and 2.2.1 are based on information submitted by importers and exporters to the U.S. Customs and Border Protection and to the U.S. Census Bureau as reported in the NMFS Trade database.

2.1 U.S. Imports of Shark Fins

During 2016, shark fins were imported through the following U.S. Customs and Border Protection districts: Los Angeles, Miami, and New York. In 2016, countries of origin (in order of importance based on quantity) were New Zealand, China, and Hong Kong (Table 2.1.1). The mean value of imports per metric ton has consistently declined since 2012, with a more pronounced drop between 2011 and 2012. The unit price of $12,000 per metric ton in 2016 is the same as the mean value of 2013 and 2015. It should be noted that, due to the complexity of the shark fin trade, fins are not necessarily produced in the same country from which they are exported. In the United States, factors like availability of labor, overseas contacts, and astute trading can play a role in determining the locale from which exports are sent.

2.2 U.S. Exports of Shark Fins

The majority of shark fins exported in 2016 were sent from the United States to Hong Kong, with smaller amounts going to China (Table 2.2.1). The mean value of exports per metric ton had decreased from $77,000/mt in 2011 to $57,000/mt in 2015. However, 2016 saw a mean value increase to $71,000/mt, the highest mean value since 2013, when it was $66,000/mt.

2.3 International Trade of Shark Fins

The Food and Agriculture Organization of the United Nations (FAO) compiles data on the international trade of fish. The summaries of imports, exports, and production of shark fins in tables 2.3.1, 2.3.2, and 2.3.3 are based on official FAO statistics contained in FishStatJ database. The quantities and values in those tables are totals for all dried, dried and salted, fresh, or frozen shark fins. For the most recent FAO update, data were added for 2015, and global imports of shark fins were approximately 13,000 metric tons, the lowest volume since 2014. In 2015, the average value of global imports increased to $15,411 per metric ton, and the average value of global exports increased to $12,548 per metric ton. Hong Kong was the largest importer and Thailand was the largest exporter of shark fins in 2015.

Table 2.1.1 Weight and value of dried shark fins imported into the United States, by country of origin.

Note: Weight is rounded to the nearest metric ton and value is rounded to thousands of dollars. (1) means that the weight was less than 500 kilograms.
Source: U.S. Census Bureau

Country	2012		2013		2014		2015		2016	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Australia	0	0	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0	0
China	16	131	10	75	0	0	0	0	3	14
China, Hong Kong	2	39	3	89	1	43	1	16	1	50
India	0	0	0	0	0	0	0	0	0	0
Indonesia	0	0	(1)	8	0	0	0	0	0	0
Japan	0	0	0	0	0	0	0	0	0	0
Netherlands									15	180
New Zealand	26	595	50	551	34	406	23	272	37	443
South Africa	0	0	(1)	3	0	0	0	0	0	0
Spain	(1)	8	(1)	12	0	0	0	0	0	0
Total	44	773	63	739	35	449	24	288	56	688
Mean value	$18,000/mt		$12,000/mt		$13,000/mt		$12,000/mt		$12,000/mt	

Table 2.2.1 Weight and value of dried shark fins exported from the United States, by country of destination.

Note: Data in table are "total exports" which is a combination of domestic exports (may include products of both domestic and foreign origin) and re-exports (commodities that have entered the United States as imports and not sold, which, at the time of re-export, are in substantially the same condition as when imported). (1) means that the weight was less than 500 kilograms.

Source: U.S. Census Bureau

Country	2012		2013		2014		2015		2016	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Canada	0	0	0	0	0	0	0	0	(1)	3
China	(1)	60	1	71	1	130	2	136	3	242
China, Hong Kong	51	2,790	7	572	10	565	12	729	9	605
Taiwan	0	0	4	135	7	193	4	163	0	0
Egypt	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0	0	0	0
Japan	0	0	0	0	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0
South Korea	0	0	0	0	0	0	0	0	0	0
Thailand	0	0	0	0	1	91	0	0	0	0
Turkey	0	0	(1)	10	0	0	0	0	0	0
Total	51	2850	12	788	19	979	18	1027	12	850
Mean value	$56,000/mt		$66,000/mt		$52,000/mt		$57,000/mt		$71,000/mt	

Table 2.3.1 Weight and value of shark fins imported by countries other than the United States.
Note: Weight is rounded to the nearest metric ton and value is rounded to thousands of dollars. (1) means that the weight was less than 500 kilograms.
Source: Food and Agriculture Organization of the United Nations, FishStatJ database, www.fao.org

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Angola	-	-	-	-	-	-	-	-	1	6
Aruba	-	-	-	-	-	-	(1)	2	-	-
Austria	-	-	-	-	-	-	(1)	5	-	-
Australia	16	915	27	1,074	23	947	18	682	6	503
Bahrain	-	-	-	-	-	-	(1)	2	-	-
Belgium	-	-	-	-	(1)	1	-	-	-	-
Brunei Darussalam	-	-	91	545	81	452	82	425	121	564
Bulgaria	-	-	-	-	-	-	-	-	2	11
Canada	104	6,351	275	3,347	243	3,541	187	2,905	160	2,545
China	160	1,065	113	1,434	39	339	20	205	11	121
China, Hong Kong	10,322	345,469	8,283	219,391	5,408	121,136	5,741	115,492	5,542	126,810
China, Macao	116	7,570	120	6,998	103	6,047	94	5,849	109	6,206
Taiwan	1,270	14,305	635	7,103	979	7,974	1,208	8,469	1,105	8,657
Republic of Fiji	-	-	25	1,126	25	618	17	407	1	(1)
France	-	-	2	30	-	-	-	-	-	-
Germany	-	-	1	8	-	1	1	7	1	6
Greece	-	-	-	-	-	-	-	-	1	2
Indonesia	101	1,762	53	1,029	41	349	29	257	35	108
Iraq	-	-	-	-	-	-	-	-	4	26
Ireland	-	-	30	372	35	203	8	54	18	234

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Italy	-	-	2	57	5	171	62	252	205	260
Japan	-	-	33	6,406	92	7,698	39	5,762	31	3,031
Kuwait	-	-	1	17	-	-	-	-	-	-
Laos	-	-	-	-	-	-	-	-	7	34
Latvia	-	-	-	-	17	1	-	-	-	-
Luxembourg	-	-	(1)	4	(1)	(1)	-	-	-	-
Malaysia	3,489	10,248	3,013	9,833	18,048	17,612	3,026	10,795	2,370	7,595
Mauritius	-	-	46	171	85	380	25	32	10	12
Mongolia	-	-	(1)	3	(1)	1	-	-	-	-
Myanmar	601	1,635	294	938	52	110	122	264	87	208
Namibia	-	-	3	2	3	9	-	-	-	-
Netherlands	-	-	-	-	20	954	-	-	-	7
New Zealand	-	-	1	101	-	-	(1)	1	-	-
North Korea	(1)	8	-	-	(1)	2	(1)	4	(1)	1
Peru	71	688	30	680	94	967	111	1,355	191	2,312
Philippines	25	40	62	70	22	14	183	104	162	149
Poland	-	-	-	-	-	-	-	-	61	402
Qatar	-	-	-	-	-	-	-	-	15	73
Romania	-	-	-	-	1	4	1	7	-	-
Singapore	595	43,863	2,708	61,195	2,695	41,580	2,570	33,644	2,623	39,180
South Africa	-	-	8	126	54	418	57	443	46	122
South Korea	6	602	8	570	2	391	5	94	-	56
Spain	-	-	127	616	20	29	-	-	3	41
Sri Lanka	2	22	(1)	1	2	8	-	-	8	41

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Thailand	96	1,021	105	1,047	51	469	92	881	122	863
Timor-Leste	131	29	-	-	-	-	-	-	-	-
Trinidad and Tobago	(1)	1	-	-	-	-	(1)	1	(1)	1
United Arab Emirates	26	1,209	6	53	41	125	37	218	54	234
United Kingdom	-	-	5	25	(1)	1	1	11	3	20
Vietnam	-	-	22	846	30	1,120	104	3,872	76	2,842
Zambia	-	-	-	-	-	-	15	(1)	-	-
Total	**17,131**	**436,803**	**16,129**	**325,218**	**28,311**	**213,672**	**13,855**	**192,501**	**13,191**	**203,283**
Mean value	**$25,498/mt**		**$20,164/mt**		**$7,547/mt**		**$13,894/mt**		**$15,411/mt**	

Table 2.3.2 Weight and value of shark fins exported by countries other than the United States.
Note: Data are for "total exports," which is a combination of domestic exports (may include products of both domestic and foreign origin) and re-exports (commodities that have entered into a country as imports and not sold, which, at the time of re-export, are in substantially the same conditions as when imported). Weight is rounded to the nearest metric ton and value is rounded to thousands of dollars. (1) indicates that the weight < 500 kilograms.
Source: Food and Agriculture Organization of the United Nations, FishStatJ database, www.fao.org

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Angola	19	873	15	797	6	439	7	320	5	244
Argentina	70	2,312	3	87	6	49	-	-	-	-
Aruba	-	-	-	-	-	-	(1)	1	(1)	1
Australia	-	-	(1)	34	-	-	1	89	3	191
Austria	-	-	-	-	(1)	3	(1)	4	(1)	3
Bangladesh	-	-	-	-	-	-	1	33	-	-
Botswana	-	-	-	-	(1)	1	-	-	-	-
Brazil	59	2,109	39	1,777	31	1,294	28	978	28	813
Brunei Darussalam	1	14	-	-	-	-	-	-	-	-
Canada	-	-	69	766	10	127	4	43	3	49
Chile	3	167	4	223	3	115	2	53	-	-
China	489	12,218	339	11,731	350	15,464	364	12,773	324	9,150
China, Hong Kong	3,362	88,918	2,427	58,942	2,004	31,412	2,049	31,558	1,875	27,752
China, Macao	8	444	31	1,480	5	315	6	240	11	529
Colombia	10	724	18	601	17	444	13	394	5	225
Congo, Dem. Rep. of the	5	287	5	299	3	112	7	367	(1)	24
Congo, Republic of	17	800	6	350	6	300	3	150	6	341
Cook Islands	-	-	(1)	3	-	-	-	-	-	-
Costa Rica	112	628	17	257	39	2,851	48	3,547	55	5,023

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Cuba	4	204	4	182	4	118	-	-	2	36
Denmark	-	-	-	-	30	40	-	-	1	16
Ecuador	226	4,399	123	2,662	76	656	71	459	89	995
El Salvador	-	-	11	844	9	526	12	561	8	493
Republic of Fiji	-	-	34	2,408	13	611	2	54	-	-
France	-	-	(1)	1	1	8	(1)	1	(1)	1
Gabon	3	322	1	97	-	-	-	-	-	-
Germany	-	-	(1)	(1)	(1)	(1)	(1)	1	(1)	2
Ghana	-	-	-	-	-	-	1	(1)	-	-
Greece	-	-	1	3	-	-	-	-	-	-
Guatemala	-	-	47	43	24	11	24	9	43	40
Guinea	56	3,288	50	2,300	12	1,000	-	-	-	-
Guinea-Bissau	-	-	2	107	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	(1)	1	-	-
India	135	8,310	168	13,211	51	3,086	54	5,883	113	9,359
Indonesia	1,607	13,570	514	8,654	367	4,391	248	4,562	287	4,304
Iran	-	-	24	700	1	30	4	107	1	27
Italy	-	-	(1)	(1)	-	-	(1)	4	(1)	4
Japan	131	8,759	116	5,081	103	2,434	129	2,236	118	1,797
Kiribati	3	50	2	80	(1)	8	-	-	-	-
Kuwait	-	-	(1)	17	-	-	-	-	-	-
Latvia	-	-	2	4	199	92	61	60	44	13
Liberia	3	317	1	50	1	59	-	-	(1)	10
Madagascar	-	-	-	-	2	28	(1)	4	5	55

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Malaysia	417	1,981	298	1,542	687	3,563	1,012	4,551	901	4,453
Marshall Islands	24	1,717	23	564	3	113	-	-	-	-
Mauritania	-	-	-	-	-	-	-	-	12	328
Mauritius	-	-	40	241	90	539	26	47	10	16
Mexico	-	-	81	409	94	4,104	170	6,030	205	11,420
Morocco	-	-	-	-	-	-	-	-	16	346
Namibia	-	-	7	2	7	2	-	-	(1)	(1)
Netherlands	-	-	-	-	23	1,169	-	-	-	-
New Zealand	-	-	61	1,408	9	281	21	283	29	261
Nicaragua	-	-	21	83	(1)	3	4	49	4	125
Oman	-	-	70	109	9	13	30	37	161	151
Panama	24	1,481	43	906	58	458	8	418	3	94
Papua New Guinea	25	2,200	1	268	8	658	3	177	1	33
Peru	206	13,648	134	6,379	146	4,153	236	5,525	387	8,461
Philippines	154	1,125	83	740	213	1,503	627	1,398	233	737
Poland	-	-	1	4	-	-	-	-	-	-
Portugal	-	-	36	446	39	236	58	421	59	535
Saudi Arabia	40	160	1	11	3	43	7	192	2	30
Senegal	96	2,870	63	2,100	69	1,300	-	-	23	155
Seychelles	491	3,501	403	3,481	286	2,679	55	2,977	69	3,537
Sierra Leone	2	44	3	51	-	-	-	-	-	-
Singapore	238	20,295	2,260	42,199	2,583	37,557	2,469	29,507	2,521	41,594
Solomon Islands	6	190	4	135	5	130	-	-	-	-
Somalia	-	-	-	-	6	74	2	25	3	4

Country	2011		2012		2013		2014		2015	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
South Africa	-	-	50	681	79	1,545	143	1,834	80	1,301
South Korea	93	4,491	95	3,568	28	621	46	869	55	1,328
Spain	-	-	62	1,765	137	3,606	25	1,409	98	6,860
Sri Lanka	91	2,086	58	1,230	34	992	32	1,154	39	1,258
Suriname	178	561	5	63	33	118	49	177	-	-
Sweden	-	-	-	-	-	-	-	-	381	110
Taiwan	1,067	13,663	542	7,826	249	2,574	362	3,522	551	6,868
Thailand	7,723	40,245	5,455	27,008	3,892	20,868	4,050	17,679	5,043	19,868
Togo	33	3,600	36	2,900	18	1,100	26	2,100	29	1,800
Trinidad and Tobago	364	2,281	538	2,672	421	2,062	39	399	62	449
United Arab Emirates	479	14,823	306	13,022	366	9,661	324	7,685	204	6,435
United Kingdom	-	-	(1)	1	-	-	-	-	-	-
Uruguay	10	87	9	94	5	32	3	19	2	15
Vanuatu	-	-	2	90	-	-	-	-	36	130
Venezuela	16	77	-	-	-	-	-	-	-	-
Vietnam	223	1,105	(1)	20	8	295	(1)	5	(1)	8
Yemen	347	12,428	54	369	90	322	270	818	139	286
Total	**18,670**	**293,372**	**14,918**	**236,178**	**13,071**	**168,398**	**13,236**	**153,799**	**14,384**	**180,493**
Mean value	**$15,714/mt**		**$15,832/mt**		**$12,883**		**$11,620/mt**		**$12,548/mt**	

Table 2.3.3 Production of shark fins in metric tons by country other than the United States.

Note: The production of shark fins represents the amount that a country processed at the fin level (not the whole animal level). NA = data not available.

Source: Food and Agriculture Organization of the United Nations, FishStatJ database, www.fao.org

Country	2011	2012	2013	2014	2015
Bangladesh	-	-	1	-	-
Brazil	60	40	31	28	28
Ecuador	226	118	75	71	98
El Salvador	-	11	9	12	8
Republic of Fiji	82	33	11	7	1
Guyana	75	208	209	63	57
India	425	116	130	95	100
Indonesia	1,395	500	310	240	280
Madagascar	-	16	33	27	22
Pakistan	91	96	99	104	112
Senegal	35	91	54	50	49
Singapore	210	220	210	208	210
South Korea	93	95	28	46	55
South Africa	-	53	79	143	80
Sri Lanka	90	60	30	30	40
Taiwan	29	132	127	167	1,507
Uruguay	8	12	5	9	6
Yemen	347	54	90	270	140
TOTAL (mt)	3,166	1,855	1,531	1,570	2,793

Section 3: International Efforts to Advance the Goals of the Shark Finning Prohibition Act

The key components of a comprehensive framework for international shark conservation and sustainable management have been established in global and regional agreements, as well as through resolutions and measures adopted by international organizations. These relevant mechanisms and fora have identified, adopted, and/or published detailed language, provisions, or guidance to assist States and regional fisheries management organizations (RFMOs) in the development of measures for the conservation and sustainable management of sharks. Some of these mechanisms have created international legal obligations with regard to shark conservation and management, while others are voluntary. To that end, the United States continues to promote the global conservation and sustainable management of sharks by having ongoing consultations regarding the development of international agreements consistent with the Shark Finning Prohibition Act. Discussions have focused on possible bilateral, multilateral, and regional work with other nations. The Act calls for the United States to pursue an international ban on shark finning and to advocate for improved data collection, including biological data, stock abundance, bycatch levels, and information on the nature and extent of shark finning and trade. Determining the nature and extent of shark finning is the key step toward reaching agreements to decrease the incidence of finning worldwide. To learn more about the United States' international shark conservation activities go here[1].

3.1 Bilateral Efforts

The United States continues to participate in bilateral discussions with a number of States and entities to address issues relating to international shark conservation and management. Emphasis in these bilateral consultations has been on the collection and exchange of information, including requests for shark fin landings, transshipping activities, catch and trade data, stock assessments, and life history data collection. In addition, the United States continues to encourage other countries to implement the FAO's International Plan of Action (IPOA) for the Conservation and Management of Sharks by finalizing, implementing and periodically updating their own National Plans of Action and to adopt a policy that requires all sharks to be landed with their fins naturally-attached.

[1] https://www.fisheries.noaa.gov/national/international-affairs/shark-conservation

For example, in an effort to better identify and monitor shark product trade in light of several shark species listings in CITES Appendix II, NMFS in partnership with the U.S. Fish and Wildlife Service and several NGO partners continue to help build capacity in Latin America, the Caribbean, and West Africa. SWFSC scientists continue to support the pilot project[2] in Ecuador, to train local scientists in genetic identification of sharks.

At a part of the U.S. Chile Bilateral agreement, scientists at the Southwest Fisheries Science Center have been collaborating with both academic and government scientists in Chile to study several highly migratory shark species. Our two main collaborators are the Universidad Católica del Norte and Chile's Fisheries Development Institute (IFOP). The main focus has been on genetic analyses and electronic tagging of a few species common to both regions to look at stock structure and connectivity. In 2016, the SWFSC provided support on electronic tag data analyses. The SWFSC hosted a workshop on August 22-23, 2016 lead by engineers of Wildlife Computers to introduce methods of tag data analysis. This collaboration not only strengthens international partnerships, but will provide valuable information on common species.

Figure 3.1. Scientists attach a mini-PAT satellite tag to a juvenile mako shark.

3.2 Regional Efforts

The U.S. Government continues to prioritize shark conservation and sustainable management globally and to work within RFMOs and other regional entities to facilitate shark research, data collection, monitoring, and management initiatives, as appropriate. In recent years, the United States has successfully led efforts to implement measures within a number of such organizations. Table 3.2.1 lists RFMOs and regional/multilateral programs in which the United States has worked to address shark conservation and management. Of the list in Table 3.2.1, the United States is a party to ICCAT, NAFO, CCAMLR[3], WCPFC, and IATTC. Six of the organizations or programs listed (ICCAT, NAFO, WCPFC, IATTC, IOTC, and NEAFC) have adopted finning prohibitions. In 2014, NEAFC was the first RFMO to require Contracting Parties to land sharks with their fins naturally attached, and NAFO followed suit in 2016. Recent activities of the RFMOs to which the United States is a Party are discussed below.

[2] https://www.fisheries.noaa.gov/content/latin-america-pilot-project-identify-products-shark-trade
[3] CCAMLR is a conservation organization with an ability to manage fisheries within the area under its Convention and thus is included here as one of the regional fishery management programs.

Table 3.2.1 Regional Fishery Management Organizations and Programs.

Regional Fishery Management Organizations and Programs
• Northwest Atlantic Fisheries Organization (NAFO)
• Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
• Inter-American Tropical Tuna Commission (IATTC)
• International Commission for the Conservation of Atlantic Tunas (ICCAT)
• Western and Central Pacific Fisheries Commission (WCPFC)
• Western Central Atlantic Fishery Commission (WECAFC)
• International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)
• Indian Ocean Tuna Commission (IOTC)
• North East Atlantic Fisheries Commission (NEAFC)
• Commission for the Conservation of Southern Bluefin Tuna (CCSBT)

Northwest Atlantic Fisheries Organization (NAFO)

At its 2016 Annual Meeting, NAFO adopted a U.S. led-proposal to strengthen its shark finning ban by prohibiting the removal of shark fins at sea. Previously, NAFO allowed fins to be removed at sea, as long as the fin-to-carcass weight ratio did not exceed 5%, a practice that is challenging to enforce. Additionally, and again as a result of a U.S. led-initiative, NAFO scientists were requested to develop advice for Greenland sharks, including life history, population status, records, and fishing mortality in NAFO fisheries, and develop precautionary management advice for consideration by 2018. Greenland sharks can be vulnerable to fishing due to their extreme longevity and low fecundity.

Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)

In 2016, the United States, for the fifth time, led a proposal to revise the existing conservation measure prohibiting directed fishing on sharks to require that any sharks incidentally caught and retained be landed with fins naturally attached. The co-sponsors of this proposal included Argentina, Australia, Brazil, Chile, European Union, Namibia, South Africa, and Uruguay. A couple members again objected to the proposal, preventing the consensus needed to adopt the proposed requirement.

Inter-American Tropical Tuna Commission (IATTC)

In 2005, the IATTC adopted Resolution C-05-03[4], which placed controls on shark finning by applying a five percent fin-to-carcass weight ratio requirement. For several years, proposals have been submitted to the IATTC to replace current controls on shark finning in Resolution C-05-03 with a prohibition on the retention of shark fins that are not naturally attached to the

[4] https://www.iattc.org/PDFFiles2/Resolutions/C-05-03-Sharks.pdf

carcass until the first point of landing. The United States continues to strongly support a fins-attached proposal at the IATTC, however, the Commission has been unable to reach consensus.

The IATTC scientific staff has been unable to conduct a stock assessment for silky shark in the eastern Pacific Ocean (EPO) due to a lack of historical catch data. The IATTC scientific staff presented updated stock status indicators for silky shark[5] at the IATTC's Scientific Advisory Committee in 2016. These indicators show an overall declining trend in catch per set purse seine data since 1995 for the proposed north and south stocks of silky shark in the EPO. Since 2012, a proposal on silky shark management measures have been proposed at the IATTC meetings. In 2016, the IATTC adopted Resolution C-16-06[6] that includes fishing restrictions on silky shark caught by purse seine and longline vessels in the EPO. At the 7th Bycatch Working Group meeting held in La Jolla, California in May 2016, a report on the situation of sharks in the EPO was presented, including bycatch and fisheries interactions, and updated purse-seine indicators for silkly sharks in the EPO. Results of the updated FAO-GEF shark project were also presented.

International Commission for the Conservation of Atlantic Tunas (ICCAT)

At the 2016 ICCAT annual meeting, the United States again presented a proposal that would prohibit the removal of shark fins at sea and require that all sharks be landed with their fins naturally attached (fully or partially) through the point of first landing of the shark. Initially co-sponsored by Belize, the European Union, Gabon, Honduras, and Senegal, the number of co-sponsors grew to 30 Contracting Parties (Venezuela, United Kingdom –Overseas Territories, Angola, France-St Pierre et Miquelon, Namibia, Nicaragua, Russia, Guinea Rep., Sao Tomé and Principe, Liberia, Nigeria, Sierra Leone, Albania, Côte D'Ivoire, St. Vincent and the Grenadines, Curaçao, El Salvador, Egypt, Libya and South Africa) and several other Contracting Parties spoke in favor. Despite the increasing support, however, the proposal continued to be opposed on the floor by Japan, China, and Morocco. Those opposing suggested that proponents should implement these provisions on a voluntary basis in their own EEZs. The proposal was referred to Plenary for further discussion but was not adopted.

The SCRS Shark Species Group held a data preparatory meeting in 2016 in preparation for the 2017 shortfin mako stock assessment of their North and South Atlantic stocks.

Western and Central Pacific Fisheries Commission (WCPFC)

At its 13th Regular Session (WCPFC13) in December 2016, the WCPFC decided to begin working towards the development of a comprehensive approach to shark and ray management, with a view to adopting a new Conservation and Management Measure (CMM) at the WCPFC's annual meeting in 2018. The objective of the new comprehensive CMM will be to unify the WCPFC's existing shark CMMs (CMM 2010-07, CMM 2011-04, CMM 2012-04, CMM 2013-08, & CMM 2014-05) and to provide a framework for adopting new components as needs and datasets evolve. Elements that will be considered for the new CMM include: policies on full utilization/prohibition on finning; prohibitions on retention of shark catch; safe release and handling practices; gear modifications; management plans; catch limits; identification of key shark species and schedules for their stock assessments; species-specific limit reference points;

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[5] https://www.iattc.org/Meetings/Meetings2015/6SAC/PDFs/SAC-06-08b-Updated-indicators-for-silky-sharks.pdf
[6] https://www.iattc.org/PDFFiles2/Resolutions/C-16-06-Conservation-of-sharks.pdf

and any data reporting requirements. The WCPFC also agreed that manta and mobula rays should be considered WCPFC key species for assessment and thus listed under the recently-adopted five-year Shark Research Plan (2016-2020), noting that data gaps may preclude a traditional stock assessment approach.

The 12th Regular Session of the Scientific Committee (SC12) of the WCPFC noted that the South Pacific blue shark stock assessement was preliminary and should be considered a work in progress. Due to lack of available data, the assessment could not be used to determine stock status or to form the basis of management advice. SC12 recommeded prioritizing work to improve the amount and quality of data to enhance the assessment of South Pacific blue shark. A full stock assessement of Pacific bigeye thresher shark was schedeuled for 2016, however, a full report could not be completed in time for review at SC12. A finalized bigeye thresher assessment will be provided for discussion at SC13. There were no new stock assessments conducted for oceanic whitetip shark, silky shark or North Pacific blue shark.

SC12 developed and adopted a scope of work to advance development of limit reference points for WCPFC sharks. SC12 also reviewed a number of existing shark CMMs, including CMM 2010-07. Based on a request from the WCPFC, SC12 evaluated and was unable to confirm the validity of using a 5% fins to carcass ratio, a provision included in CMM 2010-07, and suggested that a full evaluation of the 5% ratio is not currently possible due to insufficient data. SC12 was able to review only one existing study, which demonstrated that shark fin weight data have some serious limitations, potential biases and errors.

Western Central Atlantic Fishery Commission (WECAFC)

At the 16th session of WECAFC (WECAFC16) in June 2016 draft terms of reference were agreed for the establishment of a joint working group. The objective of the working group is to provide a basis for the conservation and sustainable management of shark populations in WECAFC member countries. In pursuing this goal, the working group will be fulfilling the national and regional responsibilities for the conservation and management of sharks as specified by FAO International Plan of Action-Sharks, CITES 16th Conference of Parties and WECAFC 15. The scope of the working group is the management and conservation of sharks in the Wider Caribbean Region. This includes the development of national and regional plans of action in order to regulate target and bycatch fisheries, as well as manage existing populations within the region. The 2017 workplan was also agreed at WECAFC16 to include development of a Regional Plan of Action (RPOA) for the conservation and management of sharks.

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)

The 16th ISC Plenary, held in Sapporro, Japan from 13-18 July 2016, was attended by members from Canada, Chinese Taipei, Japan, Korea, and the United States as well as the WCPFC.

The ISC Shark Working Group (SHARKWG) reiterated advice based on the 2015 ISC analysis of North Pacific shortfin mako shark, concluding that better data are needed to determine status of the stock. It was again recommended that data for missing fleets be developed for use in the next stock assessment scheduled for 2018, and that available catch and CPUE data be monitored for changes in trends.

The SHARKWG proposed a work plan for the coming year and an assessment schedule for providing stock status information on North Pacific blue and shortfin mako sharks to the ISC Plenary in 2017 and 2018, respectively. The SHARKWG plans to conduct a benchmark assessment of North Pacific blue shark in 2017, and the first full stock assessment of North Pacific shortfin mako shark in 2018. The SHARKWG also held a webinar in April 2016 to advance the interim work and plan for the 2017 North Pacific blue shark assessemnt.

During 2016, NOAA PIFSC and SWFSC scientists started developing a stock assessment for blue shark in the North Pacific Ocean using a fully-integrated size-structured model. The last assessment was conducted in 2014. Time series data updated through 2015 (catch, relative abundance, and sex-specific length composition from multiple fisheries), new biological information, and research into the parameterization of a low-fecundity stock recruitment relationship (LFSR) enabled the development of an improved size-structured model.

3.3 Multilateral Efforts

The U.S. Government continues to work within other multilateral fora to facilitate shark research, data collection, monitoring, and management initiatives, as appropriate. Table 3.3.1 lists some of these multilateral fora.

Table 3.3.1 Other multilateral fora.

Other Multilateral Fora
• Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) • World Customs Organization (WCO) • Food and Agriculture Organization of the United Nations (FAO) • United Nations General Assembly (UNGA) • Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

The 17th Meeting of the Conference of the Parties (CoP17) to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was held September 24 – October 5, 2016, in Johannesburg, South Africa. CITES is the key convention for efforts to combat wildlife trafficking, and at this meeting the Parties made important decisions regarding the status of shark and ray species in the CITES Appendices. A proposal to include silky shark (*Carcharhinus falciformis*) in Appendix II prevailed after a vote by secret ballot, with 111 Parties voting in favor, 30 against and five abstaining. A proposal to include thresher sharks (*Alopias* spp.) in Appendix II passed after a vote by secret ballot, with 108 Parties voting in favor, 29 against and five abstaining. It was agreed there would be a 12-month delayed implementation, which the United States had advocated for to provide time to address administrative and technical issues associated with the new listings. The United States supported these proposals. The listings for these species became effective October 4, 2017. A U.S.-cosponsored proposal to include nine species of devil rays (*Mobula* spp.) in Appendix II was accepted through a secret ballot, with 110 in favor, 20 against and 3 abstaining. It was agreed there would be a six month delay in implementation to provide time to help ensure effective implementation. The listings for these species became effective April 4, 2017.

At CoP17, several decisions related to the conservation and management of sharks and rays were adopted. Among the actions called for in the decisions, CITES Parties are encouraged to undertake consultations with relevant stakeholders concerning the implementation of the shark and ray listings in CITES; share experiences and examples of non-detriment findings (NDFs) for CITES-listed sharks and rays; strengthen efforts to make NDFs; continue collection of species-specific harvest and trade data; and share knowledge on forensic means to effectively, reliably, and cost-effectively identify shark products in trade. The CITES Secretariat is required to take several actions, including making guidance, materials, and forensic approaches available for the identification of products of CITES-listed sharks and rays and provide a summary of trade in CITES-listed sharks and rays. The CITES and FAO Secretariats are invited to continue and expand collaboration on actions towards the conservation of and trade in sharks and rays, and the CITES Standing Committee is directed to consider issues related to management and trade of these species, provide guidance as appropriate, and report to the 18th meeting of the Conference of the Parties to CITES.

Convention on the Conservation of Migratory Species of Wild Animals (CMS) Memorandum of Understanding on the Conservation of Migratory Sharks (Sharks MoU)

The Second Meeting of Signatories (MOS2) was held February 15-19, 2016, in San Jose, Costa Rica, with over 30 countries participating in the meeting. Twenty-two species of sharks and rays were added to the Annex of the MoU. The species were: five species of sawfish, the reef manta ray, the giant manta ray, silky shark, the great hammerhead shark, and the scalloped hammerhead shark. The MOS2 also established a Conservation Working Group that will develop a strategy for cooperation with fisheries-related bodies and organizations. The Third Meeting of Signatories is expected to occur in 2018.

Resumed Review Conference on the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNFSA)

The Review Conference was held May 23-27, 2016, at the United Nations Headquarters in New York. UNFSA was adopted in 1995 and sets out principles for the conservation and management of straddling and highly migratory fish stocks. It, *inter alia*, prescribes that a precautionary approach and the best available scientific information be used in fishery management, impacts of fishing on associated and dependent species be managed, pollution be minimized, and overfishing and excess fishing capacity be prevented or eliminated. The UNFSA has provisions which help to ensure that key fishery resources that occur both within a State's exclusive economic zone (EEZ) and on the high seas are conserved and managed on a sustainable basis.

The Resumed Review Conference recommends specific actions and approaches that States and RFMOs could undertake to strengthen the implementation of UNFSA's provisions. These recommendations are centered around 4 core themes: (1) Conservation and management of stocks; (2) Mechanisms for international cooperation and nonmembers; (3) Monitoring, control and surveillance and compliance and enforcement; and (4) Developing States and non-parties. At the Resumed Review Conference, many delegates expressed concern that the adoption of conservation and management measures for shark and their implementation had progressed slowly. The Resumed Review Conference recommended that States and regional economic integration organizations, individually and collectively through regional fisheries management organizations and arrangements:
Taking into account the International Plan of Action for Conservation and Management of Sharks, adopted by FAO, including the precautionary approach, encourage cooperation in the management and conservation of shark species through their participation under appropriate instruments and strengthen the conservation and management of sharks by:
(i) Establishing and implementing species-specific data collection requirements for shark species caught in directed shark fisheries or as by-catch in other fisheries;
(ii) Conducting biological assessments for such shark species;
(iii) Developing science-based conservation and management measures for sharks;
(iv) Strengthening, on the basis of the best scientific information available, enforcement of existing prohibitions on shark finning by requiring that sharks be landed with their fins naturally attached or through different means that are equally effective and enforceable.

Section 4: 2016 NOAA Research on Sharks

Large predators such as sharks are a valuable part of marine ecosystems. Many shark species are vulnerable to overfishing because they are long-lived, take many years to mature, and only have a few young at a time. To manage sharks sustainably, we need information about their biology and the numbers caught (either as target species, incidentally, or as bycatch) to make sure their populations are not depleted. NMFS Fisheries Science Centers are investigating shark catch, abundance, age, growth, diet, migration, fecundity, and requirements for habitat. Additional research aims to identify fishing methods that minimize the incidental catch of sharks and/or maximize the survival of captured sharks after release. A summary of the research completed in 2016 is presented here, but more complete descriptions of ongoing research taking place in each region is found in Section 5.

4.1 Data Collection and Quality Control, Biological Research, and Stock Assessments

Pacific Islands Fisheries Science Center (PIFSC)

Silky shark population genetics
The PIFSC is currently involved in a collaboration with the Hawaii Insititute of Marine Biology to conduct a global genetic inventory of silky sharks, one of the three most important sharks in the fin trade, and the most common bycatch in purse-seine fisheries around the world. This pelagic shark, formerly abundant in all tropical oceans, has declined by an estimated 85% in the last 19 years, and is now listed as near-threatened and declining by IUCN. A global inventory of genetic diversity will allow identification of management units on a global scale. The resulting DNA barcodes will allow identification of sharks in trade specifically to both species and oceanic region, providing a much-needed scientific foundation for management plans. During 2016, the researchers reached 1600 tissue specimens from global shark samples, completing this section of the work. Additionally, barcoding is nearly complete, and analysis is currently underway.

Recent research has found regional population partitioning in silky sharks, occurring between ocean basins such as the Red Sea, the Indo- Pacific Ocean, and the western Atlantic. Additionally, there are significant population structure between the Eastern Pacific and the Western Pacific populations. However, both of these studies sequenced the mitochondrial control region only. The approach will be genome-wide, examining multiple nuclear loci, identifying SNP’s and barcoding, which could reveal previously hidden structure and complex behaviors such as male-mediated gene flow. We anticipate finding population structure between the Eastern and Western Atlantic, the Gulf of Mexico, the Indian Ocean, the Red Sea, and across the Pacific. Given our extensive sample coverage across the globe, the completion of this study will be an important step in the conservation of the species.

Spatial dynamics of tiger sharks (Gelocerdo Cuvier) around Maui and Oahu
PIFSC scientists collaborated with researchers at the Hawaii Institute of Marine Biology to assess the movement behavior and habitat use of tiger sharks around Maui in comparison to that of other islands (Meyer et al. 2016). Maui has experienced more shark bites than any other Hawaiian island. In an attempt to explain this phenomenon, a combination of acoustic and satellite tagging was used to quantify movements of tiger sharks captured near high-use ocean recreation sites around Maui and Oahu. Scientists compared shark spatial behavior in Maui and Oahu waters with behavior observed elsewhere in Hawaii. Twenty-six tiger sharks were tagged at sites around Maui, and an additional 15 tiger sharks around Oahu. Individual sharks were tracked for periods of up to 613 days. We compared our results with previous data obtained from 55 tiger sharks captured between 2003 and 2013 at French Frigate Shoals atoll, Oahu and Hawaii Island, and tracked for periods of up to six years.

The movements of tiger sharks captured around Maui and Oahu during the current study were broadly similar to those documented by previous research conducted in Hawaii. Individual tiger sharks tended to utilize a particular ‘core’ island, but also swam between islands and sometimes ranged far offshore (up to 1,400 km). However, the current study also revealed new details of tiger shark habitat use, showing that tiger shark movements were primarily oriented to insular shelf habitat (0-200 m depth) in coastal waters, and that individual sharks utilized well-defined core areas within this habitat. The core areas of multiple individuals overlapped at locations such as Kihei, Maui, and Kahuku Point off Oahu. Overall, core use areas for large tiger sharks were closer to high-use ocean recreation sites around Maui than Oahu. Individual tiger sharks made infrequent (average of one visit every 13.3 days) and short (average of 11.8 minutes in duration) visits to shallow ocean recreation sites monitored around Oahu and Maui. However, frequency of tiger shark detections (proportion of monitored days on which any electronically-tagged tiger shark was detected) was higher at monitored ocean recreation sites around Maui (62-80%) than Oahu (<6%).

Overall, these results suggest the insular shelf surrounding Maui Nui is an important natural habitat for Hawaii tiger sharks, and consequently large tiger sharks are routinely and frequently present in the waters off ocean recreation sites around Maui. However, historical precedent in Hawaii has shown that culling sharks neither eliminates nor demonstrably reduces shark bite incidents. Our current results further clarify why historical shark culling was ineffective. Tiger sharks found around Maui exhibit a broad spectrum of movement patterns ranging from resident to highly transient. This mixture ensures a constant turnover of sharks at coastal locations. This suggests that sharks removed by culling are quickly replaced by new individuals from both local and distant sources.

Habitat use and movement behavior of oceanic sharks around West Hawaii

Pelagic shark populations are declining in many regions worldwide. Commercial fisheries on the high seas have been implicated as major contributors to these declines due to high rates of fishing mortality to blue, *Prionace glauca*, bigeye thresher, *Alopias superciliosus*, mako, *Isurus oxyrhincus*, silky, *Carcharhinus falciformis*, and oceanic whitetip, *C. longimanus,* sharks. These species are all encountered seasonally in the waters surrounding west Hawaii and are often incidentally captured in several local, small scale fisheries. Several of these species also inflict high rates of depredation, drastically reducing the value of the catch for fishers operating in the area. Due to the conflict arising from these interactions, many sharks are killed, which may have compounding effects if this region is being utilized for biological imperatives such as; reproduction, feeding, or as a nursery area. This study is designed to engage local fishers in a collaborative tagging effort, with both acoustic and satellite tags, to understand the movement behavior, habitat use and residency patterns of these species in west Hawaii. Additionally, fishers have been tasked with devising testable methods to deter oceanic whitetip sharks from the catch and in the development of non-lethal bycatch mitigation strategies.

Insular shark surveys

Densities of insular sharks have been estimated at most of the U.S. island possessions within the Tropical Central, Northern, and Equatorial Pacific on mostly biennial (now triennial) surveys conducted by the PIFSC Coral Reef Ecosystem Program since 2000. These estimates include surveys of major shallow reefs in the Northwestern Hawaiian Islands, the main Hawaiian Islands, and the Pacific remote islands, American Samoa, Guam and the Commonwealth of the Northern Marianas Islands, Johnston Atoll, and Wake Atoll.

Although 11 species of shark have been observed during Coral Reef Ecosystem Division surveys, only four species are typically recorded by towed divers in sufficient frequency to allow meaningful analyses: grey reef shark (*Carcharhinus amblyrhynchos*), Galapagos shark (*Carcharhinus galapagensis*), whitetip reef shark (*Triaenodon obesus*), and blacktip reef shark (*Carcharhinus melanopterus*). Spatial analyses of data up to 2011 showed a highly significant negative relationship between gray reef and Galapagos shark densities and proximity to human population centers (e.g., proxy for potential fishing pressure and other human impacts). Even around islands with no human habitation, but within reach of populated areas, gray reef and Galapagos shark densities are significantly lower. Trends in whitetip and blacktip reef shark numbers are similar but less dramatic (I.D. Williams et al., 2011; Nadon et al., 2012). More recent data are entirely consistent with those findings. From 2013 to 2015, deployment of baited and un-baited remote underwater video cameras to measure fish and shark abundance levels, including extending surveys into deeper waters (30-100m), have provided information on the distribution and relative abundance of sharks over a much wider range of habitats than are routinely surveyed by NOAA divers. Overall, shark densities from baited video (at depths from 0 to 100m) were 5 times higher in the remote Northwestern Hawaiian Islands (NWHI) than in the populated Main Hawaiian Islands (MHI). Peak densities for species that are commonly recorded during diver surveys - Galapagos (*Carcharhinus galapagensis)* and Whitetip reef (*Trianodon obesus*) sharks - were in 30-53m deep hardbottom habitats. Sandbar sharks (*Carcharhinus plumbeus*), were recorded by BRUV only in deeper (53-100m) softbottom habitats, and were approximately equally abundant in the NWHI and MWHI (Asher at al 2017). Analysis of BRUV surveys from Tutuila and Guam that is currently underway will help us to understand the generality of those patterns and improve estimates of relative abundance across a larger portion of sharks' primary habitat.

Mitigation of shark predation on Hawaiian monk seal pups at French Frigate Shoals
Shark predation on Hawaiian monk seal pups (*Monachus schauinslandi*) has become unusually common at one breeding site, French Frigate Shoals (FFS) in the Northwestern Hawaiian Islands (NWHI). Since 1997, NMFS has frequently observed Galapagos sharks (*Carcharhinus galapagensis*) patrolling and attacking monk seal pups. Tiger sharks (*Galeorcerdo cuvier*) also prey on monk seals and are abundant at FFS; however, tiger sharks have not been observed to attack pups. For these reasons, FFS continues to focus monitoring and mitigation efforts on Galapagos sharks. Shark tagging studies at FFS indicate that, although Galapagos sharks are the most abudant shark species, they generally prefer deeper water and only a small fraction of the population, equating to a few tens of individuals, likely frequents the shallow areas around monk seal pupping islets (Dale et al. 2011).

Reducing shark predation on pups at FFS is one of several key activities identified in the Hawaiian Monk Seal Recovery Plan (NMFS 2007). Since 2000, NMFS has attempted to mitigate shark predation through harassment and culling of sharks, shark deterrents, and translocation of weaned pups to islets in the atoll with low incidence of shark attacks (Baker et al. 2011; Gobush 2010). NMFS implemented a highly selective shark removal project to mitigate predation on monk seal pups from 2000-2016, with the exception of 2008-2009 when deterrents were tested. Sixteen Galapagos sharks frequenting the nearshore areas of pupping islets have been lethally removed to date. In 2009, the number of shark sightings and predation incidents at two pupping islets did not differ significantly between the control and two experimental treatments: (1) acoustic playback and a moored boat, and (2) continuous human presence, versus a control (Gobush and Farry 2012). No Galapagos sharks were removed at FFS in 2016.

<u>**Southwest Fisheries Science Center (SWFSC)**</u>

Abundance Surveys

Juvenile Shortfin Mako (Isurus oxyrinchus) and Blue Shark (Prionace glauca) Survey
In 2016, the SWFSC did not conduct the annual juvenile shark survey. However, the results from the 28-year survey were published in 2016. The annual nominal CPUE for both species has a negative trend over the duration of the survey. The blue shark nominal CPUEs have been at record lows in recent years (Runcie et al. 2016).

Neonate Common Thresher Shark (Alopias vulpinus) Survey
The common thresher shark pre-recruit index and nursery ground survey was initiated in 2003 to develop a fisheries-independent index of pre-recruit abundance and has been conducted in each year since. In 2016, SWFSC scientists and volunteers conducted the survey aboard the F/V Outer Banks. Unlike in 2015, when there was anomalously warm water due to El Niño and the "warm blob," conditions in the Southern California Bight (SCB) were more typical. The catch rate (nCPUE) of thresher sharks in the SCB survey area was 1.98 threshers per hundred hook hours and a total of 144 thresher sharks were caught. Water temperature and nCPUE fell within the range of those recorded during prior surveys, with the exception of 2015 during which the warmest water and lowest catch of threshers were recorded. During the expanded effort beyond the SCB survey area, which was mostly in nearshore waters between Point Conception and San Francisco Bay, seven thresher sharks were caught. The additional sets made north of Point Conception were part of a pilot effort to make the survey cover more of the common thresher sharks range, and more adaptive given the influences of oceanography on the distribution of marine organisms.

In addition to providing important information on abundance and distributions, the thresher shark survey enhances other ongoing research at the SWFSC including age and growth, foraging, and habitat-utilization studies. One hundred and sixty three (163) sharks were tagged with conventional tags for movement and stock structure studies. One hundred and forty five (145) of these sharks, including 141 threshers, 1 blue, and 3 mako sharks, were marked with oxytetracycline (OTC) for age validation studies. A juvenile white shark (male, 145 cm FL) was caught near Rincon Point and released in good condition with a pop-off archival tag. The shark was tagged as part of a Monterey Bay Aquarium project to study the behavior and habitat use of juvenile white sharks. DNA samples were collected from 187 fish for genetic studies. Cloacal swabs to look for carnobacteria were collected from several thresher sharks to contribute to the Master's thesis project of a California State Long Beach researcher. In addition, SWFSC scientists collected detailed morphometric information and biological samples from animals that did not survive.

Electronic Tagging Studies
Since 1999, SWFSC scientists have used data logging tags and satellite technology to characterize the essential habitats of large pelagic fish to better understand how populations might shift in response to changes in environmental conditions on short or long time scales; sharks tagged are primarily blue sharks, shortfin mako, and common thresher sharks, while other species are tagged opportunistically. In recent years, the SWFSC has collaborated with Mexican colleagues at Centro de Investigación Científica y de Educación Superior de Ensenada

(CICESE), Canadian colleagues at the Department of Fisheries and Oceans Pacific Biological Station in Nanaimo, British Columbia, and the Tagging of Pelagic Predators program on shark tagging.

No additional satellite tags were deployed in 2016, as efforts shifted to data analyses and the preparation of publications. Data from 113 shortfin mako, 100 blue sharks, and 29 thresher sharks were analyzed in 2016. Analyses included state-space models, Baysian models, and habitat modeling using EcoCast.

Age Validation Studies
Age and growth of mako, common thresher, and blue sharks are being estimated from band formation in vertebrae. In addition to being important for studying basic biology, accurate age and growth curves are needed in stock assessments. SWFSC scientists are validating ageing methods for these three species based on band deposition periodicity determined using oxytetracycline (OTC). Annual research surveys provide an opportunity to tag animals with OTC. When the shark is recaptured and the vertebrae recovered, the number of bands laid down since the known date of OTC injection can be used to determine band deposition periodicity. Since the beginning of the program in 1997, more than 4,000 individuals have been injected with OTC.

Blue Sharks
Age validation work on blue sharks in the northeast Pacific Ocean culminated in a 2016 publication, which demonstrated that blue sharks lay down one vertebral band pair per year. Vertebrae from 26 blue sharks were used to validate one growth band per year for blue sharks for sharks of ages 1 to 8 years. Length-frequency modal analysis from 26 years of research and commercial catch data also supported annual band pair deposition in blue sharks (Wells et al. 2016).

Thresher Sharks
During 2016, work continued on age validation of common thresher sharks, and 141 threshers were injected with OTC. Since 1998, a total of 1,739 common thresher sharks ranging in size from 45 to 240 cm FL have been injected with OTC. Natalie Spear of Texas A&M University completed an age validation study of threshers as part of her master's thesis in March 2016. She examined vertebrae from 60 OTC marked sharks (size range at tagging: 63-145 cm FL) with an average time-at-liberty of 352 days. Annual vertebral band pair deposition was validated for 26 individuals at liberty for over 10 months, with a maximum time-at-liberty of 1,389 days (3.8 years). This work is currently being prepared for publication.

Northwest Fisheries Science Center (NWFSC)

Monitoring and Assessment Activities
The NWFSC conducts and supports several activities addressing the monitoring and assessment of sharks along the West Coast of the United States and in Puget Sound. The Pacific Fishery Information Network (PacFIN) serves as a clearinghouse for commercial landings data, including sharks. In addition, the At-Sea Hake and West Coast Groundfish Observer Programs collect data on shark species caught on vessels selected for observer coverage.

The NWFSC conducts annual trawl surveys of the West Coast, designed primarily to acquire abundance data for West Coast groundfish stocks. The tonnages of all shark species collected during these surveys are documented. In the past, the survey program conducted numerous special projects in recent years to help researchers acquire data and samples necessary for research on various shark species. Since 2002, the survey has collected biological data and tissue samples from spiny dogfish, including dorsal spines, which can be used to age the fish.

Stable Iotope Analysis

NWFSC ecologists have led the collection of samples for sixgill sharks in Puget Sound and analysis of stable isotope ratios. This research has improved understanding of the diet of these sharks, which can include spiny dogfish, through the application of Bayesian mixing models to estimate diet proportions. Some of this research is reported in a chapter of *Advances in Marine Biology, Vol. 77,* entitled "Stable Isotope Applications for Understanding Shark Ecology in the Northeast Pacific Ocean (Reum, et al., 2017). An additional research paper on related topics is undergoing final revisions.

Forensic Shark Species Identification

NWFSC Forensic Laboratory staff along with an NRC postdoctoral fellow to the Genetics and Evolution Program inspected several west coast shark fin trans-shipments for potential ESA or CITES-protected species. Fins and other samples submitted to the Laboratory by NOAA Office of Law Enforcement cases were subject to detailed forensic analysis to determine species identity. Legal action based in part on forensic analyses resulted in the forfeiture of a 490 kg seizure in San Diego, and a 1,000 kg seizure in Seattle. Additionally, the Forensic Laboratory delivered training to OLE agents on morphological identification, triage and sampling of shark fin shipments, and continued to collect and analyze vouchers to augment the database used for identifications.

Figure 4.1. NWFSC Forensic Analyst Kathy Moore examines seized fins.

<u>Alaska Fisheries Science Center (AFSC, Auke Bay Laboratory)</u>

Stock Assessments of Shark Species Subject to Incidental Harvest in Alaskan Waters

Stock assessments are currently completed on the shark species most commonly encountered as incidental catch: Pacific sleeper sharks (*Somniosus pacificus*), spiny dogfish (*Squalus suckleyi*), and salmon sharks (*Lamna ditropis*). In both the Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BSAI) fishery management plans, sharks are managed as a complex. Directed fishing for all sharks is prohibited. In the BSAI, the shark complex is managed with catch limits based on historical maximum catch. In the GOA, catch limits for the complex are the sum of individual species recommendations: spiny dogfish catch limits are based on survey biomass estimates and the remaining species are based on historical average catch. Stock assessments are summarized annually and are available online (see Tribuzio et al. 2016a and 2016b, or the most recent North Pacific Groundfish Stock Assessment and Fishery Evaluation Reports).

Migration and Habitat Use of Spiny Dogfish
Spiny dogfish (*Squalus suckleyi*) are a small species of shark, common in coastal waters of the eastern North Pacific Ocean. Previous tagging studies have shown that they have the potential to undertake large scale migration and that there are seasonal patterns to movement. This study aims to investigate movement on an even finer scale. The miniaturization of pop-off satellite archival tags (PSATs) has enabled smaller species to be tagged. Since 2009, we have deployed 173 PSATs on spiny dogfish at locations across the Gulf of Alaska, British Columbia (Canada), and Puget Sound (Washington, USA) waters. To date, 151 tags have been recovered, (8 of which were physical recoveries, resulting in high resolution data). As well, 6 spiny dogfish were double tagged with acoustic tags and deployed in Puget Sound. Data analysis is ongoing; however, preliminary results, such as pop-off location are already elucidating surprising movement patterns. Many spiny dogfish tagged in the Gulf of Alaska remained in the Gulf of Alaska, but a surprising number of fish moved as far south as Southern California and some crossed over to Russian and Japanese waters. Further, the fish that undertook the large scale migrations, tended to have a different daily movement pattern from those that remained. A great deal of analysis remains on this project, but early results are intriguing and suggest that spiny dogfish are more highly mobile than previously believed.

Age and Growth Methods of deep water sharks
Scientists at Auke Bay Laboratory and AFSC's Resource Ecology and Fisheries Management Division age and growth lab are investigating potential methods for ageing Pacific sleeper sharks. Initial work attempted to use the method recently developed for Squalus suckleyi, which has shown promise for other deep water shark species, however, banding patterns could not be seen on Pacific sleeper shark vertebrae. Staff are preparing to try bomb radio carbon methods on both eye lens and vertebrae centra, as well as investigate microchemistry to see if any patterns are apparent.

Population Genetics of Pacific sleeper shark
Two species of the subgenus *Somniosus* are considered valid in the northern hemisphere: *S. microcephalus*, or Greenland shark, found in the North Atlantic and Arctic, and *S. pacificus*, or Pacific sleeper shark, found in the North Pacific and Bering Sea. The purpose of this study was to investigate the population structure of sleeper sharks in Alaskan waters. Tissue samples were opportunistically collected from 141 sharks from British Columbia, the Gulf of Alaska, and the Bering Sea. Sequences from three regions of the mitochondrial DNA, cytochrome oxidase c-subunit 1 (CO1), control region (CR), and cytochrome b (cytb), were evaluated. A minimum spanning haplotype network separated the sleeper sharks into two divergent groups, at all three mtDNA regions. Percent divergence between the two North Pacific sleeper shark groups at CO1, cytb, and CR, respectively were all approximately 0.5 percent. Greenland sharks were found to diverge from the two groups by 0.6 percent and 0.8 percent at CO1, and 1.5% and 1.8 percent at cytb. No Greenland shark data was available for CR. The consistent divergence from multiple sites within the mtDNA between the two groups of Pacific sleeper sharks indicates a

historical physical separation. There appears to be no phylogeographic pattern, as both types were found throughout the North Pacific and Bering Sea. Development of nuclear markers (microsatellites) is currently underway and will allow for a better understanding of the level of introgression, if any, between these two 'populations' of sharks.

Managing large sharks by numbers instead of weight, when observers cannot sample large fish
The Pacific sleeper shark (*Somniosus pacificus*) is a common bycatch species in the Gulf of Alaska and Bering Sea, currently managed as part of the "Shark Complex" with harvest limits specified in tons. Management of the species is reliant on using estimates of total catch weight that are dependent on observed weight data. Sleeper sharks are difficult to handle onboard most vessels; they get tangled in fishing gear, their large size either precludes bringing them onboard or poses safety hazards to crew and observers, and they are difficult to weigh or incorporate into random catch sampling plans. Thus, they are uniquely challenging to manage. Conversely, observers are generally able to obtain accurate counts, either because the species is often pre-sorted by vessel crew and set aside for sampling or they are tallied at the rail as gear is retrieved. The goal of this study is to investigate if managing by numbers would be an improvement for sleeper sharks. Current catch estimates show that most of the sleeper shark catches occurs in longline fisheries, where observed weight data is likely biased low because of the difficulty bringing large animals onboard. Overall, count data may provide a better estimate of total sleeper shark catch than currently used weight estimates. We discuss how counts could be incorporated into the existing harvest specification process and associated issues with a change in management methods.

Using tag data to inform biomass estimates for spiny dogfish.
In the Gulf of Alaska (GOA) many data-poor stocks are managed using Tier 5 approach, where the product of the biomass and a fishing mortality rate is used to determine harvest specifications. This method requires that a reliable biomass is available. The biennial GOA trawl survey is considered "unreliable" or "at best an index of relative abundance" for this species, therefore the species does not qualify for Tier 5 designation. In this study we are using archival tag data to examine if the reliability of the bottom trawl survey biomass for this species can be improved. The goals of this study are to 1) examine if the trawl survey overlaps with spiny dogfish distribution, both horizontally and vertically; 2) determine if a catchability (q) parameter can be estimated for the species to apply to the trawl survey biomass; and 3) investigate if the trawl survey biomass can be adjusted to be considered "reliable." Temperature and depth data was recovered from 121 tags, where the release and/or recovery locations were in the GOA during the same time frame as the trawl survey. A preliminary analysis of a subset of the tags showed that average depth by time of day in the summer was less than 50 meters for all hours, with 95 percent confidence intervals ranging from the surface to 200 meters. Based on the tagging data and trawl survey haul data, the tagged spiny dogfish spent approximately 9 percent of the time within the depth range of the trawl survey gear.

Northeast Fisheries Science Center (NEFSC)

Fishery Independent Coastal Shark Bottom Longline Survey
The fishery independent survey of Atlantic large and small coastal sharks is conducted bi-annually in U.S. waters, depending on funding. Its primary objective is to conduct a

standardized, systematic survey of the shark populations off the U.S. Atlantic coast to provide unbiased indices of relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. The time series of abundance indices from this survey are critical to the evaluation of coastal Atlantic shark species. Standardized catch rates and length data for dusky sharks caught during this survey were used in the 2016 Southeast Data Assessment and Review (SEDAR) update for the SEDAR 21 assessment of dusky sharks (McCandless and Natanson 2016).

Collection of Recreational Shark Fishing Data and Samples

Historically, species-specific landings data from recreational fisheries is lacking for sharks. In an effort to augment these data, the NEFSC has been attending recreational shark tournaments continuously since 1961 collecting data on species, sex, and size composition from individual events; in some cases, for nearly 50 years. In 2016, biological samples for life history studies and catch and morphometric data for more than 121 pelagic sharks were collected at 8 recreational fishing tournaments in the northeastern United States. Time series data from these recreational tournaments were analyzed for use in the species status review for common thresher sharks, which were petitioned for potential listing under the Endangered Species Act (ESA, Young et al. 2016b).

Endangered Species Act

NEFSC staff contributed to and participated on three separate Status Review Teams during 2016 in response to positive 90-day findings, indicating that petitions presented substantial information that listing under the Endangered Species Act (ESA) as threatened or endangered may be warranted for common and bigeye thresher sharks, porbeagle, and oceanic whitetip sharks. The Status Review Reports for common and bigeye thresher sharks (Young et al. 2016b) and for porbeagle (Curtis et al. 2016) were made public following the publication of the negative 12-month findings, indicating that listing under the ESA was determined to be unwarranted for these species. The Status Review Report for oceanic whitetip shark (Young et al. 2016a) was made public following the publication of the positive 12-month finding indicating that this species warrants listing under the ESA as threatened.

Cooperative Shark Tagging Program (CSTP)

The CSTP provides information on distribution, movements, and essential fish habitat for shark species in U.S. Atlantic and Gulf of Mexico waters. This program has involved more than 6,000 volunteer recreational and commercial fishermen, scientists, and fisheries observers since 1962. In 2016, information was received on 5,000 tagged and 400 recaptured fish bringing the total numbers tagged to 285,000 sharks of more than 50 species and 17,400 sharks recaptured of 33 species. This information was provided to the NMFS Atlantic HMS Management Division in 2016 to facilitate updates to the essential fish habitat (EFH) designations for all managed shark species. A presentation on the CSTP was given during the Cooperative Fisheries Research in Marine and Freshwater Systems: From Policy to Practice Symposium at the annual American Fisheries Society meeting in 2016 (Gervelis et al. 2016).

Atlantic-wide Ageing and Intercalibration studies for the Shortfin Mako (Isurus oxyrinchus)

In 2016, a study was initiated to conduct an Atlantic-wide age and growth study for the shortfin mako shark that can contribute to the 2017 ICCAT assessment for this species. NEFSC staff co-hosted an ICCAT SRDCP (Shark Research and Data Collection Program) Workshop on Shortfin

Mako Age Reading and Growth with the SEFSC and the Portuguese Institute for the Ocean and Atmosphere with the goal of inter-calibrating the readings. Participants also included personnel from the Centro de Investigación y Conservación Marina-CICMAR, Uruguay and students from the University of Rhode Island. Since the workshop was completed, NEFSC staff cut and processed all shortfin mako shark vertebra collected since 2002, edited the photographs obtained by all participating researchers for consistency in age work, and counted a preliminary set of 60 samples. A manuscript for age estimate of the North Atlantic population is in progress while work on the South Atlantic is ongoing.

Critical Examination of a Purported Trophic Cascade

In 2016, NEFSC staff in cooperation with others from the Florida State University, the SEFSC, the U.S. Geological Survey, the Greater Atlantic Regional Fisheries Office, and the Virginia Institute of Marine Science published a critical assessment of a purported trophic cascade in the northwest Atlantic Ocean where the depletion of large coastal sharks was thought to trigger predation release of cownose rays leading to the collapse of commercial bivalve stocks (Grubbs et al. 2016). Based on these claims a predator-control fishery for cownose rays was developed. A reexamination of data from this purported trophic cascade indicated that declines in large coastal sharks did not coincide with purported rapid increases in cownose ray abundance nor did the increase in cownose ray abundance coincide with declines in commercial bivalves. The lack of temporal correlations coupled with published diet data for large coastal sharks and cownose rays suggests the purported trophic cascade is lacking the empirical linkages required of a trophic cascade. Additionally, the life history parameters of cownose rays indicate that they are incapable of rapid increases due to low reproductive potential. This assessment emphasizes the need for hypothesized trophic cascades to be closely scrutinized as spurious conclusions may negatively influence conservation and management decisions.

Elasmobranch Vulnerability to Climate Change off the Northeast US

NEFSC staff contributed to the first multispecies assessment of climate vulnerability for fish and invertebrates that occur off the northeastern U.S. In 2016, the Northeast Climate Vulnerability Assessment examined 82 species, including all commercially managed marine fish and invertebrate species in the northeast, a large number of recreational marine fish species, all marine fish species listed or under consideration for listing under the Endangered Species Act, and a range of ecologically important marine species (Hare 2016). NEFSC staff contributed expertise on the 12 elasmobranch species assessed.

Common Thresher Shark (Alopias vulpinus) Movement Patterns and Stock Structure

A multi-faceted investigation of the horizontal and vertical movement patterns, spatial and temporal habitat use, and stock structure of the common thresher shark in the western North Atlantic Ocean was funded in 2016 through a Saltonstall-Kennedy Grant. Researchers from University of Massachusetts, MassDMF, and the New England Aquarium, in collaboration with NEFSC staff, planned the first field season including ordering tags and equipment and coordinating with fishermen.

Dusky Shark (Carcharhinus obscurus) Post-release Mortality

A study on quantifying and reducing post-release mortality for dusky sharks discarded in the commercial pelagic longline fishery was funded by the NMFS Bycatch Reduction Engineering

Program. This study is conducted in conjunction with NEFSC staff and researchers from the University of New England, Gulf of Maine Research Institute, and the SEFSC. In 2016, pop-up satellite archival tags were attached to 50 dusky sharks prior to release from pelagic longline gear to evaluate extended (~30 days) post-release mortality. Biological, physical, and capture variables including time on the hook, size, sex, hook location, water temperature, tissue damage and gangion length, were recorded at time of release.

Southeast Fisheries Science Center (SEFSC)

Observer Programs

The shark longline observer program was created to obtain better data on catch, bycatch, and discards in the shark bottom longline fishery. Recent amendments to the Consolidated Atlantic HMS Fishery Management Plan have significantly modified the major directed shark fishery and implemented a shark research fishery. NMFS selects a limited number of commercial shark vessels (five in 2012) on an annual basis to collect life history data and catch data for future stock assessments. Outside the research fishery, vessels targeting shark and possessing valid directed shark fishing permits were randomly selected for coverage with a target coverage level of 4 to 6 percent. From January to December 2016, a total of 76 trips on 11 vessels with a total of 119 bottom longline hauls were observed. Sharks comprised 97.6% of the catch, followed by teleost (1.0%), batoids (0.8%), turtles (0.2%), unknown animal (0.02%), invertebrates (0.02%), and sawfish (0.02%). Sandbar shark comprised 73.3% of the shark catch, other large coastal shark species comprised 22.3% of the shark catch and small coastal shark species comprised 12.0%. Prohibited shark species were also caught including dusky shark (2.7% of shark catch), sand tiger shark (2.0%), and white shark (0.02%). Fishing locations ranged from North Carolina to the Florida Keys in the Atlantic Ocean and the Gulf of Mexico. While an observer program exists for the southeast shark gillnet fishery, the trend of declining effort in the shark targeted gillnet fishery continued to be observed in 2016. Strike gillnet gear was observed exclusively in teleost (king mackerel) targeted sets. The majority of sink gillnet fishers continued to target teleost species. Incidental take of protected species, such as sea turtles and marine mammals, remained a rare occurrence, with none observed in 2016. The general gillnet fishing effort has decreased significantly in the last 5 years. Based on the NMFS Coastal Logbook System, gillnet fishing trips decreased by over half, from 669 trips in 2011, to 302 trips in 2015. The number of active gillnet fishers has also decreased, suggesting that some of the older generation are retiring and younger fishers are not replacing them.

Elasmobranch Feeding Ecology

Studies are currently underway describing the diet and foraging ecology, habitat use, and predator–prey interactions of elasmobranchs. The diets of multiple shark species caught by commercial longline gear, including silky (*C. falciformis*), and tiger (*Galeocerdo cuvier*) sharks, are currently being investigated. Along with basic diet analysis, stomach contents will be examined for evidence of line feeding, or depredation, on longline gear. This study will help to test the hypothesis that diet studies based on longline-caught animals could be biased due to longline depredation. Additional data are being collected during SEFSC bottom longline surveys to examine spatial variability in the diets and feeding behaviors of various shark species.

Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey (GULFSPAN) and Tagging Database

The SEFSC Shark Population Assessment Group manages and coordinates a survey of coastal bays and estuaries from Florida to Louisiana. Surveys identify the presence or absence of neonate (newborn) and juvenile sharks and attempt to quantify the relative importance of each area as it pertains to essential fish habitat. A database currently includes over 19,000 tagged animals from 1993 to the present for both the Gulf of Mexico and U.S. southeast Atlantic Ocean.

Monitoring the Recovery of Smalltooth Sawfish (Pristis pectinata)

The smalltooth sawfish was the first marine fish listed as endangered under the Endangered Species Act (ESA). Smalltooth sawfish has been listed under the ESA since 2005, and the completion of the Smalltooth Sawfish Recovery Plan in early 2009 identified new research and monitoring priorities that are currently being implemented. Surveys identify the presence or absence of neonates, young-of-the-year, and juveniles in southwest Florida and research in the Florida Keys and Florida examines the distribution and abundance of adult animals.

Life History Studies of Elasmobranchs

In collaboration with Florida State University, scientists are examining age, growth, and reproduction of Cuban dogfish. In addition, research is also being conducted with the Bimini Biological Station on the life history of the lemon shark. Studies on the life history of night shark and shortfin mako are being conducted with the Northeast Fisheries Science Center.

Stock Assessment of Dusky Sharks

An updated assessment of dusky sharks was conducted in 2016 under the SEDAR process (update assessment to SEDAR 21). The assessment, and an ensuing addendum, concluded that the Atlantic and Gulf of Mexico stock of dusky sharks continues to be overfished and overfishing is still occurring despite a substantial reduction in the level of overfishing since the previous stock assessment was conducted in 2011. Estimates of current (for 2015) biomass-related benchmarks (SSF_{2015}/SSF_{MSY} where SSF is spawning stock fecundity) from five plausible states of nature scenarios ranged from 0.44 to 0.69, indicating that the stock was overfished. Estimates of current (for 2015) apical fishing mortality relative to MSY (F_{2015}/F_{MSY}) were highly uncertain but lower than those estimated in 2011 for SEDAR 21, ranging from 1.08 to 2.92. According to these results, it was estimated that a median reduction in fishing mortality of 53% was still required for the stock to achieve a 70% probability of rebuilding by the target year.

Shark Assessment Research Surveys

The SEFSC has conducted annual bottom longline surveys in the northern Gulf of Mexico and off the east coast of the United States since 1995. The primary objective is to utilize standardized gear to assess the distribution and abundance of large and small coastal sharks across their known ranges to provide fisheries-independent time series data for trend analysis. The survey is the largest of its kind and is considered essential for accurate stock assessments of sharks occurring off the East Coast of the United States and throughout the northern Gulf of Mexico. This survey also provides a platform for other shark research activities including identification of essential habitats, reproductive biology, feeding behavior, gear selectivity, movement patterns, and effects of deleterious anthropogenic impacts. To date, over 43,000 fishes have been collected during the survey of which approximately 85 percent were sharks.

Atlantic Highly Migratory Species (HMS) Management Division

New York Bight Shark Studies

Staff from the HMS Management Division collaborated on multidisciplinary electronic tagging and biological sampling research on sharks off Long Island, New York, including juvenile white sharks, dusky sharks, and smooth dogfish. In cooperation with OCEARCH, Harbor Branch Oceanographic Institute, and other collaborators, satellite-linked Smart Position or Temperature transmitting (SPOT) and coded acoustic tags were attached to juvenile white sharks to study their movements, migration, and habitat use patterns. Dusky and smooth dogfish were also fitted with acoustic tags, and numerous biological samples (fin clips, blood, muscle tissue, parasites) were collected for collaborating institutions studying stress physiology, stable isotopes, population genetics, contaminants, and parasitology.

Basking Sharks (Cetorhinus maximus)

Staff from the HMS Management Division have been collaborating with scientists from the Massachusetts Division of Marine Fisheries, Woods Hole Oceanographic Institution, University of Massachusetts – Dartmouth, NEFSC, and the North Atlantic Right Whale Consortium to study the distribution, movements, migrations, and habitat selection patterns of basking sharks in the western North Atlantic. A total of 57 basking sharks were tagged with pop-up satellite archival tags (PSATs) off the coast of Massachusetts, and tracked for 7-423 days. An additional ten basking sharks were tagged with SPOT tags and local movements were tracked for 5-45 days. Basking shark tracks, and sightings from marine mammal surveys, have been analyzed with respect to numerous environmental factors and potential exposure to fisheries bycatch.

4.2 Incidental Catch Reduction

Pacific Islands Fisheries Science Center (PIFSC)

Developing bycatch mitigation strategies for oceanic sharks captured in purse seine gear

In tropical tuna purse seine fisheries an increasing amount of fishing effort is based on setting gear around drifting Fish Aggregating Devices (FADs). In the Western Central Pacific Ocean 21% of the effort is conducted on FADs and results in 40% of the total tuna catch (Williams and Terawasi 2016). FAD-associated sets have increased rates of shark bycatch in comparison to non-FAD sets. PIFSC scientists in collaboration with researchers from several institutions around the world are working with the International Seafood Sustainability Foundation (ISSF) to develop and test shark bycatch mitigation strategies in tropical tuna purse seines (Restrepo et al. 2016) in every ocean. Between 2011 and 2015, eleven research cruises were conducted. During 2015, ISSF and PIFSC Project scientists worked on both commercial purse seine vessels and chartered research vessels in collaboration with industry to test a shark release panel in strategic positions in purse seine nets. They also worked to tag silky and oceanic whitetip sharks captured at drifting FADs to better understand their FAD associative behavior, residence times and habitat use. These data are advancing knowledge of the movement behavior of silky and oceanic whitetip sharks, and providing insight into potential catch mitigation techniques and safe release mechanisms.

Understanding FAD residency and behavior of oceanic whitetip sharks

Oceanic whitetip sharks (*Carcharhinus longimanus*) are a large component of the shark bycatch in tuna purse seine and longline fisheries worldwide (Rice and Harley, 2012). Oceanic whitetip shark (OCS) populations, historically one of the most numerically abundant species in tropical waters (Bonfil et al. 2008), have undergone significant declines in all oceans. OCS were listed in appendix II of CITES in 2014. NMFS received a petition in September 2015 to list the oceanic whitetip shark as threatened or endangered under the ESA, and to designate critical habitat concurrent with any final listing. In 2016, NMFS proposed to list the oceanic whitetip shark as a threatened species under the ESA (81 FR 96304, December 29, 2016). A stock assessment conducted by the Secretariat to the Pacific Community found oceanic whitetip shark populations in the Pacific Ocean to be in decline as a result of overfishing and concluded overfishing was still occurring (Rice & Harley, 2012). Locally, OCS have also shown significant declines in relative abundance in the Hawaii longline fishery since 1995 (Walsh and Clarke, 2011). They are currently the subject of an investigation on ways to reduce OCS mortality in the FAD associated purse seine fishery. Conservation and management measures have been implemented by several of the tuna RFMOs that ban the retention of this species (Clarke et al. 2015). No-retention policies can reduce targeted fishing effort but may have little effect on reducing total mortality in OCS bycatch. In an effort to build the stock, fisheries scientists have called for additional research on the reproductive biology of this species and for tagging studies to gain a better understanding of the basic ecology and stock structure (Rice and Harley, 2012). OCS are a highly migratory species, and yet, few studies have focused on OCS movements to identify any migratory patterns. However, a recent paper documented evidence of residency and philopatry on OCS tagged in the Atlantic Ocean (Howey-Jordan et al. 2013). OCS are temporally resident at anchored FADs and found in association with tuna schools and pilot whales around Hawaii. As such they are subject to interactions with local troll fisherman and are known to cause high rates of depredation in troll-captured fish. These interactions are often fatal for the sharks because local fishers are known to kill sharks. Therefore, the primary objective of this study is to inform conservation engineering efforts to reduce OCS mortality in the FAD associated purse seine fishery. By identifying potential spatial mitigation factors present in their behavior at anchored FADs in Hawaii, and by working with local fishers to elucidate movement behavior times and areas of high depredation rates in the Kona based troll fishery, the researchers hope to come up with practical solutions to reduce OCS-fishery interactions.

Southwest Fisheries Science Center (SWFSC)

Dynamic Ocean Management

One goal of efforts to characterize the habitats of sharks through electronic tagging has been to support efforts in dynamic ocean management (DOM). DOM involves developing habitat models for target and bycatch species that, when combined, will allow fishers to identify areas with lower bycatch probability while still maintaining target catch. In a collaboration between the Fisheries Resources Divison (FRD) and Environmental Research Division (ERD) at the SWFSC, scientists have used a modeling/visualization platform called ECOCAST to identify habitats across species, including blue sharks. Using this approach it is possible to create daily maps of target and bycatch probabilities (Figure 4.2.1). The data used for blue sharks to characterize habitats included both electronic tagging data and catch data from local fisheries. This has been identified by the Pacific Fisheries Management Council as an important potential tool for west coast swordfish fisheries and is currently being beta tested by drift gillnet fishers off California.

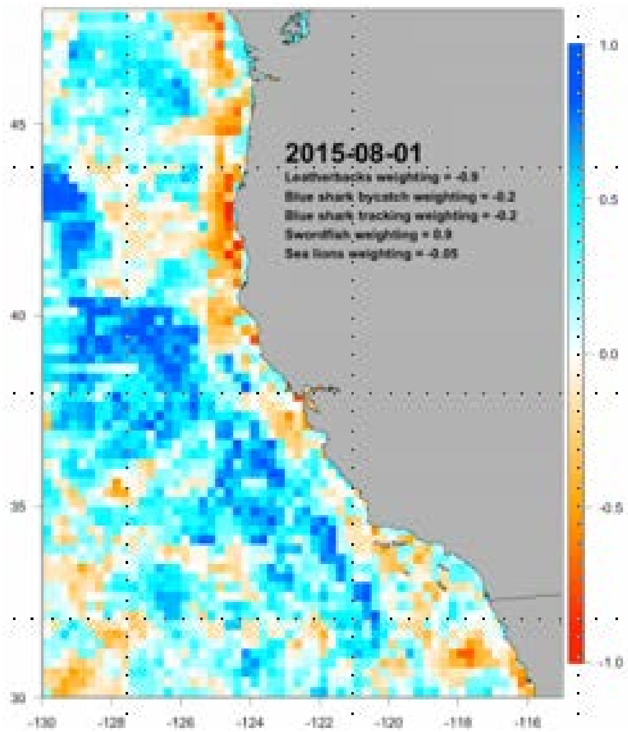

Figure 4.2.1. Weighted probabilities of swordfish catch rates and bycatch rates (blue shark, leatherback sea turtles and California sea lions) for Aug. 1, 2015 based on habitat models.

Shark Bycatch in the Drift Gillnet Fishery

While no additional research on alternative gear is planned at the SWFSC, a second component of research has been a characterization of the shark bycatch in the CA drift gillnet fishery (CA DGN). Working with a Scripps Institution of Oceanography masters student, SWFSC examined the bycatch of sharks in the drift gillnet fishery by both weight and numbers. Comparisons were made between periods where significant differences in management were in place. The major divisions occur in 1998, when net extenders were implemented to reduce cetacean bycatch, and in 2001 when the Pacific Leatherback Conservation Area (a time area closure) was put in place. While causation is difficult to demonstrate, a decline in catch per set of blue sharks is apparent around 1998, when the net extenders were implemented (Figure 4.2.2), while common thresher shark and mako catch per set has remained relatively constant. Total shark catch has also declined due to the drop in blue shark catch, and because of the dramatic reductions in effort in this fishery. Overall, the blue shark landings in the DGN fleet make up a small fraction of the total Pacific-wide landings by weight, 0.18% in 2012.

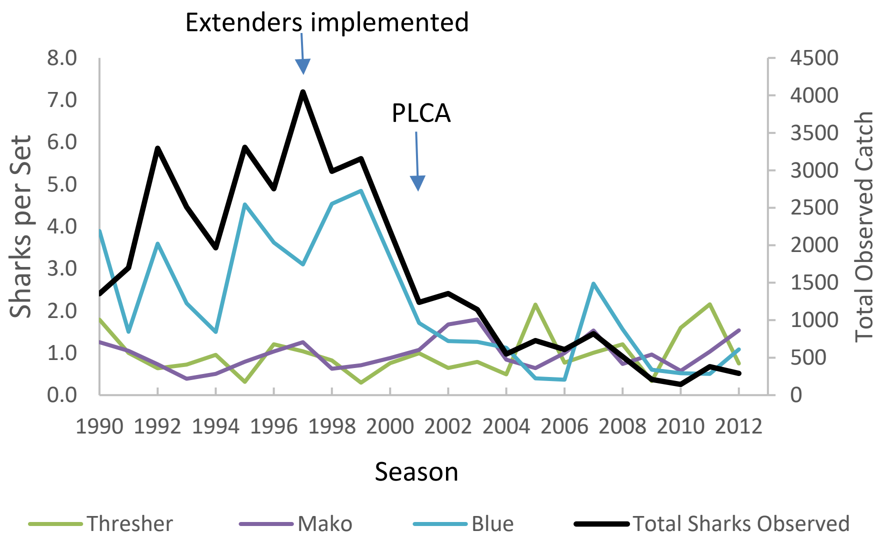

Figure 4.2.2. Observed catch per set of Common Thresher, Blue and Mako sharks in the CA Drift Gillnet Fishery from 1990-2012 in addition to the total number of observed catch of all sharks.

4.3 Post-Release Survival

Northeast Fisheries Science Center (NEFSC)

Post-release Recovery and Survivorship Studies in Sharks—Physiological Effects of Capture Stress

This ongoing cooperative research is directed toward coastal and pelagic shark species caught on recreational and commercial fishing gear. This work is collaborative with researchers from Massachusetts Division of Marine Fisheries (MassDMF) and many other state and academic institutions. These studies use blood and muscle sampling methods, including hematocrit, plasma ion levels, and red blood cell counts, coupled with acoustic tracking and pop-up satellite archival tag (PSAT) data to quantify the magnitude and impacts of capture stress. The primary objectives of the new technology tag studies are to examine shark migratory routes, potential nursery areas, swimming behavior, and environmental associations. Secondarily, these studies can assess the physiological effects of capture stress and post-release recovery in commercially- and recreationally-captured sharks. These electronic tagging studies include: 1) acoustic tagging and bottom monitoring studies for coastal shark species in Delaware Bay and the USVI as part of COASTSPAN; 2) tracking of porbeagle sharks with acoustic and PSATs in conjunction with the MassDMF; 3) placing real-time satellite (SPOT) and PSAT tags on shortfin makos and blue sharks in the Northeast U.S. and on their pelagic nursery grounds; 4) placing PSAT tags on sand tigers in Delaware Bay and Plymouth Bay (Massachusetts) as part of a fishery independent survey and habitat study; and 5) placing PSAT and SPOT tags on dusky and tiger sharks in conjunction with Monterey Bay Aquarium, University of California Long Beach, and MassDMF. Integration of data from new-technology tags and conventional tags from the CSTP is necessary to provide a comprehensive picture of the movements and migrations of sharks along with possible reasons for the use of particular migratory routes, swimming behavior, and environmental associations. In addition, the results of this research will be critical to evaluate the extensive current catch-and-release management strategies for sharks. In 2016, electronic tags were placed on shortfin makos, porbeagles, and dusky sharks as part of ongoing post-release recovery and migration studies.

Southeast Fisheries Science Center (SEFSC)

Determination of Alternate Fishing Practices to Reduce Mortality of Prohibited Dusky Shark in Commercial Longline Fisheries

SEFSC continues to conduct a series of fishing experiments using commercial longline fishing vessels to investigate methods to reduce at-vessel mortality of dusky shark, a prohibited species. Pop-off archival satellite tags have also been deployed on select individuals to aid in determining the efficacy of closed areas for dusky shark. The results will reflect the potential of bycatch mortality rates to influence already depleted populations, and these results could be used to propose regulations on longline soak time that could aid in population recovery of this species.

The effect of circle hooks vs J-style hooks on shark catchability and at-vessel mortality in bottom longline fisheries

Circle hooks are commonly recommended to reduce at-vessel mortality on pelagic longlines targeting tunas, swordfish and sharks. However, for bottom longlines targeting sharks there are few studies to advance any recommendations on the use of circle hooks over J-style hooks. To provide information to managers on their potential regulatory adoption, controlled experiments were conducted to compare 12/0 J-style and 18/0 circle hook types in regards to catchability and mortality. No significant differences in catch rates were found between hook types (n= 29,441 hooks). Median hooking times varied between species (4.4-4.8 hours) suggesting that some sharks may be more susceptible to bottom longline gears. At-vessel mortality varied among species, but overall, circle hooks vs J-style hooks did not significantly reduce at-vessel mortality. This is likely due to similar hook widths (gape) that precludes the shark from swallowing the hook. Given that catchability was not decreased when using circle hooks, a recommendation to require the use of circle hooks would not reduce the fishery yield and prevent the use of smaller J-style hooks.

New line cutter developed to facilitate release of non-target species

Releasing large marine organisms captured on longline gear can often be difficult due to problems associated with the use of conventional line cutters. For example, struggling animals can remain below the water's surface for extended periods, thus providing limited access to the end of the leader nearest the hook. A new line cutter was developed that outperforms conventional designs. The line cutter can be deployed by a single individual and severs leader material in close proximity to the location of hooks while negating the need to bring the captured organism to the surface. The use of the line cutter reduces stress and potential injury to captured animals, is easily and inexpensively constructed, and has applications beyond its intended use, such as freeing lines snagged or entangled under vessels.

Influence of bait type on catch rates of predatory fish species on bottom longline gear in the northern Gulf of Mexico

Identifying effective methods of reducing shark bycatch in hook-based fisheries has received little attention despite reports of declines in some shark populations. Previously proposed shark bycatch mitigation measures include gear modifications, time and area closures, avoidance of areas with high shark abundance, use of repellents, and use of specific bait types. Regardless of the method of shark bycatch reduction, knowledge of the effects of the chosen method on the catch rates of targeted fish species should be understood. To examine the effects of bait type on catch rates of sharks and teleosts on bottom longline gear, standardized gear was deployed with bait alternating between Atlantic mackerel (*Scomber scombrus*) and northern shortfin squid (*Illex illecebrosus*). For all shark species examined, except the scalloped hammerhead (*Sphyrna lewini*), a preference for hooks baited with Atlantic mackerel was observed. Commercially and recreationally important teleosts had no significant preference for a specific bait, with the exception of the red drum (*Sciaenops ocellatus*), which had a significant preference for hooks baited with northern shortfin squid. Bait preference decreased as total catch rate increased on individual longline sets. Our results point to the use of specific baits as a viable method to reduce shark catch rates without decreasing catches of targeted teleosts.

Section 5: Additional Information About Ongoing NOAA Shark Research

Alaska Fisheries Science Center (AFSC, Auke Bay Laboratory)

The AFSC conducts a variety of surveys that provide data for the stock assessments. In the Gulf of Alaska (GOA) there is a biennial trawl and annual longline survey. The trawl survey provides an estimate of biomass for spiny dogfish and the longline survey provide a relative index of abundance for spiny dogfish and Pacific sleeper sharks. The trawl surveys in the Bering Sea/Aleutian Islands (BSAI) do not sample sharks well and are not used in the stock assessment. The International Pacific Halibut Commission also conducts an annual longline survey in the GOA and BSAI, which samples a large number of stations each year and provides a relative index of abundance for both spiny dogfish and Pacific sleeper shark. The IPHC survey likely provides the most informative index because it samples both species of sharks across the full range of the survey and regularly at most of the stations.

Stock assessment and research efforts at the Alaska Fisheries Science Center's Auke Bay Laboratory (not described above) are focused on:

- Improving stock assessments and collection of data to support stock assessments of shark species subject to incidental harvest in waters off Alaska.
- Migration and habitat use of Pacific sleeper sharks.
- Migration and habitat use of spiny dogfish.

- Development and validation of improved ageing methods for Pacific sleeper sharks.
- Investigations into life history characteristics and population demography.
- Examining the accuracy of catch estimates in weight for large, hard to weigh sharks, and exploring managing large sharks by numbers instead of weight.

Stock Assessments of Shark Species Subject to Incidental Harvest in Alaskan Waters
Species currently assessed in Alaskan waters include Pacific sleeper sharks (*Somniosus pacificus*), spiny dogfish (*Squalus suckleyi,* note that this was formerly referred to as *S. acanthias*; see Ebert et al. 2010 for details of the species description), and salmon sharks (*Lamna ditropis*). These are the shark species most commonly encountered as incidental catch in Alaskan waters. In both the Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BSAI) fishery management plans, sharks are managed as a complex. There are no directed fisheries for sharks in either area and directed fishing for all sharks is prohibited. Most shark species are considered Tier 6, where annual catch limits are based on estimated historical incidental catch in the groundfish fisheries. In the GOA, spiny dogfish is currently Tier 5, with annual catch limits based on biomass and natural mortality. Biomass is currently estimated from the NMFS fishery-independent bottom trawl survey; however, it is thought that other surveys may better reflect the populations. Efforts are underway to develop a model to estimate biomass for spiny dogfish that would include data such as the NMFS and International Pacific Halibut Commission annual longline surveys. Stock assessments are summarized annually in the North Pacific Fishery Management Council's Stock Assessment and Fishery Evaluation Report (see Tribuzio et al. 2015 and 2016).

Northwest Fisheries Science Center (NWFSC)

Monitoring and Assessment Activities
The NWFSC conducts and supports several activities addressing the monitoring and assessment of sharks along the West Coast of the United States and in Puget Sound. The PacFIN serves as a clearinghouse for commercial landings data, including sharks. In addition, the At-Sea Hake and West Coast Groundfish Observer Programs collect data on shark species caught on vessels selected for observer coverage.

The NWFSC conducts annual trawl surveys of the West Coast, designed primarily to acquire abundance data for West Coast groundfish stocks. The tonnages of all shark species collected during these surveys are documented. In addition, the survey program has conducted numerous special projects in recent years to help researchers acquire data and samples necessary for research on various shark species.

In addition to these monitoring activities, the NWFSC conducted the first assessment for longnose skate in 2007. This assessment was reviewed during the 2007 stock assessment review (STAR) process, and was adopted by the PFMC for use in management. The NWFSC last conducted an assessment of spiny dogfish along the Pacific coast of the United States in 2011 (see section 2.3 of the 2014 Shark Finning Report to Congress).

Southwest Fisheries Science Center (SWFSC)

Shark research
The NOAA Fisheries Southwest Fisheries Science Center (SWFSC) shark research program focuses on pelagic sharks that occur along the U.S. Pacific Coast, including blue sharks (*Prionace glauca*), basking sharks (*Cetorhinus maximus*), shortfin mako (*Isurus oxyrinchus*), and three species of thresher sharks: bigeye, common, and pelagic threshers (*Alopias superciliosus*, *A. vulpinus*, and *A. pelagicus*, respectively). Center scientists are studying the sharks' biology, distribution, movements, stock structure, population status, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks. In addition to the work discussed above, the sections below describe other research also being carried out at the center.

Electronic tagging data analyses
Starting in 1999, SWFSC scientists have been using satellite technology to study the movements and behaviors of large pelagic sharks, primarily blue, shortfin mako, and common thresher sharks, while other species are tagged opportunistically. Shark tag deployments have been carried out in collaboration with a number of partners in the U.S., Mexico, and Canada. The goals of these projects are to document and compare the movements and behaviors of these species in the California Current and to link these data to physical and biological oceanography. This approach will allow characterization of the essential habitats of sharks and a better understanding of how populations might shift in response to changes in environmental conditions over short or long time scales.

Shortfin Mako Shark
Since 2002, over one hundred shortfin mako sharks have been tagged with either SPOT or PSAT tags, or both, during the SWFSC's collaborative electronic tagging study. Partners include the Tagging of Pacific Pelagics (TOPP) Program, CICESE, the Guy Harvey Institute, and several recreational anglers.

Data from 55 PSAT tags and 85 SPOT tags deployed on shortfin mako sharks are currently being analyzed. This is an enormously rich data set that includes tracks throughout a large part of the eastern North Pacific. Tracks range from near the U.S.-Canada border to the subtropics, into the Sea of Cortez and out near Hawaii. Tracks longer than six months showed that mako sharks tagged during the SWFSC HMS survey spent the summer and fall months near southern California after which they dispersed to the north, south, and offshore. Tags which recorded data for more than 12 months showed that the majority of tagged makos returned to the SCB the following summer. A comparison of habitat-use across regions show considerable diversity in vertical movements. In some areas, a distinct diel pattern is apparent whereas in others there is no obvious pattern. One consistent pattern, also observed in other species, is that as shark moved offshore they moved deeper into the water column. This is likely linked to the increased depth of the mixed layer and deep-scattering layer in more oligotrophic waters. The high degree of variability in dive patterns suggests that they are likely foraging throughout the water column.

In addition to using these data to characterize the general movement patterns and habitat-use, additional analyses are now focused on state-space modeling which separates migratory from resident behaviors. The assumption is that resident behaviors occur in preferred habitats and are often linked to foraging. Foraging is one of the most important motivators for migrations and key to understanding movements over short-and longer time frames. The data for both males and females have been run through the state-space model (Figure 5.1). Results show that the majority of resident behavior occurs closer to the coast although there are some additional regions offshore that appear to be important. The next step will be to link the regions of high residency to environmental parameters in order to quantify the oceanographic characteristics that define preferred habitat in near and off-shore regions.

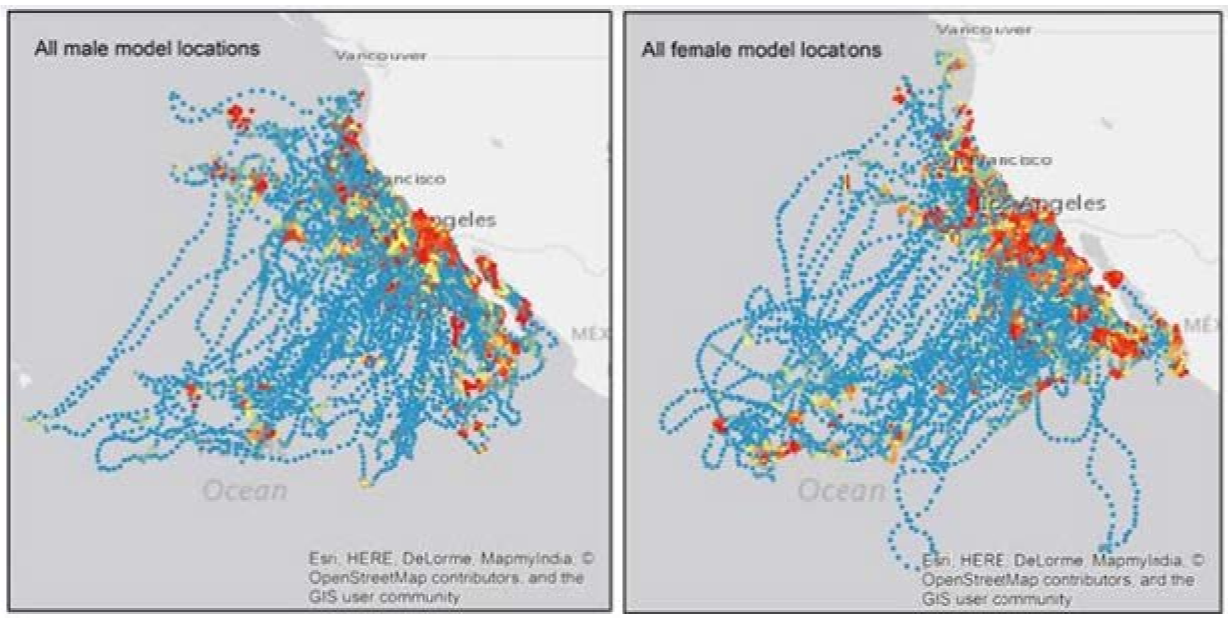

Figure 5.1. Results from state-space analyses showing the movements of shortfin mako sharks tagged with SPOT tags and the points where different migratory behaviors occured. Red and orange show resident behaviors while blue shows time spent in transit.

Blue Shark

The SWFSC has been deploying satellite tags on blue sharks since 2002 to examine movements and habitat use in the eastern North Pacific. To date, a total of 100 sharks (51 males and 49 females) have been tagged with some combination of SPOT (n=95) and/or PSAT tags (n=60), with 55 sharks carrying both tag types. The majority of sharks were tagged in the SCB, although 14 sharks were tagged off Baja California Sur, Mexico, and another 12 off southwest Canada. Five sharks died shortly after tagging and seven PSAT tags were recovered providing archival data on temperature, depth, and light levels. Satellite tag deployment durations for both tag types are substantially shorter than for mako sharks. For the 37 PSAT tags that provided data, 8 of which remained attached until the programmed pop-up date, the average deployment duration was 115 days. The mean SPOT tag track duration was 88 days, however, six tags transmitted for 337 days or more allowing for an examination of seasonal patterns. Interestingly, the four mature male sharks with long tracks all returned to the waters off southern California during the summer the year after they were tagged. Two of these tracks are shown in Figure 5.2. While the sample size is too small to draw conclusions about differences in migration patterns, the two females with longer tracks were far to the south the following summer (Figure 5.2). Additional tracks will be needed to determine if these patterns are consistent for females and large males for migrations greater than one year, and if so, if they are related to sex or maturity. The females were 4 and 5 years of age when tagged and maturity in females is reported to occur between 5-7 years of age.

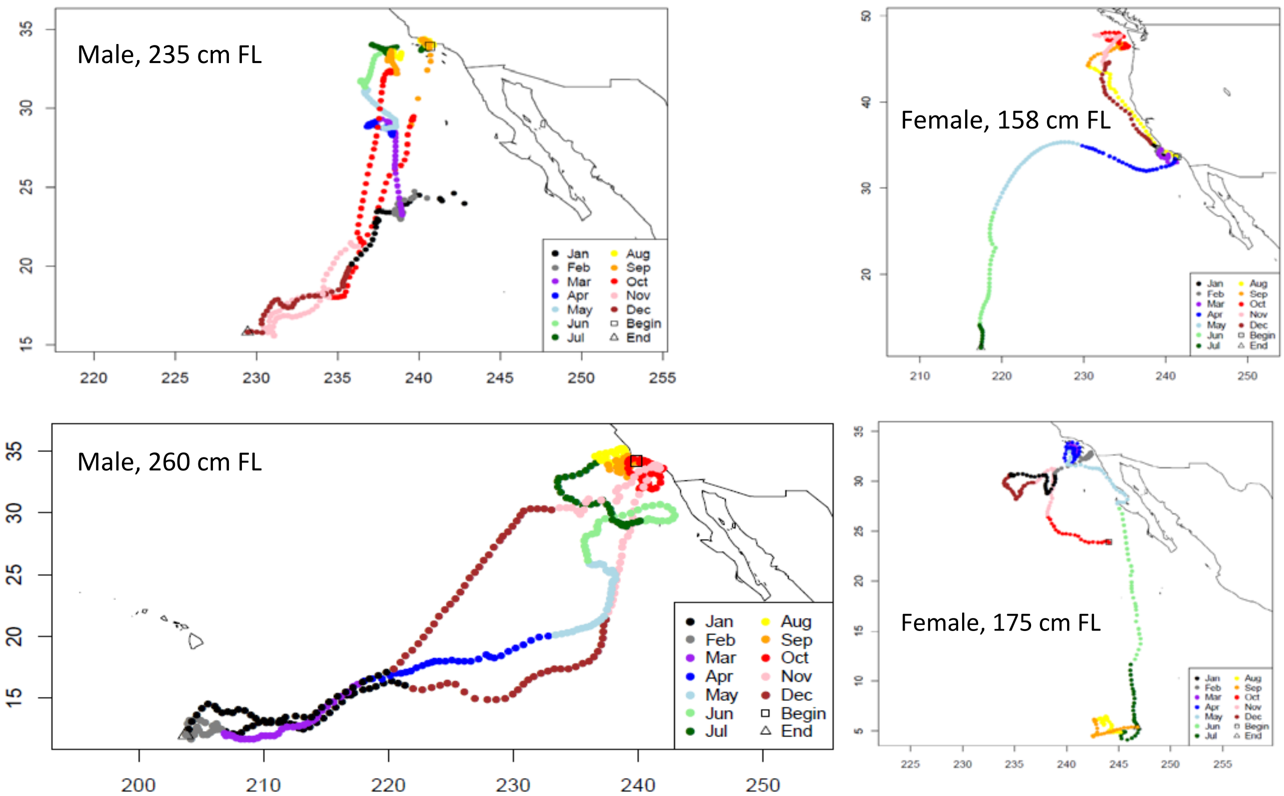

Figure 5.2. Tracks from four blue sharks with tracks of 337 days or greater. Month is indicated by color.

Data transmitted and recovered from the PSAT tags provide information on vertical and thermal habitat use. Blue sharks occupied waters from 4.4 to 29.8ºC, with sea surface temperature ranging from 10.8 to 29.8ºC. A common pattern in archival records was repetitive dives to depths consistent with foraging in association with the deep-scattering layer during the day and the average maximum depth across all fish differed significantly comparing day (154 m) and night (65 m). However, archival records revealed a range of vertical movements with some periods of no diel activity. A comparison of size classes (either < or > 160 cm FL) reveals that smaller sharks have shallower average maximum depths (124 m) in comparison to larger sharks (175 m), which may be linked to behavioral thermoregulation and the increase in thermal inertia with size. A manuscript examining geographic and vertical movement patterns is in preparation.

Common Thresher Shark

Since 2004, scientists at the SWFSC have been opportunistically tagging common thresher sharks with electronic tags during the annual neonate thresher shark and HMS abundance surveys. To date 29 common thresher sharks have been released with either PSAT3, SPOT4, or both since 2004. Depth data indicate that threshers spend much more time near the surface in the mixed layer than they do at greater depths, and that vertical excursions below the mixed layer primarily occur during the day, potentially due to their unique hunting strategy, which relies on visual prey detection. Work in 2015 and 2016 focused on developing a Bayesian movement model to provide a quantitative approach to inferring the effects of various environmental conditions on the horizontal movement of threshers.

Despite threshers being released with both SPOT and PSAT tags, to date SPOT tags have returned little to no data on the majority of tagged animals. PSAT data on the horizontal movements of these animals are harder to characterize than vertical movements because the light-based geolocation estimates determined from PSATs are less accurate than the locations from the satellite-linked SPOTs. Due to these difficulties, data from tags are being analyzed using a Bayesian approach, which will allow us to generate posterior distributions with which to characterize the effects of tested environmental factors on thresher movement. This model was developed and tested during 2016 and a publication on its effectiveness at analyzing movement data for data-limited species was produced and is currently under review with PLOS One (Kinney *et al.* In Review). Using this Bayesian movement model, SWFSC researchers aim to understand what biological and environmental variables influence whether threshers remain within the SCB or move into the surrounding waters in a predictable manner. Analysis suggests that fork length and the spring season are the strongest predictors of thresher shark movement out of the SCB, with their posteriors shifted furthest from zero. El Niño index and sex are also influential drivers. The movement models will be used with fishery-dependent and -independent data to estimate the overlap of threshers with local fisheries and aid in the development of more adaptive surveys. A manuscript on the movement of thresher sharks based on this Bayesian model is currently being drafted.

Foraging Ecology of Pelagic Sharks

The California Current is a productive eastern boundary current that functions as an important nursery and foraging ground for a number of highly migratory shark species. To better understand niche separation and the ecological role of spatially overlapping species, SWFSC researchers have been analyzing the stomach contents of pelagic sharks since 1999. Stomachs are obtained primarily from the CA DGN observer program, but with decreasing effort in the fishery, fewer shark stomachs have been available for analysis in recent years. Stomach content analysis of blue, shortfin mako, thresher, and bigeye thresher sharks is ongoing. In 2016, data were finalized for the period 2002-2014.

For the mako shark, jumbo squid was the most important prey item by weight and combined indices. Pacific saury (*Cololabis saira*) was the second most important prey by GII and IRI, but the most important for frequency of occurrence, and the most abundant by number. Other dominant teleost prey included Pacific sardine, Pacific mackerel, striped mullet (*Mugil cephalus*) and jack mackerel. Makos also preyed on marine mammals and other elasmobranchs. One mako preyed on a short-beaked common dolphin (*Delphinus delphis*), blue sharks were found inside five mako stomachs, and one mako fed on four tope sharks (*Galeorhinus galeus*).

For blue sharks squids dominated the diet. Squid of the genus *Gonatus* ranked first for GII and IRI and frequency of occurrence. Jumbo squid ranked second for GII and IRI, but they were the most important in weight. Other dominant prey included octopuses of the genus *Argonauta*, and the flowervase jewell squid (*Histioteuthis dofleini*). Forty-seven blue shark stomachs (23% of all stomach samples) contained prey that was bitten in chunks and were found in a fresh state of digestion (states 1 and 2) which were interpreted as depredation from the net. One stomach contained 21 pork steaks wrapped in paper and another stomach contained vegetables (onions, bell peppers, shredded carrots) and a tea bag, all these items were likely discarded at sea and scavenged by the blue sharks. Other than one mako, depredation was not apparent for the other shark species.

For the thresher shark, northern anchovy (*Engraulis mordax*) ranked first in both the GII and IRI, and had the highest number and weight. Pacific sardine ranked second in both the GII and IRI. Other dominant identified prey included market squid, Pacific hake, and Pacific mackerel. Pacific saury, Jack mackerel (*Trachurus symmetricus*) and Duckbill barracudina (*Magnisudis atlantica*) were found in at least 16 stomachs. Pelagic red crab was the most frequent crustacean (F=12).

For bigeye thresher, jumbo squid was the most important prey (for GII and IRI), it was also the most frequent prey, and had the highest weight. Duckbill barracudina and other Paralepididae ranked second and third. Other important prey included Pacific hake, Pacific mackerel, Pacific saury and *Gonatus* spp. squids. Fourteen individuals of king-of-the-salmon were present in two bigeye thresher stomachs.

Generalized additive models, redundancy analysis, and ecological indices calculations are in progress to determine how the prey of these four sharks is affected by environmental and biological variables.

Pacific Islands Fisheries Science Center (PIFSC)

Developing bycatch mitigation strategies for oceanic sharks captured in purse seine gear

In tropical tuna purse seine fisheries an increasing amount of fishing effort is based on setting gear around drifting Fish Aggregating Devices (FADs). In the Western Central Pacific Ocean 21% of the effort is conducted on FADs and results in 40% of the total tuna catch (Williams and Terawasi 2016). FAD-associated sets have increased rates of shark bycatch in comparison to non-FAD sets. PIFSC scientists, in collaboration with researchers from several institutions around the world, are working with the International Seafood Sustainability Foundation (ISSF) to develop and test shark bycatch mitigation strategies in tropical tuna purse seines (Restrepo et al. 2016) in every ocean. Between 2011 and 2017, eleven research cruises have been planned or conducted. During 2016, ISSF and PIFSC scientists on both commercial purse seine vessels and chartered research vessels in collaboration with industry to test a shark release panel in strategic positions in purse seine nets. PIFSC scientists involved in the ISSF bycatch project are in the process of developing next steps in testable shark bycatch mitigation strategies for upcoming cruises.

Movements and habitat use of juvenile silky sharks in the Pacific Ocean inform conservation strategies

Understanding the habitat use and behavior of commercially exploited species throughout ontogeny is useful for devising effective management and conservation strategies. Differences in habitat use can often be exploited to separate target and non-target species, while determinations of home range size can inform the proper scale of conservation actions. In tropical tuna purse seine fisheries in the Pacific Ocean juvenile silky sharks, *Carcharhinus* *falciformis*, comprise greater than 90% of the total elasmobranch bycatch. There is now growing recognition of declines in silky shark populations and the need for international collaboration in conservation efforts. Yet very little is known about the movement behavior or habitat use for this species. In this study, movement behavior of juvenile silky sharks was investigated using pop-up satellite archival tags placed on sharks that were captured during research cruises chartered by the ISSF, on a commercial tuna purse seine fishing vessel using drifting FADs in the Western Central Pacific Ocean, and on sharks captured using pelagic longlines in the Eastern Tropical Pacific. Analysis of horizontal and vertical movement behavior revealed silky sharks spend nearly 100% of their time in the shallow warm waters of the mixed layer. Juvenile silky shark depth and thermal preferences overlapped with the preferred habitat of the primary target tuna species, indicating vulnerability to capture in purse seine and shallow set longline fisheries throughout the tropical and subtropical regions of the Pacific Ocean where temperatures range between 24 and 29°C. Reconstruction of horizontal movements showed dispersal between adjacent national jurisdictions and high seas international waters, highlighting the need for international collaborations in the implementation of conservation measures.

Using net illumination to reduce elsamobranch bycatch

PIFSC has been involved in the development of shark bycatch reduction technologies incoastal gillnet fisheries. Net illumination through the use of LED lights have been tested in small scale coastal gillnet fishery based in Baja California, MX. Experiments using short wavelength (UV range), mid length (green wavelengths) and long wavelengths (orange/red) have been conducted to understand the effects on shark catch composition. Analysis of results show that UV illumination of gillnets significantly reduces the catch rates of elasmobranchs, in particular guitarfish and scalloped hammerhead sharks (*S. lewini*). In addition, experiments with orange (605 nautical miles wavelength) net illumination suggest that elasmobranch interaction rates can also be reduced. Both types of net illumination do not affect the target catch rates or significantly change the market value. This suggests that net illumination may be a useful strategy to reduce shark interactions in coastal gillnet fisheries. During 2016, scientists completed data collection and began analysis of the data.

Figure 5.3. LED trials to determine potential reduction of elasmobranch bycatch in gillnets.

Fishery Data Collection

Market data from the PIFSC shoreside sampling program contain detailed biological and economic information on sharks in the Hawaii-based longline fishery dating from 1987. These data are primarily collected from fish dealers who are required to submit sales/transaction data to the State of Hawaii. The Western Pacific Fishery Information Network (WPacFIN) is a Federal–State partnership collecting, processing, analyzing, and sharing, fisheries data on sharks and other species from U.S. island territories and states in the Central and Western Pacific(Hamm et al. 2011). The WPacFIN program has assisted other U.S. islands’ fisheries agencies in American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands in modifying their data-collection procedures to include bycatch information. These modifications have improved the documentation of shark interactions with fishing gear. Shark catches in the Hawaii-based longline fishery have been monitored by a logbook program since 1990 and by an observer program since 1994. American Samoa has had a federal logbook program since 1996, and an observer program since 2006. Longline landings of sharks are reported by the PIFSC Fisheries Research and Monitoring Division's (FRMD) International Fisheries Program (IFP).

Insular Shark Surveys

Densities of insular sharks have been estimated at most of the U.S. island possessions within the Tropical Central, Northern, and Equatorial Pacific on annual or biennial surveys conducted by the PIFSC Ecosystem Science Division (ESD) since 2000.

These estimates include surveys of:

- 12 major shallow reefs in the Northwestern Hawaiian Islands (2000, 2001, 2002, 2003, 2004, 2006, 2008, 2010, 2013, 2016).
- The Main Hawaiian Islands (2005, 2006, 2008, 2010, 2013, 2015, 2016).
- The Pacific Remote Island Areas of Howland and Baker in the U.S. Phoenix Islands and Jarvis Island, and Palmyra and Kingman Atolls in the U.S. Line Islands (2000, 2001, 2002, 2004, 2006, 2008, 2010, 2012, 2015).
- American Samoa, including Rose Atoll and Swains Island (2002, 2004, 2006, 2008, 2010, 2012, 2015, 2016).
- Guam the Commonwealth of the Northern Marianas Islands (2003, 2005, 2007, 2009, 2011), Johnston Atoll (2004, 2006, 2008, 2010), and Wake Atoll (2005, 2007, 2009, 2011, 2012, 2015).

Table 5.1 Shark species observed in PIFSC-ESD Reef Assessment and Monitoring Program (RAMP) surveys around U.S. Pacific Islands.

Shark species observed	
Common Name	Species
Grey reef shark	*Carcharhinus amblyrhynchos*
Galapagos shark	*Carcharhinus galapagensis*
Whitetip reef shark	*Triaenodon obesus*
Blacktip reef shark	*Carcharhinus melanopterus*
Silvertip shark	*Carcharhinus albimarginatus*
Sicklefin lemon shark	*Negaprion acutidens*
Tiger shark	*Galeocerdo cuvier*
Tawny nurse shark	*Nebrius ferrugineus*
Whale shark	*Rhincodon typus*
Scalloped hammerhead shark	*Sphyrna lewini*
Great hammerhead shark	*Sphyrna mokarran*
Zebra shark	*Stegostoma varium*

Although 12 species of shark have been observed during RAMP surveys (see Table 5.1), only four species are typically recorded in sufficient frequency by towed divers to allow meaningful statistical analyses: grey reef shark (*Carcharhinus amblyrhynchos*), Galapagos shark (*Carcharhinus galapagensis*), whitetip reef shark (*Triaenodon obesus*), and blacktip reef shark(*Carcharhinus melanopterus*). Analyses show a highly significant negative relationship between grey reef and Galapagos shark densities and proximity to human population centers (e.g., proxy for potential fishing pressure and other human impacts). Average combined numerical density for these two species near population centers is less than 10 percent of densities recorded at the most isolated islands (e.g., no human population, very low present or historical fishing pressure or other human activity). Even around islands with no human habitation, but within reach of populated areas, grey reef and Galapagos shark densities are only between 15 and 40 percent of the population densities around the most isolated near-pristine reefs. Patterns in whitetip and blacktip reef shark numbers are similar, but less dramatic.

Because all RAMP shark data were gathered by SCUBA divers, surveys were limited by safe diving practices to reef areas of 30 meters or shallower, which is the upper end of reef sharks' potential depth distribution. In addition, surveys by SCUBA divers are potentially biased by acquired behavioral differences of sharks in the presence of divers between isolated and fished locations. For those reasons, diver-independent assessments of shark populations over wider depth ranges – as are possible by deploying remote video systems – would likely yield stronger finromation on the relative abundance of reef sharks. As of 2016, NOAA ESD have conducted a small number of baited remote video (BRUV) surveys at locations in Hawaii, Tutuila, and Guam, at depths down to 100m. Only data from Hawaii have been fully analyzed to date, but results from those sruveys confirm a general pattern for substantial depletion of reef sharks in the populated MHI compared to the isolated NWMI – shark densities in MHWI BRUV surveys being approximatley five times higher in the NWHI (Asher et al, 2017).

Insular Shark Population Model

PIFSC scientists study the status of reef shark populations in the central-western Pacific Ocean. During PIFSC coral reef assessment and monitoring surveys conducted between 2004 and 2010, shark observations were recorded around 46 individual U.S. islands, atolls, and banks. PIFSC scientists analyzed shark count data from 1,607 towed-diver surveys conducted on fore reefs (seaward slope of a reef) using techniques developed specifically to survey large-bodied species of reef fishes.

The shark count data were used to build a computer model capable of explaining observed reef shark abundances at various reefs by examining the effects of variables related to human impacts, oceanic productivity, sea surface temperature, and reef habitat physical complexity. This model was used to predict reef shark densities in the absence of humans (i.e., baseline or pristine abundance) and found that current reef shark numbers around populated islands in Hawaii, the Mariana Archipelago, and American Samoa are down to about three to ten percent of their baseline values (Figure 6.3). These results show the extent of the detrimental effect of human activities on reef shark population. However, the exact cause of the decline is not known. The likely causes are probably related to prey population depletion (i.e., reef fish biomass around populated islands is about 50-80 percent lower than on pristine reefs) and direct removal through fishing (bycatch, recreational, or targeted) (Nadon et al. 2012).

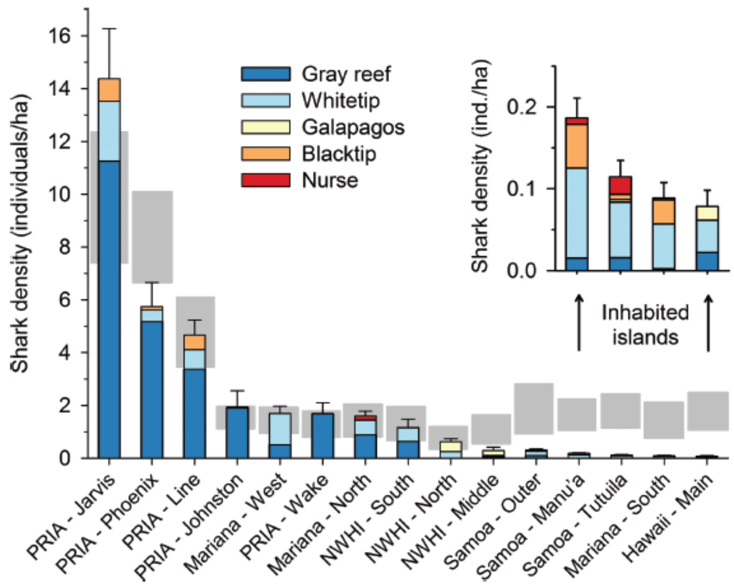

Figure 5.4. Mean (SE) observed densities of reef sharks in the U.S. Pacific. Colors represent actual densities; gray rectangles represent model predictions in the absence of humans.

Mitigation of Shark Predation on Hawaiian Monk Seal Pups at French Frigate Shoals

Shark predation on Hawaiian monk seal pups (*Monachus schauinslandi*) has become unusually common at one breeding site, French Frigate Shoals (FFS) in the Northwestern Hawaiian Islands (NWHI). Since 1997, NMFS has frequently observed Galapagos sharks (*Carcharhinus galapagensis*) patrolling and attacking monk seal pups. Tiger sharks (*Galeorcerdo cuvier*) also prey on monk seals and are abundant at FFS; however, Tiger sharks have not been observed to attack pups (Gobush 2010, unpublished data). For these reasons, monitoring and mitigation efforts at FFS continue to be focused on Galapagos sharks. Shark tagging studies at FFS indicate that, although Galapagos sharks are the most abudant shark species, they generally prefer deeper water and only a small fraction of the population, equating to a few tens of individuals, likely frequents the shallow areas around monk seal pupping islets (Dale et al. 2011).

Reducing shark predation on pups at FFS is one of several key activities identified in the Hawaiian Monk Seal Recovery Plan (NMFS 2007). Since 2000, NMFS has attempted to mitigate shark predation through harassment and culling of sharks, shark deterrents, and translocation of weaned pups to islets in the atoll with low incidence of shark attacks (Baker et al. 2011; Gobush 2010). NMFS implemented a highly selective shark removal project to mitigate predation on monk seal pups from 2000-2016, with the exception of 2008–2009 when deterrents were tested (see appendix for more details). Fifteen Galapagos sharks frequenting the nearshore areas of pupping islets have been lethally removed to date. In 2009, the number of shark sightings and predation incidents at two pupping islets did not differ significantly between the control and two experimental treatments: (1) acoustic playback and a moored boat, and (2) continuous human presence, versus a control (Gobush and Farry 2012). No sharks were removed at FFS during the 2016 season (after 72.75 fishing hours).

Electronic Tagging Studies and Movement Patterns
PIFSC scientists are using acoustic, archival, and pop-up satellite archival tags (PSATs) to study vertical and horizontal movement patterns in commercially and ecologically important tuna, billfish, and shark species, as well as sea turtles. The work is part of a larger effort to determine the relationship of oceanographic conditions to fish and sea turtle behavior patterns. This information is intended for incorporation into population assessments, addressing fisheries interactions and allocation issues, as well as improving the overall management and conservation of commercially and recreationally important tuna and billfish species, sharks, and sea turtles. PIFSC is finishing manuscripts detailing the movements of pelagic sharks in relation to oceanographic conditions.

Physiological investigations of sharks captured in tropical tuna purse seine fisheries.
The tropical tuna purse seine fishery and other commercial fisheries have high rates of incidental shark capture. In the western central Pacific Ocean (WCPO) purse seine fishery, juvenile silky sharks comprise greater than 90% of the shark bycatch. These sharks are of low market value and are discarded at sea. While discarded sharks are often released alive, several studies have shown that they may have sustained injuries (both physical trauma from capture and handling and physiological disturbances) that can have immediate or delayed effects that result in mortality. Blood borne biochemical indicators of stress are increasingly being used to elucidate the post release condition of elasmobranchs released after being captured in commercial fisheries. To identify the physiological perturbations that occur in silky shark bycatch in a purse seine, PIFSC, ISSF and University of Hawaii scientists quantified several blood borne indices of stress including: pH, lactate, glucose, adrenaline, blood gases, electrolytes and osmolality, from animals sampled during every stage of the fishing operation, including sharks that were sampled with a minimal amount of handling prior to interaction with purse seine fishing gear. The results show increasing lactate concentrations and decreases in pH as the fishing procedure progressed. This suggests that metabolic acidosis takes place following prolonged exposure to netting procedures. The levels of the potassium and calcium were higher in moribund sharks landed later in the fishing operations, suggesting intracellular leakage. Overall, irreparable physiological damage (and ultimately mortality) occurred once the sharks have been confined in the sack portion of the net. Thus, sharks discarded after purse seine capture, have a low probability of post-release survival.

Barbless Hooks and De-hookers
Hawaii-based longline fisheries are required to carry and use dehookers for removing hooks from sea turtles. These dehookers can also be used to remove external hooks and ingested hooks from the mouth and upper digestive tract of fish, and could improve post-release survival and condition of released sharks. Sharks are generally released from the gear by one of the following methods: (1) severing the branch line; (2) hauling the shark to the vessel to slice the hook free; or (3) dragging the shark from the stern until the hook pulls free. Fishermen are encouraged to use dehooking devices to minimize trauma and stress of bycatch by reducing handling time and to mitigate post-hooking mortality.

Testing of the dehookers on sharks during research cruises has indicated that removal of circle hooks from shark jaws with the dehookers can be quite difficult. PIFSC is looking into the feasibility of barbless circle hooks for use on longlines, which would make it easier to dehook unwanted catch with less harm. Preliminary research in the Hawaii shore fishery has indicated that barbless circle hooks catch as much as barbed hooks, but the situation could be different with more passive gear such as longlines, where bait must soak unattended for much of the day and fish have an extended period in which to try to throw the hook. Initial results from very limited longline testing of barbless hooks on research cruises in American Samoa, and in collaboration with NMFS Narragansett Laboratory, indicated a substantial increase in bait loss using barbless hooks. Subsequent testing used rubber retainers to prevent bait loss. Summary information from before and after the use of bait retainers showed no difference between barbed and barbless hooks in the catch and catch rates of targeted species and sharks, although catches have so far been too few to provide much statistical power. Also in this study, the efficacy of the pigtail dehooker (the device required by U.S. regulations for releasing sea turtles) showed a 67 percent success rate in dehooking and releasing live sharks on barbless hooks, compared to a 0 percent success rate when used with sharks caught on barbed hooks.

Post-release Survival and Biochemical Profiling

Successful management strategies in both sport and commercial fisheries require information about long-term survival of released fish. Catch-and-release sport fishing and non-retention of commercially caught fish are justifiable management options only if there is a reasonable likelihood that released fish will survive for long periods. All recreational anglers and commercial fisherman who practice catch-and-release fishing hope the released fish will survive, but it is often not known what proportion of released fish will survive. Many factors, like fish size, water temperature, fight time, and fishing gear could influence survival.

Post-release survival is typically estimated using tagging programs. Historically, large-scale conventional tagging programs were used. These programs yielded low return rates, consistent with a high post-release mortality. For example, in a 30-year study of Atlantic blue sharks, only 5 percent of tags were recovered. Short-duration studies using ultrasonic telemetry have shown that large pelagic fish usually survive for at least 24 to 48 hours following release from sport fishing or longline gear. PIFSC researchers and collaborators from other agencies, academia, and industry have been developing alternative tools to study longer-term post-release mortality. Whereas tagging studies assess how many fish survive, new approaches are being used to understand why fish die. A set of diagnostic tools is being developed to assess the biochemical and physiological status of fish captured on various gear. These diagnostics are being examined in relation to survival data obtained from a comprehensive PSAT program. Once established as an indicator of survival probability, such biochemical and physiological profiling could provide an alternative means of assessing consequences of fishery release practices.

Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery

Juvenile silky sharks, *Carcharhinus falciformis*, comprise the largest component of the incidental elasmobranch catch taken in tropical tuna purse seine fisheries. During a 2015 chartered cruise on board a tuna purse seine vessel conducting typical fishing operations, we investigated the post-release survival and rates of interaction with fishing gear of incidentally captured silky sharks using a combination of satellite linked pop-up tags and blood chemistry analysis. To identify trends in survival probability and the point in the fishing interaction when sharks sustain the injuries that lead to mortality, sharks were sampled during every stage of the fishing procedure. The total mortality rates of silky sharks captured in purse seine gear was found to exceed 84%. We found survival to precipitously decline once the silky sharks had been confined in the sack portion of the net just prior to loading. Additionally, shark interactions recorded by the scientists were markedly higher than those recorded by vessel officers and the fishery observer. Future efforts to reduce the impact of purse seine fishing on silky shark populations should be focused on avoidance or releasing sharks while they are still free swimming.

Assessing shark bycatch condition and the effects of discard practices on post-release survival rates in the Hawaii & American Samoa-permitted tuna longline fisheries
Sharks captured in commercial longline fisheries are typically discarded at sea, due to finning and no-retention management measures or low-market values. The post-release fate of these sharks is unobserved and may be a large source of cryptic mortality for some populations. The three main factors that have the largest effect on post-release survivorship have been identified as; 1) the underlying physiology of some species make them more vulnerable to effects of capture related stress; 2) the amount of time a shark spends struggling on the line; and 3) the handling and dispatch procedures that the fishers use to remove an animal from the fishing gear. In this study initiated in 2016, PIFSC scientists are working with pelagic longline fishers and observers in Hawaii and American Samoa to tag; blue, bigeye thresher, oceanic whitetip and silky sharks that are captured and subsequently released from longline gear targeting tropical tunas with pop-off archival satellite tags. These tags validate post-release fate whereby quantitative estimates of post-release mortality rates can be generated. These data will also assist in the identification of best handling practices for discarding sharks from pelagic longline fishing gear to improve survivorship.

Southeast Fisheries Science Center (SEFSC)

Do Vertebral Chemical Signatures Distinguish Juvenile Blacktip Shark (Carcharhinus limbatus) Nursery Regions in the Northern Gulf of Mexico?
Identifying and protecting shark nurseries is a common management strategy used to help rebuild overfished stocks, yet we know little about connectivity between juvenile and adult populations. By analysing trace metals incorporated into vertebral cartilage, it may be possible to infer natal origin based on nursery-specific chemical signatures. To assess the efficacy of this approach, we collected juvenile blacktip sharks (Carcharhinus limbatus; n ¼ 4 93) from four regions in the Gulf of Mexico in 2012 and 2013 and analysed their vertebral centra with laser ablation–inductively coupled plasma–mass spectrometry. We observed significant regional differences in six element : Cal ratios in both 2012 and 2013. Multi-element chemical signatures were significantly different among regions and between year-classes. Year-class-specific linear discriminant function analysis yielded regional classification accuracies of 81% for 2012 and 85% for 2013, although samples were not obtained from all four regions in 2012. Combining year-classes resulted in an overall classification accuracy of 84%, thus demonstrating the usefulness of this approach. These results are encouraging yet highlight a need for more research to better evaluate the efficacy of vertebral chemistry to study elasmobranch population connectivity.

Targeted Catch-and-Release of Prohibited Sharks: Sand Tigers in Coastal Delaware Waters

The popularity of recreational shark fishing appears to be on the rise in recent years, with current policies often failing to address the direct targeting of protected species in this sector. Examination of catch trends from the past decade revealed that more than 66 million sharks were caught by recreational anglers along the U.S. eastern coast alone, including more than 1.2 million prohibited species. Using Sand Tigers, *Carcharias taurus*, captured by volunteer anglers as a case study to evaluate post-release mortality, 33 individuals were fitted with external acoustic tags and passively tracked using an array of acoustic receivers. Although rates of internal hooking and gear retention were high (57% and 60%), short-term post-release mortality was relatively low (6%) and was heavily influenced by hook location and retention. Given the dramatic increase in the range and extent of recreational fishing targeting prohibited species, even relatively low mortality rates may still pose a signifcant threat to recovery.

Revised Analyses Suggest That the Lesser Electric Ray Narcine bancroftii Is Not at Risk of Extinction

Among rays inhabiting US coastal waters in the western North Atlantic Ocean, a species of potential concern is the lesser electric ray Narcine bancroftii. The most recent International Union for the Conservation of Nature (IUCN) Red List Assessment indicates the species is Critically Endangered, which represents the highest risk of extinction based on IUCN criteria. The basis of this alarming designation was a reported 98% decline in abundance based on analyses of a long-term, fisheries-independent trawl survey conducted in the northern Gulf of Mexico since 1972. The status of this species generated considerable concern within the conservation community, prompting a petition for its inclusion under the US Endangered Species Act. We critically examined all available sources of data relative to the abundance of lesser electric ray, including those utilized in the original analysis, and found lesser electric rays do not appear to be at risk of extinction. Contrary to the earlier analysis, we found no evidence of decline in the relative abundance of lesser electric rays, with trends in abundance being relatively flat with high variability. Our investigation determined that analyses of previous trawl surveys did not address major changes over time in survey design and disregarded the strong habitat preference of lesser electric rays. It is critical that the best possible information be used when considering the conservation status of a given species to minimize undue burdens and ensure that increasingly limited resources are applied to the recovery of those species that are truly in peril.

Electronic Tagging Studies and Movement Patterns of Large Pelagic Sharks

SEFSC scientists are using fin-mounted smart position tags (SPOT) to study the horizontal movement patterns of tiger (*Galeocerdo cuvier*) and scalloped (*Sphyrna lewini*) hammerheads in the Gulf of Mexico. This work is part of a collaborative effort with the Louisiana Department of Wildlife and Fisheries and the University of Southern Mississippi. The information collected in this study is intended to address fisheries interactions and improve the management and conservation of these ecologically important sharks in the Gulf of Mexico. In 2015, fin-mounted SPOT tags were deployed on four sharks; two scalloped hammerheads and two tiger sharks. In addition, four SPOT tags deployed in 2014 on two scalloped hammerheads and two tiger sharks reported well into 2015. Data are being analyzed to investigate any possible season, sex, and size differences in movement patterns.

Long-term Assessment of Whale Shark Population Demography and Connectivity using Photo-identification in the Western Atlantic Ocean

The predictable occurrence of whale sharks, *Rhincodon typus*, has been well documented in several areas. However, information relating to their migratory patterns, residency times and connectivity across broad spatial scales is limited. In the present study, photo-identification data is used to describe whale shark population structure and connectivity among known aggregation sites within the Western Central Atlantic Ocean (WCA). From 1999 to 2015, 1,361 individuals were identified from four distinct areas: Yucatan Peninsula, Mexico (n = 1,115); Honduras (n = 146); northern Gulf of Mexico, United States (n = 112), and Belize (n = 49). Seasonal patterns in whale shark occurrence were evident with encounters occurring in the western Caribbean Sea earlier in the year than in the GOM. There was also a significant sex bias with 2.6 times more males present than females. Seventy sharks were observed in more than one area and the highest degree of connectivity occurred among three aggregation sites along the Mesoamerican Reef. Despite this, the majority of resightings occurred in the area where the respective sharks were first identified. This was true for the WCA as a whole, with the exception of Belize. Site fidelity was highest in Mexico. Maximum likelihood modelling resulted in a population estimate of 2,167 (95% c.i. 1585 - 2909) sharks throughout the entire region. This study is the first attempt to provide a broad, regional population estimate using photo-identification data from multiple whale shark aggregations. Our aim is to provide population metrics, along with the description of region-scale connectivity that will help guide conservation action in the WCA. At a global level, rapidly growing photographic databases are allowing researchers to look beyond the description of single aggregation sites and into the ocean-scale ecology of this pelagic species.

Quantifying Post-Release Mortality for Dusky Sharks, Carcharhinus obscurus, Caught on Commercial Pelagic Longline Gear

Scientists in the SEFSC in a collaborative effort with scientists at the University of New England are investigating post-release mortality for dusky sharks caught with commercial pelagic longline fishing gear. Recent stock assessments for the dusky shark, *Carcharinus obscurus*, indicate the population is overfished and experiencing overfishing. As part of a rebuilding plan the retention of dusky sharks has been prohibited since 2000, including commercial and recreational takes. Despite this prohibition, dusky sharks are bycatch in multiple fisheries, including the pelagic longline fleet where post-release mortality (PRM) estimates are unknown. Here we estimated the post-release mortality of dusky sharks captured with standard pelagic longline gear in the western north Atlantic. Fifty dusky sharks were tagged with PSAT LIFE tags (Lotek Inc.), brought alongside the vessel, identified and assigned an injury condition. The time spent hooked for tagged sharks ranged from 0.8 to 8.1 hours (4.3±0.28). No at-vessel mortality was observed for any dusky shark caught or tagged in this study (n=151). Forty-three of the 50 tags reported data (86%) with deployment times ranging from one to 28 days (11.2 ± 9.8 days). Four dusky sharks were in poor condition at release, and two individuals suffered PRM, which occurred immediately after release. Dusky shark PRM rate in this study was 5%, far below current ICCAT estimates from bottom longline gear (55%) and reinforcing that PRM must be evaluated by each gear type.

Movement and Oceanographic Preferences of Scalloped Hammerhead Sharks (Sphyrna lewini) in the Gulf of Mexico

Information on movement and habitat use of large marine predators is needed to identify important areas for proper conservation and implement sound spatially explicit management strategies. Identifying important habitat(s) and the mechanisms responsible for movement is inherently difficult due to the mobility of large marine predators as they often move across multiple ecosystems or habitats. Moreover, patterns of habitat use and residency are influenced by dynamic oceanographic conditions (e.g., mesoscale eddies or currents) and distribution and movement of prey resources. The objective of this study was to better understand movement dynamics of Scalloped Hammerhead sharks (*Sphyrna lewini*) throughout the Gulf of Mexico (GOM) using Smart Position or Temperature (SPOT) transmitting tags attached to the dorsal fin. A total of 33 scalloped hammerhead sharks were captured and tagged throughout the northern GOM ranging from five to 479 days at large. Average number of days at large was 146 days with an average size at tagging of 159 cm fork length (FL) (range: 102-220 cm FL). Movement patterns are being analyzed relative to remotely sensed oceanographic parameters including sea surface temperature, salinity, sea surface height anomaly, chlorophyll concentration and bathymetry. In addition, Bayesian state-space switching models are being used to examine directed movement and residency periods of individual sharks. Results will provide critical information on fine-scale habitat use and movement patterns that can be used to improve predictability models to highlight priority areas and environmental preferences of Scalloped Hammerhead sharks throughout the GOM.

Regional Comparison of the Diet of the Atlantic Sharpnose shark (Rhizoprionodon terraenovae) from Across the Northern Gulf of Mexico

The Atlantic sharpnose, *Rhizoprionodon terraenovae*, is the most abundant shark species in the northern Gulf of Mexico (nGOM), and understanding their diet can provide a better understanding of the trophic ecology of sharks in the nGOM. While several studies describing the diet of the Atlantic sharpnose shark have been conducted in spatially discrete inshore areas, this study was carried out in offshore waters (>10 m) across the entire nGOM during a single year, 2011. The objective of this study is to describe the diet of the Atlantic sharpnose shark across the nGOM and determine if regional differences (east vs west) in the diet exist. Three hundred and twenty-five stomachs were examined using stomach content analysis of which 166 contained prey items. Diet was analyzed using total weight (%W) and percent index of relative importance (%IRI). Cumulative prey curves were generated to determine if adequate sample sizes were used to describe the diet. Teleost fishes made up the largest portion of the diet, comprising 59.8 %W and 76.9 %IRI in the west and 59.8 %W and 49.5 %IRI in the east. Atlantic croaker (*Micropogonia undulatus*) and penaeid shrimp were the two main prey items in both regions. However, Gulf menhaden (*Brevoortia patronus*) and cutlassfish (*Trichiurus lepturus*) were important prey in the west region, whereas squid (*Loliginidae*), *Ophichthidae* and *Sciaenidae* were important prey in the east. The regional difference in prey item abundance was directly proportional to the relative abundance of this species in each region, suggesting that Atlantic sharpnose sharks are opportunistic predators. Another 100+ stomachs from 2011 are currently being examined to increase our sample size and strengthen the power of the analysis.

Elasmobranch Feeding Ecology

The current Consolidated Atlantic HMS FMP gives little consideration to ecosystem function because there are little quantitative species-specific data on diet, competition, predator-prey interactions, and habitat requirements of sharks. Therefore, several studies are currently underway describing the diet and foraging ecology, habitat use, and predator-prey interactions of elasmobranchs in various communities.

Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey (GULFSPAN) and Tagging Database

The SEFSC Shark Population Assessment Group manages and coordinates a survey of coastal bays and estuaries from Cedar Key, Florida, to Terrebonne Bay, Louisiana. Surveys identify the presence or absence of neonate (newborn) and juvenile sharks and attempt to quantify the relative importance of each area as it pertains to essential fish habitat (EFH). The Group initiated a juvenile shark abundance index survey in 1996. The index is based on random, depth-stratified gillnet sets conducted throughout coastal bays and estuaries in coastal areas of the Gulf of Mexico from April to October. The species targeted in the index of abundance survey are juvenile sharks in the large and small coastal management groups. This index has been used as an input to various stock assessment models. A database containing tag and recapture information on elasmobranchs tagged by GULFSPAN participants currently includes over 19,000 tagged animals from 1993 to present for both the Gulf of Mexico and U.S. southeast Atlantic Ocean.

Monitoring the Recovery of Smalltooth Sawfish (Pristis pectinata)

The smalltooth sawfish was listed as endangered under the ESA in 2003. Smalltooth sawfish are the first marine fish and first elasmobranch listed under the ESA. Smalltooth sawfish were once common in the Gulf of Mexico and off the southeast coast of the United States. Decades of fishing pressure, both commercial and recreational, and habitat loss caused the population to decline by up to 95 percent during the second half of the twentieth century. Today, they exist primarily in southern Florida.

The completion of the Smalltooth Sawfish Recovery Plan in early 2009 brought about a new phase of research and management for the U.S. population of smalltooth sawfish. Research and monitoring priorities identified in the Recovery Plan are now being implemented. Field work is underway to gather information on determining critical habitat and monitoring the population. This information will evaluate the effectiveness of protective and recovery measures and help determine if the population is rebounding or, at the very least, stabilizing.

One of the high-priority research areas is monitoring of the number of juvenile sawfish in various regions throughout Florida to provide a baseline and time series of abundance. One of the more important regions for smalltooth sawfish identified in previous research is the section of coast from Marco Island to Florida Bay, Florida. This region encompasses the coast of the Ten Thousand Islands National Wildlife Refuge and Everglades National Park. Scientists from the SEFSC conduct monthly surveys in southwest Florida to capture, collect biological information, tag, and then release smalltooth sawfish. Preliminary results indicate that juvenile sawfish exhibit a high degree of site fidelity. Genetic identification of recaptured individuals indicates that sawfish caught on the same mudflat, for example, are siblings and a single adult female sawfish may give birth on that same mudflat year after year.

Highly productive, protected habitats have been shown to serve as nurseries for many marine fishes. However, few studies quantitatively measure the biotic characteristics that often drive a habitat's function as a nursery. We used a combination of passive acoustic monitoring and quantification of biotic attributes to assess nursery habitat use of juvenile smalltooth sawfish. Acoustic receivers were deployed within Everglades National Park to quantify residency, identify the timing of emigration, and detect migration of juvenile smalltooth sawfish. Benthic grain size and organic content along with mangrove prop root density and limb overhang were quantified throughout the array to test for relationships between habitat attributes and smalltooth sawfish presence. Results indicated that sawfish moved quickly through deep-water, narrow creeks, and rivers between shallow tidally-influenced bays. A stepwise regression analysis of detections per hour indicated that sawfish had an increased probability of being encountered in areas with high prop root density. Observed residency within the nursery ranged from days to several months with some overwintering, which has never previously been documented. Given the large amount of individual variability of movement within the study area, future studies of juvenile smalltooth sawfish habitat should strive to investigate the relationships between occurrence and other potential divers of habitat use such as prey fish assemblage and relative flow at multiple spatiotemporal scales.

Identifying habitat features and environmental requirements of threatened and endangered species is crucial to conservation and recovery efforts. Many species at risk of extinction have habitat ranges that have been significantly depressed, thus, identifying specific habitat features that a species requires is necessary for the protection and preservation of critical habitats. Predictive spatial modeling is a powerful tool that can be used to identify important habitats for species that are at risk of extinction. Smalltooth sawfish (*Pristis pectinata*; Latham 1794) is listed as Endangered under the U.S. Endangered Species Act and Critically Endangered according to the International Union for the Conservation of Nature Red List criteria. We analyzed data from a seven-year scientific gillnet survey to identify the most important environmental factors that influenced juvenile smalltooth sawfish occurrence. Combining habitat preferences with the environmental characteristics within a boosted regression tree model, we predicted occurrence throughout areas of known nursery use. Black mangrove pneumatophores, water temperature, depth, and salinity had the highest relative percentage contributions to predicting juvenile smalltooth sawfish occurrence. Juvenile smalltooth sawfish were more likely to be found in locations with mangroves and in shallow (< 1 m) waters with temperatures >25°C and salinities >20 ppt. Spatially explicit predictions of smalltooth sawfish probability of occurrence indicated Chokoloskee Bay in Everglades National Park as the location with the highest probability of juvenile smalltooth sawfish occurrence based on the combination of all predictor variables. Other locations with predictive occurrence were sporadic throughout designated critical habitat and included several regions that had been minimally sampled. This study emphasizes the importance of identifying specific environmental features that can affect distribution and potential population recovery of a critically endangered species. Spatial predictions can be used to formulate policy and should be taken into consideration when developing conservation and population recovery strategies.

Successful recovery of sawfish populations requires juvenile recruitment success and initiatives now strive to include the protection of areas used by juveniles in order to promote survivorship. Initial studies have identified sheltered, shallow, mangrove areas as nursery habitat with subsequent studies finding warmer water temperatures and variable salinity associated with the capture of juvenile sawfish. However, further refinement is required to fully predict the essential features smalltooth sawfish require as juveniles. Since 2009, a fisheries-independent gillnet survey of smalltooth sawfish abundance has occurred in Everglades National Park, US.

Life History Studies of Elasmobranchs

Biological samples are obtained through research surveys and cruises, recreational and commercial fishermen, and collection by onboard observers on commercial fishing vessels. Age and growth rates and other life-history aspects of selected species are processed and analyzed following standard methodology. This information is vital as input to population models used to predict the productivity of the stocks and to ensure they are harvested at sustainable levels.

Cooperative Research on Shortfin Makos

During 2016, the SEFSC was involved in several activities of the ICCAT Standing Committee on Research and Statistics (SCRS) Shark Species Group (SSG) Shark Research and Data Collection Program (SRDCP) focusing on biological and other aspects of the shortfin mako and contemplating extensive collaborative work among national scientists from Portugal, Japan, Uruguay, and the US with the ultimate goal of contributing information to the forthcoming 2017 shortfin mako stock assessment. The SRDCP project includes the four following ongoing activities: a pan-Atlantic age and growth study; a population genetics study to estimate the stock structure and phylogeography of Atlantic shortfin mako; a post-release mortality study focusing on pelagic longline fisheries; and a movements, stock boundaries, and habitat use study.

Age and Growth of Shortfin Mako in the Atlantic Ocean

This project, led by a colleague from EU-Portugal, includes the participation of scientists from Portugal, Uruguay and United States (SEFSC and NEFSC). There still remain uncertainties about the age and growth parameters of shortfin mako and this project aims to update the available estimates by ageing specimens from multiple areas in the Atlantic. To that end, an inventory of existing vertebral samples available at each national laboratory was compiled, and additional sampling was carried out. The current sample includes a total of 698 vertebrae: 253 from the Northwest Atlantic, 103 from the Northeast Atlantic, 268 from the southwest Atlantic, and 74 from the southeast Atlantic. All samples were being processed and digital images uploaded to an ICCAT online repository. In June 2016, a two-day age and growth workshop was organized by NOAA-NEFSC (Narragansett Laboratory) with the participation of the involved scientists, with the objective of establishing the initial reference set for ageing the samples. Sampling processing was almost completed by December 2016. One biologist from each participating institution will read and estimate the ages from all the samples, based on the agreed ages from the reference set, and growth models will be developed based on those readings.

Genetic Analysis of Shortfin Mako in the Atlantic Ocean

The main goal of this project, led, by a Japanese colleague, is to investigate the genetic stock structure of the Atlantic shortfin mako using mitochondrial and microsatellite DNA of specimens collected across the entire Atlantic Ocean. A total of 392 shortfin makos were collected though collaboration with national scientists of the SSG from the entire Atlantic and part of the southwestern Indian Ocean. The observed mitochondrial and microsatellite diversities were comparable among sampling locations. The preliminary mitochondrial analyses indicated that the Atlantic shortfin mako was significantly differentiated among the northern, southwestern, and southcentral and southeastern areas, which supports current stock structure hypotheses of Atlantic shortfin makos, and also suggests the possibility of multiple stocks within the South Atlantic. In contrast, the microsatellite analyses did not show any genetic structuring of the

Atlantic shortfin mako. Considering the difference of hereditary pattern between these markers, the discrepancy of inference between markers would be caused by sex-biased dispersal, which means that the male-biased gene flow prevents the genetic structuring which is created by the female philopatric behaviour. The SSG agreed to continue this study with additional samples, such as from the Caribbean Sea and Mediterranean to explore further detailed genetic flow of this species.

Post-release Mortality of Shortfin Mako in the Atlantic Ocean
This project, led by a colleague from Uruguay, aims to quantify the post-release mortality of Atlantic shortfin makos on pelagic longlines, which is currently non-existent, to potentially contribute to their assessment and management. To that end a total of 14 survivorship Popup Satellite Archival Transmitting Tags (sPATs) were acquired by ICCAT in late 2015 and distributed to the participating laboratories for deployment in three main areas of the Atlantic: the northwest, the tropical northeast and equatorial region, and the southwest. A total of 8 sPATs have been deployed thus far by scientific observers from IPMA (EU-Portugal) and NOAA (USA). Preliminary data are available from five tags, which indicate that three specimens survived and two died as a result of post-release mortality. The remaining tags were to be deployed in 2017, and additional tags from other projects involving the same partners were also going to be deployed in these same areas, which cover both hemispheres and both sides of the Atlantic.

Movements, Stock Boundaries and Habitat Use of Shortfin Mako in the Atlantic Ocean
The purpose of this project, led by a colleague fom Portugal, is to use satellite telemetry to gather and provide information on stock boundaries, movement patterns and habitat use of shortfin mako in the Atlantic Ocean to potentially contribute to their assessment and management. To that end, a total of 9 mini Pop-up Satellite Archival Transmitting Tags (miniPATs) were acquired by the ICCAT Secretariat in late 2015, for deployment on both adult and juvenile specimens of both sexes in main areas of the Atlantic, including the temperate, tropical northeast and equatorial region, and the southwest. A total of 7 miniPAT tags have been deployed so far by scientific observers from DINARA (Uruguay) and IPMA (EU-Portugal). The data from those 7 tags are already available, and a total of 333 tracking days have been recorded. Of the deployed tags, two released according to the original programming (120 days), two tags had premature releases (66 and 6 days), and three tags were on specimens that suffered post-release mortality (2 to 17 days). The two remaining tags from this project are prepared to be deployed soon. Additional tags from other projects involving the same partners may also be deployed in these same areas, which cover both hemispheres and both sides of the Atlantic. Among those additional tags are 9 miniPATs acquired under a NOAA International Science project that were sent to our Portuguese and Uruguayan colleagues for deployment.

Shark Assessment Research Surveys
The SEFSC has conducted bottom longline surveys in the Gulf of Mexico (see Figure 5.9), Caribbean, and Southern North Atlantic since 1995. The primary objective is assessment of the distribution and abundance of large and small coastal sharks across their known ranges in order to develop a time series for trend analysis. The surveys, which are conducted at depths between 9 and 366 fathoms, were designed specifically for stock assessment purposes. The bottom longline surveys are the only long-term, nearly stock-wide, fishery-independent surveys of

western North Atlantic Ocean sharks conducted in U.S. waters and neighboring waters. Recently, survey effort has been extended into depths shallower than 5 fathoms (9.1 meters) to examine seasonality and abundance of sharks in inshore waters of the northern Gulf of Mexico and to determine what species and size classes are outside of the range of the sampling regime of the long-term survey. This work is being done in cooperation with SEAMAP partner institutions. For all surveys, ancillary objectives are to collect biological and environmental data, and to tag and release sharks. The surveys continue to address expanding fisheries management requirements for both elasmobranchs and teleosts.

Northeast Fisheries Science Center (NEFSC)

Fishery Independent Coastal Shark Bottom Longline Survey

The fishery independent survey of Atlantic large and small coastal sharks is conducted bi-annually in U.S. waters, depending on funding. Its primary objective is to conduct a standardized, systematic survey of the shark populations off the U.S. Atlantic coast to provide unbiased indices of relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. This survey also provides an opportunity to tag sharks with conventional and electronic tags as part of the NEFSC Cooperative Shark Tagging Program (CSTP), to inject with oxytetracycline for age validation studies, and to collect biological samples and determine life history characteristics (age, growth, reproductive biology, trophic ecology, etc.). In addition, the collection of morphometric information provides data needed to calculate length to length and length to weight conversions. The time series of abundance indices from this survey are critical to the evaluation of coastal Atlantic shark species. Standardized catch rates and length data for dusky sharks caught during this survey were used in the 2016 Southeast Data Assessment and Review (SEDAR) update for the SEDAR 21 assessment of dusky sharks (McCandless and Natanson 2016). The next survey is scheduled for spring of 2018.

Figure 5.5. Releasing a sandbar shark during the NEFSC Coastal Shark Bottom Longline Survey. Source: L.J. Natanson / NMFS photo.

Fishery Independent Surveys for Monitoring and Assessing Delaware Bay Sharks

Delaware Bay is surveyed annually by NEFSC staff as part of the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) program. A random stratified longline sampling plan, based on depth and geographic location, was developed in 2001 to assess and monitor the juvenile sandbar shark population during the nursery season. In 2006 another longline survey using larger hooks and fixed stations based on NEFSC historical data and environmental niche predictors was initiated to target sand tigers for identifying Essential Fish Habitat (EFH) and for future stock assessment purposes. In 2016, sandbar sharks were the most abundant sharks caught in both surveys (82 percent of the total catch), followed by sand tigers and smooth dogfish. Additionally, six adult male Atlantic sharpnose sharks and one adult female blacktip shark were caught in Delaware Bay in 2016. The majority (97 percent) of sandbar sharks caught were immature, with 14 percent as young of the year; the remaining sandbar sharks caught were considered mature females based on length and girth measurements. Smooth dogfish were represented primarily by juveniles (76 percent) in 2016, with young of the year dominating the catch. The sand tigers caught in 2016 were primarily immature sharks, 32 percent were considered mature based on clasper calcification for males and length and girth measurements for females. Data from these surveys are used to update and refine EFH designations for multiple life stages of managed shark species and the standardized indices of abundance developed from these surveys are used in the stock assessments process and/or species status updates.

Figure 5.6. Sandbar shark ready to be tagged and released. Source: Lisa J. Natanson / NMFS photo.

Collection of Recreational Shark Fishing Data and Samples

Historically, species-specific landings data from recreational fisheries is lacking for sharks. In an effort to augment these data, the NEFSC has been attending recreational shark tournaments continuously since 1961 collecting data on species, sex, and size composition from individual events; in some cases, for nearly 50 years. In addition, these tournaments provide a source of biological samples for pelagic and some coastal sharks to be used in NEFSC shark food habits, reproduction, and age/growth studies that provide biological reference points for ICCAT pelagic shark assessments and the SEDAR process. Analysis of these tournament landings data was initiated by creating a database of historic information (1961-2016) and producing preliminary summaries of some long-term tournaments. These analyses have been used to provide advice on future minimum size catch requirements for these tournaments. The collection and analysis of these data are critical for input into species and age specific population and demographic models for shark management. In 2016, biological samples for life history studies and catch and morphometric data for more than 121 pelagic sharks were collected at 8 recreational fishing tournaments in the northeastern United States. Participation at recreational shark tournaments and the resultant information is very valuable as a monitoring tool to provide long-term data that can detect trends in species and size composition, provide critical specimens and tissue for life history and genetic studies, provide outreach opportunities for recreational fishermen and the public, and finally, to provide additional information on movements that complement the NMFS CSTP. Time series data from these recreational tournaments were analyzed for use in the species status review for common thresher sharks, which were petitioned for potential listing under the Endangered Species Act (ESA, Young et al. 2016b).

NEFSC Historical Longline Survey Database

The NEFSC recovered the shark species catch per set data from the exploratory shark longline surveys conducted by the Sandy Hook and Narragansett Laboratories from 1961 to 1991. In addition to the fishery-independent surveys conducted by the NEFSC, scientific staff has been working with the University of North Carolina (UNC) to electronically recover the data from an ongoing coastal shark survey in Onslow Bay that began in 1972. These surveys provide a valuable historical perspective for evaluating the stock status of Atlantic sharks. This data recovery process is part of a larger, systematic effort to electronically recover and archive historical longline surveys and biological observations of large marine predators (swordfish, sharks, tunas, and billfishes) in the North Atlantic. When completed, these efforts will include reconstructing the historic catch, size composition, and biological sampling data into a standardized format for time series analysis of CPUE and size. Standardized indices of abundance developed for sharks caught during these longline surveys have been and will continue to be used in stock assessments as part of the SEDAR process. Analyzing catch rates according to differences in time, space, or methods provide an opportunity to better understand seasonal distribution patterns and relative vulnerability of various species to different fishing practices. In 2016, these data were analyzed for possible use in species status reviews for potential listings under the Endangered Species Act (ESA).

Figure 5.7. Tagged blacktip shark released during the NEFSC Coastal Shark Bottom Longline Survey. Source: NMFS photo.

Southeast Data, Assessment, and Review (SEDAR) Process
NEFSC Staff contributed to the update for the Southeast Data Assessment and Review (SEDAR) 21 for dusky sharks conducted in 2016. A working paper was submitted detailing the length data and standardized catch rates through 2015 for dusky sharks caught during the NEFSC Coastal Shark Bottom Longline Survey (McCandless and Natanson 2016) and NEFSC staff reviewed the stock assessment report from this SEDAR update.

Endangered Species Act
NEFSC staff contributed to and participated on three separate Status Review Teams during 2016 in response to positive 90-day findings indicating that petitions presented substantial information that listing under the ESA as threatened or endangered may be warranted for the common and bigeye thresher sharks, the porbeagle, and the oceanic whitetip shark. The Status Review Report for the common and bigeye thresher sharks (Young et al. 2016b) was made public following the publication of the negative 12-month finding indicating that listing under the ESA was determined to be unwarranted for these species. The Status Review Report for the porbeagle (Curtis et al. 2016) was made public following the publication of the negative 12-month finding indicating that listing under the ESA was determined to be unwarranted for this species. The Status Review Report for the oceanic whitetip shark (Young et al. 2016a) was made public following the publication of the positive 12-month finding indicating that this species warrants listing under the ESA as threatened. NEFSC staff also reviewed the Status Review Report and Assessment of Extinction Risk for the thorny skate conducted by the Extinction Risk Analysis

Team members in response to a petition to list this species as endangered or threatened under the ESA.

Pelagic Nursery Grounds

Pelagic shark biology, movements, and abundance studies continued in 2016 with further investigations of pelagic nursery grounds in conjunction with the high seas commercial longline fleet. This fishery-dependent collaborative work offers a unique opportunity to sample and tag blue sharks (*Prionace glauca*) and shortfin makos (*Isurus oxyrinchus*) in a potential nursery area on the Grand Banks, to collect length-frequency data and biological samples, and to conduct conventional and electronic tagging of these species. A total of 500 blue sharks have been double tagged using 2 different tag types to help evaluate tag-shedding rates used in sensitivity analyses for population estimates and to calculate fishing mortality and movement rates for this pelagic shark species. In 2007-2008, 2 real-time satellite (SPOT) tags and 5 pop-up satellite archival tags (PSAT) tags were deployed on shortfin makos and 1 PSAT tag was deployed on a blue shark. In 2016, 5 shortfin makos and 4 porbeagles were also tagged with satellite tags. Thus far, over 3,700 sharks have been tagged with conventional tags (including 60 fish tagged in 2016) and over 300 recaptured; the recaptures are primarily blue sharks recovered by commercial fishermen working in the mid-Atlantic Ocean.

Figure 5.8. Shortfin mako brought aboard during the NEFSC Pelagic Nursery Ground cruise. Source: Lisa Natanson / NMFS photo.

Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Program

The NEFSC manages and coordinates this program, which surveys Atlantic coastal waters from Florida to Massachusetts and in the U.S. Virgin Islands (USVI) by conducting cooperative, comprehensive, and standardized investigations of coastal shark nursery habitat. COASTSPAN surveys are used to describe habitat preferences, and to determine the relative abundance, distribution, and migration of shark species through longline and gillnet sampling and mark-recapture data. In 2016, our COASTSPAN participants were the Massachusetts Division of Marine Fisheries (MDMF), Virginia Institute of Marine Science, South Carolina Department of Natural Resources, University of North Florida (conducted the survey in both Georgia and northern Florida waters), and Florida Atlantic University. The NEFSC staff conducts the survey in Delaware Bay and MDMF staff conducts a survey in the U.S. Virgin Islands using COASTSPAN gear and methods. Data from COASTSPAN surveys are used to update and refine EFH designations for multiple life stages of managed coastal shark species. Standardized indices of abundance from COASTPAN surveys are used in the stock assessments for large and small coastal sharks. In 2016, data from these COASTSPAN surveys were provided to NMFS Highly Migratory Species Management Division for use in updating the Essential Fish Habitat

Figure 5.9. Tagging a juvenile sandbar shark during the NEFSC COASTSPAN Program Survey. Source: W. David McElroy / NMFS photo.

designations for all managed shark species and the annual Stock Assessment and Fisheries Evaluation (SAFE) report.

Essential Fish Habitat (EFH) Designations

NEFSC staff participates on a working group with others from the NMFS HMS Management Division and SEFSC to update and refine the EFH designations for managed shark species. This process was ongoing in 2016 and entailed providing summaries from COASTSPAN surveys and the CSTP databases to update EFH for coastal shark species and information for the EFH section of the annual Stock Assessment and Fisheries Evaluation Report. Additionally, NEFSC staff provided to the NMFS HMS Management Division expert advice, updates to previously supplied data, results from ongoing research, and verified and compiled all available shark bycatch data from past and present NEFSC surveys and projects to facilitate updates to the essential fish habitat designations for 35 managed shark species.

Elasmobranch Life History Studies

NEFSC life history studies are conducted on Atlantic species of elasmobranchs to address priority knowledge gaps and focus on species with declines and management issues. NEFSC staff have already developed growth models, completed reproductive studies, characterized the diet, and finished movement and migration studies for many shark species. In recent years, studies have concentrated on a complete life history for a species to obtain a total picture for management. This comprehensive life history approach encompasses studies on age and growth rates and validation, diet and trophic ecology, movement and migration patterns, and reproductive biology essential to estimate parameters for demographic, fisheries, and ecosystem models. Biological samples for these studies are obtained on research surveys and cruises, on commercial vessels, at recreational fishing tournaments, and opportunistically from strandings. Non-lethal techniques are also being used, such as using stomach eversion techniques for obtaining food habits samples and collaborative work using hormone levels for determining stages of maturity. Tagging data, both conventional and electronic, are also obtained through research surveys and cruises, as well as, chartered vessel trips and through the CSTP. Collaborative projects to examine the biology and population dynamics of pelagic and coastal shark species in the North Atlantic are ongoing.

Figure 5.10. White shark ready to be tagged and released. Source: Lisa J. Natanson / NMFS photo.

Cooperative Shark Tagging Program (CSTP)

The CSTP provides information on distribution, movements, and essential fish habitat for shark species in U.S. Atlantic and Gulf of Mexico waters. This program has involved more than 6,000 volunteer recreational and commercial fishermen, scientists, and fisheries observers since 1962. In 2016, information was received on 5,000 tagged and 400 recaptured fish bringing the total numbers tagged to 285,000 sharks of more than 50 species and 17,400 sharks recaptured of 33 species. This information was provided to the NMFS HMS Management Division in 2016 to facilitate updates to the essential fish habitat designations for all managed shark species. To improve the quality of data collected through the CSTP, the Guide to Sharks, Tunas, & Billfishes of the US Atlantic and Gulf of Mexico has been reprinted and made available to recreational and commercial fishermen through the Rhode Island Sea Grant. In addition, identification placards for coastal and pelagic shark species were distributed. A toll-free number has been established as well as online reporting to collect information on recaptures for all species. A presentation on the CSTP was given during the Cooperative Fisheries Research in Marine and Freshwater Systems: From Policy to Practice Symposium at the annual American Fisheries Society Meeting in 2016 (Gervelis et al. 2016).

CSTP Integrated Mark-Recapture Database Management System (I-MARK)
The NEFSC Integrated Mark-Recapture Database System (I-MARK) provides a platform to keep multi-species tagging program data in a common format for management and analysis. Initiated by the Cooperative Research Program, the database design and application were developed collaboratively by the shark (CSTP), yellowtail flounder, black sea bass, and scup tagging programs, and Data Management Systems. A web application is used for data input and quality control. I-MARK was designed to track fish and tags independently. It consists of several web application modules including inventory of tags, initial release events, subsequent recapture events, bulk data entry of cruise releases, contact name and address information, map display, reports and statistical queries. Fate of animal, fate of tag, double tags, and multiple recaptures can be accommodated within the database. Extensive quality control is achieved using the web application to enter and maintain the I-MARK data. These audits can be applied to data for all fisheries or a specific fishery and encompass standard audits such as checking data type, land locations, and allowable values as well as more complex validations which check relationships between the fate of animal, fate of tag and event type. A constituent release recapture letter is generated by the web application with a map, size, location, time at liberty and distance traveled information. Annually, the system and validation parameters are updated. In 2016, all mark/recapture data were processed and scanned tag card images from the CSTP were linked to the existing I-MARK system.

Structure and Function of Vertebral Band Pairs for Elasmobranch Species
Accurate age estimation is critical to population assessment and conservation strategies for sharks and rays as it allows for the calculation of important demographic information including longevity, growth rate, and age at sexual maturity; management decisions based on improper age estimates can inadvertently lead to overexploitation. The primary method for estimating age of sharks relies on counting band pairs that are assumed to be annual in vertebrae. While it is widely acknowledged that the assumption of annual deposition should be tested by an independent method, most shark species lack this validation, and current research suggests that the band pair are not annual throughout life in at least 30% of species aged thus far. NEFSC staff is leading a multidisciplinary research team to examine the function and mechanics of the band pairs along the vertebral column of multiple elasmobranch species. This represents a collaboration between NMFS NEFSC, AK Department of Fish and Game, MDMF, University of Rhode Island, and FL Atlantic University. This work began in 2016 and is ongoing.

Atlantic-wide Ageing and Intercalibration studies for the Shortfin Mako (Isurus oxyrinchus)
In 2016, a study was initiated to conduct an Atlantic-wide age and growth study for the shortfin mako shark that can contribute to the 2017 ICCAT assessment for this species. NEFSC staff co-

hosted an ICCAT SRDCP (Shark Research and Data Collection Program) Workshop on Shortfin Mako Age Reading and Growth with the SEFSC and the Portuguese Institute for the Ocean and Atmosphere with the goal of inter-calibrating the readings. Participants also included personnel from the Centro de Investigación y Conservación Marina-CICMAR, Uruguay and students from the University of Rhode Island. Since the workshop was completed, NEFSC staff cut and processed all shortfin mako shark vertebra collected since 2002, edited the photographs obtained by all participating researchers for consistency in age work, and counted a preliminary set of 60 samples. A manuscript for age estimate of the North Atlantic population is in progress while work on the South Atlantic is ongoing.

Ageing and Validation of Skate Species from Northeast Assemblage

NEFSC staff, in conjunction with a Ph.D. Candidate at the University of Rhode Island, continued research on a project involving ageing and validation of several species of skates from the North East assemblage. A 13-month captive study was underway in 2016 to assess growth of mature little skates, *Leucoraja erinacea*, and is scheduled to conclude in 2017. Thirty-eight skates were collected under a Rhode Island Scientific Collector's Permit. These were dissected and each vertebra was measured in three dimensions to examine change in vertebral shape within an individual.

Reproductive Biology of the Blue Shark (Prionace glauca)

The reproduction of the blue shark in the North Atlantic has not been comprehensively studied since a 1979 publication by Pratt. Since that time, NEFSC biologists have obtained more samples to update the parameters and examine the possibility of compensatory changes in reproductive values for this species. In 2016, NEFSC staff, in conjunction with a Masters Candidate at University of Rhode Island, continued analysis of these data in conjunction with ageing of blue sharks for which reproductive condition is known (to provide actual ages as related to reproductive condition). This study will also involve examination of the migrations of the blue shark relative to size, sex and reproductive condition. To date, 212 vertebral samples have been collected with associated reproductive data as well as a total of 457 new reproductive samples.

Figure 5.11. Blue shark ready to be tagged and released. Source: Lisa J. Natanson / NMFS photo.

Research Intercalibrations

NEFSC staff hosted and worked at a shark tournament with staff from the NMFS Panama City FL Laboratory to ensure the comparability of reproductive measurements between the Laboratories for shortfin mako sharks. In addition, NEFSC staff collaborated with personnel from MDMF on inter-calibration on vertebral band pair counts on North Atlantic blue sharks and with Malcolm Francis, NIWA, for inter-calibration of vertebral band pair counts on New Zealand blue sharks.

Multi-Species Feeding Ecology Studies

Using the food habits data collected by the NEFSC Apex Predators Program over the past 40 years, temporal changes in prey species, taxonomic and ecological prey groups, and overall trophic levels for the blue shark and the shortfin mako. Indices of standardized diet composition were analyzed to identify changes in the prey species consumed, and then related to temporal changes in the distribution and abundance of these prey items. The two shark species have dissimilar feeding strategies and respond differently to environmental changes and fluctuations in prey availability. The blue shark has a generalized diet and easily switches between prey types. Over the four-decade period, some prey categories showed dramatic increases in the diet (spiny dogfish, marine mammals), others declined (cephalopods, flatfishes, hakes), and others fluctuated (bluefish, herrings, mackerels). The shortfin mako is more specialized, consuming mainly bluefish, and appears resistant to dietary change when its preferred prey becomes less abundant. In 2016, databases were updated to include blue shark and shortfin mako samples collected at recreational shark fishing tournaments and opportunistically throughout the year.

Critical Examination of a Purported Trophic Cascade

In 2016, NEFSC staff in cooperation with others from Florida State University, the Southeast Fisheries Science Center, the U.S. Geological Survey, the Greater Atlantic Regional Fisheries Office, and the Virginia Institute of Marine Science published a critical assessment of a purported trophic cascade in the northwest Atlantic Ocean where the depletion of large coastal sharks was thought to trigger predation release of cownose rays leading to the collapse of commercial bivalve stocks (Grubbs et al. 2016). Based on these claims a predator-control fishery for cownose rays was developed. A reexamination of data from this purported trophic cascade indicated that declines in large coastal sharks did not coincide with purported rapid increases in cownose ray abundance nor did the increase in cownose ray abundance coincide with declines in commercial bivalves. The lack of temporal correlations coupled with published diet data for large coastal sharks and cownose rays suggests the purported trophic cascade is lacking the empirical linkages required of a trophic cascade. Additionally, the life history parameters of cownose rays indicate that they are incapable of rapid increases due to low reproductive potential. This assessment emphasizes the need for hypothesized trophic cascades to be closely scrutinized as spurious conclusions may negatively influence conservation and management decisions.

Elasmobranch Vulnerability to Climate Change off the Northeast US

NEFSC staff contributed to the first multispecies assessment of climate vulnerability for fish and invertebrates that occur off the northeastern U.S. In 2016, the Northeast Climate Vulnerability Assessment examined 82 species, including all commercially managed marine fish and invertebrate species in the northeast, a large number of recreational marine fish species, all marine fish species listed or under consideration for listing on the federal Endangered Species Act, and a range of ecologically important marine species (Hare 2016). NEFSC staff contributed expertise on the 12 elasmobranch species assessed.

Migrations and Biology of the Spiny Dogfish (Squalus acanthias)

The NEFSC Cooperative Research and Apex Predators Program began tagging spiny dogfish in the Gulf of Maine, Southern New England, and Georges Bank regions in 2011. This project aims to answer long-standing questions about stock structure, movement patterns, and life history to update and improve spiny dogfish stock assessments. Over a two-year period, dogfish were tagged during the winter, summer, and fall using three commercial vessels. During the tagging phase of this project, a total of 34,604 spiny dogfish were tagged. Of these tagged fish, 922 have been recaptured through 2016. Some tagged dogfish were injected with oxytetracycline (OTC) for an age validation study. Through 2016, 221 fish that were OTC injected have been recaptured and 89 of the fish returned to the NEFSC have been dissected for this age validation study.

Many populations of spiny dogfish are known to have a two-year gestation period, however, this has never been comprehensively studied in the western North Atlantic. The primary purpose of this study was to determine the gestation period and gather information on seasonality of mating and pupping and size at birth of spiny dogfish in Southern New England. Samples of mature females were collected monthly (a total of 24 months) and sample dissections were completed in 2015. In 2016, analyses began on the collected reproduction data for publication.

Common Thresher Shark (Alopias vulpinus) Movement Patterns and Stock Structure

A multi-faceted investigation of the horizontal and vertical movement patterns, spatial and temporal habitat use, and stock structure of the common thresher shark in the western North Atlantic Ocean was funded in 2016 through a Saltonstall-Kennedy Grant. Researchers from University of Massachusetts, MDMF, and the New England Aquarium in collaboration with NEFSC staff planned the first field season including ordering tags and equipment and coordinating with fishermen.

Dusky Shark (Carcharhinus obscurus) Post-release Mortality

A study on quantifying and reducing post-release mortality for dusky sharks discarded in the commercial pelagic longline fishery was funded in 2015 by the Bycatch Reduction Engineering Program. This study is conducted in conjunction with NEFSC staff and researchers from the University of New England, Gulf of Maine Research Institute, and the SEFSC. In 2016, pop-up satellite archival tags were attached to 50 dusky sharks prior to release from pelagic longline gear to evaluate extended (~30 days) post-release mortality. Biological, physical, and capture variables including time on the hook, size, sex, hook location, water temperature, tissue damage and gangion length, were recorded at time of release.

Section 6: References & Internet Information Sources

Andrews, A.H, and L.A.Kerr (2014). Validated age estimates for large white sharks of the northeastern Pacific Ocean: altered perceptions of vertebral growth shed light on complicated bomb Δ14C results. Environ Biol Fish DOI 10.1007/s10641-014-0326-8

Andrews AH, Kerr LA, Passerotti MS, Natanson LJ, Wintner SP. 2014. Maximum age and missing time in shark vertebrae: the limits and validity of age estimates using bomb radiocarbon dating [abstract]. Presented at: Shark International; Durban SA; 2-6 June 2014.

Andrews, A.H., L.A. Kerr, M.S. Passerotti, L.J. Natanson, and S.P. Wintner. 2015. Maximum age and missing time in shark vertebrae: the limits and validity of age estimates using bomb radiocarbon dating. Oral presentation at the 2015 American Elasmobranch Society Meeting (July 19, 2015), given during the 2015 Joint Meeting of Ichthyologists and Herpetologists in Reno, Nevada.

Andrews AH, Natanson LJ, Kerr LA, Burgess GH, and GM Cailliet. 2011. Bomb radiocarbon and tag-recapture dating of sandbar shark (Carcharhinus plumbeus). Fishery Bulletin 109: 454-465.

Andrews, KS, GD Williams, D Farrer, N Tolimieri, C J Harvey, G Bargmann, and PS Levin. 2009. Diel activity patterns of sixgill sharks, *Hexanchus griseus*: the ups and downs of an apex predator. Animal Behaviour 78:525-536.

Andrews, KS, GD Williams, and PS Levin. 2010. Seasonal and ontogenetic changes in movement patterns of sixgill sharks. Plos One 5.

Asher J., Williams ID., Harvey ES. 2017. An Assessment of Mobile Predator Populations along Shallow and Mesophotic Depth Gradients in the Hawaiian Archipelago. *Scientific Reports* 7:3905.

Baker, JD, et al., 2011. Translocation as a tool for conservation of the Hawaiian monk seal. Biological Conservation 144**:** 2692-2701.

Benavides, MT, RL Horn, KA Feldheim, MS Shivji, SC Clarke, S Wintner, L Natanson, M Braccini, JJ Boomer, SJB Gulak, and D Chapman. 2011. Global phylogeny of the dusky shark *Carcharhinus obscurus*: implications for fisheries management and monitoring in the shark fin trade. Endangered Species Research 14:13-22

Bernal, D, C Sepulveda, M Musyl, and R Brill. 2009. The eco-physiology of swimming and movement patterns of tunas, billfishes, and large pelagic sharks. *In*: Fish locomotion—An eco-ethological perspective (P Domenici and BG Kapoor, Eds.), Chapter 14, pp. 433–438. Enfield, New Hampshire: Science Publishers.

Beverley, S, D Curran, M Musyl, and B Molony. 2009. Effects of eliminating shallow hooks from tuna longline sets on target and non-target species in the Hawaii-based pelagic tuna fishery. Fisheries Research 96: 281–288.

Brill, R, P Bushnell, L Smith, C Speaks, M Sundaram, E Stroud, and JH Wang. 2009. The repulsive and feeding deterrent effects of electropositive metals on juvenile sandbar sharks (*Carcharhinus plumbeus*). Fishery Bulletin 107: 298–307.

Cardeñosa, D., Hyde, J., & Caballero, S. (2014). Genetic Diversity and Population Structure of the Pelagic Thresher Shark (*Alopias pelagicus*) in the Pacific Ocean: Evidence for Two Evolutionarily Significant Units. *PloS one*,*9* (10), e110193.

Clarke, S, MK McAllister, EJ Milner-Gulland, GP Kirkwood, CGJ Michielsens, DJ Agnew, EK Pikitch, H Nakano, and MS Shivji. 2006. Global estimates of shark catches using trade records from commercial markets. Ecology Letters 10:1115–1126.

Clarke, S. 2004. Understanding pressures on fishery resources through trade statistics: a pilot study of four products in the Chinese dried seafood market. Fish and Fisheries 5: 53–74.

Clarke, SC, MK McAllister, and CGJ Michielsens. 2004. Estimates of shark species composition and numbers associated with the shark fin trade based on Hong Kong auction data. Journal of Northwest Atlantic Fisheries Science 35:1-13.

Cotton, C.F., Andrews, A.H., Cailliet, G.M., Grubbs, R.D., Irvine, S.B., Musick, J.A. (2014) Assessment of radiometric dating for age validation of deep-water dogfish (Order: Squaliformes) finspines. Fisheries Research 151:107– 113.

Courtney, DL, and L Hulbert. 2007. Shark research in the Gulf of Alaska with satellite, sonic, and archival tags. *In:* Sheridan, P, JW Ferguson, and SL Downing (eds.). Report of the National Marine Fisheries Service workshop on advancing electronic tagging technologies and their use in stock assessments. U.S. Department of Commerce, NOAA Technical Memo NMFS-F/SPO-82, 82 p.

Curran, D, and K Bigelow. 2010. Catch and bycatch effects of large circle hooks in a tuna longline fishery [abstract]. 61th Tuna Conference, Lake Arrowhead, CA, May 17–20, 2010.

Curran D, and K Bigelow. 2011. Effects of circle hooks on pelagic catches in the Hawaii-based tuna longline fishery. Fisheries Research 109: 265–275.

Curtis, T. H., C.T. McCandless, J.K. Carlson, G.B. Skomal, N.E. Kohler, L.J. Natanson, G. H. Burgess, J.J. Hoey, and H.L. Pratt, Jr. 2014. Seasonal distribution and historic trends in abundance of white sharks, *Carcharodon carcharias,* in the western North Atlantic Ocean. PLoS ONE 9(6): e99240. Doi:10.137/journal.pone.0099240

Curtis, T.H. and K.A. Sosebee. 2016. Landings composition of the northeast U.S. skate, rajidae, wing fishery and the effectiveness of prohibited species regulations. Marine Fisheries Review 77(4):1-8.

Curtis, T.H., S. Laporte, E. Cortes, G. DuBeck, and C. McCandless. 2016. Status review report: Porbeagle Shark (*Lamna nasus*). Final Report to National Marine Fisheries Service, Office of Protected Resources. February 2016. 56 pp.

Dale, JJ, et al., 2011. The Shark assemblage at French Frigate Shoals Atoll, Hawai‘i: species composition, abundance and habitat use. Plos One. 6: e16962.

Domingo, A., M. Pons, S. Jiménez, P. Miller, C. Barceló, and Y. Swimmer. 2012. Circle hook performance in the Uruguayan pelagic longline fishery. Bulletin of Marine Science. 88: 499-511.

Eddy, C, D Bernal1, G Skomal, NE Kohler, and LJ Natanson. 2011. The life history and feeding ecology of the Galapagos shark (*Carcharhinusgalapagensis*) in the waters off Bermuda. Abstract at the 2011 American Elasmobranch Society, Providence, RI.

Faunce, C., J. Cahalan, J. Gasper, T. A’mar, S. Lowe, F. Wallace, and R. Webster. 2014. Deployment performance review of the 2013 North Pacific Groundfish and Halibut Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-281, 74 p.

Frazier, B.S. and C.T. McCandless. 2013. Standardized catch rates for bonnethead (*Sphyrna tiburo*) caught during the South Carolina Department of Natural Resources trammel survey. SEDAR34-WP-32.

Frazier, B., D. Bethea, W. Driggers, R. Hueter, C. McCandless, J. Tyminski. 2015. Growth rates of Bonnetheads (Sphyrna tiburo) estimated from tag-recapture data. Oral presentation at the 2015 American Elasmobranch Society Meeting (July 19, 2015), given during the 2015 Joint Meeting of Ichthyologists and Herpetologists in Reno, Nevada.

Gervelis, B.J. and L.J. Natanson. 2013. Age and growth of the common thresher shark in the

western North Atlantic Ocean. Transactions of the American Fisheries Society 142:1535-1545.
Gervelis, B., N.E. Kohler, L.J. Natanson, C.T. McCandless, and J.J. Hoey. 2016. 50 years of collaboration: the NMFS Cooperative Shark Tagging Program. Oral Presentation during the Cooperative Fisheries Research in Marine and Freshwater Systems: From Policy to Practice Symposium of the Annual American Fisheries Society Meeting in Kansas City, Missouri. August 22, 2016.
Gilman E, Chaloupka M, Swimmer Y, Piovano S (2016) A cross-taxa assessment of pelagic longline bycatch mitigation measures: conflicts and mutual benefits to elasmobranchs. *Fish and Fisheries*.
Gobush, KS. 2010.Shark Predation on Hawaiian Monk Seals: Workshop II & Post Workshop Developments, November 5-6, 2008. In: PIFSC (Ed.). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Honolulu, Hawaii, pp. 43.
Gobush, KS, and S Farry. 2012. Non-lethal efforts to deter shark predation of Hawaiian monk seal pups. Aquatic Conservation.
Godin, AC, Wimmer T, Wang JH, Worm B. (2013). No effect from rare-earth metal deterrent on shark bycatch in a commercial pelagic longline trial. Fisheries Research. 43: 131-135.
Goldman, K.J. 2012. Sharks in Alaska - Really? Onchorhynchus 32 (2):1-5.
Goldman, K.J., Calliet, G.M., Andrews, A.H., and Natanson, L.J. 2012. Assessing the Age and Growth of Chondrichthyan Fishes. *In: Carrier, J.C. & Musick, J.A. & Heithaus, M.R. (eds) Biology of Sharks and their Relatives, Edition 2.* CRC Press, Boca Raton, Florida: 423-452
Grassmann M., Natanson L.J., Slager C., Herbert K. 2012. Observations of growth and demography in captive-born Pacific angel sharks (*Squatina californica*) at Aquarium of the Bay [abstract]. Presented at: American Elasmobranch Society Meeting; Vancouver BC; 8-14 Aug 2012; p 265.
Grubbs, R.D., J.K. Carlson, J.G. Romine, T.H. Curtis, W. D. McElroy, C.T. McCandless, C.F. Cotton, and J.A. Musick. 2016. Critical assessment and ramifications of a purported marine trophic cascade. Scientific Reports 6:20970. doi:10.1038/srep20970 (2016).Hamady L.L., L.J. Natanson, G.B. Skomal, and S. Thorrold. 2014. Bomb carbon age validation of the white shark, *Carcharodon carcharias*, in the western North Atlantic Ocean. Plos One 9(1):e84006.
Hamm D.C., M.M.C. Quach, K.R. Brousseau, and A.S. Tomita. 2012. Fishery statistics of the western Pacific, Volume 27. Pacific Islands Fisheries Science Center Administrative Report H-12-05, var. pag.
Hare, J.A., W.E. Morrison, M.W. Nelson, M.M. Stachura, E.J. Teeters, R.B. Griffis, M.A. Alexander, J.D. Scott, L. Alade, R.J. Bell, A.S. Chute, K.L. Curtis, T.H. Curtis, D. Kircheis, J.F. Kocik, S.M. Lucey, C.T. McCandless, L.M. Milke, D.E. Richardson, E. Robillard, H.J. Walsh, M.C. McManus, K.E. Marancik, and C.A. Griswold. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLoS ONE 11(2): e0146756. doi:10.1371/journal.pone.0146756.
Harvey, CJ. 2009. Effects of temperature change on demersal fishes in the California Current: a bioenergetics approach. Canadian Journal of Fisheries and Aquatic Sciences 66:1449-1461.
Heberer, C., S.A. Aalbers, D. Bernal, S. Kohin, B. DiFiore, and C.A. Sepulveda. 2010. Insights

into catch-and-release survivorship and stress-induced blood biochemistry of common thresher sharks (*Alopias vulpinus*) captured in the southern California recreational fishery. Fisheries Research 106:495-500.

Hoolihan, JP, J Luo, FJ Abascal, SE Campana, G DeMetrio, H Dewar, ML Domeier, LA Howey, ME Lutcavage, MK Musyl, JD Neilson, ES Orbesen, ED Prince, and JR Rooker. 2011. Evaluating post-release behaviour modification in large pelagic fish deployed with pop-up satellite archival tags. ICES Journal of Marine Science 68:880–889.

Huang H, Swimmer Y, Bigelow K, Gutierrez A, Foster D. 2013. Circle hook effectiveness for the mitigation of sea turtle bycatch and catch of target species in the Taiwanese longline fishery in the tropical Atlantic Ocean. ICCAT Subcommittee on Ecosystems Working Group, SCRS.

Hutchinson, MR, JH Wang, Y Swimmer, K Holland, S Kohin, H Dewar, J Wraith, R Vetter, C Heberer, and J Martinez. 2012. The effects of a lanthanide metal alloy on shark catch rates. Fisheries Research 131-133: 45-51.

International Commission for the Conservation of Atlantic Tunas (ICCAT). 2012. Guide for the identification of Atlantic Ocean sharks.

The International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC). 2015. Indicator-based analyses of the status of shortfin mako shark in the North Pacific Ocean. Report of the shark working group. International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean 15-20 July 2015 Kona, Hawaii, U.S.A. Appendix 12.

Kinney, M.J., Wells, R.J.D. and Kohin, S. 2016. Oxytetracycline age validation of an adult shortfin mako shark Isurus oxyrinchus after 6 years at liberty. Journal of Fish Biology, 89(3): 1828-1833.

Kleiber, P, S Clarke, K Bigelow, H Nakano, M McAllister, and Y Takeuchi. 2009. North Pacific blue shark stock assessment. U.S. Department of Commerce, NOAA Technical Memo NOAA-TM-NMFS-PIFSC-17, 74p.

Kleiber, P, Y Takeuchi, and H Nakano. 2001. Calculation of plausible maximum sustainable yield (MSY) for blue sharks (*Prionace glauca*) in the North Pacific. Southwest Fisheries Science Center, Administrative Report H-01-02, 10 p.

Kneebone, J., J. Chisholm, and G.Skomal. 2014. Movement patterns of juvenile sand tigers (*Carcharias taurus*) along the east coast of the USA. Marine Biology 161:1149-1163.

Kneebone, J., J. Chisholm, D. Bernal, and G. Skomal. 2013. The physiological effects of capture stress, recovery, and post-release survivorship of juvenile sand tigers (*Carcharias taurus*) caught on rod and reel. Fisheries Research 147:103-114.

Kneebone, J., J. Chisholm, and G.B. Skomal. 2012. Seasonal residency, habitat use, and site fidelity of juvenile sand tiger sharks *Carcharias taurus* in a Massachusetts estuary. Marine Ecology Progress Series. 471: 165-181.

Kohler, N.E., P.A. Turner, M. Pezzullo, and C.T. McCandless. 2014. Mark/recapture data for the smooth dogfish, *Mustelus canis*, in the Western North Atlantic from the NMFS Cooperative Shark Tagging Program. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-20

Kohler, N.E., L. Sawicki, P.A. Turner, and C.T. McCandless. 2013b. Mark/recapture data for the bonnethead (*Sphyrna tiburo*), in the western North Atlantic from the NEFSC Cooperative Shark Tagging Program. SEDAR34-WP-26.

Legare, B, B DeAngelis, R Nemeth, S Pittman, and G Skomal. 2011. Site fidelity, residency, and movements of juvenile blacktip (*Carcharhinus limbatus*) and lemon (*Negaprion brevirostris*) sharks in nursery areas of St John, USVI. Abstract at the 2011 American Elasmobranch Society, Providence, RI.

Levin, PS, P Horne, KS Andrews, and G Williams. 2012. An empirical movement model for sixgill sharks in Puget Sound: combining observed and unobserved behavior. Current Zoology 58:103-115.

Lowe MK, Quach MMC, Brousseau KR, Tomita AS. 2013. Fishery statistics of the western Pacific, Volume 28. Pacific Islands Fisheries Science Center Administrative Report H-13-06, var. pag.

Lucas, Z, and LJ Natanson. 2010. Two shark species involved in predation on seals at Sable Island, Nova Scotia, Canada. Proceedings of the Nova Scotian Institute of Science 45(2): 64–88.

Lyons K., Preti, A., Madigan, D. J., Wells, R. J. D., Blasius, M. E., Snodgrass, O. E., Kacev, D., Harris, J. D., Dewar, H., Kohin, S., MacKenzie, K., and Lowe, C.G. (2015) Insights into the life history and ecology of a large shortfin mako shark (*Isurus oxyrinchus*) captured in southern California. J. Fish. Biol. 87, 200–211.

Mataronas, SL.2010. The life history of *Torpedo cf. nobiliana*caught off the coast of southern New England. Master's thesis, University of Rhode Island, Kingston

McCandless, C.T. 2014a. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) longline survey in Delaware Bay. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-16.

McCandless, C.T. 2014b. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the University of Rhode Island trawl survey conducted by the Graduate School of Oceanography. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-11.

McCandless, C.T. 2014c. Hierarchical analysis of U.S. Atlantic smooth dogfish and Gulf of Mexico smoothhound species indices of abundance. Southeast Data Assessment and Review (SEDAR) 39 Assessment Workshop Document, SEDAR39-AW-02.

McCandless, C.T., Conn, P., Cooper, P., Cortés, E., Laporte, S.W., and M. Nammack. 2014a. Status review report: northwest Atlantic dusky shark (*Carcharhinus obscurus*). Report to National Marine Fisheries Service, Office of Protected Resources. October 2014. 72 pp.

McCandless, C.T. and B.S. Frazier. 2014. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the South Carolina Department of Natural Resources red drum longline survey. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-19.

McCandless, C.T., and K. Gottschall. 2014. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Long Island Sound Trawl Survey conducted by the Connecticut Department of Energy and Environmental Protection. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-12.

McCandless, C.T., and C. Grahn. 2014. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Peconic Bay Small Mesh Trawl Survey conducted by the New York State Department of Environmental Conservation. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-13.

McCandless, C.T. and M. Greco. 2014. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Delaware Division of Fish and Wildlife trawl surveys. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-15.

McCandless, C.T. and J.J. Mello. 2014. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Northeast Fisheries Observer Program. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-09.

McCandless, C.T. and S.D. Olszewski. 2014. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Rhode Island Department of Environmental Management trawl surveys. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-10.

McCandless, C.T., J. Pyle, G. Hinks, and L. Barry. 2014b. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the New Jersey Division of Fish and Wildlife trawl surveys. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-14.

McCandless, C.T., C. Stewart, and H. White. 2014c. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the Ocean Gillnet Program conducted by the North Carolina Division of Marine Fisheries**.** Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-17.

McCandless, C.T., Schwartz, F.J., and J.J. Hoey. 2014d. Standardized indices of abundance for smooth dogfish, *Mustelus canis*, from the University of North Carolina shark longline survey south of Shakleford Banks. Southeast Data Assessment and Review (SEDAR) 39 Data Workshop Document, SEDAR39-DW-18.

McCandless, C.T. and L.J. Natanson. 2016. Updated standardized catch rates for dusky sharks from the NMFS Northeast Longline Survey. Southeast Data Assessment and Review (SEDAR) 21 Update Working Document for Dusky Sharks in SEDAR21-DW-28. March 2016.

MacKenzie, K., & Abaunza, P. (1998). Parasites as biological tags for stock discrimination of marine fish: a guide to procedures and methods. *Fisheries Research*, *38*(1), 45-56.

Meyer CG, O'Malley JM, Papastamatiou YP, Dale JJ, Hutchinson MR, et al. (2014) Growth and Maximum Size of Tiger Sharks (Galeocerdo cuvier) in Hawaii. PLoS ONE 9(1): e84799. doi:10.1371/journal.pone.0084799estimates in post-release survival studies. Marine Ecology Progress Series 396: 157–159.

Moyes, CD, N Fragoso, MK Musyl, and RD Brill. 2006. Predicting post release survival in large pelagic fish. Transactions of the American Fisheries Society 135(5): 1389–1397

Musyl, MK, RW Brill, DS Curran, NM Fragoso, LM McNaughton, A Nielsen, BS Kikkawa, and CD Moyes. 2011a. Post-release survival, vertical and horizontal movements, and thermal habitats of five species of pelagic sharks in the Central Pacific Ocean. Fishery Bulletin 109(4): 341–368.

Musyl, MK,ML Domeier, N Nasby-Lucas, RW Brill, LM McNaughton, JY Swimmer, MS Lutcavage, SG Wilson, B Galuardi, and JB Liddle. 2011b. Performance of pop-up satellite archival tags. Marine Ecology Progress Series 433: 1–28.

Musyl, MK, CD Moyes, RW Brill, and NM Fragoso. 2009. Factors influencing mortality estimates in post-release survival studies. Marine Ecology Progress Series 396: 157–159.

Nadon MO, JK Baum, ID Williams, JM McPherson, BJ Zgliczynski, BL Richards, RE Schroeder, and RE Brainard. 2012. Re-creating missing population baselines for Pacific reef sharks. Conservation Biology 26(3): 493-503.

Nakano, H, and S Clarke. 2005. Standardized CPUE for blue sharks caught by the Japanese longline fishery in the Atlantic Ocean, 1971–2003. Collective Volume of Scientific Papers ICCAT 58(3): 1127–1134

Nakano, H, and S Clarke. 2006. Filtering method for obtaining stock indices by shark species from species-combined logbook data in tuna longline fisheries. Fisheries Science 72:322–332

Natanson, L.J. and B.J. Gervelis. 2013. The reproductive biology of the common thresher shark in the western North Atlantic Ocean. Transactions of the American Fisheries Society 142: 1546-1562.

Natanson, L.J., D.H. Adams, M. Winton, and J. Maurer. 2014. Age and growth of the bull shark *Carcharhinus leucas*, in the western North Atlantic Ocean. Transactions of the American Fisheries Society, 143(3): 732-743.

Natanson, L.J., B.J. Gervelis, M.V. Winton, L.L. Hamady, S.J.B. Gulak and J.K. Carlson. 2013. Validated age and growth estimates for *Carcharhinus obscurus* in the northwestern Atlantic Ocean, with pre- and post management growth comparisons. Environmental Biology of Fishes. DOI 10.1007/s10641-01300189-4.

Natanson, L.J., and G.B. Skomal. 2015. Validated age and growth of the White Shark, *Carcharodon carcharias*, in the western North Atlantic Ocean. Marine and Freshwater Research. 66 (5): 387-398.

Natanson, L.J., L.L. Hamady, and B. Gervelis. 2015. Analysis of bomb radiocarbon data for Common Thresher Sharks, *Alopias vulpinus*, in the northwestern Atlantic Ocean with revised growth curves. Environmental Biology of Fishes. 99 (1) DOI: 10.1007/s10641-015-0452-y.

Nielsen, A, JR Sibert, S Kohin, and MK Musyl. (2009). State space model for light based tracking of marine animals: Validation on swimming and diving creatures. *In:* J. L. Nielsen et al. (eds.), Methods and technologies in fish biology and fisheries: Tagging and tracking of marine animals with electronic devices. Series 9: 295–309.

O'Leary, S.J., K.A. Feldheim, A.T. Fields, L.J. Natanson, S. Wintner, N. Hussey, M.S. Shivji, and D.D. Chapman. 2015. Genetic Diversity of White Sharks, Carcharodon carcharias, in the Northwest Atlantic and Southern Africa. Journal of Heredity. 106(3): 258-265.

Passerotti**,** M. S., Andrews**,** A. H., Carlson**,** J. K., Wintner**,** S. P., Goldman, K. J. and L. J. Natanson (2014). Maximum age and missing time in the vertebrae of sand tiger shark (*Carcharias taurus*): validated lifespan from bomb radiocarbon dating in the western North Atlantic and southwestern Indian Oceans. Marine and Freshwater Research. 65:674–687

Passerotti, M. S., Andrews, A. H., Carlson, J. K., Wintner, S. P., Goldman, K. J. and L. J. Natanson (2014). Validated lifespan of sand tiger shark *Carcharias taurus* from bomb radiocarbon dating in the western North Atlantic and southwestern Indian Oceans Presented at: Shark International; Durban SA; 2-6 June 2014.

Passerotti, M.S., A.H. Andrews, J.K. Carlson, S.P. Wintner, K.J. Goldman, and L.J. Natanson. 2014. Maximum age and missing time in the vertebrae of sand tiger shark (*Carcharias taurus*): validated lifespan from bomb radiocarbon dating in the western North Atlantic and southwestern Indian Oceans. Marine and Freshwater Research http://dx.doi.org/10.1071/MF13214

Preti, A, CU Soykan, H Dewar, RJD Wells, N Spear and S Kohin. 2012. Comparative feeding ecology of shortfin mako, blue and common thresher sharks in the California Current. Environmental Biology of Fishes, 95(1), 127-146. DOI 10.1007/s10641-012-9980-x.

Reum, J.C.P., Williams, G.D., and Harvey, C.J., Stable Isotope Applications for Understanding Shark Ecology in the Northeast Pacific Ocean. In: Shawn E. Larson and Dayv Lowry, editors, *Advances in Marine Biology, Vol. 77*, Oxford: Academic Press, 2017, pp. 149-178. ISBN: 978-0-12-811831-3

Rice, J. and Harley, S. (2012) Stock assessment of oceanic whitetip sharks in the western and central Pacific Ocean. Western and Central Pacific Fisheries Commission Scientific Committee Eighth Regular Session. WCPFC-SC8-2012/SA-WP-06 Rev 1. 53pp.

Rice, J., Tremblay-Boyer, L., Scott, R., Hare, S. and Tidd, A. (2015) Analysis of stock status and related indicators for key shark species of the Western Central Pacific Fisheries Commission. Western and Central Pacific Fisheries Commission, Scientific Committee Eleventh Regular Session. WCPFC-SC11-2015/EB-WP-04-Rev 1, 146 pp.

Runcie, R., Holts, D., Wraith, J., Xu, Y., Ramon, D., Rasmussen, R. and Kohin, S. 2016. A fishery-independent survey of juvenile shortfin mako (Isurus oxyrinchus) and blue (Prionace glauca) sharks in the Southern California Bight, 1994–2013. Fish. Res. 183: 233-243.

Schwartz, FJ, CT McCandless, and JJ Hoey. 2010. Standardized catch rates for blacknose, dusky and sandbar sharks caught during a UNC longline survey conducted between 1972 and 2009 in Onslow Bay, NC.SEDAR 21, Data Workshop Document 33.

Schwartz, F.J., C.T. McCandless, and J.J. Hoey. 2013. Standardized indices of abundance for Atlantic sharpnose sharks from the University of North Carolina bottom longline survey. SEDAR34-WP-38.

SEDAR (Southeast Data Assessment and Review). 2015. SEDAR Procedural Workshop 7: Data Best Practices. SEDAR, North Charleston SC. 151 pp. http://sedarweb.org/pw-07.

Sepulveda, C. A., Heberer, C., Aalbers, S. A., Spear, N., Kinney, M., Bernal, D., & Kohin, S. (2015). Post-release survivorship studies on common thresher sharks (*Alopias vulpinus*) captured in the southern California recreational fishery. *Fisheries Research*, *161*, 102-108

Sibert, J, A Nielsen, M Musyl, B Leroy, and K Evans. 2009. Removing bias in latitude estimated from solar irradiance time series. *In*: (JL Nielsen et al., eds), Tagging and tracking of marine animals with electronic devices, Reviews: Methods and Technologies in Fish Biology and Fisheries 9, Series Vol. 9, Springer.

Smith, S. E., Rasmussen, R. C., Ramon, D. A., & Cailliet, G. M. (2008). The biology and ecology of thresher sharks (Alopiidae). *Sharks of the open ocean: biology, fisheries and conservation*, 60-68.

Sulikowski, JA, AM Cicia, JR Kneebone, LJ Natanson, and PCW Tsang. 2009. Age and size at sexual maturity for the smooth skate, *Malacoraja senta*, in the western Gulf of Maine. Journal of Fisheries Biology 75 (10): 2832–2838.

Swimmer, Y, JH Wang, and L McNaughton. 2008. Shark deterrent and incidental capture workshop, April 10–22, 2008. U.S. Department of Commerce, NOAA Technical Memo. NOAA-TM-NMFS-PIFSC-16, 72 p.

Swimmer Y, Suter J, Arauz R, Bigelow K, Lopez A, Zanela I, Bolanos A, Ballestero J, Suarez R, Wang J, and C Boggs. 2011. Sustainable fishing gear: the case of modified circle hooks in a Costa Rican longline fishery. Marine Biology 158: 757-767.

Swinsburg, W.A. 2013. Survival of the blacktip shark, *Carcharhinus limbatus*. University of Rhode Island. Master of Science in Biological and Environmental Sciences. 137 pp.

Teo, S., Rodriquez, E., Sosa-Nishizaki, O. (In Review) Status of Common Thresher Shark along the West Coast of North America. NMFS Tech Memo. NOAA-TM-NMFS-SWFSC-557.

Tribuzio, C, K Echave, C Rodgveller, and P Hulson. 2016a. Assessment of the shark stock complex in the Bering Sea and Aleutian Islands. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands as projected for 2015. North Pacific Fishery Management Council, 605 W 4th Ave. Suite 306, Anchorage, AK 99501. https://www.afsc.noaa.gov/REFM/docs/2016/BSAIshark.pdf

Tribuzio, C, K Echave, C Rodgveller, and P Huslon. 2016b. Assessment of the shark stock complex in the Gulf of Alaska. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 2015. North Pacific Fishery Management Council, 605 W 4th Ave. Suite 306, Anchorage, AK 99501. https://www.afsc.noaa.gov/REFM/docs/2016/GOAshark.pdf

Walsh, WA, KA Bigelow, and KL Sender. 2009. Decreases in shark catches and mortality in the Hawaii-based longline fishery as documented by fishery observers. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 1:270–282.

Walsh WA, Clarke SC. 2011. Analyses of catch data for oceanic whitetip and silky sharks reported by fishery observers in the Hawaii-based longline fishery in 1995-2010. Pacific Islands Fisheries Science Center Administrative Report H-11-10, 43 p. + Appendices.

Wang, JH, M Hutchinson, L McNaughton, K Holland, and Y Swimmer. 2009.Use of electropositive metals to reduce shark feeding behavior. Proceedings of the 60th Tuna Conference, Lake Arrowhead, CA, May 18–21, 2009.

Wang, JH, M Hutchinson, L McNaughton, K Holland, and Y Swimmer. 2010. The effects of Nd/Pr alloy on feeding and catch rates in coastal and pelagic shark species. IATTC Technical Meeting on Sharks, August 30, 2010.

Watson JT, Bigelow KA. 2014. Trade-offs among catch, bycatch, and landed value in the American Samoa longline fishery. Conservation Biology. DOI: 10.1111/cobi.12268.

Wells, R. J., Smith, S. E., Kohin, S., Freund, E., Spear, N., & Ramon, D. A. (2013). Age validation of juvenile shortfin mako (*Isurus oxyrinchus*) tagged and marked with oxytetracycline off southern California. *Fishery Bulletin*, *111*(2), 147-160.

Wells, R., Spear, N. and Kohin, S. 2016. Age validation of the blue shark (Prionace glauca) in the eastern Pacific Ocean. Marine and Freshwater Res. http://dx.doi.org/10.1071/MF16054

Williams, GD, KS Andrews, DA Farrer, GG Bargmann, and PS Levin. 2011. Occurrence and biological characteristics of broadnose sevengill sharks (*Notorynchus cepedianus*) in Pacific Northwest coastal estuaries. Environmental Biology of Fishes 91:379-388.

Williams, GD, KS Andrews, SL Katz, ML Moser, N Tolimieri, DA Farrer, and PS Levin. 2012. Scale and pattern of broadnose sevengill shark *Notorynchus cepedianus* movement in estuarine embayments. Journal of Fish Biology 80:1380-1400.

Williams, ID, BL Richards, SA Sandin, JK Baum, RE Schroeder, MO Nadon, BZ Gliczynski, P Craig, JL McIlwain, and RE Bainard. 2011. Differences in reef fish assemblages between populated and unpopulated reefs spanning multiple archipelagos across the central and western Pacific. Journal of Marine Biology, DOI:10.1155/2011/82623.

Williams, ID, BLRichards, SA Sandin, JK Baum, RE Schroeder, MO Nadon, BZ Gliczynski, P Craig, JL McIlwain, and RE Bainard. 2011. Differences in reef fish assemblages between populated and unpopulated reefs spanning multiple archipelagos across the central and western Pacific. Journal of Marine Biology, DOI:10.1155/2011/82623.

Wilson, SG, JJ Polovina, BS Stewart, and MG Meekan. 2006. Movements of whale sharks (*Rhincodon typus*) tagged at Ningaloo Reef, Western Australia. Marine Biology 148(5):

1157–1166.
Wilson, SG, BS Stewart, JJ Polovina, MG Meekan, JD Stevens, and B Galuardi. 2007. Accuracy and precision of archival tag data: a multiple-tagging study conducted on a whale shark (*Rhincodon typus*) in the Indian Ocean. Fisheries Oceanography 16(6): 547–554.
Young, C.N., J. Carlson, M. Hutchinson, C. Hutt, D. Kobayashi, C.T. McCandless, and J. Wraith. 2016a. Status review report: oceanic whitetip shark (*Carcharhinus longimanus*). Final Report to National Marine Fisheries Service, Office of Protected Resources. November 201. 162 pp.
Young, C.N., J. Carlson, M. Hutchinson, D. Kobayashi, C. McCandless, M.H. Miller, S. Teo, and T. Warren. 2016b. Status review report: common thresher (*Alopias vulpinus*) and bigeye thresher (*Alopias superciliosus*). Final Report to National Marine Fisheries Service, Office of Protected Resources. March 2016. 199 pp.

Internet Sources and Information

Federal Management

2000 Shark Finning Prohibition Act
http://www.gpo.gov/fdsys/pkg/BILLS-106hr5461enr/pdf/BILLS-106hr5461enr.pdf

The 2010 Shark Conservation Act
http://www.gpo.gov/fdsys/pkg/BILLS-111hr81enr/pdf/BILLS-111hr81enr.pdf

National Marine Fisheries Service
https://www.fisheries.noaa.gov/welcome

Atlantic Ocean Shark Management

Copies of the 2006 Consolidated Atlantic Highly Migratory Species (HMS) Fishery Management Plan (FMP) and its Amendments and Atlantic commercial and recreational shark fishing regulations and brochures can be found on the National Marine Fisheries Service HMS website at https://www.fisheries.noaa.gov/topic/atlantic-highly-migratory-species. Information on Atlantic shark fisheries is updated annually in the Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic HMS, which are also available on the website. The website includes links to current fishery regulations (50 FR 635), shark landings updates, and the U.S. National Plan of Action for Sharks.

Domestic stock assessments under the SouthEast Data, Assessment, and Review (SEDAR) process are available online: http://sedarweb.org/

Pacific Ocean Shark Management

The U.S. West Coast Highly Migratory Species FMP and the Pacific Coast Groundfish FMP and annual SAFE Reports are currently available on the Pacific Fishery Management Council website: https://www.pcouncil.org/.

Data reported in Appendix 1, Table 1.3.3 (Shark landings (round weight equivalent in metric tons) for California, Oregon, and Washington, 2001–2016) was obtained from the Pacific States Marine Fisheries Commission's PacFIN Database, which may be found on their website at: http://pacfin.psmfc.org/pacfin_pub/data.php.

Information about pelagic fisheries of the Western Pacific Region FMP is available on the Western Pacific Fishery Management Council's website: http://www.wpcouncil.org/fishery-plans-policies-reports/.

Data reported in Table 1.3.8 (Shark landings (mt) from the Hawaii-based longline fishery and the American Samoa longline fishery, 2003-2013) was partially obtained from the Western Pacific Fisheries Information Network (WPacFIN). http://www.pifsc.noaa.gov/wpacfin/.

The Bering Sea/Aleutian Islands Groundfish FMP and the Groundfish of the Gulf of Alaska FMP are available on the North Pacific Fishery Management Council's (NPFMC) website: https://www.npfmc.org/bering-seaaleutian-islands-groundfish/.

Stock assessments and other scientific information for sharks are summarized annually in the NPFMC SAFE Reports that are available online: https://www.afsc.noaa.gov/REFM/stocks/assessments.htm.

International Efforts to Advance the Goals of the Shark Finning Prohibition Act

NOAA Fisheries Office of International Affairs
https://www.fisheries.noaa.gov/topic/international-affairs

FAO International Plan of Action for the Conservation and Management of Sharks
http://www.fao.org/ipoa-sharks

U.S. NPOA for the Conservation and Management of Sharks
https://www.fisheries.noaa.gov/webdam/download/64444114

NAFO Conservation and Enforcement Measures
https://www.nafo.int/Fisheries/Conservation

IATTC: https://www.iattc.org/

ICCAT: https://www.iccat.int/en/

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC): http://isc.fra.go.jp/

WCPFC: https://www.wcpfc.int/

UNGA: http://www.un.org/en/sections/what-we-do/uphold-international-law/index.html

Memorandum of Understanding on the Conservation of Migratory Sharks
http://sharksmou.org/

U.S. Imports and Exports of Shark Fins

Summaries of U.S. imports and exports of shark fins are based on information submitted by importers and exporters to the U.S. Customs and Border Protection. This information is compiled by the U.S. Census Bureau and is reported in the NMFS Trade database: http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/index

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