2008 Shark Finning Report to Congress

Pursuant to the

Shark Finning Prohibition Act of 2000

(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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Abbreviations and Acronyms

ABC ....Allowable Biological Catch
ADF&G..Alaska Department of Fish and Game
AFSC...Alaska Fisheries Science Center
ALWTRP ....Atlantic Large Whale Take Reduction Plan
BLL ....bottom longline
BSAI ....Bering Sea/Aleutian Islands
C ....carbon
CCAMLR..Commission for the Conservation of Antarctic Marine Living Resources
CITES ....Convention on International Trade in Endangered Species of Wild Fauna and Flora
CICESE...Centro de Investigación Científica y de Educación Superior de Ensenada
CFR ....*Code of Federal Regulations*
CMS ....Convention on Migratory Species
COASTSPAN ....Cooperative Atlantic States Shark Pupping and Nursery
COFI ....Food and Agriculture Organization's Committee on Fisheries
CPCs ....Parties and cooperating non-parties, cooperating fishing entities, or regional economic integration organizations of the IATTC
CPUE ....catch per unit effort
CSTP ....Cooperative Shark Tagging Program
dw..dressed weight
EEZ ....Exclusive Economic Zone
EFH ....essential fish habitat
EPO ....Eastern Pacific Ocean
FAO...Food and Agriculture Organization of the United Nations
FMP...fishery management plan
FR..*Federal Register*
GCEL ....General Counsel for Enforcement and Litigation
GOA ....Gulf of Alaska
GULFSPAN.....................................Gulf of Mexico States Shark Pupping and Nursery
HMS ....highly migratory species
IATTC...Inter-American Tropical Tuna Commission
ICES ....International Council for the Exploration of the Sea
ICCAT...International Commission for the Conservation of Atlantic Tunas
IPOA ....International Plan of Action

KD II ....KING DIAMOND II
kg..kilogram
LCS ....large coastal sharks
MAFMC...Mid-Atlantic Fishery Management Council
MDMF ....Massachusetts Division of Marine Fisheries
MHI..Main Hawaiian Islands
MSA...Magnuson-Stevens Fishery Conservation and Management Act
mt ....metric tons
N...nitrogen
n..sample size
NEFSC ....Northeast Fisheries Science Center
NEFMC..New England Fishery Management Council
NMFS...National Marine Fisheries Service
NOAA ....National Oceanic and Atmospheric Administration
NAFO...Northwest Atlantic Fisheries Organization
NOVA ....Notice of Violation and Assessment
NPFMC ....North Pacific Fishery Management Council
NPOA...National Plan of Action
NRIFSF ....National Research Institute for Far Seas Fisheries
NWFSC..Northwest Fishery Science Center
NWHI...Northwestern Hawaiian Islands
OFL ....overfishing levels
OLE..Office of Law Enforcement
OTC..oxytetracyline
PacFIN ....Pacific Fisheries Information Network
PIFSC...Pacific Island Fishery Science Center
PSAT..popoff satellite archival tags
PFMC...Pacific Fishery Management Council
PRIA ....Pacific remote island areas
RFMO ....regional fishery management organization
SAFE..Stock Assessment and Fishery Evaluation
SCRS..Standing Committee on Research and Statistics
SCS ....small coastal sharks
SEDAR ....Southeast Data, Assessment, and Review
SEFSC..Southeast Fisheries Science Center
SFPA ....Shark Finning Prohibition Act
SPOT..Smart Position and Temperature Transmitting tags
SSL...sound scattering layer
STAR ....Stock Assessment and Review
SWFSC ....Southwest Fisheries Science Center

SWRO ....Southwest Regional Office
TAC...total allowable catch
UAF...University of Alaska Fairbanks
UNGA ....United Nations General Assembly
USCG...United States Coast Guard
USVI ....United States Virgin Islands
VMS..Vessel Monitoring System
WCPFC ....Western and Central Pacific Fisheries Commission
WPacFin...Western Pacific Fishery Information Network
WPFMC ....Western Pacific Fishery Management Council

Executive Summary

Because of their biological and ecological characteristics, sharks present an array of issues and challenges for fisheries management and conservation. Many shark species are characterized by relatively late maturity, slow growth, and low reproductive rates, which can make them particularly vulnerable to overexploitation. Concern has grown over the past decade about the status of shark stocks and the sustainability of their exploitation in world fisheries, as demand for some shark species and shark products (i.e., fins) has increased.

Shark finning is the practice of taking a shark, removing a fin or fins (whether or not including the tail), and returning the remainder of the shark to the sea. The Shark Finning Prohibition Act of 2000 prohibited the practice of shark finning for any person under U.S. jurisdiction. The Act requires the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) to promulgate regulations to implement the prohibitions of the Act, initiate discussion with other nations to develop international agreements on shark finning and data collection, and establish research programs. This report describes NMFS' efforts to carry out the Shark Finning Prohibition Act during calendar year 2007.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) forms the basis for fisheries management in Federal waters, and requires NMFS and the eight regional fishery management councils to take specified actions. In the U.S. Atlantic Ocean, sharks and other highly migratory species (HMS) are managed directly by NMFS. In the U.S. Pacific Ocean, three regional fishery management councils—Pacific, North Pacific, and Western Pacific—are responsible for developing fishery management plans. Sharks in Federal waters are currently managed under eight different fishery management plans. In 2007, domestic management of sharks included the following major actions:

- On February 7, 2007, NMFS published a final rule (72 FR 5633) to implement additional handling, release, and disentanglement requirements for sea turtles and other non-target species caught in the commercial shark bottom longline (BLL) fishery in the Atlantic. In addition, this final rule established measures to complement those implemented by the Caribbean Fishery Management Council on October 29, 2005 (70 FR 62073), to prohibit all vessels issued HMS permits with BLL gear onboard from fishing with, or deploying, any fishing gear in six distinct areas off the U.S. Virgin Islands and Puerto Rico, year-round. The intent of these restrictions is to minimize adverse impacts to Essential Fish Habitat and reduce fishing mortality on other fish species.
- On July 27, 2007, NMFS published a proposed rule (72 FR 41392) that would amend the Consolidated Atlantic HMS Fishery Management Plan based on recent stock assessments for Large Coastal Sharks (LCS), dusky sharks, and porbeagle sharks. The proposal to reduce shark harvests to prevent overfishing and rebuild stocks will be finalized in 2008.
- NMFS publishes rules each year to adjust quotas based on landings from the previous season. A final rule was published on April 26, 2007 (72 FR 20765), which established the 2007 second and third trimester seasons' commercial quotas for LCS, small coastal sharks, and pelagic sharks based on overharvests or underharvests from the 2006 second and third trimester seasons. In addition, a final rule establishing the commercial seasons and quotas for the first trimester of 2008 was published on November 29, 2007 (72 FR 67580).

Additional information on shark management in the United States can be found in sections 2.1 through 2.3 of this report.

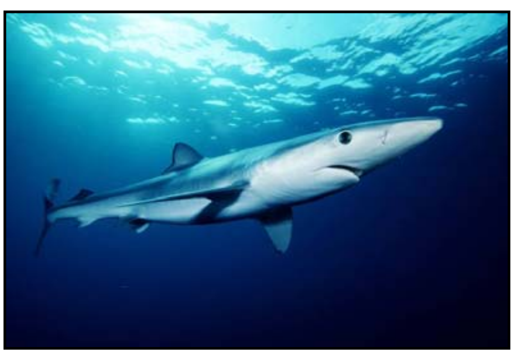
The Department of Commerce and the Department of State have been active in promoting development of international agreements consistent with the Shark Finning Prohibition Act. In 2007, the United States was successful in the following international efforts:

- In 2007, the International Commission for the Conservation of Atlantic Tunas (ICCAT) adopted a measure proposed by the United States to strengthen ICCAT's management of sharks by addressing the impacts of directed shark fisheries for porbeagle and shortfin mako sharks. The measure requires a reduction in fishing mortality in fisheries targeting these species until such time as sustainable levels of harvest can be determined.
- In June 2007, at the 14th Conference of the Parties in the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), the United States successfully proposed sawfishes (Pristidae) to be listed in Appendix I, thus banning commercial trade in sawfish and sawfish products.
- In 2007, the United States developed and proposed new language on shark conservation and management for inclusion in the annual United Nations General Assembly (UNGA) Sustainable Fisheries Resolution. The resolution, which was adopted by consensus in December 2007, included language based on the U.S. proposal aimed at strengthening protections for vulnerable and endangered shark populations around the world, and called on States and Regional Fishery Management Organizations (RFMOs) to take *immediate and concerted actions* to improve shark conservation and management.

Further information on international efforts to advance the goals of the shark finning prohibition can be found in Section 4 of this report.

Numerous research studies undertaken by NMFS Science Centers have produced much valuable information on shark status, mobility, migration, habitat, ecology, and age and growth characteristics—all of which will be incorporated into effective shark fishery management decisions. A detailed description of NMFS' research efforts regarding sharks can be found in Section 5 of this report.

Overall, compared to the years before enactment of the Shark Finning Prohibition Act, great strides continue to be made in shark conservation, data gathering, management, research, and education on a national and global scale that will contribute to sustainable management of sharks. For current information on shark management, go to www.nmfs.noaa.gov.



Blue shark swimming off southern California.
Source: Mark Conlin/NMFS Photo

1. Introduction

Sharks, skates, and rays are within the class Chondrichthyes—the cartilaginous fishes—and the subclass Elasmobranchii. Sharks are an ancient and diverse group of fishes presenting an array of issues and challenges for fisheries management and conservation due to their biological and ecological characteristics. Most sharks are predators at the top of the food chain, and many shark species are characterized by relatively late maturity, slow growth, and low reproductive rates. Abundance of these top predators is often low compared to organisms at lower trophic levels. The combination of these characteristics makes sharks particularly vulnerable to overexploitation.

Over the past few decades—as demand for some shark species and shark products has increased, and as international fishing effort directed at sharks and evidence of overfishing have increased—concern has grown about the status of shark stocks and the sustainability of their exploitation in world fisheries. This situation has resulted in several international initiatives to promote greater understanding of sharks in the ecosystem and in greater efforts to conserve the many shark species in world fisheries.

In U.S. fisheries in 2007, three out of 12 shark stocks or stock complexes with a known overfishing status are listed as subject to overfishing[1] (Table 1). Three out of 11 shark stocks or stock complexes with a known overfished status are listed as overfished[2] (Table 1). Twenty-two and 23 shark stocks or stock complexes have an unknown or undefined status in terms of their overfishing and overfished status, respectively (Table 1).

Shark finning is the practice of taking a shark, removing a fin or fins (whether or not including the tail), and returning the remainder of the shark to the sea.[3] Because the meat of the shark is usually of low value, the finless sharks are thrown back into the sea and subsequently die. Shark fins are very valuable and are among the most expensive fish products in the world. Shark fins are considered a delicacy in East Asia and are used to make shark fin soup. The growth in demand for some shark products, such as fins, continues to drive increased exploitation of sharks (Bonfil 1994; Rose 1996; Walker 1998).

On December 21, 2000, President Clinton signed into law the Shark Finning Prohibition Act of 2000 out of concern for the status of shark populations and the effects of fishing mortality associated with finning on shark populations. Section 3 of this Act amended the Magnuson-Stevens Fishery Conservation and Management Act (MSA) to prohibit any person under U.S. jurisdiction from: (i) engaging in the finning of sharks; (ii) possessing shark fins aboard a

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[1] A stock that is subject to overfishing has a fishing mortality (harvest) rate above the level that provides for the maximum sustainable yield.

[2] A stock that is overfished has a biomass level below a biological threshold specified in its fishery management plan.

[3] As defined in Section 9 of the Shark Finning Prohibition Act.

fishing vessel without the corresponding carcass; and (iii) landing shark fins without the corresponding carcass. Section 3 of the Shark Finning Prohibition Act contains a rebuttable presumption that any shark fins landed from a fishing vessel or found on board a fishing vessel were taken, held, or landed in violation of the Act if the total weight of shark fins landed or found on board exceeds 5 percent of the total weight of shark carcasses landed or found on board. This is commonly referred to as the "5 percent rule."

The Shark Finning Prohibition Act requires NMFS to promulgate regulations to implement its prohibitions (Section 4), initiate discussion with other nations to develop international agreements on shark finning and data collection (Section 5), provide Congress with annual reports describing efforts to carry out the Shark Finning Prohibition Act (Section 6), and establish research programs (Sections 7 and 8). Section 9 of the Act defines shark finning.

Consistent with Section 4 of the Act, NMFS published a proposed rule (66 FR 34401; June 28, 2001) and final rule (67 FR 6194; February 11, 2002) to implement the provisions of the Shark Finning Prohibition Act. The final rule prohibits: 1) any person from engaging in shark finning aboard a U.S. fishing vessel; 2) any person from possessing shark fins on board a U.S. fishing vessel without the corresponding shark carcasses; 3) any person from landing from a U.S. fishing vessel shark fins without the corresponding carcasses; 4) any person on a foreign fishing vessel from engaging in shark finning in the U.S. Exclusive Economic Zone (EEZ), from landing shark fins without the corresponding carcass into a U.S. port, and from transshipping shark fins in the U.S. EEZ; and 5) the sale or purchase of shark fins taken in violation of the above prohibitions. In addition, all shark fins and carcasses are required to be landed and weighed at the same time, once a landing of shark fins and/or shark carcasses has begun.

Section 6 of the Shark Finning Prohibition Act requires that the Secretary of Commerce, in consultation with the Secretary of State, provide Congress with annual reports describing efforts to carry out the Act. The Act specifically states that the report:

(1) includes a list that identifies nations whose vessels conduct shark finning and details the extent of the international trade in shark fins, including estimates of value and information on harvesting of shark fins, and landings or transshipment of shark fins through foreign ports;
(2) describes the efforts taken to carry out this Act, and evaluates the progress of those efforts;
(3) sets forth a plan of action to adopt international measures for the conservation of sharks; and
(4) includes recommendations for measures to ensure that United States actions 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).

These four topics are described in this *Report to Congress*. Regarding item 1 above, no reliable information exists to determine those nations whose vessels conduct shark finning. However, information on the international trade of shark fins is available from the Food and Agriculture Organization of the United Nations (FAO), and information on U.S. import and export of shark fins is available from the U.S. Census Bureau. This information can be found in Section 3 of this report. However, it is important to note that, due to the complexity of the shark fin trade, fins are not necessarily produced in the same country from which they are exported.

Consistent with item 2 above, this *Report to Congress* summarizes all of the recent management (Sections 2.1 to 2.3), enforcement (Section 2.4), international efforts (Section 4), and research activities (Section 5) related to sharks that are in support of the Shark Finning Prohibition Act. This report, prepared in consultation with the Department of State, also provides an update to last year's report, and includes complete information for 2007 activities.

Regarding item 3 above, the United States participated in the development of and endorsed the FAO's International Plan of Action (IPOA) for the Conservation and Management of Sharks. Consistent with the IPOA, the United States developed a National Plan of Action (NPOA) for the Conservation and Management of Sharks in February 2001. In addition to meeting the statutory requirement of the Shark Finning Prohibition Act, the annual *Report to Congress* serves as a periodic updating of information called for in the IPOA and NPOA.

Regarding item 4 above, NMFS has no specific recommendations for shark conservation and management at this time. Consistent with the provisions of Section 5 of the Shark Finning Prohibition Act, the Department of Commerce and the Department of State have been active in promoting development of international agreements consistent with the Act. Recommendations are brought forward through bilateral, multilateral, and regional efforts. As agreements are developed, the United States implements those agreements and reports on them in the annual *Report to Congress*. Information on recent international efforts, including CITES, can be found in Section 4 of this report.

Continuing efforts are being made nationally and internationally to increase data collection on shark stock assessments, develop gear modifications and capture/release techniques to minimize lethal shark bycatch, and increase our knowledge of shark ecology. These efforts should lead to improved shark management and are supported through agreements with international fishery management organizations, including: Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Inter-American Tropical Tuna Commission (IATTC), Western and Central Pacific Fisheries Commission (WCPFC), Northwest Atlantic Fisheries Organization (NAFO), International Commission for the Conservation of Atlantic Tunas (ICCAT), United Nations General Assembly (UNGA), CITES, FAO, and FAO's Committee on Fisheries (COFI).

Table 1 Status of shark stocks and stock complexes in U.S. fisheries in 2007.
Source: NMFS 2008.

Status of shark stocks and stock complexes in U.S. fisheries in 2007			
FMP & Jurisdiction	Stock or Stock Complex	Overfishing?	Overfished?
Spiny Dogfish FMP — NEFMC & MAFMC	Spiny dogfish	No	No – rebuilding[1]
Consolidated Atlantic Highly Migratory Species FMP — NMFS Highly Migratory Species Division	Sandbar shark[2]	Yes	Yes
	Gulf of Mexico blacktip shark[2]	No	No
	Atlantic blacktip shark[2]	Unknown	Unknown
	Large coastal shark complex[3]	Unknown[4]	Unknown[4]
	Finetooth shark[5]	Yes	No
	Atlantic sharpnose shark[5]	No	No
	Blacknose shark[5]	No	No
	Bonnethead shark[5]	No	No
	Small coastal shark complex[6]	No	No
	Shortfin mako shark[7]	Unknown	Unknown
	Porbeagle shark[7]	No	Yes
	Blue shark[7]	Unknown	Unknown
	Dusky shark	Yes	Yes
	Pelagic shark complex[8]	Unknown	Unknown
Pacific Coast Groundfish FMP — PFMC	Leopard shark	Unknown	Unknown
	Soupfin shark	Unknown	Unknown
	Spiny dogfish	Unknown	Unknown
West Coast Highly Migratory Species FMP & Pelagic Fisheries of the Western Pacific Region FMP — PFMC & WPFMC	Common thresher – North Pacific	Unknown	Unknown
	Shortfin mako shark – North Pacific	Unknown	Unknown
	Blue shark – North Pacific	No	No
	Bigeye thresher shark – North Pacific	Unknown	Unknown
	Pelagic thresher shark – North Pacific	Unknown	Unknown

Pelagic Fisheries of the Western Pacific Region FMP — WPFMC	Longfin mako shark – North Pacific	Unknown	Unknown
	Oceanic white-tip shark – Tropical Pacific	Unknown	Unknown
	Silky shark – Tropical Pacific	Unknown	Unknown
	Salmon shark – North Pacific	Unknown	Unknown
Coral Reef Ecosystems of the Western Pacific Region — WPFMC	Coral Reef Ecosystem Multi-Species Complex – Hawaiian Archipelago[9]	Unknown	Unknown
	Coral Reef Ecosystem Multi-Species Complex – American Samoa[9]	Unknown	Unknown
	Coral Reef Ecosystem Multi-Species Complex – Northern Mariana Islands[9]	Unknown	Unknown
	Coral Reef Ecosystem Multi-Species Complex – Guam[9]	Unknown	Unknown
	Coral Reef Ecosystem Multi-Species Complex – Pacific remote island areas[10]	Unknown	Unknown
Gulf of Alaska Groundfish FMP — NPFMC	Other species complex[11]	Undefined	Undefined
Bering Sea/Aleutian Island Groundfish FMP — NPFMC	Other species complex[12]	No	Undefined
Totals:		3 "yes" 9 "no" 21 "Unknown" 1 "Undefined"	3 "yes" 8 "no" 21 "Unknown" 2 "Undefined"

Notes to table 1:

[1] Although there is no B_{target} identified for this stock, there is an approved minimum biomass threshold; based on this approved threshold, the biomass estimates indicate the stock is not overfished.

[2] This stock is part of the Large Coastal Shark Complex, but is assessed separately.

[3] In addition to sandbar shark, Gulf of Mexico blacktip, and Atlantic blacktip shark, the Large Coastal Shark Complex also consists of additional stocks including spinner, silky, bull, tiger, lemon, nurse, scalloped hammerhead, great hammerhead, and smooth hammerhead shark. In addition, several LCS species cannot be retained in commercial or recreational fisheries, including bignose, Galapagos, night, Caribbean reef, narrowtooth, sand tiger, bigeye sand tiger, whale, basking, and white shark.

[4] The latest stock assessment concluded that the status of the LCS complex was unknown. The current assessment indicates that the peer reviewers of 2006 Large Coastal Shark Assessment felt it was unclear what exactly the results of the assessment represented, making it impossible to support the use of the results for management of the complex. The previous stock assessment concluded that the stock was subject to overfishing and overfished.

[5] This stock is part of the Small Coastal Shark Complex, but is assessed separately.

[6] In addition to finetooth, Atlantic sharpnose, blacknose, and bonnethead shark, the Small Coastal Shark Complex also consists of Atlantic angel, Caribbean sharpnose, and smalltail shark; these three species cannot be retained in recreational or commercial fisheries.

[7] This stock is part of the Pelagic Shark Complex, but is assessed separately.

[8] In addition to shortfin mako, blue, and porbeagle shark, the Pelagic Shark Complex also consists of oceanic whitetip shark and thresher shark. This complex also consists of stocks that cannot be retained in recreational or commercial fisheries, which include bigeye thresher, bigeye sixgill, longfin mako, sevengill, and sixgill shark.

[9] This complex contains up to 146 “currently harvested coral reef taxa” and innumerable “potentially harvested coral reef taxa.”

[10] This complex contains up to 146 “currently harvested coral reef taxa” and innumerable “potentially harvested coral reef taxa.” The Pacific remote island areas (PRIA) are U.S. island possessions in the Pacific Ocean that include Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, Wake Island, and Midway Atoll. All reefs of the PRIA except Wake Island, which is under the jurisdiction of the Department of Defense, are National Wildlife Refuges. Fishing for coral reef-associated species is prohibited in all these areas except Palmyra Atoll, Johnston Atoll, Wake Island, and Midway Atoll.

[11] The Other Species Complex consists of the following stocks: Pacific sleeper shark, salmon shark, spiny dogfish, numerous octopi, squid, and sculpins. There is no overfishing level specified for this complex. The total allowable catch (TAC) is set at an amount less than or equal to 5 percent of the combined TACs for the remainder of the groundfish fishery.

[12] The Other Species Complex consists of the following stocks: Pacific sleeper shark, salmon shark, spiny dogfish, and numerous skates, octopi, and sculpins. The overfishing determination is based on the overfishing level (OFL), which is computed by using abundance estimates of skates and sculpins and average historical catch for sharks and octopus.

2. Management and Enforcement

2.1 Management Authority in the United States

Previous reports to Congress discussed the MSA and other legal authorities for management entities governing U.S. fisheries in which sharks are directed catch, incidental catch, or bycatch. The MSA forms the basis for fisheries management in Federal waters and requires NMFS and the eight regional fishery management councils to take specified actions. State agencies and interstate fishery management commissions are bound by State regulations and, in the Atlantic region, by the Atlantic Coast Fisheries Cooperative Management Act.

2.2 Current Management Authority in the Atlantic Ocean

Development of fishery management plans (FMPs) is the responsibility of one or more of the eight regional fishery management councils, except for Atlantic highly migratory species (HMS), which include tunas, swordfish, billfish, and sharks. Since 1990, shark fishery management in Federal waters of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea (excluding spiny dogfish, skates, and rays) has been the responsibility of the Secretary of Commerce, delegated to NMFS.

In 1993, NMFS implemented the FMP for Sharks of the Atlantic Ocean. Under the FMP, three management units were established for shark species: large coastal sharks (LCS), small coastal sharks (SCS), and pelagic sharks (Table 2.2.1). NMFS identified LCS as overfished, and therefore, among other things, implemented commercial quotas for LCS and established recreational harvest limits for all sharks. At that time, NMFS also banned finning of all sharks in the Atlantic Ocean.

In April 1999, NMFS published the FMP for Atlantic Tunas, Swordfish, and Sharks, which included numerous measures to rebuild or prevent overfishing of Atlantic sharks in commercial and recreational fisheries. The 1999 FMP replaced the 1993 FMP, and addressed numerous shark management measures, including: reducing commercial LCS and SCS quotas; establishing a commercial quota for blue sharks and a species-specific quota for porbeagle sharks; expanding the list of prohibited shark species; implementing a limited access permitting system in commercial fisheries; and establishing season-specific overharvest and underharvest adjustment procedures.

On December 24, 2003, the final rule implementing Amendment 1 to the FMP for Atlantic Tunas, Swordfish, and Sharks was published in the *Federal Register* (68 FR 74746). This final rule revised the shark regulations based on the results of the 2002 stock assessments for SCS and LCS. In Amendment 1 to the 1999 FMP, NMFS revised the rebuilding timeframe for LCS to 26 years from 2004, and implemented several new regulatory changes, including: using maximum sustainable yield as a basis for setting commercial quotas; eliminating the commercial minimum size restrictions; implementing trimester commercial fishing seasons effective January 1, 2005; implementing a time/area closure off the coast of North Carolina effective January 1, 2005; and establishing three regional commercial quotas (Gulf of Mexico, South Atlantic, and North Atlantic) for LCS and SCS management units. In addition, as of November 15, 2004, directed shark vessels with gillnet gear on board, regardless of location, are required to have a Vessel Monitoring System (VMS) installed and operating during right whale calving season (November 15–March 31); and, as of January 1, 2005, directed shark vessels with bottom longline fishing gear on board, located between 33° and 36° 30′ N latitude, were required to have a VMS installed and operating during the mid-Atlantic shark closure period (January 1–July 31).

The first individual stock assessment for dusky sharks was completed in May 2006. Due to potential identification problems and catch data originating from a variety of sources, the magnitude of dusky shark catch has previously been difficult to ascertain. Three models were used to ascertain the current status of a single dusky shark stock, the most optimistic of which indicated that the dusky shark population has been depleted by 62 to 80 percent of the unfished virgin biomass. The assessment also summarized the relevant biological data, discussed the fisheries affecting dusky sharks, and detailed the data and methods used to assess shark status. Some recommendations were also made regarding future avenues of research and issues to consider in future stock assessments.

The latest stock assessment on LCS, which followed the Southeast Data Assessment and Review (SEDAR) process, was completed in June 2006. During the Review Workshop, an official recommendation was made to alter the current regime for conducting LCS complex-based assessments to species-specific assessments. During the 2006 LCS assessment, the Atlantic stock of sandbar sharks was individually assessed and found to be overfished with overfishing occurring. Regulatory actions are required to be in place by 2008 to adjust the commercial quota of sandbar sharks as necessary to achieve rebuilding by the target year of 2070. Blacktip sharks were divided into two stocks, a Gulf of Mexico stock and an Atlantic stock. Due to an absence of reliable estimates of abundance, biomass, and exploitation rates, the current status of blacktips in the Atlantic is unknown. Alternatively, the Gulf of Mexico stock is not overfished and overfishing is not occurring; however, it was recommended that current catch rates of this stock be maintained.

The latest stock assessments for the SCS complex—and for Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks individually—were conducted in 2007. The Review Panel for the 2007 SCS SEDAR concluded that, although the assessment of the status of the complex was adequate based on the available data, given that species-specific assessments were also conducted, any conclusions should be based on the results of the individual species assessments. Results of the finetooth shark assessment indicated the stock was not overfished and overfishing was not occurring, in contrast to the findings of the 2002 SCS assessment, which found that overfishing was occurring. However, because of the general level of uncertainty in the data, the Review Panel suggested cautious management of this resource. For blacknose sharks, the assessment indicated the stock was overfished and overfishing was occurring both in 2005 and in the preceding 2001–2004 period. However, due to uncertainty in life history parameters, catches, and indices of relative abundance, the Review Panel cautioned that stock status could change substantially in an unpredictable direction in future assessments. In contrast, the assessments for Atlantic sharpnose and bonnethead sharks determined the stocks were not overfished and that overfishing was not occurring.

On October 2, 2006, the 1999 FMP 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 the second dorsal and anal fin to remain on shark carcasses through landing, required shark dealers to attend shark identification workshops, and included measures to address overfishing of finetooth sharks (71 FR 58058). This FMP manages several species of sharks (Table 2.2.1). The 2001–2006 commercial shark landings and the 2007 preliminary commercial shark landings are shown in tables 2.2.2 and 2.2.3, respectively.

On February 7, 2007, NMFS published a final rule (72 FR 5633) to implement additional handling, release, and disentanglement requirements for sea turtles and other non-target species caught in the commercial shark bottom longline (BLL) fishery. These additional handling requirements require the commercial shark BLL fishery to utilize equipment and protocols consistent with the requirements for the pelagic longline fishery (July 6, 2004, 69 FR 40734). Additionally, this final rule established measures to complement those implemented by the Caribbean Fishery Management Council on October 29, 2005 (70 FR 62073), to prohibit all vessels issued HMS permits with BLL gear onboard from fishing with, or deploying, any fishing gear in six distinct areas off the U.S. Virgin Islands and Puerto Rico, year-round. The intent of these restrictions is to minimize adverse impacts to Essential Fish Habitat and reduce fishing mortality on other fish species.

On July 27, 2007, NMFS published a proposed rule (72 FR 41392) that would amend the Consolidated Atlantic Highly Migratory Species Fishery Management Plan based on recent stock assessments for LCS, dusky sharks, and porbeagle sharks. The proposed rule included measures that would adjust quotas and retention limits, modify authorized species for the commercial shark fishery, establish a shark research fishery, require that all sharks be landed with all fins naturally attached, and modify the species that can be landed by recreational fishermen. Final measures should be effective in 2008.

NMFS publishes rules each year to adjust quotas based on landings from the previous season. The first trimester season is typically established 30 days prior to the end of the preceding year, and the second and third trimester seasons are established prior to the start of the second trimester each year. Two such actions were published in 2007. A final rule was published on April 26, 2007 (72 FR 20765), which established the 2007 second and third trimester seasons' commercial quotas for LCS, SCS, and pelagic sharks based on overharvests or underharvests from the 2006 second and third trimester seasons. Because of the large LCS overharvests during 2006, NMFS merged the 2007 second and third trimester seasons for LCS in the Gulf of Mexico and South Atlantic regions. During the 2007 third trimester season, the North Atlantic was closed to LCS fishing. SCS and pelagic shark quotas continue to be divided into trimester seasons for 2007. The final rule establishing the commercial seasons and quotas for the first trimester of 2008 was published on November 29, 2007 (72 FR 67580). In this rule, NMFS established quotas and seasons for SCS and pelagic sharks but closed the first trimester for LCS because of the limited amount of quota available and resulting likelihood that the quota would be exceeded.

Coordinated State management of sharks is vital to ensuring healthy populations of Atlantic coastal sharks. The Atlantic States Marine Fisheries Commission has been in the process of developing an Interstate Coastal Shark FMP since 2005. A goal of this FMP is to improve consistency between Federal and State management of sharks in the Atlantic Ocean. The final FMP is expected to be completed in 2008.

Observer coverage in the shark BLL fishery began in 1994 on a voluntary basis. Since 2002, observer coverage has been mandatory for selected BLL and gillnet vessels. NMFS aims to obtain 4 to 6 percent observer coverage of the commercial effort, and deploys approximately five to seven observers to monitor 300 to 400 commercial fishing trips per year. The data collected through the observer program are critical to the monitoring of takes and mortality estimates for protected sea turtles, sea birds, marine mammals, 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 contingent upon requirements implemented by the Atlantic Large Whale Take Reduction Plan (ALWTRP).

The most recent regulations amending the ALWTRP were published in the *Federal Register* on June 25, 2007 (72 FR 34632), and on October 5, 2007 (72 FR 57104). The ALWTRP, as amended, implements specific regulations for the shark gillnet component of the HMS fisheries. Revisions to the ALWTRP regulations include:

- Expanded the Southeast U.S. Restricted Area to include waters within 35 nautical miles of the South Carolina coast.
- Divided the Southeast U.S. Restricted Area at 29º N latitude into two areas, the Southeast U.S. Restricted Areas North and South. Possession of and fishing with gillnet gear in the Southeast U.S. Restricted Area North is prohibited from November 15 through April 15, with an exemption for transition through the area if gear is stowed. Fishing with gillnet gear is prohibited in the Southeast U.S. Restricted Area South from December 1 through March 31, with an exemption for strike-net component of the Southeastern U.S. Atlantic shark gillnet fishery. Fishing for sharks with gillnet with a 5-inch or greater stretch mesh size in the Southeast U.S. Restricted Area is exempt from the restrictions if the following criteria are met:
    - the gillnet is deployed so that it encloses an area of water;
    - a valid commercial directed shark limited access permit has been issued to the vessel in accordance with 50 CFR 635.4 and is on board;
    - no net is set or remains in the water at night or when visibility is less than 500 yards (460 m);

  - each set is made under the observation of a spotter plane;
  - no gillnet is set within 3 nautical miles (5.6 km) of a right, humpback, or fin whale;
  - gillnet is removed immediately from the water if a right, humpback, or fin whale moves within 3 nautical miles (5.6 km) of the set gear;
  - a vessel operator calls the Southeast Fisheries Science Center, Panama City Laboratory (phone 850-234-6541, fax 850-235-3559) at least 48 hours prior to departure on fishing trips in order to arrange for observer coverage. If Panama City Laboratory requests that an observer be taken, gillnetting is not allowed unless an observer is onboard the vessel during the fishing trip; and
  - gear is marked as follows:
    - Gear is marked with a green marking (to indicate gillnet gear) and a blue marking (to indicate area); marks must be 4 inches long and the two color marks must be within 6 inches of each other. If the color of the rope is the same as or similar to a color code, a white mark may be substituted for that color code.
    - Marks may be dyed, painted, or marked with thin, colored whipping line; thin, colored plastic or heat-shrink tubing or other material; or a thin line may be woven into or through the line.
    - All buoy lines must be permanently marked within 2 feet of the top and midway along the length of the buoy line. Each net panel must be marked along both the float line and the lead line at least once every 100 yards.
- Renamed and redefined the boundaries of the Southeast U.S. Observer Area. The new "Southeast U.S. Monitoring Area" includes regulated waters landward of 80°W longitude from 27°51′N latitude to 26°46.5′N latitude. During the period from December 1 through March 31, VMS is being used in this area in lieu of requiring 100 percent observer coverage of the HMS shark gillnet fishery during that time frame. NMFS continues to maintain observer coverage in this and other areas at a level sufficient to produce statistically reliable results for evaluating protected resource interactions. The ALWTRP amended the dates stated in Amendment 1 to the HMS FMP, such that NMFS-approved VMS is required for gillnet vessels issued directed shark limited access permits that have gillnet gear on board between December 1 and March 31 (to reflect the new season).
- Created a new management area, "Other Southeast Gillnet Waters," and management measures, effective April 5, 2008, for the area east of 80° W longitude from 32° N latitude south to 26° 46.5′ N latitude and out to the eastern edge of the EEZ.

The Mid-Atlantic Fishery Management Council has the lead in consultations with the New England Fishery Management Council for the management of spiny dogfish in Federal waters of the Atlantic Coast pursuant to the Spiny Dogfish FMP, which became effective in February 2000. The FMP incorporates the MSA regulations governing the harvest, possession, landing, purchase, and sale of shark fins from 50 CFR Part 600, Subpart N. The management program establishes a restrictive spiny dogfish possession limit of 600 pounds per trip and a coastwide commercial quota further split into two seasonal quotas (Period I and Period II). Upon attainment of the coastwide quota, the fishery is closed to further landings by Federally permitted vessels. The fishery is managed in State waters by the Atlantic States Marine Fisheries Commission through an Interstate FMP for Spiny Dogfish.

Table 2.2.1 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)**	
Sandbar	*Carcharhinus plumbeus*	Atlantic sharpnose	*Rhizoprionodon terraenovae*
Silky	*Carcharhinus falciformis*	Finetooth	*Carcharhinus isodon*
Tiger	*Galeocerdo cuvier*	Blacknose	*Carcharhinus acronotus*
Blacktip	*Carcharhinus limbatus*	Bonnethead	*Sphyrna tiburo*
Spinner	*Carcharhinus brevipinna*		
Bull	*Carcharhinus leucas*	**Pelagic Sharks**	
Lemon	*Negaprion brevirostris*	Shortfin mako	*Isurus oxyrinchus*
Nurse	*Ginglymostoma cirratum*	Common thresher	*Alopias vulpinus*
Scalloped hammerhead	*Sphyrna lewini*	Porbeagle	*Lamna nasus*
Great hammerhead	*Sphyrna mokarran*	Oceanic whitetip	*Carcharhinus longimanus*
Smooth hammerhead	*Sphyrna zygaena*	Blue	*Prionace glauca*
Prohibited Species			
Sand tiger	*Carcharias taurus*	Caribbean reef	*Carcharhinus perezi*
Bigeye sand tiger	*Odontaspis noronhai*	Narrowtooth	*Carcharhinus brachyurus*
Whale	*Rhincodon typus*	Caribbean sharpnose	*Rhizoprionodon porosus*
Basking	*Cetorhinus maximus*	Smalltail	*Carcharhinus porosus*
White	*Carcharodon carcharias*	Atlantic angel	*Squatina dumeril*
Dusky	*Carcharhinus obscurus*	Longfin mako	*Isurus paucus*
Bignose	*Carcharhinus altimus*	Bigeye thresher	*Alopias superciliosus*
Galapagos	*Carcharhinus galapagensis*	Sevengill	*Heptranchias perlo*
Night	*Carcharhinus signatus*	Sixgill	*Hexanchus griseus*
		Bigeye sixgill	*Hexanchus vitulus*
Deepwater and Other Species (Data Collection Only)			
Iceland catshark	*Apristurus laurussoni*	Great lanternshark	*Etmopterus princeps*
Smallfin catshark	*Apristurus parvipinnis*	Smooth lanternshark	*Etmopterus pusillus*
Deepwater catshark	*Apristurus profundorum*	Fringefin Lanternshark	*Etmopterus schultzi*
Broadgill catshark	*Apristurus riveri*	Green lanternshark	*Etmopterus virens*
Marbled catshark	*Galeus arae*	Cookiecutter shark	*Isistius brasiliensis*
Blotched catshark	*Scyliorhinus meadi*	Bigtooth cookiecutter	*Isistius plutodus*
Chain dogfish	*Scyliorhinus retifer*	Smallmouth velvet dogfish	*Scymnodon obscurus*
Dwarf catshark	*Scyliorhinus torrei*	Pygmy shark	*Squaliolus laticaudus*
Japanese gulper shark	*Centrophorus acus*	Roughskin spiny dogfish	*Squalus asper*
Gulper shark	*Centrophorus granulosus*	Blainville's dogfish	*Squalus blainvillei*
Little gulper shark	*Centrophorus uyato*	Cuban dogfish	*Squalus cubensis*
Kitefin shark	*Dalatias licha*	Bramble shark	*Echinorhinus brucus*
Flatnose gulper shark	*Deania profundorum*	American sawshark	*Pristiophorus schroederi*
Portuguese shark	*Centroscymnus coelolepis*	Florida smoothhound	*Mustelus norrisi*
Greenland shark	*Somniosus microcephalus*	Smooth dogfish	*Mustelus canis*
Lined lanternshark	*Etmopterus bullisi*		
Broadband dogfish	*Etmopterus gracilispinnis*		
Caribbean lanternshark	*Etmopterus hillianus*		

Table 2.2.2 Commercial landings for Atlantic large coastal, small coastal, and pelagic sharks in metric tons dressed weight,[4] 2001–2006.
Source: Cortés and Neer (2002, 2005); Cortés (2003); Cortés pers. comm. (2008).

2001–2006 Commercial Shark Landings						
Species Group	2001	2002	2003	2004	2005	2006
Large coastal sharks	1,549	1,883	1,947	1,458	1,500	1,698
Small coastal sharks	329	279	242	205	295	373
Pelagic sharks	157	212	289	308	122	85
Total	2,035	2,374	2,478	1,971	1,917	2,156

[4] Dressed weight is the weight of fish after the gills, guts, head, and fins have been removed and discarded (usually at sea).

Table 2.2.3 Preliminary landings estimates in metric tons and dressed weight for the 2007 Atlantic shark commercial fisheries. Landings are based on the quota monitoring system.

2007 Preliminary Commercial Shark Landings					
Species Group	Region	First Season	Second Season	Third Season	Group Total
Large coastal sharks* (i.e., sandbar, silky, tiger, blacktip, spinner, bull, lemon, nurse, and hammerheads)	Gulf of Mexico	202.2	546.3		
	South Atlantic	15.2	184.9		**1056.5**
	North Atlantic	0.4	107.5		
Small coastal sharks (i.e., Atlantic sharpnose, finetooth, blacknose, bonnethead)	Gulf of Mexico	14.8	81.1		
	South Atlantic	27.6	159.5		**292.6**
	North Atlantic	0	9.6		
Blue sharks		0	0		
Porbeagle sharks	No regional quotas	0.1	1.3		**115.5**
Pelagic sharks (other than blue or porbeagle)		25.6	88.5		
Total:		285.9	1178.7		1464.6

2.3 Current Management of Sharks in the Pacific Ocean

<u>**Pacific Fishery Management Council (PFMC)**</u>

The PFMC's area of jurisdiction is the Exclusive Economic Zone (EEZ) off the coasts of California, Oregon, and Washington. In late October 2002, the PFMC adopted the U.S. West Coast Highly Migratory Species (HMS) Fisheries FMP. This FMP's management area also covers adjacent high-seas waters for fishing activity under the jurisdiction of the HMS FMP. The final rule implementing the HMS FMP was published in the *Federal Register* on April 7, 2004 (69 FR 18443). This FMP manages several sharks as part of the management unit (Table 2.3.1), including the common thresher and shortfin mako (sharks valued but not primarily targeted in the West Coast-based fisheries), as well as blue sharks (a frequent bycatch species), bigeye thresher, and pelagic thresher (incidental catch) sharks. The HMS FMP also includes some shark species for monitoring purposes (Table 2.3.1). These species, which often comprise a fishery's bycatch, are monitored on a consistent and routine basis to the extent practicable. Lastly, the HMS FMP also designated some shark species as prohibited because of their special status (Table 2.3.1). If intercepted, these species—including great white, megamouth, and basking sharks—must be released immediately, unless other provisions for their disposition are established.

The FMP proposed precautionary annual harvest guidelines for common thresher and shortfin mako sharks in order to prevent localized depletion, which could take decades to correct given the biological characteristics of the species. The common thresher shark and the shortfin mako shark are considered vulnerable to overexploitation due to their low fecundity, long gestation periods, and relatively old age at maturation. The FMP also establishes a formal requirement for fishery monitoring and annual Stock Assessment and Fishery Evaluation (SAFE) reports, as well as a full FMP effectiveness review every 2 years. This should ensure new information will be collected and analyzed so additional conservation action can be taken if any species is determined to need further protection.

The Pacific Coast Groundfish FMP includes three shark species (leopard, soupfin, and spiny dogfish) in the groundfish management unit (Table 2.3.2). Beginning in 2003, NMFS established a "rockfish conservation area" closing large areas to fishing for groundfish, including sharks, by most gear types that catch groundfish. In addition, the Pacific Coast Groundfish FMP manages its shark species with a combined annual optimal yield for all "other fish," which includes sharks, skates, ratfish, morids, grenadiers, kelp greenling, and some other groundfish species. This optimal yield is reduced by a precautionary adjustment of 50 percent from the acceptable biological catch. Beginning in 2006, NMFS implemented 2-month cumulative trip limits for spiny dogfish for both open access and limited entry fisheries to control the harvest of dogfish and associated overfished groundfish species. Table 2.3.3 lists landings (round weight[5] equivalent in metric tons) for various sharks from fisheries off California, Oregon, and Washington from 1995 through 2007.

[5] Round weight is the weight of the whole fish before processing or removal of any part.

Table 2.3.1 Shark species in the West Coast Highly Migratory Species Fishery Management Plan.

West Coast Highly Migratory Species FMP	
Sharks listed as management unit species	
Common thresher	*Alopias vulpinus*
Shortfin mako	*Isurus oxyrinchus*
Blue shark	*Prionace glauca*
Bigeye thresher	*Alopias superciliosus*
Pelagic thresher	*Alopias pelagicus*
Sharks included in the FMP for monitoring purposes	
Blue shark	*Prionace glauca*
Whale shark	*Rincodon typus*
Prickly shark	*Echinorrihinus cookie*
Salmon shark	*Lamma ditropis*
Leopard shark	*Triakis semifasciata*
Hammerhead sharks	Sphyrnidae
Soupfin shark	*Galeorhinus galeus*
Silky shark	*Carcharhinus falciformis*
Oceanic whitetip shark	*Carcharhinus longimanus*
Blacktip shark	*Carcharhinus limbatus*
Dusky shark	*Carcharhinus obscurus*
Sixgill shark	*Hexanchus griseus*
Spiny dogfish	*Squalus acanthias*
Prohibited species	
Great white	*Carcharodon carcharias*
Megamouth	*Megachasma pelagios*
Basking sharks	*Cetorhinus maximus*

Table 2.3.2 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	
Leopard shark	*Triakis semifasciata*
Soupfin shark	*Galeorhinus zyopterus*
Spiny dogfish	*Squalus acanthias*

Table 2.3.3 Shark landings (round weight equivalent in metric tons) for California, Oregon, and Washington, 1995–2007, organized by species group.[6]
Source: PacFIN Database, the Washington, Oregon, and California All Species Reports (Report # 307) and the PFMC Groundfish Management Team Reports, as of July 2008, www.psmfc.org/pacfin/data.html

Shark Landings (mt) for California, Oregon, and Washington													
Species Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007[7]
Bigeye thresher shark	31	20	32	11	6	5	2	--	5	5	10	4	5
Blue shark	5	1	1	3	< 1	1	2	42	1	< 1	1	< 1	10
Common thresher shark	270	319	320	361	320	295	373	301	294	115	179	160	200
Leopard shark	10	8	11	15	14	13	12	13	10	11	13	11	11
Other shark	1	2	3	5	6	5	38	4	20	3	5	4	2
Pelagic thresher shark	5	1	35	2	10	3	2	2	4	2	< 1	< 1	2
Shortfin mako	95	96	132	100	63	80	46	82	69	54	33	46	45
Soupfin shark	44	65	63	54	75	48	45	32	35	27	26	30	17
Spiny dogfish[8]	367	251	425	462	515	628	567	876	450	412	495	431	466
Unspecified shark	16	5	7	7	13	6	3	4	3	6	5	5	5
Pacific angel shark	18	16	31	50	48	34	28	22	17	13	12	15	8
Total	**862**	**782**	**1,060**	**1,070**	**1,070**	**1,114**	**1,115**	**1,377**	**905**	**904**	**1,003**	**870**	**977**

North Pacific Fishery Management Council (NPFMC)

The NPFMC manages fisheries in Federal waters off Alaska. Sharks are managed under the "other species" category in the Gulf of Alaska (GOA) Groundfish FMP and the Bering Sea/Aleutian Island (BSAI) Groundfish FMP. The "other species" category is composed of taxonomic groups that are of slight economic value and are not generally targeted. The category includes sharks, skates, octopus and sculpins in the BSAI and sharks, octopus, squid, and sculpins in the GOA. These species have limited economic potential and are important components of the ecosystem, but sufficient data are lacking to manage each separately; therefore, an aggregate annual quota limits their catch. Aggregate catch of the whole category must be recorded and reported.

[6] This report includes all annual landings into the States of Washington, Oregon, and California for all marine species. This report was generated using the fish-ticket-line table and includes all catch areas including Puget Sound, Alaska, and possibly Canadian catch areas.
[7] For the most up-to-date report of shark landings, check the PacFIN website: www.psmfc.org/pacfin/data.html, as the data may continue to be updated.
[8] Spiny dogfish are sharks primarily caught in the groundfish fishery and some of the catch landed in Washington, Oregon, and California may have been made outside of the jurisdiction of the PFMC (i.e., Puget Sound, Alaska, and Canadian waters); therefore, the PFMC groundfish management team reports were used to report these landings.

In the BSAI and GOA, a survey is conducted biannually for the "other species" category, most recently in 2006 in the BSAI and in 2007 in the GOA. These survey results were incorporated into the SAFE reports for "other species" in the BSAI and GOA (available from the North Pacific Fishery Management Council (NPFMC)). A NMFS survey of "other species" is scheduled for 2008 in the BSAI and in 2009 in the GOA, and the results will be incorporated in the 2008 and 2009 SAFE reports.

Each year the BSAI Plan Team recommends to the Council overfishing levels (OFL) and Allowable Biological Catch (ABC) amounts for the "other species" category based on the best available and most recent scientific information. The Council recommends total allowable catch (TAC) levels for "other species" in the BSAI. In recent years the Council has recommended a TAC for these species estimated as sufficient to meet incidental catch amounts in other directed groundfish fisheries but not sufficient to allow for a directed fishery on these species. The NPFMC has initiated analysis of alternative management measures for the "other species" category in the BSAI. Specifically, the analysis will examine the feasibility of breaking out the major taxonomic components of the "other species" and setting separate OFLs and ABCs for each component: sharks, skates, sculpins, and octopus.

In the GOA, because assessments for the "other species" category have not been regularly conducted, the GOA Plan Team does not recommend OFL and ABC amounts for the "other species" category. The Alaska Fisheries Science Center (AFSC) prepared preliminary stock assessments for "other species" in the GOA in 2006. In 2006, NMFS implemented Amendment 69 to the GOA FMP, which allows the Council to recommend an annual TAC for the "other species" category in the GOA at a level less than or equal to 5 percent of the sum of all other TACs established for assessed species. Since 2006, the Council has recommended an annual TAC of 4,500 metric tons (mt) for the "other species" category. The NPFMC's recommendation was based on the GOA Plan Team's estimate of incidental catch needs in other directed groundfish and Pacific halibut fisheries (4,000 mt) and comments from the Scientific and Statistical Committee, the Advisory Panel, and the public. An annual TAC of 4,500 mt would meet incidental catch needs in the directed groundfish and halibut fisheries and allow for a modest directed fishery for the "other species" category of approximately 500 mt each year and the development of markets for these species.

Seven shark species have been identified during fishery surveys or observed during groundfish fishing in Alaskan waters (Table 2.3.4). The brown cat, basking, sixgill, and blue sharks are very rarely taken in any sport or commercial fishery and are not targeted for harvest. Pacific sleeper, salmon, and spiny dogfish sharks are taken incidentally in groundfish fisheries and are monitored in season by NMFS. Sharks are the only group in the complex consistently identified to species in catches by fishery observers. 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. The most recent estimates of the incidental catch of sharks in the GOA and BSAI are from 2007. These data are included in Chapter 18 of the 2007 BSAI SAFE report and Appendix 1d to the 2007 GOA SAFE report and the NMFS Catch Accounting System. Estimates of the incidental catch of sharks in the GOA and BSAI groundfish fisheries from 2000 through 2007 have ranged from 418–1,300 mt and

234–1,362 mt, respectively (Table 2.3.5). Due to limited catch reports on individual species and larger taxonomic groups in the "other species" category, estimates of the incidental catch of sharks in the BSAI and GOA are largely based on NMFS survey results, observer data, and NMFS Catch Accounting System data.

Table 2.3.4 Shark species identified during fishery surveys or observed during groundfish fishing in Alaskan waters.

Common Name	Species Name
Pacific sleeper shark	*Somniosus pacificus*
Salmon shark	*Lamna ditropis*
Spiny dogfish shark	*Squalus acanthias*
Brown cat shark	*Apristurus brunneus*
Basking shark	*Cetorhinus maximus*
Sixgill shark	*Hexanus griseus*
Blue shark	*Prionace glauca*

Table 2.3.5 Incidental catch (in metric tons) of sharks in the Gulf of Alaska and Bering Sea/Aleutian Islands commercial groundfish fisheries, 2000–2007.
Source: NMFS Survey, Observer Data, and NMFS Catch Accounting System Data

Incidental Catch of Sharks (mt)									
Fishery	Species	2000	2001	2002	2003	2004	2005	2006	2007
Gulf of Alaska groundfish fishery	**Spiny dogfish**	397.6	494.0	117.0	368.6	175.6	415.5	948.0	715.4
	Pacific sleeper shark	608.2	249.0	225.6	292.5	232.3	454.2	240.0	295.4
	Salmon shark	37.8	32.8	58.2	35.7	21.6	52.7	28.6	95.0
	Unidentified shark	73.6	77.0	16.8	52.3	39.0	60.4	83.2	107.2
	Total	1,117.2	852.8	417.6	749.1	468.5	982.8	1,299.8	1213.0
Bering Sea and Aleutian Islands groundfish fishery	**Spiny dogfish**	8.9	17.3	9.4	11.3	8.6	11.4	6.9	2.9
	Pacific sleeper shark	490.4	687.3	838.5	279.6	420.1	332.9	306.7	256.3
	Salmon shark	23.3	24.4	46.6	196.4	25.6	46.7	61.0	44.3
	Unidentified shark	67.6	35.0	467.8	32.9	60.1	26.2	305.4	24.9
	Total	590.2	764.0	1,362.3	520.2	514.4	417.2	680.0	328.4

Very few of the sharks incidentally taken in the groundfish fisheries in the BSAI and GOA are retained. Table 2.3.6 lists the amounts of sharks discarded and retained between 2003 and 2007 in the GOA and BSAI. The amount of sharks retained during the period ranged from 1.8 to 9.0 percent of the total incidental catch in the BSAI, and from 1.4 to 4.8 percent in the GOA. In 2006, two vessels targeted sharks using hook and line gear in the GOA, one vessel using a Federal Fishing Permit and another vessel using a permit issued by the Commissioner of the Alaska Department of Fish and Game (ADF&G) for use in State waters. The catches of these vessels is confidential but catches of sharks were very low, and effort was very short-lived and deemed unsuccessful by the participants.

Table 2.3.6 Utilization (in metric tons) of sharks incidentally caught in the Gulf of Alaska and Bering Sea/Aleutian Islands commercial groundfish fisheries, 2003–2007. Source: Observer Data and NMFS Catch Accounting System Data

Utilization of Sharks (mt)						
Gulf of Alaska groundfish fishery	Species	2003	2004	2005	2006	2007
	Retained	10.8	9.9	35.5	62.1	45.4
	Discarded	738.3	458.6	947.3	1237.7	1167.6
	Total	749.1	468.5	982.8	1299.8	1213.0
	Percent Retained	1.4	2.1	3.6	4.8	3.7
Bering Sea and Aleutian Islands groundfish fishery	**Retained**	9.5	13.3	20.3	26.6	29.6
	Discarded	510.7	501.1	396.9	653.4	298.8
	Total	520.2	514.4	417.2	680.0	328.4
	Percent Retained	1.8	2.6	4.9	3.9	9.0

The ADF&G manages the recreational shark fishery in State and Federal waters with a daily bag limit of one shark of any species per person per day, and an annual limit of two sharks of any species per person. There have been no reported incidents of sport-caught sharks being finned and discarded, and State regulations prohibit the intentional waste or destruction of any sport-caught species. The catch consists almost entirely of spiny dogfish and salmon shark. Although most spiny dogfish are released, they are believed to be the primary species harvested. There is a recreational fishery for salmon sharks in Prince William Sound involving a small number of charter boats. Recreational harvest of all shark species combined is estimated through a mail survey of sport fishing license holders. In addition, harvest of salmon sharks by guided anglers is required to be reported in charter logbooks. About 867 sharks of all species were harvested by the sport fishery in State and Federal waters of Southeast and Southcentral Alaska in 2006 (most recent mail survey estimate). The highest harvests were in the Prince William Sound area, and no sport harvest of sharks was reported in western Alaska. Charter boats reported salmon shark harvests of 284 fish Statewide in 2006 and 243 fish in 2007. Although estimates of salmon shark harvest are not available for unguided anglers, the charter fleet is believed to account for the majority of salmon shark harvest. In addition to the mail survey and logbook, shark fisheries are monitored in Southcentral Alaska through biological sampling for species, size, age, and sex composition, as well as spatial distribution of the harvest.

State of Alaska regulations prohibit directed commercial fishing of sharks Statewide except for a spiny dogfish permit fishery (5 AAC 28.379) adopted by the Alaska Board of Fisheries for the Cook Inlet area in 2005. Sharks taken incidentally to commercial groundfish and salmon fisheries may be retained and sold provided the fish are fully utilized as described in 5 AAC 28.084. The State limits the amount of incidentally taken sharks that may be retained to 20 percent of the round weight of the directed species on board a vessel except in the Southeast District, where a longline vessel or a troller may retain up to 35 percent round weight of sharks to round weight of the target species on board (5AAC 28.174 (1) and (2)). 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)). All sharks landed must be recorded on an ADF&G fish ticket. To date, a single permit was issued in 2006 for the Cook Inlet spiny dogfish fishery and there was a single landing of incidentally taken sharks from southcentral Alaska waters. Harvest data are confidential if less than three landings occur.

Western Pacific Fishery Management Council (WPFMC)

In the western Pacific region the conservation of sharks is governed under the provisions of the Shark Finning Prohibition Act and the MSA. The MSA (Section 317) makes it unlawful for any person to chum for sharks, except for harvesting purposes. The WPFMC's Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region identifies nine sharks as management unit species (Table 2.3.6). Five species of coastal sharks are listed in the Coral Reef Fisheries Management Plan (Table 2.3.7) as currently harvested.

The longline fisheries in the Western Pacific, in Hawaii and American Samoa, were responsible for the vast majority of the sharks landed. Shark landings (estimated whole weight) by the Hawaii-based longline fisheries peaked at about 2,870 mt in 1999, due largely to the finning of blue sharks (Table 2.3.8). A State of Hawaii law prohibiting landing shark fins without an associated carcass passed in mid-2000 (Hawaii Revised Statutes 188.40-5). This law apparently decreased shark landings by almost 50 percent in 2000. With the subsequent enactment of the Federal Shark Finning Prohibition Act, shark landings from 2001 to 2006 were down by more then 93 percent from their peak. Landings in 2006 (preliminary data) were the lowest seen since 2001. Today, sharks are marketed as fresh shark fillets and steaks in Hawaii supermarkets and restaurants, and are also exported to the U.S. mainland.

The American Samoa longline fishery landed a small amount of sharks relative to Hawaii's longline fishery (Table 2.3.8). The pattern of shark landings by the American Samoa longline fishery was similar to shark landings by the Hawaii-based longline fishery. Landings increased from 1 mt in 1995 to 13 mt in 1999, followed by a decline. The decline in shark landings by the American Samoa longline fishery is also attributed to the Shark Finning Prohibition Act.

Table 2.3.7 Pacific sharks in the pelagic management unit in the Pelagic Fisheries of the Western Pacific Region Fisheries Management Plan (as amended in March 2004).

Pelagic Fisheries of the Western Pacific Region FMP	
Shark species in the pelagic management unit	
Blue shark	*Prionace glauca*
Shortfin mako shark	*Isurus oxyrinchus*
Longfin mako shark	*Isurus paucus*
Oceanic white-tip shark	*Carcharhinus longimanus*
Common thresher shark	*Alopias vulpinus*
Pelagic thresher shark	*Alopias pelagicus*
Bigeye thresher shark	*Alopias superciliosus*
Silky shark	*Carcharhinus falciformis*
Salmon shark	*Lamna ditropis*

Table 2.3.8 Five coastal sharks listed as management unit species in the Coral Reef Ecosystems of the Western Pacific Fishery Management Plan and designated as currently harvested coral reef taxa. Other coastal sharks in the management unit of the FMP belonging to the families Carcharhinidae and Sphyrnidae are designated as potentially harvested coral reef taxa.

Coral Reef Ecosystems of the Western Pacific Fishery Management Plan	
Sharks listed as management unit species and designated as currently harvested coral reef taxa	
Grey reef shark	*Carcharhinus amblyrhynchos*
Silvertip shark	*Carcharhinus albimarginatus*
Galapagos shark	*Carcharhinus galapagenis*
Blacktip reef shark	*Carcharhinus melanopterus*
Whitetip reef shark	*Triaenodon obesus*

Table 2.3.9 Shark landings (mt) from the Hawaii-based longline fishery and the American Samoa longline fishery, 1995–2007.
Source: Pacific Islands Fisheries Science Center's Fisheries Monitoring and Analysis Program and Western Pacific Fisheries Information Network (WPacFin)

Shark Landings (mt)														
Fishery	Species	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Hawaii-based longline fishery	**Blue shark**	1,400	1,900	2,100	2,500	2,400	1,200	30	30	20	60	30	12	7
	Mako shark	70	50	60	90	110	80	60	80	90	70	110	95	127
	Thresher shark	30	30	60	120	190	100	50	50	50	60	30	33	44
	Miscellaneous shark	120	30	70	110	170	70	10	20	10	10	-	11	8
	Total shark landings	**1,620**	**2,010**	**2,290**	**2,820**	**2,870**	**1,450**	**150**	**180**	**170**	**200**	**170**	**151**	**186**
American Samoa longline fishery	**Total shark landings**	**1**	**3**	**5**	**11**	**13**	**4**	**1**	**3**	**4**	**1**	**< 1**	**1**	**2**

2.4 NOAA Enforcement of the Shark Finning Prohibition Act

The NMFS Office for Law Enforcement (OLE) has responsibility for enforcing the Shark Finning Prohibition Act and its implementing regulations. During calendar year 2007, most violations of the Act were detected, investigated, and prosecuted in the Northeast, Southeast, Southwest, or Pacific Islands Enforcement Divisions. In general, the most common violations were the illegal finning of sharks, and failure to maintain sharks in proper form. Additional "non-finning" violations included possession of prohibited shark species, possession of undersized sharks, exceeding bag limits, and failure to possess or display required permits. During the reporting period, the NOAA Office of General Counsel for Enforcement and Litigation (GCEL) initiated several enforcement actions for violations of the Act.

The following cases are highlighted as significant enforcement actions by the OLE and GCEL:

- In April 2007, special agents from OLE's Northeast Division and personnel from the U.S. Coast Guard (USCG) boarded and inspected a commercial fishing vessel in Massachusetts. During the boarding, the USCG boarding team and OLE special agents found shark carcasses and shark fins onboard. Further investigation revealed that the vessel possessed shark fins in excess of the 5 percent "fin to carcass" ratio. OLE special agents seized 4 shark carcasses and 26 pounds of shark fins. GCEL issued a written warning to the vessel operator for the violation.

- In April 2007, and pursuant to a Federal enforcement agreement with the OLE, officers from the Mississippi Department of Marine Resources boarded a commercial shrimp vessel off the coast of Mississippi. During the boarding, the officers discovered approximately 93 shark fins, without the corresponding shark carcasses onboard the vessel, along with 75 pounds of filleted fish. GCEL issued a Notice of Violation and Assessment (NOVA) to the vessel's owner assessing a $22,000 penalty and a 60-day permit sanction for the unlawful possession of the fins and filleted fish.

- In June 2007, personnel from the USCG boarded a Honolulu-based longline fishing vessel at sea. During the inspection, the USCG boarding team discovered 4 bags containing a total of 110 shark fins. The USCG seized the fins and transferred them to OLE. Subsequent investigation by OLE revealed that the fins came from blue sharks, which had been finned and the carcasses disposed of at sea in violation of the Shark Finning Prohibition Act. The case is under review by GCEL.

- United States v. Approximately 64,695 Pounds of Shark Fins,[9] C.A. No 05-56274 (Ninth Circuit Court of Appeals) This case involved the civil forfeiture of over 32 tons of shark fins seized by NOAA for violations of the Shark Finning Prohibition Act in 2002. On March 17, 2008, after four years of litigation a panel decision from the Court of Appeals for the Ninth Circuit found that the forfeiture violated the due process rights of the owner

[9] While litigation in this case was conducted in 2007, the final decision from the Ninth Circuit Court of Appeals was not received until 2008. It is being included in the 2008 *Report to Congress* because it is a significant event in the implementation of the Shark Finning Prohibition Act.

of the shark fins because neither the plain language of the statutes nor the applicable regulations gave fair notice to the owner that the vessel carrying the fins would be considered a "fishing vessel" and thus subject to the statutory prohibition on possession of shark fins without the corresponding carcasses.

On June 18, 2002, the U.S.-flagged vessel KING DIAMOND II (KD II) departed on a 3-month voyage to purchase and take delivery of shark fins at sea from foreign longline fishing vessels and transport the fins to Guatemala for resale. In doing so, the vessel paid almost $400,000 in cash to 26 foreign vessels operating in remote areas of the Central Pacific Ocean, and took possession of 64,695 pounds of shark fins in exchange. The vessel was intercepted by the U.S. Coast Guard approximately 250 miles off the coast of Guatemala and was escorted to San Diego, California, where the fins were seized for forfeiture under the Shark Finning Prohibition Act. Statutory and regulatory limitations on shark finning make it unlawful for any person "to have custody, control, or possession of any such fin aboard a fishing vessel without the corresponding carcass." See 16 U.S.C. §1857(1)(P) and 50 CFR. §600.1203(a)(1)-(3).

For purposes of the Magnuson-Stevens Act and its implementing regulations, a "fishing vessel" is defined as "[a]ny vessel, boat, ship or other craft which is used for, equipped to be used for, or of a type which is normally used for . . . (B) aiding or assisting one or more vessels at sea in the performance of any activity relating to fishing, including, but not limited to, preparation, supply, storage, refrigeration, transportation, or processing." 16 U.S.C. § 1802(17).

Claimant challenged the forfeiture in the District Court for the Southern District of California, claiming that the definition of "fishing vessel" did not apply to their operation because they had no intention to aid or assist the foreign vessels. The district court rejected that argument, finding that the KD II's storage and transportation of the fins in fact aided and assisted the foreign fishing vessels. On appeal, the Ninth Circuit reversed, finding that activities which aid and assist must be those which are done for the benefit of the party receiving the aid and assistance.

Enforcement personnel from OLE's Southeast Division initiated 17 additional investigations involving violations of Atlantic HMS regulations with respect to sharks, exceeding bag limits, and failure to possess or display required permits.

2.5 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 and other U.S. shark management bodies have:

1. Developed training tools and programs in elasmobranch identification (such as identification posters and color guidebooks). For example, the Consolidated Highly Migratory Species Fishery Management Plan requires that all Federally permitted shark dealers in the Atlantic Ocean and Gulf of Mexico attend Atlantic Shark Identification Workshops. The objective of these workshops is to reduce the number of unknown and improperly identified sharks reported in the dealer reporting form and increase the accuracy of species-specific dealer-reported information.
2. Developed information and materials to raise awareness among recreational fishermen, commercial fishermen, fishing associations, and other relevant groups about the need and methods to reduce bycatch mortality and increase survival of released elasmobranchs where bycatch occurs. For example, starting in 2007, all Atlantic commercial shark fishermen using gillnet and/or longline gear were required to attend a mandatory handling and release workshop on protected resources and non-target bycatch prior to renewing their permits. Also, staff from NMFS' Southwest Region Sustainable Fisheries Division co-authored an article in the July 2007 edition of *Pacific Sportfishing* magazine and the May 2007 edition of the *Western Outdoor News* on current research, best angling practices to minimize catch and release mortality, and conservation measures in place for common thresher sharks captured by recreational fishermen in the southern California area. In addition, the NMFS Southwest Region Sustainable Fisheries Division, Southwest Fisheries Science Center, and the Pfleger Institute of Environmental Research sponsor an annual three-part informational thresher shark seminar series. The primary goal of the seminars is to bring together fishermen, scientists, and resource managers to discuss current research findings, innovative fishing tactics to increase post-release survival, and measures to promote a sustainable recreational thresher shark fishery.
3. Attempted to raise awareness among the non-fishing public about the ecological benefits from elasmobranch populations, detrimental effects of habitat destruction (e.g., coastal development and coastal pollution), and appropriate conservation measures to avoid, minimize, or mitigate adverse effects on necessary habitats.

2.6 Fishing Capacity

Numerous management tools are used in U.S. fisheries to reduce capacity, including limited entry, vessel and permit buybacks, and exclusive quota programs (e.g., individual fishing quotas, community development quotas, and cooperatives). A limited access permit program for Atlantic sharks has been in place since 1999 that has capped the number of commercial shark permits in the fishery. This limited access permit program includes both directed and incidental commercial shark permits. The directed shark permit, which allows a vessel to target sharks using any authorized gear, also has vessel-upgrading restrictions, further restricting capacity growth. A limited entry program for the U.S. West Coast Swordfish/Thresher Shark Drift Gillnet Fishery has been in place since 1980. Permits that are not renewed on an annual basis are retired with no replacements allowed into the fishery. As a result, fishing efforts and associated shark catch levels (target common threshers and non-target short-finned mako and blue sharks) have been decreasing in this fishery. Additional capacity reduction measures are still being investigated as an effective method for increasing the sustainability of elasmobranch fisheries.

Some participants in the Atlantic shark fishery expressed interest in reducing fishing capacity for sharks via some form of buyout program, and thus requested that an industry "business plan" be developed. The business plan was drafted under a cooperative agreement with the Gulf & South Atlantic Fishery Development Foundation. NMFS received the final report on September 12, 2006. The report concluded, "An evaluation of the Buyout Business Plan options, and comments received by commercial fishermen, indicates that the total allowable catch (TAC) of the shark fishery cannot adequately support a buyback which industry would support." The report also concluded that a buyout program within the shark fishery could still be feasible if issues surrounding latent effort and additional financial resources outside of the shark fishery fleet could be addressed.

Pursuant to both an ongoing analytical program and to provisions in the recently reauthorized MSA, NMFS continues to assess levels of capacity in Federally managed fisheries, including fisheries for sharks, skates, and rays that are managed by fishery management plans. NMFS completed its congressionally mandated report on excess harvesting in May 2008, and included in its analysis two fishery management plans (FMPs) that have components targeting sharks: 1) the Atlantic HMS FMP targets tunas, sharks, and billfish; and 2) the West Coast HMS FMP mainly targets tuna and sharks. Notably, both the Atlantic and West Coast HMS FMPs were included in the list of 20 Federally managed fisheries that exhibit the "most severe examples of excess harvesting capacity," and overcapacity levels for both FMPs were estimated at almost 50 percent. In the Atlantic HMS FMP, the capacity problem seems to be most serious in the fleets that fish large coastal sharks, while the West Coast HMS FMP had relatively low overcapacity in the shark fisheries but much higher rates for albacore and other coastal tuna fisheries. The conclusion seems to be that there are fairly high rates of excess capacity and overcapacity in the Federally managed fisheries for shark species, in particular for Atlantic fleets that target large coastal sharks. Note that excess capacity is the ratio of capacity to harvests, and overcapacity is the ratio of capacity to a management target (usually a catch quota). In part to address catch quotas being exceeded in the Atlantic large coast shark fishery, NMFS proposed a rule on July 27, 2007 (72 FR 41392) amending the Consolidated Atlantic HMS FMP as discussed previously in section 2.2.

3. Imports and Exports of Shark Fins

The summaries of annual U.S. imports and exports of shark fins in Tables 3.1.1 and 3.2.1 are based on information submitted by importers and exporters to U.S. Customs and Border Protection and to the U.S. Census Bureau as reported in the NMFS Trade database. Exports of shark fins far exceed imports in both weight and value. The total weight and value of imports has increased every year since 2003. The total weight of exports has decreased every year since 2004.

3.1 U.S. Imports of Shark Fins

During 2007, imports of shark fins were entered through the following U.S. Customs and Border Protection districts: Los Angeles, New York City, San Francisco, and Portland, Maine. In 2007, countries of origin (in order of importance based on quantity) were Hong Kong, China, Canada, Peru, Australia, and Indonesia (Table 3.1.1). The mean value of imports per metric ton (mt) increased from $10,000/mt in 2003 to $58,000/mt in 2007. 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 such as availability of labor, overseas contacts, and astute trading can all play a role in determining the locale from which exports are sent.

3.2 U.S. Exports of Shark Fins

The vast majority of shark fins exported in 2007 were sent from the United States to Hong Kong, Canada, and Finland, and small amounts were sent to Mexico and Portugal (Table 3.2.1). The mean value of exports per metric ton (mt) has decreased from $81,000/mt in 2006 to $73,000/mt in 2007. Using data from Table 3.2.1, mean values of dried shark fins for all countries combined has fluctuated between $28,000/mt and $84,000/mt from 2002 to 2007.

3.3 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 shark fins in tables 3.3.1, 3.3.2, and 3.3.3 are based on information provided in FAO's FishStat database. The quantities and values in those tables are totals for all dried, dried and salted, fresh, or frozen shark fins. Total global imports of shark fins have fluctuated between 15,217 mt and 17,789 mt from 2002 to 2006, while the total global exports of shark fins have fluctuated between 10,139 mt and 15,609 mt from 2002 to 2006. Hong Kong is the largest importer and exporter of shark fins.

Table 3.1.1 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	2002		2003		2004		2005		2006		2007	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Argentina	0	0	(1)	7	0	0	0	0	0	0	0	0
Australia	1	12	(1)	10	(1)	3	(1)	11	0	0	1	13
Bangladesh	(1)	5	0	0	0	0	0	0	0	0	0	0
Brazil	0	0	(1)	2	0	0	2	31	0	0	0	0
Canada	1	40	0	0	0	0	0	0	(1)	5	2	11
China	21	578	0	0	2	19	(1)	8	4	132	5	656
China, Hong Kong	3	145	1	41	5	107	7	524	16	1053	20	954
China, Taipei	0	0	(1)	5	0	0	0	0	0	0	0	0
Costa Rica	(1)	3	0	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	(1)	2	0	0	0	0
India	4	22	6	30	3	17	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	1	12	0	0	(1)	7
Japan	1	108	0	0	(1)	28	0	0	0	0	0	0
Madagascar	(1)	7	0	0	0	0	0	0	0	0	0	0
Mexico	3	34	0	0	0	0	0	0	(1)	4	0	0
Namibia	(1)	7	0	0	0	0	0	0	0	0	0	0
New Zealand	0	0	0	0	0	0	0	0	1	26	0	0
Nicaragua	0	0	0	0	0	0	1	23	(1)	22	0	0
Panama	0	0	0	0	4	160	1	73	7	139	0	0
Peru	0	0	0	0	0	0	0	0	0	0	2	36
Philippines	0	0	1	3	0	0	16	67	0	0	0	0
Singapore	5	61	0	0	0	0	0	0	0	0	0	0
Vietnam	0	0	2	12	1	11	0	0	0	0	0	0
Total	39	1024	11	110	14	344	27	752	29	1382	29	1677
Mean value	$26,000/mt		$10,000/mt		$25,000/mt		$28,000/mt		$48,000/mt		$58,000/mt	

Table 3.2.1 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 (this may include products of both domestic and foreign origin) and re-exports. Re-exports of "foreign" products are 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. 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	2002		2003		2004		2005		2006		2007	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Aruba	(1)	4	0	0	0	0	0	0	0	0	0	0
Canada	52	395	5	525	2	270	2	217	2	246	3	238
China	0	0	0	0	16	150	2	118	0	0	0	0
China, Hong Kong	45	2932	38	3441	61	4179	57	3390	42	3536	32	2347
China, Taipei	4	26	1	53	1	69	0	0	0	0	0	0
Colombia	0	0	0	0	(1)	3	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	3	133	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	1	33
Germany	0	0	0	0	0	0	0	0	3	91	0	0
Japan	2	45	2	42	0	0	0	0	2	35	0	0
Mexico	8	55	1	10	2	86	1	37	(1)	17	(1)	21
Netherlands	0	0	0	0	0	0	0	0	1	22	0	0
Portugal	0	0	(1)	3	(1)	3	(1)	3	0	0	(1)	3
South Korea	13	29	1	22	0	0	0	0	0	0	0	0
Thailand	0	0	0	0	9	107	0	0	0	0	0	0
Total	124	3485	49	4096	93	4868	65	3898	49	3945	36	2642
Mean value per mt	$28,000/mt		$84,000/mt		$52,000/mt		$60,000/mt		$81,000/mt		$73,000/mt	

Table 3.3.1 Weight and value of shark fins imported by countries other than the United States.
Source: Food and Agriculture Organization of the United Nations, FishStat database, www.fao.org
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.

Country	2002		2003		2004		2005		2006	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Angola	(1)	4	0	0	0	0	0	0	0	0
Antigua and Barbuda	(1)	1	0	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	9	1,056	7	891
Brazil	0	0	0	0	4	20	2	8	0	0
Brunei Darussalam	15	35	3	18	2	3	0	0	0	0
Cambodia	0	0	0	0	0	0	1	12	4	186
Canada	70	4,255	58	5,286	38	4,989	27	4,833	33	5,066
Chile	0	0	0	0	(1)	11	0	0	0	0
China	3,555	21,951	3,818	22,307	4,776	27,523	3,338	17,758	2,662	13,882
China, Hong Kong	10,938	282,571	12,352	308,245	11,040	329,778	10,348	306,968	9,363	253,427
China, Macao	116	2,325	108	2,471	96	2,831	59	3,368	1,060	3,728
China, Taipei	315	1,815	480	3,470	525	4,052	434	4,658	708	4,141
Djibouti	0	0	0	0	0	0	(1)	15	0	0
India	0	0	0	0	0	0	2	8	0	0
Indonesia	46	643	144	1,540	193	2,407	332	2,486	293	1,274
Laos	0	0	0	0	0	0	(1)	5	(1)	6
Malaysia	68	550	46	233	985	1,900	860	2,060	1,060	2,721
Maldives	0	0	(1)	1	(1)	1	0	0	0	0
Nepal	(1)	10	0	0	0	0	0	0	0	0
North Korea	1	296	(1)	175	1	268	1	331	2	1,222
South Africa	15	95	12	151	0	0	0	0	0	0
South Korea	18	263	4	168	5	268	2	109	6	157
Sri Lanka	0	0	0	0	0	0	0	0	16	84
Thailand	60	568	103	1,045	121	1,256	113	1,317	102	1,141
Turkmenistan	0	0	(1)	2	0	0	0	0	0	0
United Arab Emirates	0	0	0	0	0	0	0	0	(1)	15
Venezuela	0	0	(1)	12	0	0	0	0	0	0
Viet Nam	0	0	0	0	0	0	0	0	102	920
Total	**15,217**	**315,382**	**17,128**	**345,124**	**17,786**	**375,307**	**15,528**	**344,992**	**15,418**	**288,861**
Mean value per metric ton	**$20,726/mt**		**$20,150/mt**		**$21,101/mt**		**$22,217/mt**		**$18,735/mt**	

Table 3.3.2 Weight and value of shark fins exported by countries other than the United States.

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

Note: Data in table are for "total exports," which is a combination of domestic exports (this may include products of both domestic and foreign origin) and re-exports. Re-exports of "foreign" products are 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) means that the weight was less than 500 kilograms.

Country	2002		2003		2004		2005		2006	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Angola	2	113	4	224	5	249	4	265	4	224
Argentina	4	74	4	145	4	133	9	504	9	656
Bangladesh	0	0	0	0	0	0	7	552	5	177
Brazil	4	60	82	1,065	179	2,405	157	2,292	118	1,894
Brunei Darussalam	0	0	0	0	0	0	12	82	0	0
Burma	0	0	0	0	0	0	2	23	0	0
Cambodia	0	0	0	0	0	0	(1)	5	0	0
Chile	33	1,433	40	1,499	54	2,474	39	1,639	13	570
China	1,814	34,434	2,199	38,123	2,476	40,966	1,349	20,753	381	5,306
China, Hong Kong	8,927	118,747	9,113	128,646	8,560	138,005	7,134	127,102	5,962	103,818
China, Macao	0	0	0	0	0	0	24	674	29	800
China, Taipei	901	3,378	1,147	3,222	1,241	4,259	1,141	8,875	974	9,514
Colombia	19	1,157	15	987	17	1,130	14	1,034	17	1,132
Congo, Dem. Rep. of the	0	0	0	0	0	0	1	53	0	20
Congo, Republic of	8	378	12	601	14	430	18	848	10	246
Costa Rica	41	1,807	43	1,464	6	123	0	0	0	0
Côte d'Ivoire	0	0	0	0	(1)	1	0	0	0	0
Djibouti	10	34	0	0	0	0	0	0	2	47
Guinea	0	0	0	0	(1)	4	47	2,163	47	1,872
Guinea-Bissau	0	0	1	92	0	0	3	110	0	0
India	274	5,746	244	4,184	218	4,513	104	3,663	145	5,037
Indonesia	771	8,414	1,288	10,204	943	10,936	1,554	8,065	1,073	9,174
Japan	208	7,781	220	8,492	205	10,262	168	8,140	181	9,091
Kiribati	(1)	14	1	77	(1)	25	1	70	1	111
Kuwait	1	14	(1)	7	0	0	0	0	(1)	9

Liberia	0	0	(1)	1	0	0	3	296	3	271
Libya	0	0	0	27	1	27	1	59	1	52
Malaysia	25	186	8	46	634	955	104	374	127	470
Maldives	28	832	21	889	57	647	43	598	0	0
Marshall Islands	21	594	21	242	1	52	0	0	0	0
Nigeria	0	0	0	0	0	0	1	25	4	92
Oman	94	3,048	64	1,828	0	0	0	0	0	0
Pakistan	89	1,704	0	0	0	0	0	0	0	0
Panama	125	3,015	90	3,270	103	3,860	97	3,544	78	2,600
Papua New Guinea	1	104	3	342	12	271	9	652	10	495
Philippines	80	259	78	257	54	411	0	0	0	0
Samoa	0	0	0	0	0	0	0	0	1	24
Senegal	137	3,922	88	2,915	72	2,537	2	8	48	2,678
Seychelles	1	19	7	126	5	33	7	56	6	68
Solomon Islands	1	19	2	45	2	51	3	70	3	90
Somalia	(1)	39	0	0	0	0	0	0	0	0
South Africa	49	1,029	14	158	0	0	0	0	0	0
South Korea	25	864	25	696	5	293	7	357	9	438
Sri Lanka	0	0	0	0	0	0	0	0	70	2,293
Suriname	9	227	6	231	6	218	7	312	8	487
Thailand	34	970	29	905	29	1,036	44	1,916	18	772
Togo	0	0	0	0	0	0	0	0	24	207
Tonga	5	53	5	59	4	212	3	83	5	281
Tunisia	0	0	0	0	0	0	0	0	8	345
United Arab Emirates	507	14,534	474	12,425	468	10,149	539	14,381	427	13,592
Uruguay	28	597	33	526	38	977	39	570	27	509
Vanuatu	0	0	(1)	13	0	0	0	0	0	0
Venezuela	13	735	18	469	40	874	20	351	7	21
Yemen	183	4,040	141	3,530	156	5,434	179	5,846	284	8,442
Total	**14,472**	**220,374**	**15,540**	**228,032**	**15,609**	**243,952**	**12,896**	**216,410**	**10,139**	**183,925**
Mean value per metric ton	**$15,228/mt**		**$14,674/mt**		**$15,629/mt**		**$16,781/mt**		**$18,140/mt**	

Table 3.3.3 Production of shark fins in metric tons by country.
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, FishStat database, www.fao.org

Country	2002	2003	2004	2005	2006
Bangladesh	263	172	4	1	4
Brazil	0	0	0	0	118
China, Hong Kong SAR	NA	NA	NA	NA	NA
Côte d'Ivoire	32	0	0	0	0
Ecuador	123	77	59	NA	NA
El Salvador	NA	NA	136	149	100
Fiji Islands	160	180	175	160	160
Guyana	68	45	82	151	123
India	408	455	827	1,926	270
Indonesia	771	1,288	943	1,554	1,073
Japan	0	0	0	0	0
Korea, Republic of	25	25	5	7	33
Madagascar	NA	NA	NA	NA	NA
Maldives	12	19	20	13	15
Pakistan	55	52	68	81	62
Philippines	80	78	54	84	71
Senegal	140	109	33	34	27
Singapore	435	1,021	246	320	120
South Africa	49	14	0	0	0
Sri Lanka	83	83	110	80	80
Taiwan Province of China	159	137	134	137	117
Uruguay	0	39	35	43	0
Yemen	236	142	156	179	284
TOTAL	3,099	3,936	3,087	4,919	2,657

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

Consistent with the provisions of Section 5 of the Shark Finning Prohibition Act, the Department of Commerce and the Department of State have initiated ongoing consultation regarding the development of international agreements consistent with the Act. Discussions have focused on possible bilateral, multilateral, and regional agreements with other nations. The law calls for the United States to pursue an international ban on shark finning and to advocate 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 first step toward reaching agreements to decrease the incidence of finning worldwide.

4.1 Bilateral Efforts

In 2007, NMFS participated in bilateral discussions with a number of entities (including Canada, Chile, Taiwan, and the European Union), which included issues relating to international shark conservation and management. Recent emphasis in these bilateral contacts has been on the collection and exchange of information, including requests for data such as shark and shark fin landings, transshipping activities, and the value of trade. In addition, the United States continues to encourage other countries to implement the FAO's IPOA for the Conservation and Management of Sharks by finalizing their own national plans of action.

4.2 Regional Efforts

The U.S. Government continues to work within regional fishery management bodies to facilitate shark research, monitoring, and management initiatives, as appropriate. In recent years, the United States has successfully led efforts to ban shark finning and implement shark conservation and management measures within a number of such organizations. Table 4.2.1 lists regional fishery management organizations (RFMOs) and regional/multilateral programs in which the United States has worked to address shark conservation and management. Of the list in Table 4.2.1, ICCAT, NAFO, WCPFC, and the IATTC have adopted finning prohibitions. Further activities or planning of five organizations are discussed below as a supplement to last year's *Report to Congress.*

Table 4.2.1 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)
• International Council for the Exploration of the Sea (ICES)
• Asia Pacific Economic Cooperation Forum and the Convention on Migratory Species
• South East Atlantic Fisheries Organization
• Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (South Pacific Tuna Treaty)
• International Scientific Committee for Tuna and Tuna-like Species in the North Pacific
• Department of State Regional Environmental Hub Program

<u>North Atlantic Fisheries Organization (NAFO)</u>

At its 26th Annual Meeting in September 2004, the NAFO Fisheries Commission became the first regional fisheries management organization in the world to establish a catch limit for a directed elasmobranch fishery. The total allowable catch for skates in Division 3LNO (the "nose" and "tail" of the Grand Bank) was set at 13,500 metric tons, for each of the years 2005–2007. This total allowable catch was higher than the United States had initially sought, but the U.S. delegation ultimately joined the consensus of which this measure was a part. In addition to this catch limit, NAFO adopted a U.S.-proposed resolution regarding data collection and reporting relative to elasmobranchs in the NAFO Regulatory Area. At its 27th Annual Meeting in September 2005, the NAFO Fisheries Commission adopted a ban on shark finning in all NAFO-managed fisheries and mandated the collection of information on shark catches. At the 2006 NAFO Annual Meeting, a U.S. proposal for improving elasmobranch data collection was also adopted.

Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
Five shark species—*Lamna nasus*, *Somniosus antarcticus*, *Etmopterus cf. granulosus*, *Centroscymnus coelolpis,* and *Squalus acanthias*—are known to occur in the northern part of the area addressed by CCAMLR. Only the first three species appear to be abundant enough to have the potential to attract commercial interest. The identification of a sixth species, *Halaelurus canescens,* from observer reports at South Georgia has yet to be confirmed.

In 2006, CCAMLR adopted a conservation measure prohibiting directed fishing on shark species in the Convention Area, other than for scientific research purposes. The Commission agreed that the prohibition shall apply until such time as the CCAMLR Scientific Committee has investigated and reported on the potential impacts of this fishing activity and the Commission has agreed on the basis of advice from the Scientific Committee that such fishing may occur in the Convention Area. It also agreed that any bycatch of shark, especially juveniles and gravid females, taken accidentally in other fisheries, shall, as far as possible, be released alive.

During the discussion of the conservation measure at CCAMLR, the United States stated that the issue of management of shark-related fisheries, with a particular focus on the practice of shark finning, is an important one for CCAMLR to consider. The United States noted that it has enacted legislation and regulations banning the practice of shark finning, and has been using educational efforts and enforcement actions to ensure that U.S.-flagged vessels and foreign vessels making U.S. port calls comply with the statutory ban on retaining shark fins without retention of the shark carcasses to the first point of landing.

The United States expressed hope that the investigations of the Scientific Committee would yield analysis of the stock abundance, shark bycatch levels, and other important biological data of the shark species of the Southern Ocean. It is believed that this conservation measure is an important first step to an eventual ban on the practice of shark finning without utilization of the shark carcasses. The United States also mentioned the need for future efforts to collect information on the extent of shark finning in the Convention Area and the amount of trade/transshipment through ports of Contracting and non-Contracting parties. The United States urged all Contracting Parties to prepare and submit their respective National Plans of Action for the Conservation and Management of Sharks to the FAO Committee on Fisheries, as set forth in the IPOA for the Conservation and Management of Sharks, if they have not already done so.

Inter-American Tropical Tuna Commission (IATTC)
In 2005, IATTC adopted a measure (Resolution C-05-03) on the conservation of sharks caught in association with fisheries in the eastern Pacific Ocean (EPO). Resolution C-05-03 requires that each Party and cooperating non-party, cooperating fishing entity, or regional economic integration organization (collectively, CPCs) establish and implement a national plan of action for conservation and management of shark stocks, in accordance with the FAO International Plan of Action for the Conservation and Management of Sharks. CPCs must take the necessary measures to ensure that fishermen utilize any retained catches of sharks, retaining all parts of the shark except the head, guts, and skin to the first point of landing. In addition, CPCs must ensure that vessels never have shark fins onboard that total more than 5 percent of the total weight of shark carcasses onboard, up to the first point of landing. The resolution also encourages: 1) the release of live sharks, especially juveniles, to the extent practicable, that are caught incidentally

and are not used for food and/or subsistence in fisheries for tunas and tuna-like species that are not directed at sharks; and 2) further research on making fishing gears more selective, identifying shark nursery areas, and data collection on shark catches, landings, and stock assessments.

In May 2006, the IATTC Working Group on Stock Assessment provided advice on the stock status of key shark species and a proposal for a research plan for a comprehensive assessment of these stocks as required by Resolution C-05-03. The proposal for a research plan for a comprehensive assessment of key shark stocks includes: 1) identification of key species, 2) compilation of available life-history data, 3) compilation and standardization of catch per unit effort (CPUE) data and length frequency data, and 4) population dynamics modeling. A series of actions was proposed, along with the required funding and resources; these included salary for a 14-month research position, catch and effort data for fisheries that take sharks in the EPO, and unpublished life history data. The study is intended as a Pacific-wide study, and it is hoped that the Western and Central Pacific Fisheries Commission would be involved, as would the national observer programs in the EPO.

The IATTC Working Group on Stock Assessment also reviewed the ratio of fins to body weight at their May 2006 meeting, as required by Resolution C-05-03. The Working Group identified several problems with the 5 percent ratio of fins to body weight. For example, it was not specified whether the standard applies to the wet or dry weight of shark fins (the length of the trip determines how dry the fins are), the dressed weight or whole weight of the shark, the whole fin or just what is sold in the market, how the fin was cut ("L" or straight cut), and the size of the shark. It was also recommended that there should be different weight ratios for different species because the ratios of fins to body weight can differ dramatically by species.

In 2007, the IATTC Working Group on Stock Assessment met again and further refined their recommendations to the Commission. These recommendations included using demographic methods and investigating outside funding sources as a part of the comprehensive research plan, and clarifying Resolution C-05-03 to reflect that the 5 percent ratio of fins to body weight only applies to the dressed weight, rather than the whole weight of the shark. The working group's recommendations have not yet been discussed by the Commission as of the last Commission meeting in June 2008, presumably because the Commission has been primarily focused on establishing tuna conservation and management measures for 2008 and beyond.

<u>International Commission for the Conservation of Atlantic Tunas (ICCAT)</u>

In 2004, ICCAT adopted a significant agreement on sharks that requires full utilization of shark catches and mandates fishermen to retain all parts of the shark except the head, guts, and skin to the point of first landing. Countries are required to ensure their vessels retain onboard fins totaling no more than 5 percent of the weight of sharks on board up to the first point of landing. Parties not requiring fins and carcasses to be offloaded together at the point of first landing must ensure compliance with the ratio through certification, monitoring, or other means. These requirements, which parallel current U.S. law, are significant because they provide the means to enforce the prohibition on finning even when no fishery observers are aboard the vessel. The 2004 agreement also: 1) establishes requirements for data collection on catches of sharks; 2) calls for research on shark nursery areas; and 3) encourages the release of live sharks, especially juvenile sharks.

In 2005, the Standing Committee on Research and Statistics (SCRS) reviewed the stock assessment of shortfin mako sharks, as well as the appropriateness of the 5 percent fin-to-carcass ratio. The SCRS concluded that the 5 percent ratio is not inappropriate with respect to mixed species shark fisheries that keep the primary fin set (first dorsal, two pectoral, and lower lobe of the caudal fin). The fin-to-carcass ratios are, however, highly variable depending on the species, fin set used, and fin cutting techniques. Other variables relate to how sharks are dressed and whether fins are dried on board. SCRS recommended that conversion factors between fins and body weights be developed and implemented on a species-specific and/or fleet-specific basis. The Commission did not consider alterations to the 5 percent fin-to-carcass ratio at its 2005 meeting.

In 2005, SCRS concluded that the shortfin mako biomass in the North Atlantic may be below the biomass that can support maximum sustainable yield, as trends in catch per unit effort suggest depletions of 50 percent or more. The SCRS, therefore, recommended the Commission take actions to reduce fishing mortality if ICCAT wants to improve the status of the stock. SCRS noted reductions in fleet capacity and effective effort could provide the most direct benefit to the stock. In 2007, the Commission adopted a measure proposed by the United States to strengthen ICCAT's management of sharks by addressing the impacts of directed shark fisheries for porbeagle and shortfin mako sharks. The measure requires a reduction in fishing mortality in fisheries targeting these species until such time as sustainable levels of harvest can be determined. The measure calls for a stock assessment of porbeagle sharks to be completed by 2009. Shortfin mako and blue sharks will be assessed in 2008. The United States is hopeful that new tagging data that will be available for the 2008 assessment will improve accuracy and data confidence.

Western and Central Pacific Fisheries Commission (WCPFC)

In December 2006, the WCPFC adopted a binding measure for the conservation and management of sharks. The measure went into effect January 1, 2008. The measure includes provisions for WCPFC members to report on their implementation of the IPOA for the Conservation and Management of Sharks and to report catch and effort statistics for key shark species. The measure also requires, for vessels greater than 24 meters in length, that Members take measures to: 1) require full utilization of shark catches; 2) ensure their vessels have on board fins that total no more than 5 percent of the weight of sharks on board up to the first point of landing (or require that vessels land sharks with fins attached, or prohibit the landing of fins without corresponding carcasses); and 3) prohibit vessels from retaining on board, transshipping, landing, or trading in any fins harvested in contravention of the WCPFC measure.

The WCPFC's Scientific Committee reviewed the 5 percent ratio of fin weight to shark weight at its regular annual session in 2007. The Committee found that the ratio was reasonable, and based on that recommendation, the WCPFC, at its regular annual session in 2007, decided not to revise it.

The WCPFC continued to work on the identification of "key" shark species for the purpose of catch reporting by its Members. Members have been encouraged to provide information on shark catches to the lowest possible taxonomic level in order to assist the Scientific Committee with this task.

At its regular annual session in 2007, the WCPFC considered the recent developments at the UN General Assembly regarding shark conservation and management, and acknowledged that States and RFMOs will increasingly be called upon to adopt measures to manage both directed and non-directed shark fisheries.

4.3 Multilateral Efforts

The U.S. Government continued work within other multilateral fora to facilitate shark research, monitoring, and management initiatives, as appropriate. Table 4.3.1 lists these multilateral fora. Of the list in Table 4.3.1, the activities or planning of three organizations are discussed below as a supplement to last year's *Report to Congress.*

Table 4.3.1 Other multilateral fora.

Other Multilateral Fora
• Food and Agriculture Organization of the United Nations (FAO) Committee on Fisheries (COFI)
• International Union for Conservation of Nature and Natural Resources
• Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
• World Summit on Sustainable Development
• United Nations General Assembly (UNGA)

Food and Agriculture Organization of the United Nations (FAO) Committee on Fisheries (COFI)

In 1999, the FAO adopted the IPOA for the Conservation and Management of Sharks, which is understood to include all species of sharks, skates, rays, and chimaeras (Class Chondrichthyes). The IPOA calls on 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. The United States was one of the first countries to prepare a National Plan, which was publicly released in 2001. At the time this report was written, the following entities had developed National Plans of Action for the Conservation and Management of Sharks: Australia, Canada, Ecuador, Japan, Malaysia, Mexico, Taiwan, the United Kingdom, and the United States.

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

CITES has addressed the issue of sharks on several recent occasions. Whale sharks, great white sharks, and basking sharks have been listed in Appendix II of CITES as species that may become threatened with extinction unless trade is subject to regulation. In June 2007, at the 14th Conference of the Parties, the United States successfully proposed that sawfishes (Pristidae) be listed in Appendix I, thus banning commercial trade in sawfish and sawfish products. Proposals to list spiny dogfish and porbeagle sharks in Appendix II were well supported, including by the United States, but were rejected. In addition, CITES adopted a resolution that urges parties to implement the IPOA for the Conservation and Management of Sharks as a matter of priority, establish systems for verification of catch, and improve monitoring and reporting in cooperation with FAO and fish management bodies. It also calls on Parties that are members of fisheries management bodies to urge those bodies to develop shark management plans. It asks Parties that are landing and exporting products from shark species to improve communication between their CITES and fisheries authorities and to ensure that levels of international trade are not detrimental to the status of the species. Parties are also encouraged to continue developing manuals and guides for the identification of sharks and shark products in international trade. The CITES Secretariat is directed to liaise with FAO/RFMOs to organize a capacity-building workshop on the conservation and management of sharks. Finally, the resolution urges Parties, when developing proposals to include shark species in CITES appendices, to consider factors affecting implementation and effectiveness, including monitoring and enforcement practicalities, given that sharks are generally traded in parts (meat, fins, etc.).

United Nations General Assembly (UNGA)

In December 2005, the UNGA adopted by consensus a resolution on Oceans and the Law of the Sea: "Sustainable Fisheries, including through the 1995 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, and related instruments." The resolution, strongly supported by the United States, recognizes the importance and vulnerability of sharks and the need for measures to promote long-term sustainability of shark populations and fisheries. It confirms the role of relevant regional and subregional fisheries management organizations and arrangements in the conservation and management of sharks and encourages the implementation of the FAO IPOA for the Conservation and Management of Sharks. It further encourages the international community to increase the capacity of developing States to implement the IPOA.

In 2007, the United States developed and proposed new language on shark conservation and management for inclusion in the annual UNGA Sustainable Fisheries Resolution. The resolution, which was adopted by consensus in December 2007, included language based on the U.S. proposal aimed at strengthening protections for vulnerable and endangered shark populations around the world, and called on States and RFMOs to take *immediate and concerted actions* to improve shark conservation and management. Specifically, the resolution calls upon States, including through RFMOs, to adopt measures to fully implement the IPOA for the Conservation and Management of Sharks for directed and non-directed shark fisheries, based on the best available scientific information, through, among other things, establishing limits on shark catches, undertaking improved assessment of the health of shark stocks, reducing shark bycatch in other fisheries, and limiting shark fisheries until management measures are adopted. The resolution also calls on States to improve the implementation of and compliance with existing RFMO and national measures that regulate shark fisheries, *"in particular those measures which prohibit or restrict fisheries conducted solely for the purpose of harvesting shark fins, and, where necessary, to consider taking other measures, as appropriate, such as requiring that all sharks be landed with each fin naturally attached."* The United States intends to build on the success achieved at the UNGA by promoting shark conservation in other appropriate multilateral fora.

Convention on Migratory Species (CMS)

The United Nations Environment Programme Secretariat of the Convention on Migratory Species (CMS) convened an intergovernmental meeting on December 11–13, 2007, in Mahe, Seychelles. The main purpose of the meeting was to identify and elaborate an option for international cooperation on migratory sharks under CMS. Also known as the Bonn Convention, the CMS aims to conserve terrestrial, marine, and avian migratory species throughout their range. An intergovernmental treaty, the CMS was concluded under the aegis of the United Nations Environment Programme and currently has 109 parties. The United States is not a party to the CMS. However, non-parties are able to participate in the negotiation of and can sign onto individual instruments concluded under the CMS umbrella.

The meeting participants discussed a range of scoping options for a potential CMS instrument, including the type of instrument desired, the species to be covered, the desired geographical area, and issues that should be addressed. Possible components of a CMS shark instrument could include, but are not necessarily limited to, measures for capacity-building in developing countries, identification of shark habitats and migration routes/corridors, creation of a standardized global shark database, coordination of research efforts, promotion and regulation of non-consumptive uses such as ecotourism, processes to encourage the prohibition of shark finning, active cooperation with industry, encouragement of relevant bodies to establish appropriate management measures, encouragement of restrictions of shark bycatch in non-directed fisheries, and global promotion of shark conservation and wise use. Although the participants reached no concrete decisions by the close of the meeting, momentum seemed to favor drafting a non-binding Memorandum of Understanding, global in scope, that would initially cover the three species currently listed in CMS Appendices I & II (whale shark, basking shark, and great white shark), with a mechanism for expanding future coverage.

The U.S. focus at the meeting was to explore ways that CMS may be able to add value to our primary areas of focus related to migratory sharks, including: 1) strengthening shark management in U.S. waters; 2) working with other nations, particularly developing nations, to build capacity for shark management; 3) working through RFMOs to fulfill their mandates for sharks; and 4) improving enforcement of shark finning bans. The United States highlighted the stronger mandate for the international community regarding advancing shark conservation contained in the 2007 UNGA Sustainable Fisheries Resolution. The United States also reiterated our strong domestic shark conservation measures and our support for development and implementation of the FAO's International Plan of Action on Sharks, the adoption of shark conservation and management measures by RFMOs, and work on trade in sharks and shark products at CITES.

The United States expressed frustration that although most of the major RFMOs adopted measures banning finning, promoted the collection of shark-related data and research, and encouraged the live release of sharks caught as bycatch, the measures are not well-enforced and shark-related data continue to be seriously lacking.

The next meeting to discuss options for a CMS shark instrument was set to occur in December 2008, immediately following the Ninth Conference of the CMS Parties in Rome. The United States remains hopeful that these efforts will produce a new international instrument that can advance and add value to endeavors to improve the conservation and management of migratory sharks.

Blue shark (*Prionace glauca*)
Source: NMFS Northeast Fisheries Science Center

5. NOAA Research on Sharks

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

<u>**Pacific Islands Fisheries Science Center (PIFSC)**</u>

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, sharing, and managing fisheries data on sharks and other species from American island territories and States in the Western Pacific. The WPacFIN program has also assisted other U.S. islands' fisheries agencies in American Samoa, Guam, and the Northern Mariana Islands to modify their data-collecting procedures to collect 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.

Biometrical Research on Catch Statistics

Funding for further biometrical research on shark bycatch issues has been received through the Pelagic Fisheries Research Program (University of Hawaii). This work will use information from all three fishery data collection programs—market, logbook, and observer—to improve our understanding of shark catches in the Hawaii-based longline fishery. New analyses of shark catches will draw upon earlier published studies regarding blue shark and blue marlin (Walsh and Kleiber 2001; Walsh et al. 2002; Walsh et al. 2005) for methodology. These analyses will assess both true bycatch (i.e., discarded and without economic value) and incidental catch (i.e., retained, non-target species with economic value) of sharks in this fishery. One concern in this study is that several regulatory changes have been instituted in this fishery in recent years. Because shark catches include both true bycatch and incidentally caught species, changes in the logbook reporting behavior of fishermen may have stemmed from the regulatory changes and can be identified and described. The expectation is that bycatch reporting could become less accurate after regulatory changes, whereas reporting of incidentally caught species can be checked against market sales records and would remain largely unaffected. Another objective of the project is to use the fishery observer catch data to investigate the condition and fate of the catch. Observers record the number of retained catch and discards that come up dead during longline haulback. Preliminary results indicate that all of the species taken in substantial numbers by this fishery, especially blue shark, exhibit a high rate of survival (about 90 percent) up to the time of retrieval of the fishing gear at the boat. Although this obviously does not reveal any subsequent effects, it suggests that this fishery may cause relatively low rates of shark mortality.

Insular Shark Surveys

Densities of insular sharks (Table 5.1.1) 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 Coral Reef Ecosystem Division since 2000.

These estimates include surveys of:

- 10 major shallow reefs in the Northwestern Hawaiian Islands (2000, 2001, 2002, 2003, 2004, 2006).
- The Main Hawaiian Islands (2005, 2006).
- 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).
- American Samoa including Rose Atoll and Swains Island (2002, 2004, 2006).
- Similar surveys at Guam, and the Commonwealth of the Northern Marianas Islands (2003, 2005, 2007), Johnston Atoll (2004, 2006, 2008), and at Wake Atoll (2005, 2007).

To date, these surveys suggest that shallow (<40m) inshore water shark populations appear to be relatively abundant at most reefs in the Northwestern Hawaiian Islands (NWHI) and Pacific Remote Island Areas, but are noticeably sparse and/or small-bodied at most reefs in the Main Hawaiian Islands (MHI), American Samoa, and Marianas Archipelago, especially in the southern islands. The Coral Reef Ecosystem Division is currently working on a scientific article pertaining to these observations.

In brief, five species of sharks are typically recorded in sufficient frequency by towed-divers to allow meaningful statistical analyses: grey reef shark, Galapagos shark, whitetip reef shark, blacktip reef shark, and tawny nurse shark. Preliminary 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). The average combined numerical density for these two species near population centers is less than 1 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. Trends in whitetip and blacktip reef shark numbers are similar, but less dramatic. Tawny nurse shark densities are low around most islands. From our preliminary results we infer that some insular shark populations near human population centers are severely depressed.

Table 5.1.1 Shark species observed in PIFSC Resource Assessment and Monitoring Program surveys around U.S. Pacific Islands.

Shark species observed		
Common Name	Species	Family
Gray reef shark	*Carcharhinus amblyrhynchos*	Carcharhinidae
Silvertip shark	*Carcharhinus albimarginatus*	Carcharhinidae
Galapagos shark	*Carcharhinus galapagensis*	Carcharhinidae
Blacktip reef shark	*Carcharhinus melanopterus*	Carcharhinidae
Tiger shark	*Galeocerdo cuvier*	Carcharhinidae
Whitetip reef shark	*Triaenodon obesus*	Carcharhinidae
Tawny nurse shark	*Nebrius ferrugineus*	Ginglymostomatidae
Whale shark	*Rhincodon typus*	Rhincodontidae
Scalloped hammerhead shark	*Sphyrna lewini*	Sphyrnidae
Great hammerhead shark	*Sphyrna mokarran*	Sphyrnidae
Zebra shark	*Stegostoma varium*	Stegostomatidae

Selective Removal of Large Sharks to Reduce Monk Seal Mortality

Galapagos shark predation has become the dominant mortality source for nursing and recently weaned endangered Hawaiian monk seal pups at French Frigate Shoals, the most important breeding site in the NWHI. Intense predation by a relatively small number of sharks (~20) on preweaned pups was first detected in the late 1990s, when 19 to 31 mortalities were documented each year from 1997 to 1999. This equated to 17–32 percent of the annual cohort. Subsequent mitigation efforts resulted in the removal of 12 sharks known to be preying on monk seal pups and the ensuing predation losses dropped to 8–12 pups from 2000 to 2007 (12–21 percent of the annual cohort born at French Frigate Shoals). Sharks were removed using a combination of shore-based handline fishing, boat fishing, and hand-held harpoon. Removal attempts were unsuccessful in 2006–2007, as sharks have become progressively more wary and are now conducting their predation at times when they are least likely to encounter humans. Most predation occurred at Trig Island, but it increased at other sites over time. We attribute these results in part to shark displacement away from Trig Island due to 7 years of intense fishing effort during the monk seal pupping season in late spring and summer. The decision framework for implementing the shark removal experiment was evaluated in terms of expected costs and benefits (to both monk seals and sharks), uncertainties in the predation data, and concerns about the acceptability of a removal project within a refuge. Given the declining status of endangered monk seals and the probable minimal effect of the shark removals, we concluded that available data were sufficient to support the removal experiment. However, we elected to place a temporary moratorium on shark removals in 2008 as we investigate the efficacy and feasibility of non-lethal shark deterrents. Deterrents to be deployed in 2008 included: visual deterrents (boat anchored offshore near Trig Island, assorted visual stimuli in the water column); auditory deterrents (boat noise broadcast by an underwater loudspeaker); magnetic deterrent (permanent magnets deployed in association with the visual stimuli); and electromagnetic deterrents (powered *Shark Shield*–type device deployed at strategic access points near Trig Island). Results from the 2008 pilot project will be used to determine which, if any, of these deterrent devices are effective in reducing predation levels, and to assess whether shark removals will be necessary in future years.

Stock Assessment of Pelagic Sharks

Work was initiated in 2000 as a collaborative effort with scientists at the National Research Institute for Far Seas Fisheries (NRIFSF). A report was produced (Kleiber et al. 2001) but was not published in the peer-reviewed literature. The 2001 report indicated the blue shark stock was not being overfished. PIFSC and NRIFSF subsequently renewed this collaboration, along with scientists from the Government of Japan's Fisheries Research Agency, to update the blue shark assessment with the latest Japanese and Hawaiian longline fishery data, as well as with better estimates of Taiwanese and Korean catch and effort data.

Objectives were to determine the degree to which the blue shark population has been affected by fishing activity and whether current fishing practices need to be managed to ensure continued viability and utilization of the resource. In addition to re-estimating catch and effort data based on a longer time series of data (Nakano and Clarke 2005, 2006), this study incorporated several new features: 1) effort data were obtained from the Fisheries Administration of Taiwan, 2) catches for the Japanese inshore longline fleet were included, 3) catch estimates were contrasted with estimates from the shark fin trade, 4) catch per unit effort was standardized using both a generalized linear model and a statistical habitat model, and 5) two different stock assessment models were applied.

The two shark assessment models—a surplus production model and an integrated age and spatially structured model—represent opposite ends of the spectrum in terms of data needs. The results, soon to be published as a NOAA Technical Memorandum, show the production model to be in general agreement with the integrated model, suggesting a pattern of stock decline in the 1980s followed by recovery to a biomass that was greater than that at the start of the time series. One of the several alternate analyses indicated some probability (around 30 percent) that the population is overfished and a lower probability that overfishing may be occurring. The uncertainty could well be reduced by a vigorous campaign of tagging and by continuous, faithful reporting of catches and details of fishing gear.

Electronic Tagging Studies and Movement Patterns

PIFSC scientists are using acoustic, archival, and popoff satellite archival tags (PSATs)[10] 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. The research, sponsored by the Pelagic Fisheries Research Program and PIFSC, has shown that some large pelagic fishes have much greater vertical mobility than others. More specifically, we have found that swordfish, bigeye tuna, and bigeye thresher sharks remain in the vicinity of prey

[10] PSAT tags record measurements such as temperature, salinity, and depth. At a preset time, a battery is activated that dissolves the tag attachment, allowing the tag to float to the surface where it sends its broadcast of data to satellites.

organisms comprising the deep Sound Scattering Layer (SSL) during their extensive diel vertical migrations. In contrast, other billfish, tuna, and shark species stay in the upper 200 m of the water column both night and day. The SSL comprises various species of squids, mesopelagic fish, and euphausiids that undertake extensive diurnal vertical migrations. This composition of organisms is referred to as the SSL because the migration of these organisms was first discovered by the sound waves that reflect off gas-filled swim bladders or fat droplets within the migrating organisms. Organisms in the SSL feed in surface waters at night to avoid being seen and eaten by their predators and then return during the day to depths of 500 m or deeper. Pelagic fishes able to mirror movements of the SSL can better exploit these organisms as prey. Also, the ability of swordfish, bigeye tuna, and bigeye thresher sharks to access great depths permits them to effectively exploit the SSL for prey even after they descend to deeper water at dawn. Certainly, the ability to mirror the movements of vertically migrating prey confers selective advantages. However, other pelagic species—such as yellowfin tuna, silky sharks, oceanic white-tip sharks, blue marlin, and striped marlin—do not make extensive regular vertical excursions. PIFSC scientists have also found one of the most ubiquitous large-vertebrate species in the pelagic environment—the blue shark—occasionally displays vertical movement behaviors similar to those of swordfish, bigeye tuna, and bigeye thresher sharks. Lastly, it appears that pelagic species follow a very similar search strategy (e.g., Levy flight) in the open ocean, which allows them to find patchily distributed food resources (Sims et al. 2008).

The PIFSC, in collaboration with Australian Institute for Marine Science and the Commonwealth Scientific and Industrial Research Organization, has for the past several years been deploying electronic tags on whale sharks at Ningaloo Reef, Western Australia, to describe their vertical and horizontal movements. The work has documented that whale sharks dive below 1000 m, deeper than previously thought. After the whale sharks leave Ningaloo Reef, some travel to Indonesia while others head across the Indian Ocean (Wilson et al. 2006).

Southwest Fisheries Science Center (SWFSC)

Juvenile Shark Survey

The Southern California Bight is home to a number of pelagic shark species and a known nursery area for shortfin mako and blue sharks. The SWFSC has been monitoring the relative abundance of juvenile mako and blue sharks since 1994 using a fishery-independent longline survey. The annual survey was conducted during June and July 2007. One to two fishing sets were completed daily. A total of 5,759 hooks were fished at 28 sampling stations. Catch included 112 shortfin mako sharks, 139 blue sharks, 14 pelagic rays (*Pteroplatytrygon violacea)*, and one ocean sunfish (*Mola mola)*. The overall survey catch rate was 0.556 per 100 hook-hours for mako and 0.666 per 100 hook-hours for blue sharks. The CPUE for mako sharks has increased slightly since 2003; however, there is a small but significant decrease for both species over the time series of the survey.

Table 5.1.2 Catch per unit effort of sharks caught in SWFSC's juvenile shark survey.

Catch per unit effort of sharks caught on the juvenile shark survey (units are per 100 hook-hours)				
Species	2004	2005	2006	2007
Shortfin mako *Isurus oxyrinchus*	0.399 per 100 hook-hours	0.369 per 100 hook-hours	0.445 per 100 hook-hours	0.556 per 100 hook-hours
Blue shark *Prionace glauca*	0.499 per 100 hook-hours	0.443 per 100 hook-hours	1.350 per 100 hook-hours	0.666 per 100 hook-hours

An additional 10 days of ship time were used to conduct a hook comparison study to determine differences in selectivity with hook type. For this comparison, sets were made with alternating circle and J-hooks in blocks with high catch rates during the survey. Additional sets were made in other locations as time and conditions allowed. A total of 4,508 hooks were deployed, of which 2,252 were 16/0 Circle and 2,256 were 9/0 J-Style hooks. Circle hooks captured 28 blue sharks and 25 mako sharks, while J hooks captured 53 blue sharks and 39 mako sharks.

In conjunction with the fisheries-independent survey, additional biological studies were also conducted during the 2007 cruise. Most mako and blue sharks caught were tagged with conventional tags and marked with oxytetracyline (OTC) for age validation and growth studies, and DNA samples were taken for studies of population dynamics. In addition, to obtain more detailed information on movements and define the habitat of Pacific sharks, satellite tags were deployed on both blue and mako sharks (see below).

Essential Fish Habitat (EFH) and Pup Abundance Survey of Common Thresher Sharks

Like many other sharks, the pups of the common thresher are found in near-shore waters of the Southern California Bight. Such waters are Essential Fish Habitat (EFH) for this shark species, but the extent of this habitat is poorly defined. In 2003, the SWFSC began a survey to: 1) determine the continuity of thresher pup distribution along the coast of the Southern California Bight and 2) develop a pup abundance index. In 2007 the fifth year of sampling took place. The SWFSC team worked with the F/V *Outer Banks* to sample in the Southern California Bight from Point Conception to the Mexican border. Forty-nine longline sets were made in relatively shallow, near-shore waters. Over the 18-day cruise, 137 common thresher sharks, 2 shovelnose guitarfish (*Rhinobatos productus*), 2 soupfin sharks, 1 leopard shark, and 1 bat ray (*Myliobatis californica*) were caught. Roughly 65 percent of the thresher sharks caught were young of the year (<100 cm fork length[11]). Nearly all of the thresher sharks caught were injected with OTC for age and growth studies, tagged with conventional tags, and released. In addition, satellite tags were deployed on four thresher sharks. One tag was recovered—providing a detailed record of temperature, depth, and location—and the remaining three tags were due to release in May 2008.

[11] Fork length is a measurement used frequently for fish length when the tail has a fork shape. It is the projected straight distance between the tip of the snout and the fork of the tail.

While it is still too early to develop a pre-recruit index, a number of interesting patterns are emerging across years. Depth-stratified sampling revealed that over half of the neonates[12] were caught in shallow waters from 0 to 46 m and almost all individuals are caught shallower than 90 m. The distribution of thresher sharks is very patchy and areas of high abundance are not consistent across years. In all years a large percentage of the catch has been neonates, which were found in all areas surveyed.

Currently, the SWFSC Fisheries Resources Division is collaborating with Drs. Jeffrey Graham of Scripps Institution of Oceanography and Oscar Sosa-Nishizaki of Mexico's Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) to examine the movements, essential fish habitat, and fisheries for thresher sharks off Baja California, Mexico.

Pelagic Shark Migration Studies

As mentioned above, the SWFSC has been using electronic tags to study the movements and behaviors of blue, shortfin mako, and common thresher sharks. Use of satellite technology started in 1999 and more recently has been conducted in collaboration with the Tagging of Pacific Pelagics program (www.toppcensus.org), Mexican colleagues at CICESE, and Canadian colleagues at the Department of Fisheries and Oceans Pacific Biological Station in Nanaimo, British Columbia. The goals of the project 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 us to characterize the habitats the sharks most frequently utilize or prefer and, subsequently, to better understand how populations might shift in response to changes in environmental conditions.

While the majority of shark tagging is conducted during the abundance surveys in the Southern California Bight (see above), in summer 2007 SWFSC scientists partnered with Dr. Sandy McFarlane at the Canadian Department of Fisheries and Oceans to deploy tags on blue sharks off the coast of Vancouver Island, Canada. The tagging trip was conducted aboard the Canadian Coast Guard Vessel *Neocaligus*. The team was able to deploy both PSAT and Smart Position and Temperature Transmitting (SPOT)[13] tags on 10 blue sharks larger than sharks typically encountered in the Southern California Bight. These studies should help to answer questions about connectivity of the population along the West Coast as well as provide further insight into the

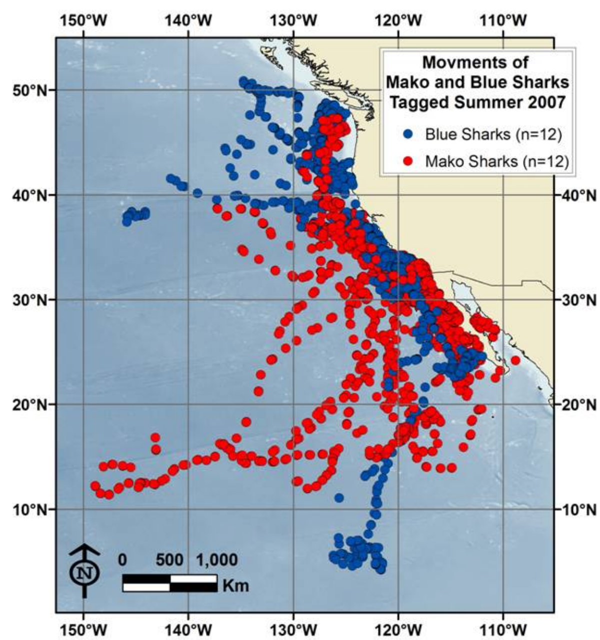

Figure 5.1.1. Movements of mako and blue sharks tagged during summer 2007. All mako sharks and four blue sharks were tagged in the Southern California Bight. Eight blue sharks were tagged off Vancouver Island in a collaborative effort with Department of Fisheries and Oceans, Canada.

[12] newborn

[13] SPOT tags record measurements such as temperature, salinity, and depth. SPOT tags regularly send their recorded data to satellites that relay the information to researchers.

behaviors and migratory patterns of subadult and adult blue sharks in the California Current.

Overall, during the three trips conducted in summer 2007, 12 mako, 4 thresher, and 14 blue sharks were tagged with PSAT tags and/or SPOT tags. Since 1999, a total of 68 makos, 62 blue sharks, and 32 common threshers have been satellite tagged through these collaborative projects. From the deployments in 2007, SPOT tags deployed on 12 makos and 12 blue sharks reported for at least 4 weeks, and 12 tags were still reporting after 8 months (Figure 5.1.1). Data have been obtained from 23 of the 27 PSAT tags, with 3 tags due to report in May 2008. Two PSAT tags have been recovered providing detailed depth and temperature data. Analysis of the 2004–2005 mako shark movement data was recently completed by a Master's student at CICESE in Ensenada, Mexico.

Pelagic Shark Feeding Ecology

Since 1999, the SWFSC has continued investigating the feeding ecology of the blue, shortfin mako, common thresher, and bigeye thresher sharks. All species are captured in the drift gillnet fishery for swordfish. Distinct diet differences among the species and across years have been identified.

Mako Shark Predation on Jumbo Squid

Stomach content data from recent years reveal that jumbo squid (*Dosidicus gigas*) are an increasingly important component of the mako shark diet. SWFSC scientists have been examining stomachs of mako sharks caught in the drift gillnet fishery off Southern California since 2002. Of 228 stomachs examined, 49 contained jumbo squid remains. Quantitative analysis of interannual variation in the diet reveals that the occurrence of jumbo squid in the diet has been increasing as jumbo squid become more abundant in the California Current. Mako sharks captured during the juvenile pelagic shark abundance survey are often covered with scars from the toothed suckers of jumbo squid.

Bigeye Thresher Shark Stomach Content Analyses

While the bigeye thresher is less frequently encountered in the drift gillnet fishery than the other pelagic shark species, stomachs of 26 bigeye threshers were collected by fishery observers between August 1998 and January 2007. Twenty-three of the stomachs contained food representing a total of 20 taxa. The six most important prey species were the barracudinas (*Paralepididae* family), followed by Pacific hake (*Merluccius productus*), Pacific saury (*Cololabis saira*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), and jumbo squid. Previous studies have suggested that species of the deep sound scattering layer may be important in the bigeye thresher's diet; however, it appears that, off California, midwater and epipelagic species are also important, as are some epibenthic species. The large number and diverse taxa suggest that the bigeye thresher is an opportunistic feeder that forages over a broad range of habitats to exploit locally abundant prey.

Trophic Status of the Common Thresher and Shortfin Mako Shark Inferred from Stable Isotope Analysis

While the common thresher and shortfin mako shark are suspected of undergoing shifts in diet during their development, there is no quantitative evidence to support this conclusion. Stomach content analyses of these two shark species are ongoing; however, stomach contents provide only a snapshot of feeding history unless sampling is exhaustive in time and space and sample sizes are large. In contrast, stable isotope[14] analysis can give an integrated view of feeding over time and provides an important complement to studies of stomach contents. Nitrogen isotope ratios ($^{15}N/^{14}N$) fractionate at predictable increments with each increase in trophic position because of differences in how the two isotopes are metabolized. Thus, if one can measure the difference in $^{15}N/^{14}N$ between the base of the food web and the predator being studied, one can estimate the trophic[15] position of the predator. In contrast, the carbon isotope ratio ($^{13}C/^{12}C$) does not fractionate with increasing trophic position and provides insight into different carbon sources at the base of the food web, providing some insights into foraging location. For example, ^{13}C decreases as one moves from near-shore to offshore environments.

The stable C and N isotope ratios of muscle and liver from 50 common thresher and 42 shortfin mako have been characterized over a broad size range. These two tissues were selected because they have different isotope turnover rates; liver turns over much more quickly than muscle and thus reflects the more recent diet. Common thresher soft tissues showed an increase in $\delta^{15}N$ with increasing size reaching an asymptote at the approximate size at sexual maturity, suggesting a gradual trophic increase from 3.0 to 4.3 with ontogeny.[16] (Note that the symbol "δ" refers to delta units relative to International standards of limestone and N gas.) An observed enrichment of muscle $\delta^{15}N$ relative to liver suggests that there may be seasonal shifts in trophic level, although most samples in this study were collected in the late summer and fall. Common thresher muscle $\delta^{13}C$ was also enriched relative to liver, suggesting potential shifts from near-shore to offshore habitats.

In contrast to the thresher shark, the shortfin mako did not show any discernable pattern in $\delta^{15}N$ with size. This suggests that there is no clear ontogenetic trophic shift over a size range from 77 to 317 cm fork length. Trophic positions for the mako ranged from 3.4 to 4.8. Similar to the thresher, muscle $\delta^{15}N$ was enriched relative to the liver in smaller sharks, although the reverse was true for all females greater than 250 cm FL, the approximate size at sexual maturity. This could also reflect seasonal diet shifts or perhaps changes in their physiology as female shortfin mako become sexually mature. The high variability in the shortfin mako $\delta^{13}C$ suggests high plasticity in their feeding ecology, with some individuals showing very near-shore signals while others show offshore signals.

Population Structure of the Shortfin Mako

The shortfin mako is a wide-ranging pelagic shark caught globally in temperate and tropical waters. The stock structure within their broad range is poorly understood, especially in the Pacific. In the North Atlantic, thousands of conventional tags have been deployed, and although 608 have been returned, not a single shark was recaptured south of 10°N. This suggests, at a minimum, a northern and southern stock. Although the more limited conventional tag returns in the Pacific reveal movement across the North Pacific from California to as far as Japan, the

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[14] Isotopes are any of the several different forms of an element each having different atomic mass. For example, most carbon in nature is present as ^{12}C, with approximately 1 percent being ^{13}C. Stable isotopes are isotopes that do not degrade measurably over the lifetime of an animal.
[15] The higher the trophic level, the higher the organism is on the food chain. Trophic levels typically range from 1 to 5.
[16] Ontogeny refers to the development of an organism.

potential for separation between the North and South Pacific is not known. A study is being conducted using mitochondrial DNA analyses from samples gathered around the Pacific to test the hypothesis that shortfin makos from the North and South Pacific are genetically distinct. In addition, this study will examine corridors of gene flow for shortfin mako sharks in the Pacific Ocean.

To date, 410 samples from seven sites in the Pacific (southern California, Hawaii, Japan, New Zealand, Australia, South America, and Chile) and one site in the North Atlantic have been analyzed. Preliminary analyses reveal that sharks in locations in closest proximity—California/Hawaii, South America/Chile, and Australia/New Zealand—show no population subdivision. This is in contrast to locations between the Northern and Southern Hemispheres where divergence is apparent. Sharks in California and Hawaii are both genetically distinct from all locations in the South Pacific. The North Atlantic site is also significantly different from all Pacific sites. After performing isolation by distance analyses, it appears that the corridors of gene flow are following a stepping stone model. With concern about global shark populations, a better understanding of stock structure is critical to developing accurate stock assessments and ensuring effective management.

Pelagic Shark Age, Growth, and Maturity

Age and growth of mako, common thresher, and blue sharks are being estimated from ring formation in vertebrae. Critical to this method is validation with OTC, which lays down a mark at the time of injection. When the shark is recaptured and the vertebrae recovered, the number of rings laid down over a known time period can be counted. In 2007, we initiated OTC validation studies on blue sharks and continued OTC validation studies on mako and thresher sharks.

Since the beginning of the program in 1997, 1,368 OTC-marked individuals have been released during juvenile shark surveys. In 2007, 128 mako, 166 blue, and 115 common thresher sharks were tagged and marked with OTC. As of January 2008, recaptured OTC-marked sharks included 68 mako, 19 common thresher, and 2 blue sharks; however, vertebrae were returned for only about half of the recaptures. Time at liberty ranged from 7 to 1,938 days, with net movements of individual sharks as high as 3,410 nautical miles. Examination of the band periodicity based on the OTC mark is ongoing for both mako and thresher sharks.

In addition to the work with OTC-marked individuals, age and growth studies are being conducted with non-marked vertebrae using various visualization techniques to identify bands, and by length frequency analysis of the fisheries and survey catch data. The purpose is to expand and refine previous ageing studies using a larger sample size with accompanying information on sex and maturity stage.

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 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. 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. Biological data and tissue samples were also collected from leopard sharks and cat sharks during the bottom trawl surveys.

In addition to these monitoring activities, the NWFSC is assessing for the first time the population status of longnose skate. This assessment is under way and will be presented and reviewed during the 2007 stock assessment review (STAR) process. The NWFSC coordinates the STAR panel review process for all such groundfish stock assessments provided as scientific advice to the PFMC.

Movement studies

The NWFSC, in collaboration with Washington Department of Fish and Wildlife and the Seattle Aquarium, has been estimating movement parameters of sixgill and sevengill sharks in Puget Sound and Willipa Bay. Vemco ultrasonic tags were surgically implanted into the body cavity of each shark and released fish at their capture site. Automated listening stations were used to detect fish tagged with ultrasonic transmitters, thus allowing shark movement to be monitored. In addition, movement was monitored with active, boat-based tracking. These data have allowed estimation of movement parameters (e.g., move length and turning angles) that allow home ranges to be estimated; daily, seasonal, and interannual movements to be described; and important habitats to be quantified. Also, models based on habitat-specific movement parameters allow for inference of relative abundance in different habitats. In addition, upon capture, biological data (e.g., genetic samples, blood samples, gut contents, and length/weight) are collected and used by the Washington Department of Fish and Wildlife to support management of these species.

Alaska Fishery Science Center (AFSC)

Shark Research and Assessments

Research efforts at the Alaska Fishery Science Center's Auke Bay Laboratory are focused on:

1. Collection of data to support stock assessments of shark species subject to incidental harvest in Alaskan waters.
2. Abundance and tagging of Pacific sleeper sharks.
3. Collaborative research with the University of Alaska Fairbanks and the University of Washington on:
    a. Life history, reproduction, and general ecology
    b. Age and growth
    c. Demography

d. Indices of abundance and bycatch modeling
e. Feeding ecology and stable isotopes

Stock Assessments of Shark Species Subject to Incidental Harvest in Alaskan Waters
Species currently assessed include Pacific sleeper sharks, spiny dogfish, and salmon sharks—the shark species most commonly encountered as bycatch in Alaskan waters. The shark stock assessment is currently limited to an analysis of commercial bycatch relative to biomass, which is estimated from NMFS fishery-independent bottom trawl surveys in the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands. Stock assessments are summarized annually in Chapter 18 in the BSAI SAFE report (Heifetz et al. 2007) and Appendix 1d in the GOA SAFE report (Rodgveller et al. 2007), both of which are available online from the North Pacific Fishery Management Council (NPFMC).

Pacific Sleeper Sharks
During the summers of 2003–2006, scientists from the Auke Bay Laboratory deployed 138 numerical Floy tags, 91 electronic archival tags, 24 electronic acoustic tags, and 17 electronic satellite popup tags on Pacific sleeper sharks in the upper Chatham Strait region of Southeast Alaska (Courtney and Hulbert 2007). Two numerical tags and 10 satellite tags have been recovered. The recovery of temperature, depth, and movement data from the electronic archival and acoustic tags will aid in the identification of Pacific sleeper shark habitat utilization and distribution in Southeast Alaska, and identify the potential for interactions between Pacific sleeper sharks and other species in this region.

Collaborative research is being conducted by the NMFS Auke Bay Laboratory, Ted Stevens Marine Research Institute, and University of Alaska Fairbanks (UAF) on ecosystem considerations of Pacific sleeper shark bycatch in the northeast Pacific Ocean. Specific topics being addressed include the determination of Pacific sleeper shark relative abundance trends, distribution, habitat, and trophic level in Alaskan marine waters. Historical trends in area-weighted CPUE of Pacific sleeper sharks in the northeast Pacific Ocean between 1979 and 2003 were determined from sablefish longline surveys (Courtney and Sigler in press). There are no directed fisheries or surveys for Pacific sleeper sharks in Alaskan marine waters; consequently, abundance estimation is limited to indirect methods. We analyzed Pacific sleeper shark incidental catch from sablefish longline surveys conducted on the upper continental slope of the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska between 1979 and 2003. Our objectives were to estimate trends in Pacific sleeper shark relative abundance and their statistical significance. A total of 1,565 Pacific sleeper sharks were captured by sablefish longline surveys between 1979 and 2003, with a sample effort of 19.7 million hooks. Area (km^2) weighted CPUE of Pacific sleeper sharks was analyzed from standardized sablefish longline surveys between 1982 and 2003 with bootstrap 95 percent confidence intervals as an index of relative abundance in numbers. Within the limited time series available for hypothesis testing, area-weighted CPUE of Pacific sleeper sharks increased significantly in the eastern Bering Sea between 1988 and 1994 and in the Gulf of Alaska between 1989 and 2003, but also decreased significantly in the Gulf of Alaska in 1997. The increasing trend in the Gulf of Alaska was driven entirely by one region, Shelikof Trough, where most (54 percent) Pacific sleeper sharks were captured. Increasing trends in area-weighted CPUE of Pacific sleeper sharks in the eastern Bering Sea and Shelikof Trough are consistent with previous analyses of fishery-dependent and fishery-independent data from the northeast Pacific Ocean and with evidence of a climatic regime shift that began in 1976 and 1977. Whether increasing trends in area-weighted CPUE of Pacific sleeper sharks from sablefish longline surveys represent an increase in the relative abundance of Pacific sleeper sharks at the population level or just reflect changes in local densities is unknown, because of caveats associated with computing area-weighted CPUE of Pacific sleeper sharks from sablefish longline surveys and because of a lack of information on the life history and distribution of Pacific sleeper sharks.

Collaborative Research of Spiny Dogfish in the Gulf of Alaska
The Auke Bay Laboratory collaborated with the Juneau Center of the UAF School of Fisheries and Ocean Sciences and with the University of Washington during 2004–2007 to investigate the population dynamics, life history, and ecological role of spiny dogfish in the Gulf of Alaska. As part of this study, Auke Bay Laboratory scientists deployed 100 electronic archival tags, 617 numerical tags, and one satellite popup tag on spiny dogfish in Yakutat Bay, Alaska. One satellite tag and one archival tag have been recovered. Data from tag recoveries will provide insights into the seasonal residency and movement patterns of spiny dogfish in Yakutat Bay and the northeast Pacific Ocean. The Auke Bay Laboratory has also provided shark bycatch data, biomass estimates, field and technical support, and a graduate student committee member in support of graduate student research. Results from graduate student research will be incorporated into annual stock assessments.

Life History, Reproduction and Ecology of Spiny Dogfish
Through the collaborative work described above, scientists were able to collect dogfish data from many regions within the Gulf of Alaska, using multiple gear types and throughout most of the year. A UAF student is currently examining the data for trends in: 1) seasonal abundance; 2) gear biases; 3) sex, size, and age distributions; and 4) reproductive information. Preliminary results suggest that the species has a low fecundity and slow reproductive cycle, and that they mature at a large size relative to the overall maximum size and at a late age—all of which are indicators of species susceptible to overfishing. This project is also examining historical commercial and survey data for abundance trends by region. One goal is to determine whether seasonal abundances coincide with abundances of other species (i.e., prey availability) or environmental factors.

Age and Growth of Spiny Dogfish
A total of 1,599 spiny dogfish spines have been collected and aged. The spines came from dogfish ranging across the Gulf of Alaska from Southeast Alaska to Kodiak Island. Male and female length at age data were used to compare a variety of growth models and determine the most appropriate model for the species. Results suggest that a two-phase growth model is the best fit for both sexes. Parameter results indicate that the spiny dogfish is among the slowest-growing shark species, as well as the longest-lived. Differences in growth models and parameters with neighboring areas (British Columbia and the U.S. West Coast) suggest that GOA spiny dogfish are biologically distinct. A manuscript detailing this research is in preparation.

Demographics of Spiny Dogfish

The growth model results were used to construct two demographic models of spiny dogfish in the Gulf of Alaska: an age-based and a stage-based model. The stage-based model had five categories, based on biologically significant life stages—neonates, juveniles, sub-adults, pregnant adults, and non-pregnant adults—whereas the age-based model had 120 individual age classes. The purpose of this project was to define the natural state of the population, or the population's natural growth rate, age distribution, and reproductive values in the absence of fishing pressure, and to perturb that population with simulated levels of fishing pressure. The secondary purpose was to determine if the simpler stage-based model produced comparable results to the fully age structured model, and if it may be used in place of the age model. Results of both models suggest that spiny dogfish can only tolerate low levels of fishing mortality ($F<0.03$) and that the ability of the population to rebound is also low. Both models were projected forward with varying levels of fishing pressure, and at $F\geq0.3$ all simulated populations went extinct in 20 years or less. A manuscript detailing this research is in preparation.

Indices of Abundance and Bycatch Modeling of Spiny Dogfish

In the Gulf of Alaska, dogfish occur frequently as bycatch (non-target catch) in commercial fisheries. Preliminary estimates of dogfish bycatch in the Gulf of Alaska exist, but the overall impacts of fishing on dogfish populations in Alaska are unknown and no stock assessment has been conducted. This study compiled available bycatch data from commercial longline fisheries as well as State and Federal surveys. This data was standardized to construct an index of abundance based solely on bycatch data. A preliminary stock assessment (using Bayesian and Classical methods) was then completed, which showed that although the potential for overfishing of dogfish is high, they are not currently overfished. A total of three manuscripts from this project are currently under review.

Feeding Ecology and Stable Isotopes of Spiny Dogfish

The stomach contents from over 900 spiny dogfish have been identified. The spiny dogfish is believed to be a generalist feeder, with no particular prey species. The purpose of this study is to determine the seasonal feeding habits of this species and to examine any regional variation in diets. This study is in the data analysis phase. Diets will be compared across sex and size, region, time of year, and prey availability. Early results suggest that the species feeds broadly, but may have seasonal and regional tendencies toward certain prey groups.

An additional collaboration between NMFS and UAF used stable isotope analysis to investigate the feeding ecology of spiny dogfish in the GOA. The stable isotopes of carbon and nitrogen were used to examine trophic variation in relation to length, sex, and geographic region. White muscle tissue was analyzed from male and female spiny dogfish collected in the GOA (n=412) ranging from 61 to 113 cm in total length. Based on a preliminary analysis, spiny dogfish increase in trophic position with length and display differences in trophic position among geographical areas in the GOA. Examining variations of the trophic position using stable isotope analysis will provide more accurate estimates of trophic position and will lead to a better understanding of the role in the GOA of different size classes of spiny dogfish.

Northeast Fisheries Science Center (NEFSC)

Fishery Independent Surveys for Coastal and Pelagic Sharks

Atlantic Surveys for Coastal and Pelagic Shark Species

The biannual fishery-independent survey of Atlantic large and small coastal sharks in U.S. waters was conducted in spring 2007. The goals of this survey are to: 1) monitor the species composition, sizes, distribution, and abundance of sharks in the coastal Atlantic; 2) tag and inject sharks for age validation and migration studies; 3) collect biological samples for age and growth, feeding ecology, and reproductive studies; and 4) collect morphometric data for size conversions. The time series of abundance indices from this survey are critical to the evaluation of coastal Atlantic shark species. Results from this 2007 survey included 457 fish (447 sharks) representing 16 species. Sharks represented 98 percent of the total catch, of which sandbar sharks were the most common, followed by tiger sharks and dusky sharks. As part of this survey, bottom longline sets were conducted in the closed area off North Carolina. Additional cooperative work included sample collections of blood, heart, and other tissues for post-release survivorship and ribosomal DNA species identification marker studies, and the deployment of electronic tags. In conjunction with Monterey Bay Aquarium, University of California Long Beach, and Massachusetts Division of Marine Fisheries (MDMF), two SPOT and three PSAT tags were placed on dusky and tiger sharks. Pelagic longline sets were made subsequent to the coastal survey as a continuation of fishery-independent longline surveys for highly migratory swordfish, tunas, and sharks conducted by NMFS and its predecessor agencies periodically since the 1950s. Goals of this research are to conduct a consistent standardized fishery-independent pelagic shark survey for research collections and to monitor their abundance and distribution for management and stock assessment.

Juvenile Shark Survey for Monitoring and Assessing Delaware Bay Sandbar Sharks

The juvenile sandbar shark population in Delaware Bay is surveyed by NEFSC staff as part of the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) project. 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 (McCandless 2007). The juvenile index of abundance from this standardized survey has been used as an input into various stock assessment models. In addition, the mark-recapture data from this project are being used to examine the temporal and spatial relative abundance and distribution of sandbar sharks in Delaware Bay (McCandless et al. 2007b). In 2007, a total of 263 sandbar sharks were caught, with 251 of the sharks (95 percent) released with tags.

Delaware Bay Sand Tiger Survey

A survey initiated in 2006, targeting the sand tiger shark for identifying essential fish habitat (EFH) and for future stock assessment purposes, continued in 2007. This study incorporates historical NEFSC sampling stations for comparison to pre-management abundance. Preliminary results indicate that this survey will be a successful monitoring tool for the Delaware Bay sand tiger population and for evaluating long-term changes in abundance and size composition. In 2007, a total of 26 sand tigers were caught, with 25 (96 percent) of the sharks released with conventional tags and one with a PSAT.

NEFSC Historical Longline Surveys
The NEFSC recently recovered the shark species catch per set data from the exploratory shark longline surveys conducted by the Sandy Hook and Narragansett Labs from 1961 to 1991, which 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 for the Atlantic sharpnose shark were developed for the exploratory shark longline surveys and used in the 2007 Small Coastal Shark Southeast Data, Assessment, and Review (SEDAR) process (McCandless and Hoey 2007). Work on the recovery of environmental data for this time series, as well as the associated individual shark data, is ongoing to further refine these indices and to develop indices of abundance for other shark species, and for future use in shark EFH designations.

NEFSC–University of North Carolina Cooperative Study to Archive and Analyze Fishery-Independent Coastal Shark Survey
In addition to the fishery-independent surveys conducted by the NEFSC, scientific staff have been working with the University of North Carolina to electronically recover the data from an ongoing coastal shark survey in Onslow Bay that began in 1972. Standardized indices of abundance for the top 10 species in numerical abundance were recently developed. The abundance indices created for small coastal sharks (small coastal complex, Atlantic sharpnose, and blacknose sharks) were used in the 2007 Small Coastal Shark SEDAR process (Schwartz et al. 2007) and the indices developed for the large coastal shark species are expected to be useful in future SEDAR processes for large coastal sharks. Efforts to recover environmental data are ongoing and will be incorporated into future generalized linear modes to further refine the standardized indices of abundance.

SEDAR Process
Staff participated in the SEDAR Data Workshop for the Small Coastal Shark Complex and contributed seven SEDAR working papers. These documents discussed: 1) small coastal shark mark-recapture data from the Cooperative Shark Tagging Program (Kohler and Turner 2007); 2) NEFSC historical longline surveys (McCandless and Hoey 2007); 3) relative abundance trends for small coastal sharks from the COASTSPAN surveys in South Carolina (McCandless et al. 2007c) and Georgia (McCandless and Belcher 2007); 4) catch rate information obtained from the NMFS Northeast longline surveys (McCandless and Natanson 2007); 5) relative abundance trends for Atlantic sharpnose sharks observed in the NEFSC Observer Program (Mello et al. 2007); and 6) relative abundance trends for small coastal sharks caught during the University of North Carolina shark longline survey (Schwartz et al. 2007).

Essential Fish Habitat
NEFSC staff participate on a working group with other staff from the NMFS HMS Division and SEFSC to update and refine the EFH designations for managed shark species. This process was ongoing in 2007 and entailed providing updated data from the Cooperative Shark Tagging Program

and NEFSC surveys for use in delineating EFH, refining the size limits of the life stages for each managed species, and refining the methodology used to determine EFH. NEFSC staff coordinated with the Atlantic States Marine Fisheries Commission's (ASMFC) coastal shark technical committee members (from Rhode Island and Massachusetts) to provide EFH and nursery data to begin formulation of ASMFC's Draft FMP for Atlantic Coastal Sharks. In addition, NEFSC staff organized and edited a peer-reviewed American Fisheries Society volume (22 chapters) on shark nursery research in the Gulf of Mexico and U.S. Atlantic coastal waters (McCandless et al. 2007a). Results from the studies detailed in this volume provided critical data needed for updating and refining EFH designations for the juvenile life stages of many coastal shark species (McCandless et al. 2007b; Merson and Pratt 2007).

Porbeagle Habitat Utilization

A study on the habitat utilization, movement patterns, and post-release survivorship of porbeagle sharks captured on longline gear in the North Atlantic was funded by the University of New Hampshire Large Pelagics Research Center's External Grants Program. This work is in conjunction with scientists from MDMF and the University of Massachusetts. The primary objective of this research is to deploy PSAT tags to examine the migratory routes, potential nursery areas, swimming behavior, and environmental associations that characterize habitat utilization by porbeagles. In addition, information will be obtained to validate the assessment of the physiological effects of capture stress and post-release recovery in longline-captured porbeagles, which will increase our understanding of capture-related stress and the potential long-term effects on survival. Moreover, these efforts will potentially allow the quantification of the stress cascade for this shark species captured using commercial gear, thereby providing fishery managers with data showing the minimum standards for capturing (e.g., longline soak time) and releasing these fishes to ensure post-release survival. To date, 17 of the 20 PSATs deployed in 2006 released in 2007. Preliminary results were obtained and will be presented at the 2008 American Elasmobranch Society meeting as well as at the Principle Investigator meeting for the funding agency.

Porbeagle shark caught on commercial longline gear during a NEFSC charter cruise.
Source: Lisa Natanson/NMFS photo

Pelagic Nursery Grounds

An investigation into pelagic nursery grounds was initiated with the collection of length-frequency data and biological samples, and the deployment of conventional and electronic tags on pelagic shark species as part of cooperative work with the high seas longline fleet. From July 27 to September 3, 2007, sampling took place on board a commercial longline vessel targeting swordfish on the Grand Banks off Newfoundland and the Flemish Cap. In 19 sets, 666 sharks, primarily juvenile blue sharks and shortfin makos, were tagged with conventional tags and two shortfin makos were tagged with SPOT tags. The SPOT tags reported immediately and continued reporting for 2 weeks. One tag reported several months later. Dissections were accomplished on over 200 sharks.

Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Survey
The NEFSC manages and coordinates this project, which surveys Atlantic coastal waters from Florida to Delaware and in the U.S. Virgin Islands (USVI) by conducting cooperative, comprehensive, and standardized investigations of coastal shark nursery habitat. Participants in the 2007 COASTSPAN survey included the North Carolina Division of Marine Fisheries, South Carolina Department of Natural Resources, Coastal Carolina University, Georgia Department of Natural Resources, and the Florida Fish and Wildlife Conservation Commission. Researchers from the NEFSC and the University of Rhode Island conducted the survey in Delaware Bay and the USVI. The first objective of the COASTSPAN survey is to determine the location of shark nursery grounds along the U.S. East Coast using presence/absence data. The second objective is to determine the relative abundance, distribution, and migrations of sharks utilizing these nursery grounds through longline and gillnet sampling and mark-recapture data. The COASTSPAN surveys in Delaware Bay and South Carolina have moved into this second phase, and these data produce standardized indices of abundance (McCandless 2007; McCandless et al. 2007c). The South Carolina indices of abundance for bonnethead, finetooth, Atlantic sharpnose, and blacknose sharks were used in stock assessments for the 2007 Small Coastal Shark SEDAR process (McCandless et al. 2007c). The NEFSC also conducts active and passive acoustic telemetry studies on juvenile blacktip and lemon sharks in Fish Bay, USVI, based on the results of the COASTSPAN survey in that area. This work is being conducted in cooperation with the MDMF and in conjunction with studies on other species by the NMFS Galveston Laboratory and NMFS Headquarters. In addition, COASTPAN data from all States and the USVI were recently used to update and refine EFH designations for juvenile life stages of managed coastal shark species.

Habitat Utilization and Essential Fish Habitat of Delaware Bay Sand Tiger Sharks
Funding was received through the NOAA Living Marine Resources Cooperative Science Center to support the second year of cooperative research with staff from Delaware State University and the University of Rhode Island on habitat use, depth selection, and the timing of residency for sand tiger sharks in Delaware Bay. Both manual and passive tracking were used to monitor sand tiger habitat utilization patterns during their Delaware Bay residency. Sand tigers were implanted with standard acoustic transmitters (sample size (n) = 19) and depth-sensing transmitters (n = 10) during the summers of 2006 and 2007. Two sand tigers tagged in June 2006 returned to Delaware Bay during the third week of June 2007, which closely corresponded to the time of first successful captures that year. A total of 72,241 detections of telemetered sand tigers were collected on receivers during the 2006 and 2007 field seasons.

Elasmobranch Life History Studies
NEFSC life history studies are conducted on Atlantic species of elasmobranchs to address identified priority knowledge gaps and focus on species of concern because of declines and management issues. Biological samples are obtained on research surveys and cruises, on commercial vessels, at recreational fishing tournaments, and opportunistically from observers on commercial fishing vessels. In recent years, studies have concentrated on a complete life history for a species to get a total picture for management. This comprehensive life history approach

encompasses studies on age and growth rates and validation, diet and trophic ecology, and reproductive biology essential to estimate parameters for demographic, fisheries, and ecosystem models.

Collection of Recreational Shark Fishing Data and Samples

Biological samples for life history studies and catch and morphometric data for more than 300 pelagic sharks were collected at eight recreational fishing tournaments in the northeastern United States. This information will enhance ongoing biological studies and will be added to a long-term database of historic landings information for the period 1961–2007.

Atlantic Blue Shark and Shortfin Mako Life History and Assessment Studies

Collaborative programs to examine the biology and population dynamics of the blue shark and shortfin mako in the North Atlantic are ongoing. These studies—critical for use in stock assessment—are being conducted in collaboration with scientists at the University of Washington (blue shark) and University of Rhode Island (shortfin mako) and have resulted in the publication of two manuscripts in 2007. The blue shark research (Aires-da-Silva and Gallucci 2007) provides fishery-independent demographic and risk analysis results for use in conservation and management with the construction of an age-structured matrix population model in which the vital rates are stochastic. The results of the demographic analyses confirm the importance of juvenile survival for population growth. The risk analysis is proposed as a supplement to the data-limited stock assessment to better evaluate the probability that a given management strategy will put the population at risk of decline. Shortfin mako survival was estimated from NMFS Cooperative Shark Tagging Program mark-recapture data (Wood et al. 2007). Estimates of survival were generated with the computer software MARK, which provided a means for estimating parameters from the 6,309 tagged animals when they were recaptured (n = 730). The results of several models were presented with various combinations of constant and time-specific survival and recovery rates and gave a range of survival for the shortfin mako from 0.705–0.873 per year. An estimate of survival is a key variable for stock assessments and subsequent demographic analyses, and is crucial when it comes to directly managing exploited or commercially viable species.

Biology of the Thresher Shark

Life history studies of the thresher shark (*Alopias vulpinus*) in the western North Atlantic continued with the completion of a manuscript on age. Age and growth estimates were generated using vertebral centra from 173 females, 135 males, and 11 individuals of unknown sex ranging in size from 56 to 264 centimeter fork length. In addition, further collection of food habits and reproductive samples were accomplished primarily at recreational fishing tournaments. Reproductive tissues were processed and sectioned using histological techniques, with the results combined with the morphological reproductive data to determine sexual sizes at maturity for this species.

Biology of the Torpedo Ray

A life history study of the torpedo ray (*Torpedo nobiliana*) continued with data collection and sampling on over 150 rays for age and growth, reproduction, and food habits. Reproductive tissues were processed and sectioned using histological techniques. Morphological data on organ measurements have been plotted and will be compared to the histological results.

Vertebrae were also processed using histology and image analysis and are currently being read. This research is part of a University of Rhode Island graduate student's master's thesis.

Age and Growth of Coastal and Pelagic Sharks

Age and growth estimates for the smooth skate, *Malacoraja senta*, were published (Natanson et al. 2007) and derived from 306 vertebral centra from skates caught in the North Atlantic off the coast of New Hampshire and Massachusetts. Male and female growth diverged at both ends of the data range and the sexes required different growth functions to describe them. Males and females were aged to 15 and 14 years, respectively. A manuscript on the ontogenetic changes in the vertebrae of the basking shark was accepted for publication by Marine Ecology Progress Series. In addition, collections of vertebrae took place at tournaments and fish were OTC-injected during fishing operations onboard sport, commercial, and research vessels.

Basking Shark Isotope Analysis

Researchers at the Woods Hole Oceanographic Institution, MDMF, and the NEFSC are using isotopic analysis on vertebrae to determine the trophic position of the basking shark as well as to learn more about their migratory behavior and ocean connectivity. This type of retrospective trophic-level reconstruction has broad applications in future studies on the ecology of this shark species to determine lifelong feeding and migratory patterns and to augment electronic tag data.

Sable Island Seal Predation

An investigation into shark predation on five species of seals on Sable Island, Nova Scotia, Canada, is under way. Flesh wound patterns, tooth fragments, and bone markings are being analyzed to determine the identification of the predator. This work is being completed in conjunction with Sable Island researcher Zoe Lucas.

Diet, Feeding Ecology, and Gastric Evacuation Studies of Delaware Bay Sandbar and Smooth Dogfish Sharks

The diet and feeding ecology of sandbar sharks and smooth dogfish (*Mustelus canis*) are being investigated within Delaware Bay. These are the two most abundant shark species in the Delaware Bay ecosystem, so their role as top predators within Delaware Bay could be substantial. Research indicates these two species exhibit distinctly different feeding strategies. Smooth dogfish stomachs nearly always contained food, which typically consisted of 5 to 10 prey items, but often more, in several states of digestion. The total relative mass of the stomach contents as a percentage body weight was usually around 1 percent. Sandbar sharks' stomachs were frequently empty, and those containing food usually contained only one or two prey items. The sandbar sharks contained a smaller total mass of stomach contents (on average 0.5 percent of body weight), but larger individual meals were consumed more frequently than in smooth dogfish. Overall, the sandbar shark had an intermittent feeding pattern relative to the rate of digestion but often consumed larger individual meals, whereas smooth dogfish had a continuous pattern with little or no pause between meals of smaller prey items. This may be at least partially linked to the energetic quality of the diet. Reported values in the literature for many of the important prey indicate lower energy content for the invertebrate prey commonly consumed by smooth dogfish than the teleost fish prey most prevalent in the sandbar shark diet; however, metabolic differences and digestive speed and efficiency also likely are not the same for the two species.

Movements and Migrations

Cooperative Shark Tagging Program

The Cooperative Shark Tagging Program (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 7,000 volunteer recreational and commercial fishermen, scientists, and fisheries observers since 1962. Through 2007, over 205,000 sharks of more than 50 species were tagged and 12,400 sharks of 33 species were recaptured. To improve the quality of data collected through the CSTP, identification placards for coastal and pelagic shark species were produced and distributed in collaboration with Rhode Island Sea Grant. Substantial progress was made on the NEFSC Integrated Mark-Recapture Management System with data modules for tagging and contact information brought online and reports (letters to constituents) finalized including location maps and data. A toll-free number was established as well as online reporting to collect information on recaptures for all species. This system creates a centralized tagging infrastructure for the more than 50 species of sharks in the CSTP and other NEFSC teleost tagging programs including cod, black sea bass, yellowtail flounder, and scup.

Tiger shark (*Galeocerdo cuvier*) with a NMFS Cooperative Shark Tagging Program tag.
Source: NMFS Northeast Fisheries Science Center

Electronic Tagging Studies and Movement Patterns

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. NEFSC electronic tagging studies include: 1) acoustic tagging and bottom monitor 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 MDMF; 3) placing PSAT and SPOT tags on dusky and tiger sharks in conjunction with Monterey Bay Aquarium, University of California Long Beach, and MDMF; and 4) placing SPOT tags on shortfin makos in the Flemish Cap. Integration of data from conventional (CSTP) and new-technology tags (28 sharks of 5 species) 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

Shortfin mako tagged by NEFSC biologist with a satellite (SPOT) and CSTP dart tag on a commercial longline vessel.
Source: Lisa Natanson/NMFS photo

associations. In addition, NEFSC staff attended a training session at the University of New Hampshire on the analysis of satellite tagging data using the statistical package KFTrack.

Southeast Fisheries Science Center (SEFSC)

Stock Assessments of Large Coastal and Prohibited Sharks

A stock assessment of the LCS complex, sandbar, and blacktip sharks was initiated in 2005 and completed in 2006 (SEDAR 11 2006). The assessment process now follows closely the SEDAR format implemented by some of the Councils, which consists of three workshops: data, assessment, and review. The Data Workshop took place in October 2005, the Assessment Workshop in February 2006, and the Review Workshop in June 2006. In addition to organizing the workshops and conducting the assessments, SEFSC scientists prepared a total of 21 documents for the data workshop and four documents for the assessment workshop. The Review Panel concluded that continued assessment of LCS as a complex was not recommendable because it was unlikely to produce effective management advice. The Panel accepted the results for sandbar sharks (overfished status and overfishing occurring) and blacktip sharks in the Gulf of Mexico (not overfished and no overfishing occurring), but concluded that stock status for blacktip sharks in the Atlantic was uncertain given the absence of reliable estimates of abundance, biomass, or exploitation rates.

An assessment of the dusky shark—a prohibited species in U.S. waters and candidate for listing under the Endangered Species Act—was also completed by SEFSC analysts in 2006 (Cortés et al. 2006) and peer-reviewed by NEFSC scientists. Application of multiple stock assessment methodologies in concert indicated that the Atlantic stock of dusky sharks has been very heavily exploited, thus implying an overfished status and that overfishing is occurring. Because of the very low productivity of this species, rebuilding times are expected to be very long.

Stock assessments for the SCS complex and the four individual species of which it is composed (Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks) were conducted in 2007. The 2007 SCS SEDAR Review Panel concluded that, while the assessment of the status of the complex was adequate based on the available data, given that species-specific assessments were also conducted any conclusions should be based on the results of the individual species assessments. Results of the finetooth shark assessment indicated the stock was not overfished nor was overfishing occurring, in contrast to the findings of the 2002 SCS assessment, which found overfishing was occurring. However, because of the general level of uncertainty in the data, the Review Panel suggested cautious management of this resource. For blacknose sharks, the assessment indicated the stock was overfished and overfishing was occurring both in 2005 and in preceding years (2001–2004). However, due to uncertainty in life history parameters, catches, and indices of relative abundance, the Review Panel cautioned that stock status could change substantially in an unpredictable direction in future assessments. In contrast, the assessments for Atlantic sharpnose and bonnethead sharks determined that the stocks were not overfished and that overfishing was not occurring.

Funds from the NMFS Protected Resources Species of Concern Program were provided in 2006 to provide an assessment of the night shark as it pertains to the species of concern criterion. Productivity, abundance trends, and endemism were assessed (Carlson et al. In press) and, based on the analysis of all current available information, night shark should be removed from the NMFS species of concern list but retained on the prohibited species list as a precautionary approach to management until a more comprehensive assessment of the status of the stock can be conducted (i.e., stock assessment). While some modeling-based frameworks (e.g. catch-free model) have been utilized for estimating stock status in situations where catch data are poor, the highly uncertain nature of the data for night shark also prevented application of these models. Previous standardized catch rates using a two-part generalized linear model gave conflicting results, with one series showing a decline, two series showing an increase, and one series showing constant abundance. To address this uncertainty, we used a hierarchical meta-analysis in a Bayesian framework to estimate changes in relative abundance from fishery-dependent and independent catch rate series. The meta-analytic estimate indicated little decline overall, suggesting night sharks have not suffered significant declines in abundance. A similar study was to be conducted on the sand tiger shark in 2008.

Observer Programs

Shark Longline Program

From 1994 to 2004, the southeastern United States commercial shark bottom longline fishery was monitored by the University of Florida Commercial Shark Fishery Observer Program. In 2005, the responsibilities of the program were moved to NMFS' Panama City Laboratory Shark Population Assessment Group in Panama City, Florida. This program is designed to meet the intent of the Endangered Species Act and the Consolidated Atlantic HMS FMP. It was created to obtain better data on catch, bycatch, and discards in the shark bottom longline fishery. All observers are required to attend a 1-week safety training and species identification course before being dispatched to the fishery. While on board the vessel, the observer records information on gear characteristics and all species caught, condition of the catch (e.g., alive, dead, damaged, or unknown), and the final disposition of the catch (e.g., kept, released, finned, etc.). The target coverage level is 3.9 percent of the total fishing effort. This level is estimated to attain a sample size needed to provide estimates of protected resource interaction with an expected coefficient of variation of 0.3. From January to November 2007, the shark bottom longline observer program covered a total of 42 trips on 25 vessels with a total of 264 hauls.

Shark Gillnet Program

Since 1993, an observer program has been underway to estimate catch and bycatch in the directed shark gillnet fisheries along the southeastern U.S. Atlantic coast. This program was designed to meet the intent of the Marine Mammal Protection Act, the Endangered Species Act, and the 1999 revised FMP for HMS. It was also created to obtain better data on catch, bycatch, and discards in the shark fishery. Historically, the Atlantic Large Whale Take Reduction Plan and the Biological Opinion issued under Section 7 of the Endangered Species Act mandated 100 percent observer coverage during the right whale calving season (November 15 to April 1). Outside the right whale calving season (i.e., April 1 to November 14), observer coverage equivalent to 38 percent of all trips is maintained. In 2007, the regulations implementing the Atlantic Large Whale Take Reduction Plan were amended and included the removal of the mandatory 100 percent observer coverage for drift gillnet vessels during the right whale calving season, but now prohibit all gillnets in an expanded southeast U.S. restricted area that covers an area from Cape Canaveral, Florida, to the North Carolina-South Carolina border, from November 15 through April 15. The rule has limited exemptions, only in waters south of 29 degrees N latitude, for shark strikenet fishing[17] during this same period and for Spanish mackerel gillnet fishing in December and March. Based on these regulations and on current funding levels, the shark gillnet observer program now covers all anchored (sink, stab, set), strike, or drift gillnet fishing by vessels that fish from Florida to the North Carolina year-round. Similar to the shark longline observer program, all observers are required to attend a 1-week safety training and species identification course and while on board the vessel they must record information on gear characteristics and all species caught, condition of the catch, and the final disposition of the catch. In 2007, a total of 5 drift gillnet vessels were observed making 84 sets on 11 trips. No vessels that targeted sharks were observed fishing gillnets in a strike fashion in 2007, but 29 trips were observed making 112 sink net sets on 6 vessels in 2007.

Ecosystem-Based Analysis and Management of Apex Predators: A Hierarchical-Bayesian Approach

Defining a trophic role for sharks in a given ecosystem is routinely accomplished through analysis of stomach contents or, increasingly, using ecological tracers. An alternative, statistical approach is to quantify relationships between predators and potential prey through time, where strong negative correlations between predator and prey indicate significant top-down effect. A major difficulty in implementing these methods, however, is the frequent mismatch between available data sets; sampling of predators and prey often occur on different occasions using different gear types. Research began in 2007 to estimate the effects of predator density on local fish communities using robust, hierarchical Bayesian-based methods. These results are expected to quantify the effect of apex predators in shaping fish community structure in the Gulf of Mexico and to be highly publishable. The conclusions will be of broad interest to fisheries managers trying to rebuild depleted fish stocks should the role of apex predators be substantial.

Elasmobranch Feeding Ecology and Shark Diet Database

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 under way describing the diet and foraging ecology, habitat use, and predator-prey interactions of elasmobranchs in various communities. A study on prey selection by the Atlantic angel shark in the northeastern Gulf of Mexico was published (Baremore et al. 2008). The diet of the roundel skate (*Raja texana*) from the northern Gulf of Mexico is also being examined (Bethea and Hale in prep.). A database containing information on quantitative food and feeding studies of sharks conducted around the world has been in development for several years and currently includes over 400 studies. This fully searchable database will continue to be updated and fine-tuned in 2008, and is being used as part of a collaborative study on ecosystem effects of fishing large pelagic predatory fish with researchers from the University of Washington, University of Wisconsin, and the Inter-American Tropical Tuna Commission. It is also expected that this shark trophic database will be very useful for other ecosystem-level studies using Ecopath/Ecosim or similar approaches and ultimately for population assessments.

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[17] When a vessel fishes for sharks with strikenets, the vessel encircles a school of sharks with a gillnet. This is usually done during daylight hours, to allow visual observation of schooling sharks from the vessel or by using a spotter plane.

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

The SEFSC Panama City 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) requirements for sharks. The Group also 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 northwest Florida monthly 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 and NMFS Mississippi Laboratories is in development and currently includes over 11,000 tagged animals and 134 recaptured animals from 1993 to present for both the Gulf of Mexico and U.S. southeast Atlantic Ocean. This fully searchable database will continue to be updated and fine-tuned in fiscal year 2008 with hopes to have it online and searchable by all participants in fiscal year 2009.

Life History Studies of Elasmobranchs

Biological samples of elasmobranchs 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 the data 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. Using x-radiography, a reanalysis of the age and growth of blacknose shark was published in 2007 (Carlson et al. 2007). Following recommendations of the 2006 Large Coastal Shark SEDAR (SEDAR 11), research is continuing to reevaluate the life history of sandbar and blacktip sharks, especially age at maturity.

Bomb radiocarbon validation

To estimate age of great hammerhead sharks, bomb carbon validation and isotope analysis are underway. This technique focuses on the well-documented increase in radiocarbon (C^{14}) in the world's oceans, caused by the atmospheric testing of atomic bombs in the 1960s. The increase in atmospheric and oceanic radiocarbon was found to be synchronous with marine organisms containing carbonate, such as bivalves, corals, and fish bones. This synchrony allows the period of increase to be used as a dated marker in calcified structures exhibiting growth bands, such as teleost otoliths and shark vertebrae.

Cooperative Research—Habitat Utilization among Coastal Sharks

Coastal habitat use and residency of a coastal bay by juvenile Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, were examined by acoustic monitoring, gillnet sampling, and conventional tag-recapture through a collaborative effort between the SEFSC Panama City Shark Population Assessment Group and the Mote Marine Laboratory. Acoustic monitoring data were used to define the residency and movement patterns of sharks within Crooked Island Sound, Florida. Over 3 years, sharks were monitored for periods of 1–37 days (d), with individuals regularly moving in and out of the study site. Individual sharks were continuously present within the study site for periods of 1–35 d. Patterns of movement could not be correlated with time of day. Home range sizes were typically small (average=1.29 km^2) and did not vary on a yearly basis. Gillnet sampling revealed that juvenile Atlantic sharpnose sharks were present in all habitat types found within Crooked Island Sound, and peaks in abundance varied depending on month within a year. Although telemetry data showed that most individuals remained within the study site for short periods of time before emigrating, conventional tag-recapture data indicate some individuals return to Crooked Island Sound after extended absences (maximum length=1352 d). Although conventional shark nursery theory suggests small sharks remain in shallow coastal waters to avoid predation, juvenile Atlantic sharpnose sharks frequently exited from protected areas and appear to move through deeper waters to adjacent coastal bays and estuaries.

Cooperative Research—Definition of Habitat and Migration Patterns for Bull Sharks in the Eastern Gulf of Mexico

A 3-year collaborative effort between the SEFSC Panama City Shark Population Assessment Group, University of Florida, and Mote Marine Laboratory began in 2005 to determine habitat use and short-term migration patterns of bull sharks. Sharks are being outfitted with PSATs during various times of the year. Preliminary results indicate sharks do not travel extensive distances while occupying summer habitats. This project is driven by the lack of data for this species and its current prominence within the Florida coastal community. A better understanding of this species is required to effectively manage this species for both commercial and recreational fishermen, as well as the general public. Concerns regarding this species will continue to be an issue, as fishermen and the public demand that State and Federal governments provide better information concerning the presence and movements of these sharks.

Cooperative Research—Brazil-U.S. pelagic shark research project

The main goal of this cooperative project between Brazil (Universidade Federal Rural de Pernambuco) and the United States (SEFSC and the University of Florida's Museum of Natural History) is to conduct simultaneous research on pelagic sharks in the North and South Atlantic Ocean. Central to this project is also the development of fisheries research capacity in Brazil through graduate student training and stronger scientific cooperation between Brazil and the United States. The main research objectives include: 1) development of bycatch reduction and habitat models, 2) investigation of movement and migratory patterns, and 3) ancillary life history studies. Bycatch reduction will be investigated with the placement of hook timers and temperature-depth recorders on fishing gear to gain information on preferential feeding times, fishing depths, and temperatures of pelagic sharks and associated fauna. This information can be used in the future for development of habitat-based models. Movement and migratory patterns are being investigated through the deployment of pop-up satellite tags on pelagic species that are frequently caught in fishing operations or are of special importance to conservation interests in both countries. Information gathered will provide insight into geographical and vertical distribution patterns, which in turn will provide data on catchability that can be used if bycatch reduction measures are implemented in the future. Data obtained from hook timers, temperature-depth recorders, and archival tags can also be used to estimate the susceptibility of pelagic shark species to surface longline fisheries under Ecological Risk Assessment approaches. To date, an oceanic whitetip, a longfin mako, and a bigeye thresher shark have been tagged with satellite tags off U.S. waters and two blue sharks have been tagged off Brazilian waters as part of this project. The ancillary studies include genetic, age and growth, reproduction, and trophic ecology analysis.

Shark Assessment Research Surveys

The SEFSC Mississippi Laboratories have conducted bottom longline surveys in the Gulf of Mexico, Caribbean, and Southern North Atlantic since 1995 (24 surveys have been completed through 2007). The primary objective was 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 5 and 200 fathoms, were designed to satisfy five important assessment principles: stockwide survey, synopticity, well-defined sampling universe, controlled biases, and useful precision. 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 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 the Dauphin Island Sea Lab and Gulf Coast Research Laboratory. 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.

Scalloped hammerhead captured in the Gulf of Mexico during a bottom longline survey.
Source: NMFS Mississippi Laboratories, Shark Team

<u>NOAA Center for Coastal Environmental Health and Biomolecular Research</u>

Ongoing sample collection and methods-development for molecular shark species identification

The Marine Forensics program at the National Ocean Service's (NOS) Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) in Charleston, South Carolina, conducts research on suitable molecular markers for identification of shark species. DNA identifications can be used to determine whether the species of landed fins match the corresponding bodies, whether prohibited species are found among fish that are not landed intact, and even the identity of dried, processed fins. The Marine Forensics program uses a method developed in-house that is based on sequencing a ~1,400-base-pair fragment of 12s/16s mitochondrial DNA (Greig et al. 2005) to identify the species of suspected sharks seized by agents of Federal and State law enforcement agencies. The published method focuses on 35 species from the U.S. Atlantic shark fishery, but sample collection and research to expand the number and range of shark species sequenced for the diagnostic DNA fragment is ongoing.

The Marine Forensics program is also collaborating with researchers at the Canadian Barcode of Life Network at the University of Guelph to explore the utility of the COI[18] "barcode" fragment for shark species identification (Hebert et al. 2003). The COI fragment targeted by barcoding is half the length of the 12s/16s fragment and, if it provides enough resolution to robustly identify shark species, it could be used on more degraded samples than the current fragment. Also, as researchers around the world are barcoding fish species occurring in their waters and submitting their sequences to a curated database, many more reference sequences will be available for the COI region through FISHBOL (a global effort to assemble a standardized reference sequence library for all fish species) than any single researcher could accrue; currently, the count stands at 30,666 barcodes from 5,473 species (www.fishbol.org).

5.2 Incidental Catch Reduction

Pacific Islands Fisheries Science Center (PIFSC)

Reducing Longline Shark Bycatch

The resumption of the previously closed Hawaii shallow-set longline fishery for swordfish in late 2004 and continuing through 2007 was anticipated to increase blue shark catches, as in the past blue sharks made up about 50 percent of the total catch in this fishery. With the ban on shark finning, these sharks are not retained and are categorized as regulatory bycatch. Although the anticipated increase in shark bycatch has been less than expected (perhaps due to the requirement to use fish bait instead of squid, or because of a shift toward an earlier fishing season in the reopened swordfish fishery), researchers at PIFSC have undertaken several projects to address shark bycatch on longlines.

Chemical and Electromagnetic Deterrents to Bycatch

One study under way since 2005 with funding from the National Bycatch Program seeks to test the use of chemical and electromagnetic deterrents to reduce shark bycatch. Previous research by Eric Stroud of SharkDefense LLC, Oak Ridge, New Jersey, was conducted to identify and isolate possible semiochemical compounds from decayed shark carcasses. Semiochemicals are chemical messengers that sharks use to orient, survive, and reproduce in their specific environments. Certain semiochemicals have the ability to trigger a flight reaction in sharks. Initial tests showed chemical repellents administered by dosing a "cloud" of the repellent into a feeding school of sharks caused favorable behavioral shifts, and teleost fishes such as pilot fish and remora accompanying the sharks were not repelled and continued to feed. This suggested other teleosts, such as longline target species (tunas or billfish), would not be repelled. Longline field testing of these chemicals was conducted in early 2006 with demersal longline sets in South Bimini using the chemicals, and similar testing of magnets, and were quite successful.

Beginning in early 2007, the PIFSC began testing the ability of electropositive metals (lanthanide series) to repel sharks from longline hooks. Electropositive metals release electrons and generate large oxidation potentials when placed in seawater. It is thought that these large oxidation reactions perturb the electrosensory system in sharks and rays, causing the animals to exhibit

[18] COI is a 648 base pair region in the mitochondrial cytochrome c oxidase 1 gene.

aversion behaviors. Since commercially targeted pelagic teleosts do not have an electrosensory sense, this method of perturbing the electric field around baited hooks may selectively reduce the bycatch of sharks and other elasmobranchs. Feeding behavior experiments were conducted to determine whether the presence of these metals would deter sharks from biting fish bait. Experiments were conducted with Galapagos sharks and sandbar sharks off the coasts off the North Shore of Oahu. Results indicate that sharks significantly reduced their biting of bait associated with electropositive metals. In addition, sharks exhibited significantly more aversion behaviors as they approached bait associated with these metals. Further studies on captive sandbar sharks in tanks indicated sharks would not get any closer than 40 cm to baits in the presence of the metal (metal approximately the same size as a 60g lead fishing weight). Experiments to examine the effects on shark catch rates on modified longlines and the feasibility of deploying electropositive metals on commercial longlines are planned to commence during 2008.

Longline Gear Effects on Shark Bycatch

To explore operational differences in the longline fishery that might reduce shark bycatch, the observer database is being used to compare bycatch rates under different operational factors (e.g., hook type, branch line material, bait type, the presence of light sticks, soak time, etc.). A preliminary analysis was completed that compared the catches of vessels using traditional tuna hooks to vessels voluntarily using size 14/0 to 16/0 circle hooks in the Hawaii-based tuna fleet. The study was inconclusive due to the small number of vessels using the circle hooks. Subsequently, 19 contracted vessels were used to test large (size 18/0) circle hooks versus tuna hooks in controlled comparisons. Preliminary analysis does not indicate these large circle hooks increase the catch rate of sharks, in contrast to findings of increased shark catch on circle hooks in studies comparing smaller circle hooks with J hooks in other fisheries.

Testing Deeper Sets

An experiment with deeper-set longline gear conducted in 2006 has been analyzed and submitted for publication. The experiment altered current commercial tuna longline setting techniques by eliminating all shallow set hooks (less than 100 m depth) from tuna longline sets. The objective was to maximize target catch of deeper dwelling species such as bigeye tuna, and reduce incidental catch of many marketable but less desired species (e.g., billfish and sharks). The deep setting technique was easily integrated into daily fishing activities with only minor adjustments in methodology. The main drawback for the crew was increased time to deploy and retrieve the gear. Catch totals of bigeye tuna and sickle pomfret were greater on the deep set gear than on the controlled sets; but the bigeye results were not statistically significant. Catch of several less valuable incidental fish (e.g., blue marlin, striped marlin, shortbill spearfish, dolphinfish, and wahoo) was significantly lower on the deep set gear than the controlled sets. Unfortunately, no significant results were found for sharks.

Results from several of the bycatch studies suggest combining methods to avoid bycatch. Perhaps a combination of electropositive metals fashioned into weights attached to longline gear and setting the gear deeper might avoid bycatch of sharks and marlins. Research is also being initiated to develop safer weights, such as weights that do not spring back toward fishermen when branch lines holding large fish break during retrieval.

Southeast Fisheries Science Center (SEFSC)

Cooperative Research—The Capture Depth, Time, and Hooked Survival Rate for Bottom Longline–Caught Large Coastal Sharks

The field aspect of a project funded through the NMFS Cooperative Research Program to examine alternative measures (such as reduced soak time, restrictions on gear length, and fishing depth restrictions) in the shark bottom longline fishery to reduce mortality on prohibited sharks was completed in 2007. Preliminary analysis has begun to analyze the data.

Temporal and Spatial Distribution of Bycatch in the U.S. Atlantic Bottom Longline Shark Fishery

A project to evaluate the composition of bycatch from the shark bottom longline fishery began in 2007. The project examines the temporal and spatial distribution of bycatch as well as factors that may influence the rate at which bycatch is caught. This information has important implications for management actions such as marine protected areas, time area closures, and gear modifications. A three-way analysis of variance (ANOVA) was performed for each taxonomic group using the number of individuals as the dependent variable and year, region, and hook type as the independent variables. Three subregions (eastern Gulf of Mexico, south Atlantic, and Mid-Atlantic Bight), 5 years (2002–2006), four hook types (small, medium, large, and other), and eight broad taxonomic categories were used in the analyses. The results indicated that the majority of bycatch was caught in the eastern Gulf of Mexico and that the Selachimorpha taxon category made up over 90 percent of the total bycatch. All three factors were significant ($p<0.1$) for this group, as were the interactions between hook type and year and hook type and region.

5.3 Post-Release Survival

Pacific Islands Fisheries Science Center (PIFSC)

Improved Release Technology

The recently resumed Hawaii-based swordfish longline fishery, as well as the tuna longline fishery, is 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 branchline, 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 the 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. In 2007, PIFSC and PIRO personnel conducted longline trials along the eastern shore of Virginia to compare catches of sharks and rays on barbed and barbless circle hooks. In a randomization test, difference in the catches between the hook types was not significant. Circle hook removal trials were also conducted simultaneously and resulting effectiveness of removing hooks from sharks were 27 percent with barbed hooks and 72 percent with barbless hooks. During the study a new dehooker was developed and tested. Preliminary results were >90 percent effective in removing both barbed and barbless circle hooks from sharks; however, the prototype appears to be more efficient on smaller sized animals.

Post-release Survival

Many large marine animals (sharks, turtles, and marine mammals) are accidentally caught in commercial fisheries. While conservationists and fisheries managers encourage release of these non-target species, the long-term fate of released animals is uncertain. 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. Although it is safe to say that 100 percent of retained fish will die, it is not known what proportion of released fish will survive. Many factors—such as fish size, water temperature, fight time, and fishing gear—could influence survival.

Post-release survival, which is not well established for any marine species, 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.

PIFSC scientists have been developing biochemical and physiological profiling techniques for use in estimating post-release survival of blue sharks, which are frequently caught as bycatch of Pacific longliners. Using NOAA research vessels, they captured 211 sharks, of which 172 were blue sharks. Using blue sharks, PIFSC scientists and collaborators developed a model to predict long-term survival of released animals (verified by PSAT data) based on analysis of small blood samples. Five parameters distinguished survivors from moribund sharks: plasma Mg^{2+}, plasma lactate, erythrocyte Hsp70 mRNA, plasma Ca^{2+}, and plasma K^{+}. A logistic regression model incorporating a combination of Mg^{2+} and lactate successfully categorized 19 of 20 (95 percent) fish of known fate and predicted that 21 of 22 (96 percent) sharks of unknown fate would have survived upon release. These data suggest that a shark captured without obvious physical damage or physiological stress (the condition of 95 percent of the sharks they captured) would have a high probability of surviving upon release. The program has PSAT-tagged 32 blue sharks, 8 bigeye thresher sharks, 16 oceanic white-tip sharks, 5 shortfin mako, and 10 silky sharks. Of the 71 PSATs reporting from released sharks, in only one case was there an indication of mortality after release (and that one mortality may have been caused by scientific sampling; see Moyes et al. 2006). These PSAT data complement the biochemical data indicating long-term survival after release from longline gear (Moyes et al. 2006). Currently, similar research and results are being written up on oceanic white-tip and silky shark.

Pop-up Satellite Archival Tags (PSAT) Performance and Metadata Analysis Project
Satellite tagging studies have been used to investigate post-release mortality of animals, either as indicated by signal failure, early pop-up, or depth data indicating rapid descent to abnormal depth before pop-up. However, these signals, or the lack thereof, may have other origins besides mortality. The purpose of this study is to explore failure (or success) scenarios in PSATs attached to pelagic fish, sharks, and turtles. Shark species in the database include bigeye thresher, blue, shortfin mako, silky, oceanic white-tip, great white, and basking sharks. Other species include: black, blue, and striped marlins; broadbill swordfish; bigeye, yellowfin, and bluefin tunas; tarpon; and green, loggerhead, and olive ridley turtles. To date, of 731 PSATs attached to sharks, billfish, tunas, and turtles, 577 (79 percent) reported data. Of the tags that recorded data, 106 (18 percent) hit their programmed pop-off date and 471 tags popped off earlier than their program date. The 154 (21 percent) non-reporting tags are not assumed to reflect fish mortality. The metadata study is designed to look for explanatory variables related to tag performance by analyzing PSAT retention rates, percentage of satellite data (i.e., depth, temperature, geolocations) retrieved, and tag failure. By examining these factors and other information about PSATs attached to vastly different pelagic species, it is anticipated certain patterns/commonalties may emerge to help improve attachment methodologies, selection of target species, and experimental designs, particularly with respect to post-release survival studies. In a companion meta-analysis of 53 papers in the literature reporting the deployment of 1,433 PSATs, we calculated a very similar reporting rate (1,089, or 76 percent) for these tags. Information derived from this study should allow an unprecedented and critical appraisal of the overall efficacy of the technology.

Southwest Fisheries Science Center

Post-release Survival of Pelagic Sharks

Common thresher, mako, and blue sharks are captured in a number of West Coast commercial fisheries. The drift gillnet fishery is the commercial fishery that catches the greatest number of each of these species. While thresher and mako sharks are landed, almost all blue sharks are discarded. Mako and thresher sharks are also targeted in the expanding recreational fisheries in the southern California Bight. Many recreational fishermen are only interested in the challenge of the fight and will frequently release their catch. The survival rate of sharks released both from the drift gillnet fishery and by recreational anglers is unknown. Reliable estimates of removals (i.e., mortalities) are necessary in order to adequately assess the status of the stocks and determine the effects of the fisheries on their abundance.

Survival of Blue Sharks Released from the Drift Gillnet Fishery

The SWFSC and Southwest Region have been working on a project to determine the survivability of blue sharks caught and released alive by the California drift gillnet fishery. Blue sharks are the second greatest bycatch species in number (behind the common mola) in this fishery. Roughly 35 percent of the blue sharks caught are released alive, but their fate is unknown. During the 2007–2008 fishing season, seven sharks in various conditions at time of release were tagged with PSAT tags. The tagged sharks were tracked and preliminary results indicate that survivability is high; all seven survived for at least 6 weeks following tagging. The study will continue in the 2008–2009 season with smaller-sized sharks tagged to determine whether size affects survival rates.

Survival of Thresher Sharks Released from the Recreational Fishery

In spring 2007, a collaborative project was initiated by the SWFSC, Southwest Region Sustainable Fisheries Division, and Pfleger Institute of Environmental Research to determine the survivability of thresher sharks caught and released alive by recreational fishermen. Anglers often hook the tails of thresher sharks and pull them backwards to the boat. When the fight time is long, the fish may be exhausted by the time it reaches the boat for release. Four thresher sharks, hooked by the tail by anglers, were fitted with PSAT tags and released. The tags were programmed to release after 10 days. Preliminary results indicated that in one case mortality occurred within hours of release. The sample size was small, and the survival rate is expected to be highest for smaller animals and when fight times are short. Further tagging is planned for 2008 to increase the sample size. In addition the team will undertake physiological studies to assess capture stress and will experiment with various gear modifications to reduce tail hooking.

Northeast Fisheries Science Center

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

This ongoing cooperative research with the MDMF and the University of Massachusetts, Dartmouth, is directed toward coastal and pelagic shark species caught on recreational and commercial fishing gear. These studies use blood and muscle sampling methods coupled with acoustic tracking and PSAT data to quantify the magnitude and impacts of capture stress.

One study utilizing blood samples taken from 62 specimens of eight shark species on the NEFSC coastal and pelagic shark surveys is used to examine their physiological stress response to longline gear. Laboratory analyses for physiological stress indicators, including hematocrit, plasma ion levels, and red blood cell counts, have been partially completed for these samples. PSATs placed on three blood-sampled tiger sharks popped up after 4 months and showed that these individuals recovered from the stress of longline capture. The combination of these PSAT data and the resulting blood analysis will provide valuable information on post-release survivorship given the magnitude of capture stress. The results of this research will be critical to evaluate the extensive current catch-and-release management strategies for sharks.

Another ongoing cooperative study is on the post-release survivorship, habitat utilization, and movement patterns of porbeagle sharks captured on longline gear in the North Atlantic using PSAT tags. One of the objectives of this research is to quantify and characterize the long-term physiological effects of capture stress and post-release recovery in longline-captured porbeagle sharks. These efforts will potentially allow the quantification of the stress cascade for this shark species captured on commercial gear, thereby providing fishery managers with data showing the minimum standards for capturing (e.g., longline soak time) and releasing these fishes while ensuring post-release survival. The second year brought analysis of the heat shock proteins on the sampled individuals. In addition, 17 of the 20 PSATs released the last 11 months after tagging. All of the tagged individuals have corresponding blood samples currently being analyzed for stress indicators. These data in conjunction, with PSAT data, will provide important information on post-release survivorship.

Shortfin mako being measured
Source: NMFS Mississippi Laboratories, Shark Team

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Appendix 1: Internet Information Sources

Atlantic Ocean Shark Management

The 2006 Final Consolidated Atlantic HMS FMP; copies of Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks; and Atlantic commercial and recreational shark fishing regulations and brochures can be found on the Highly Migratory Species (HMS) Management Division website at http://www.nmfs.noaa.gov/sfa/hms/. 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 CFR 635), shark landings updates, and the U.S. National Plan of Action for Sharks.

Pacific Ocean Shark Management

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

Data reported in Table 2.3.3 (Shark landings (round weight equivalent in mt) for California, Oregon, and Washington, 1995–2007) was obtained from the Pacific States Marine Fisheries Commission's PacFIN Database, which may be found on their website at: http://www.psmfc.org/pacfin/data.html.

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/pelagic.htm.

Data reported in Table 2.3.9 (Shark landings (mt) from the Hawaii-based longline fishery and the American Samoa longline fishery, 1995-2007.) was partially obtained from the Western Pacific Fisheries Information Network (WPacFIN). WPacFIN is a Federal-State partnership collecting, processing, analyzing, sharing, and managing fisheries data from American island territories and States in the Western Pacific. More information is available on their website at: 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: http://www.fakr.noaa.gov/npfmc/fmp/fmp.htm.

Stock assessments and other scientific information for sharks are summarized annually in an appendix to the NPFMC SAFE Reports that are available online: http://www.fakr.noaa.gov/npfmc/SAFE/SAFE.htm.

International Efforts to Advance the Goals of the Shark Finning Prohibition Act
NOAA Fisheries Office of International Affairs
http://www.nmfs.noaa.gov/ia/

FAO International Plan of Action for the Conservation and Management of Sharks
http://www.fao.org/figis/servlet/static?dom=org&xml=ipoa_sharks.xml

U.S. NPOA for the Conservation and Management of Sharks
http://www.nmfs.noaa.gov/sfa/hms/Final%20NPOA.February.2001.htm

NAFO Article 16: Conservation and Management of Sharks
http://www.nafo.int/fisheries/frames/regulations.html

IATTC RESOLUTION C-05-03: Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean
http://iattc.org/PDFFiles2/C-05-03-Sharks.pdf

ICCAT Recommendation 04-10: Recommendation Concerning the Conservation of Sharks Caught in Association with Fisheries Managed by ICCAT
http://www.iccat.int/Documents%5CRecs%5Ccompendiopdf-e%5C2004-10-e.pdf

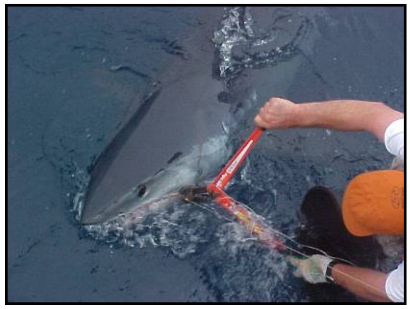
ICCAT Recommendation 05-05: Recommendation by ICCAT to Amend Recommendation [Rec. 04-10] Concerning the Conservation of Sharks Caught in Association with Fisheries Managed by ICCAT
http://www.iccat.int/Documents%5CRecs%5Ccompendiopdf-e%5C2005-05-e.pdf

WCPFC Resolution 2005-03: Resolution on Non-Target Fish Species
http://www.wcpfc.int/wcpfc2/pdf/WCPFC2_Records_I.pdf

WCPFC Conservation and Management Measure 2006-05: Conservation and Management Measure for Sharks in the Western and Central Pacific Ocean
http://www.wcpfc.int/pdf/Conservation%20and%20Management%20Measure-2006-05%20%5BSharks%5D.pdf

UNGA Sustainable Fisheries Resolution A/RES/62/177 dated December 18, 2007
http://www.un.org/ga/62/resolutions.shtml

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.gov/st1/trade/index.html



A large shortfin mako shark being released after capture and tagging during the SWFSC juvenile shark abundance survey.
Source: NMFS photo