2010 Shark Finning Report to Congress

NOAA

Issued Pursuant to the Shark Finning Prohibition Act
(Public Law 106-557)

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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Prepared by the
National Marine Fisheries Service

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Abbreviations and Acronyms

ABC ....allowable biological catch
ABL....Auke Bay Laboratory
ADF&G....Alaska Department of Fish and Game
AFSC....Alaska Fisheries Science Center
ALWTRP ....Atlantic Large Whale Take Reduction Plan
BLL ....bottom longline
BREP....Bycatch Reduction Engineering Program
BSAI ....Bering Sea/Aleutian Islands
C ....carbon
CCAMLR....Commission for the Conservation of Antarctic Marine Living Resources
CI....confidence interval
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 the Conservation of Migratory Species of Wild Animals
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
CRED ....Coral Reef Ecosystem Division
CSTP ....Cooperative Shark Tagging Program
dw....dressed weight
EEZ ....Exclusive Economic Zone
EFH ....essential fish habitat
EPO ....Eastern Pacific Ocean
ERA....ecological risk assessment
FAO....Food and Agriculture Organization of the United Nations
FEP....fishery ecosystem plan
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
Hg..mercury
HIMB ....Hawaii Institute of Marine Biology
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
IUCN..International Union for Conservation of Nature
kg..kilogram
LCS ....large coastal sharks
MAFMC...Mid-Atlantic Fishery Management Council
MDMF ....Massachusetts Division of Marine Fisheries
MEP ....Massachusetts Environmental Police
MHI..Main Hawaiian Islands
MSA...Magnuson-Stevens Fishery Conservation and Management Act
MSY ....maximum sustainable yield
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..oxytetracycline
PacFIN ....Pacific Fisheries Information Network
PIFSC...Pacific Island Fishery Science Center
PSAT..pop-up satellite archival tags
PFMC...Pacific Fishery Management Council
PRIA ....Pacific remote island areas

RFMO ....regional fishery management organization
SAFE..Stock Assessment and Fishery Evaluation
SCB ....Southern California Bight
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
SSN ....spawning stock number
STAR ....stock assessment and review
SWFSC ....Southwest Fisheries Science Center
SWRO ....Southwest Regional Office
TAC...total allowable catch
TL..total length
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 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 by 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 2009.

Sharks in Federal waters are currently managed under eight different fishery management plans under authority of the Magnuson-Stevens Fishery Conservation and Management Act (MSA). In the U.S. Atlantic Ocean, oceanic 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. In 2009, domestic management of sharks included the following major actions:

- On July 24, 2009, NMFS released a Draft Environmental Impact Statement and published a proposed rule (74 FR 36892) to amend the 2006 Consolidated Atlantic HMS Fishery Management Plan based on recent stock assessments for Small Coastal Sharks (SCS) and shortfin mako sharks. The proposed rule considered a range of measures such as commercial quotas, commercial gear restrictions, pelagic shark effort controls, and recreational measures in order to rebuild blacknose sharks and to stop overfishing of blacknose and shortfin mako sharks. The proposed rule also considered adding smooth dogfish to the Atlantic HMS management unit and a range of measures for this species.
- NMFS publishes rules each year to adjust Atlantic shark fishery quotas based on over- and under-harvests from the previous season. A final rule was published on January 5, 2010 (75 FR 250), which established the 2010 fishing season for commercial quotas for sandbar sharks, non-sandbar large coastal sharks, small coastal sharks, and pelagic sharks based on over- or under-harvests from the 2009 fishing year.

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 2009, the United States was successful in the following international efforts:

- In 2009, one shark-related measure was adopted at the International Commission for the Conservation of Atlantic Tunas (ICCAT). The measure prohibits the retention,

transshipping, landing, and sale of bigeye thresher sharks. The measure also requires the collection and submission of data to ICCAT on all thresher shark species.
- In 2009, the European Community organized and hosted the Second Joint Meeting of Tuna regional fishery management organizations (RFMOs) in San Sebastian, Spain. The Participants agreed to call on RFMOs, consistent with the Food and Agriculture Organization of the United Nations FAO International Plan of Action (IPOA)–Sharks, to establish precautionary, science-based conservation and management measures for sharks taken in fisheries within the convention areas of each tuna RFMO.
- In response to the San Sebastian meeting, the annual United Nations General Assembly Sustainable Fisheries Resolution called upon regional fisheries management organizations with the competence to regulate highly migratory species, "*to strengthen or establish precautionary, science-based conservation and management measures, as appropriate, for sharks taken in fisheries within their convention areas consistent with the International Plan of Action for the Conservation and Management of Sharks, taking into account the Course of Actions adopted at the second joint meeting of tuna regional fisheries management organizations…"*
- FAO convened an Ad Hoc Expert Panel in December 2009 to assess proposals to amend Appendices I and II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) concerning commercially exploited aquatic species. A representative from NMFS attended this workshop and presented the U.S. CITES proposals to add the oceanic whitetip shark, *Carcharhinus longimanus*, and scalloped hammerhead shark, *Sphyrna lewini*, to Appendix II.

Further information on international efforts to advance the goals of the Shark Finning Prohibition Act can be found in Section 4 of this report.

Numerous research studies undertaken by NMFS Science Centers have produced valuable information on shark status, survivorship, 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.

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 2009, four shark stocks are subject to overfishing[1] and four shark stocks are overfished[2] (Table 1). Twenty shark stocks or stock complexes (59%) have an unknown or undefined status in terms of their overfishing status. Similarly, 21 (62%) have an unknown or undefined status in terms of their overfished status (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; Clarke et al. 2007).

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 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

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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.

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. On June 24, 2008, NMFS published a final rule (73 FR 35778, corrected on July 15, 2008, 73 FR 40658) that amended the 2006 Consolidated Atlantic HMS Fishery Management Plan (FMP) that, among other things, requires that all sharks in the Atlantic HMS fishery be offloaded with the fins naturally attached.

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 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 2009 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 2009.
Source: NMFS 2010.

Status of Shark Stocks and Stock Complexes in U.S. Fisheries in 2009			
FMP & Jurisdiction	Stock or Stock Complex	Overfishing?	Overfished?
Spiny Dogfish FMP — NEFMC & MAFMC	Spiny dogfish – Atlantic coast	No	No - rebuilding
Consolidated Atlantic Highly Migratory Species FMP — NMFS Highly Migratory Species Division	Sandbar shark – Atlantic[1]	Yes	Yes
	Blacktip shark – Gulf of Mexico[1]	No	No
	Blacktip shark – South Atlantic[1]	Unknown	Unknown
	Atlantic large coastal shark complex[2]	Unknown	Unknown
	Finetooth shark – Atlantic[3]	No	No
	Atlantic sharpnose shark[3]	No	No
	Blacknose shark – Atlantic[3]	Yes	Yes
	Bonnethead – Atlantic[3]	No	No
	Atlantic small coastal shark complex[4]	No	No
	Shortfin mako – Atlantic[5]	Yes	No
	Porbeagle – Atlantic[5]	No	Yes
	Blue shark – Atlantic[5]	No	No
	Dusky shark – Atlantic	Yes	Yes
	Atlantic pelagic shark complex[6]	Unknown	Unknown
Pacific Coast Groundfish FMP — PFMC	Leopard shark	Unknown	Unknown
	Soupfin shark (also known as tope shark)	Unknown	Unknown
	Spiny dogfish	Unknown	Unknown
West Coast Highly Migratory Species FMP & Western Pacific Pelagic Fisheries FEP – PFMC & WPFMC	Thresher shark – North Pacific	Unknown	Unknown
	Shortfin mako shark – North Pacific	Unknown	Unknown
	Blue shark – Pacific	No	No
	Bigeye thresher shark – North Pacific	Unknown	Unknown
	Pelagic thresher shark – North Pacific	Unknown	Unknown

Western Pacific Pelagic Fisheries FEP — WPFMC	Longfin mako shark – North Pacific	Unknown	Unknown
	Oceanic whitetip shark – Tropical Pacific	Unknown	Unknown
	Silky shark – Tropical Pacific	Unknown	Unknown
	Salmon shark – North Pacific	Unknown	Unknown
Hawaiian Archipelago FEP — WPFMC	Hawaiian Archipelago Coral Reef Ecosystem Multi-Species Complex[7]	Unknown	Unknown
American Samoa FEP — WPFMC	American Samoa Coral Reef Ecosystem Multi-Species Complex[7]	Unknown	Unknown
Mariana Archipelago FEP — WPFMC	Guam Coral Reef Ecosystem Multi-Species Complex[7]	Unknown	Unknown
	Northern Mariana Islands Coral Reef Ecosystem Multi-Species Complex[7]	Unknown	Unknown
Pacific Islands Remote Areas FEP — WPFMC	Pacific Island Remote Areas Coral Reef Ecosystem Multi-Species Complex[8]	Unknown	Unknown
Gulf of Alaska Groundfish FMP — NPFMC	Other species category[9]	Undefined	Undefined
Bering Sea/Aleutian Island Groundfish FMP — NPFMC	Other species category[10]	No	Undefined
Totals:		4 "yes" 10 "no" 19 "Unknown" 1 "Undefined"	4 "yes" 9 "no" 19 "Unknown" 2 "Undefined"

[1]This stock is part of the Large Coastal Shark Complex, but it is assessed separately.
[2]In addition to Sandbar Shark, Gulf of Mexico Blacktip Shark, and Atlantic Blacktip Shark, the Large Coastal Shark Complex also consists of additional stocks including Spinner Shark, Silky Shark, Bull Shark, Tiger Shark, Lemon Shark, Nurse Shark, Scalloped Hammerhead Shark, Great Hammerhead Shark, and Smooth Hammerhead Shark. In addition, several LCS species cannot be retained in commercial or recreational fisheries, including Dusky Shark, Bignose Shark, Galapagos Shark, Night Shark, Caribbean Reef Shark, Narrowtooth Shark, Sand Tiger Shark, Bigeye Sand Tiger Shark, Whale Shark, Basking Shark, White Shark.
[3]This stock is part of the Small Coastal Shark Complex, but is assessed separately.
[4]In addition to Finetooth Shark, Atlantic Sharpnose Shark, Blacknose Shark, and Bonnethead Shark, the Small Coastal Shark Complex also consists of: Atlantic Angel Shark, Caribbean Sharpnose Shark, and Smalltail Shark; these 3 species cannot be retained in recreational or commercial fisheries.
[5]This stock is part of the Pelagic Shark Complex, but is assessed separately.
[6]In addition to Shortfin Mako Shark, Blue Shark, 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 Shark, Bigeye Sixgill Shark, Longfin Mako Shark, Sevengill Shark, and Sixgill Shark.
[7] In 2009, the Western Pacific Crustaceans, Bottomfish & Seamount Groundfish, Precious Corals, and Coral Reef Ecosystem FMPs were replaced by fishery ecosystem plans (FEP) for American Samoa, Hawaii, the Mariana Archipelago (Guam and the Northern Mariana Islands, and the Pacific Remote Island Areas. The western Pacific Pelagics FMP was converted to the Pelagics FEP. This complex contains up to 146 "currently harvested coral reef taxa" and innumerable "potentially harvested coral reef taxa." All commercial fishing is prohibited in the Marianas Trench (Mariana Islands) and Rose Atoll (American Samoa) Marine National Monuments.
[8] In 2009, the Western Pacific Crustaceans, Bottomfish & Seamount Groundfish, Precious Corals, and Coral Reef Ecosystem FMPs were replaced by fishery ecosystem plans (FEP) for American Samoa, Hawaii, the Mariana Archipelago (Guam and the Northern Mariana Islands, and the Pacific Remote Island Areas. The western Pacific Pelagics FMP was converted to the Pelagics FEP. 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. All commercial fishing is prohibited in the Pacific Remote Islands Marine National Monument.
[9]The Other Species Category consists of the following stocks: Pacific Sleeper Shark, Salmon Shark, Spiny Dogfish, unidentified sharks, and numerous species of octopi, squid, and sculpins. An OFL and ABC is determined for sharks, which when added to the OFLs and ABCs for octopi, squid, and sculpins becomes the overall OFL and ABC for the other species category. For sharks the overfishing determination is based on the OFL, which is based on the average historical catch.
[10]The Other Species Category consists of the following stocks: Pacific Sleeper Shark, Salmon Shark, Spiny Dogfish, unidentified sharks, and numerous species of skates, octopi, and sculpins. An OFL and ABC is determined for sharks, which when added to the OFLs and ABCs for octopi, skates, and sculpins becomes the overall OFL and ABC for the other species category. For sharks the overfishing determination is based on the OFL, which is based on the average historical catch.

2. Management and Enforcement

2.1 Management Authority in the United States

The Magnuson-Stevens Fishery Conservation and Management Act 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

Atlantic Highly Migratory Species Management

Development of 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 oceanic sharks and are managed directly by the Secretary of Commerce under the MSA. 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' HMS Division.

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 over- and under-harvest adjustment procedures.

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*	**Pelagic Sharks**	
Bull	*Carcharhinus leucas*	Shortfin mako	*Isurus oxyrinchus*
Lemon	*Negaprion brevirostris*	Common thresher	*Alopias vulpinus*
Nurse	*Ginglymostoma cirratum*	Porbeagle	*Lamna nasus*
Scalloped hammerhead	*Sphyrna lewini*	Oceanic whitetip	*Carcharhinus longimanus*
Great hammerhead	*Sphyrna mokarran*	Blue	*Prionace glauca*
Smooth hammerhead	*Sphyrna zygaena*	**Smoothhound Sharks**	
		Smooth dogfish	*Mustelus canis*
		Florida smoothhound	*Mustelus norrisi*
Prohibited Species			
Sand tiger	*Carcharias taurus*	Caribbean reef	*Carcharhinus perezii*
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 nakamurai*
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*		

***Can only be harvested within a shark research fishery, and not allowed for recreational harvest**
****Not allowed for recreational harvest**

On December 24, 2003, the final rule implementing Amendment 1 to the 1999 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).

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 2005–2009 commercial shark landings and the 2009 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). On September 23, 2008 (73 FR 54721), NMFS published a final rule that also requires U.S. HMS pelagic longline and BLL vessels to possess an additional sea turtle control device as of January 1, 2009. Additionally, the February 7, 2007, 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 June 24, 2008, NMFS published a final rule (73 FR 35778, corrected on July 15, 2008, 73 FR 40658) that amended the 2006 Consolidated Atlantic HMS FMP based on recent stock assessments for LCS, dusky sharks, and porbeagle sharks. The rule included measures to adjust quotas and retention limits, modify authorized species for the commercial shark fishery, establish a shark research fishery, require that all sharks be offloaded with all fins naturally attached, and modify the species that can be landed by recreational fishermen. Final measures were effective on July 24, 2008.

Table 2.2.2 Commercial landings for Atlantic large coastal, small coastal, and pelagic sharks in metric tons dressed weight,[4] 2005–2009.
Source: Cortés pers. comm. (2010).

2005-2009 Commercial Shark Landings					
Species Group	2005	2006	2007	2008	2009
Large Coastal Sharks	1,425	1,724	1,056	618	686
Small Coastal Sharks	288	346	280	283	303
Pelagic Sharks	114	86	118	106	91
Total	**1,827**	**2,156**	**1,454**	**1,007**	**1,080**

Table 2.2.3 Preliminary landings estimates in metric tons (mt) and pounds (lb) dressed weight (dw) for the 2009 Atlantic shark commercial fisheries. Landings are based on the quota monitoring system.

2009 Preliminary Commercial Shark Landings				
Species Group	Region	2009 Quota	Estimated Total Landings	% of Quota
Non-Sandbar Large Coastal Sharks (LCS) (i.e., silky, tiger, blacktip, spinner, bull, lemon, nurse, and hammerheads)	Gulf of Mexico	390.5 mt dw (860,896 lb dw)	320.5 mt dw (706,670 lb dw)	82.1%
	Atlantic	187.8 mt dw (414,024 lb dw)	203.3 mt dw (448,293 lb dw)	108%
Shark Research Fishery (Non-Sandbar LCS)	No Regional Quotas	37.5 mt dw (82,673 lb dw)	37 mt dw (81,572 lb dw)	98.7%
Shark Research Fishery (SRF) (Sandbar Only)		87.9 mt dw (193,784 lb dw)	Inside SRF 70.5 mt dw (155,416 lb dw)	90.9%
			Outside SRF* 9.4 mt dw (20,675 lb dw)	
Small Coastal Sharks (SCS)	No Regional Quotas	454 mt dw (1,000,888 lb dw)	285 mt dw (628,339 lb dw)	62.8%
Blue Sharks	No Regional Quotas	273 mt dw (601,856 lb dw)	2.2 mt dw (4,793 lb dw)	<1%
Porbeagle Sharks	No Regional Quotas	1.4 mt dw (3,147 lb dw)	1.6 mt dw (3,525 lb dw)	112%
Pelagic Sharks Other Than Porbeagle or Blue	No Regional Quotas	488 mt dw (1,075,856 lb dw)	94.9 mt dw (209,147 lb dw)	19.4%

* These landings are from state landings.

[4] Dressed weight is the weight of fish after the gills, guts, head, and fins have been removed and discarded (usually at sea). Prohibited species are excluded from these totals.

NMFS developed a draft environmental impact statement (DEIS) and proposed rule to amend the 2006 Consolidated Atlantic HMS FMP based on the latest SCS and shortfin mako shark stock assessments. The proposed rule (74 FR 36892; 7/24/2009) included measures to reduce fishing mortality and effort in order to rebuild blacknose sharks and end overfishing of blacknose sharks and shortfin mako sharks while ensuring that a limited shark fishery could be maintained consistent with federal law. A range of alternatives from several different topics were considered, including SCS commercial quotas, commercial gear restrictions, pelagic shark effort controls, and recreational measures for SCS and pelagic sharks. The proposed rule also considered adding smooth dogfish to the Atlantic HMS management unit as well as several management measures for this species, such as a Federal permit, a fins attached requirement, and a commercial quota.

NMFS publishes rules each year to adjust Atlantic shark fishery quotas based on over- or under-harvests from the previous fishing year (the fishing year is from January to December of each year; each shark fishery closes when the respective shark species/complex's quota reaches 80 percent with a five-day notice upon filing in the *Federal Register*). A final rule was published on January 5, 2010 (75 FR 250), which established the 2010 fishing season for commercial quotas for sandbar sharks, non-sandbar LCS, small coastal sharks, and pelagic sharks based on over- or under-harvests from the 2009 fishing year.

Shark Stock Assessments

A joint ICCAT (International Commission for the Conservation of Atlantic Tunas) / ICES (International Commission for the Exploration of the Seas) stock assessment was conducted for Atlantic porbeagle sharks in 2009. Four stocks were considered for assessment: northwest, northeast, southwest, and southeast Atlantic. For the northwest Atlantic stock, a surplus production model yielded a similar view of stock status to that found in an updated assessment undertaken by the Canadian Department of Fisheries and Oceans. Both assessments found that porbeagle sharks in the northwest Atlantic are overfished (biomass depleted to levels below MSY)[5], but that overfishing is not occurring (recent fishing mortality is below F_{MSY}). Despite the improving status of the stock, the Canadian assessment still projected that stock rebuilding will take decades due to the low productivity of this stock. NMFS had already implemented a rebuilding plan for porbeagle sharks in 2008 that included a TAC (Total Allowable Catch) of 11.3 metric tons dressed weight (mt dw) and a reduction of the U.S. Atlantic commercial quota to 1.7 mt dw per year. More information on porbeagle management is described in section 4.2 of this report.

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

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[5]Note: MSY refers to maximum sustainable yield. MSY is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological, environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets.

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 were put into place in 2008 to adjust the commercial quota of sandbar sharks, which as a result can now only be harvested within a shark research fishery, 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. The Gulf of Mexico blacktip shark 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.

In 2008, an updated stock assessment for blue and shortfin mako sharks was conducted by the ICCAT Standing Committee on Research and Statistics (SCRS). The results of these stock assessments are described in section 4.2 of this report.

Observer Coverage

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.

Shark Management by the Regional Fishery Management Councils and States

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. From 2000 through 2008, the management program established a restrictive spiny dogfish possession limit of 600 pounds per trip and a 4 million pound coastwide commercial quota further split into two seasonal quotas (Period I and Period II). Based on updated stock assessment results indicating that the stock was not overfished and overfishing was not occurring, the quota and possession limit increased to 12 million pounds and 3,000 pounds per trip, respectively, in the 2009 fishing year. Upon attainment of the coastwide quota, the fishery is closed to further landings by Federally permitted vessels.

Coordinated State management of sharks is vital to ensuring healthy populations of Atlantic coastal sharks. The Atlantic States Marine Fisheries Commission developed and individual states implemented an Interstate Coastal Shark FMP in 2008. One goal of this FMP was to improve consistency between Federal and State management of sharks in the Atlantic Ocean. Complimentary quotas were set in both state and Federal waters in the 2009 fishing year. However, the Interstate Coastal Shark FMP allocates quota regionally in state waters, rather than seasonally, as in Federal waters.

The next benchmark stock assessment is scheduled to occur in January 2010, through the Transboundary Resource Assessment Committee.

2.3 Current Management of Sharks in the Pacific Ocean

Pacific Fishery Management Council (PFMC)

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 HMS FMP is implemented by the NMFS Southwest Regional Office in Long Beach, California. 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 complex (Table 2.3.1), including the common thresher and shortfin mako (sharks commercially 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 which have been identified 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 during HMS fishing operations, these species—including great white, megamouth, and basking sharks—must be released immediately, unless other provisions for their disposition are established consistent with State and Federal regulations.

Table 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	
Whale shark	*Rincodon typus*
Prickly shark	*Echinorhinus cookei*
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 shark	*Cetorhinus maximus*

The FMP proposed precautionary annual harvest guidelines for common thresher and shortfin mako sharks in order to prevent localized depletion given the level of exploitation in some HMS fisheries at the time the FMP was adopted (e.g., large mesh drift gill net), and the uncertainty about catch in Mexico of these straddling stocks. These high exploitation rates and their impact on HMS shark stocks, if not checked, could take decades to correct given the vulnerable life history characteristics of the species. 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 Council's Highly Migratory Species Management Team is currently addressing the required elements of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, including the need to set annual catch limits (ACLs) and accountability measures (AMs) for actively managed HMS sharks.

The Pacific Coast Groundfish FMP includes three shark species (leopard, soupfin, and spiny dogfish) in the groundfish management unit (Table 2.3.2). The FMP is implemented by the NMFS Northwest Regional Office in Seattle, Washington. 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. The PFMC has designated spiny dogfish as one of the species for which benchmark assessments will be conducted and reviewed in 2011. This assessment would inform management of the species in 2013-14. Table 2.3.3 lists landings (round weight[6] equivalent in metric tons) for various sharks from fisheries off California, Oregon, and Washington.

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 galeus*
Spiny dogfish	*Squalus acanthias*

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

Table 2.3.3 Shark landings (round weight equivalent in metric tons) for California, Oregon, and Washington, 2000–2009, organized by species group.[7]
Source: PacFIN Database, the Washington, Oregon, and California All Species Reports (Report # 307) and the PFMC Groundfish Management Team Reports, as of May 2009, http://pacfin.psmfc.org/pacfin_pub/data.php

Shark Landings (mt) for California, Oregon, and Washington										
Species Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009[8]
Bigeye thresher shark	5	2	--	5	5	10	4	5	7	7
Blue shark	1	2	42	1	< 1	1	< 1	10	<1	2
Common thresher shark	295	373	301	294	115	179	160	204	148	105
Leopard shark	13	12	13	10	11	13	11	11	3	2
Other shark	5	38	4	20	3	5	4	2	2	3
Pelagic thresher shark	3	2	2	4	2	< 1	< 1	2	--	--
Shortfin mako	80	46	82	69	54	33	46	45	35	29
Soupfin shark	48	45	32	35	27	26	30	17	8	5
Spiny dogfish[9]	647	565	876	450	412	495	431	472	723	257
Unspecified shark	6	3	4	3	6	5	5	5	2	2
Pacific angel shark	34	28	22	17	13	12	15	8	12	12
Total	**1,134**	**1,116**	**1,378**	**908**	**648**	**779**	**706**	**781**	**936**	**424**

North Pacific Fishery Management Council (NPFMC)

The NPFMC manages the groundfish fisheries in federal waters off Alaska. Sharks are managed under the "other species" category in the Bering Sea/Aleutian Islands (BSAI) Groundfish FMP and the Gulf of Alaska (GOA) Groundfish FMP. "Other species" comprises taxonomic groups of slight economic value and are not generally targeted. The category includes sharks, skates, octopi, and sculpins in the BSAI and sharks, octopi, 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. Catch of "other species" must be recorded and reported at the individual species level, such as spiny dogfish, or at a broader taxonomic level, such as sculpins.

In the BSAI and GOA a survey is conducted biannually for groundfish including the "other species" category. The most recent surveys were conducted in 2008 in the BSAI and in 2009 in the GOA. These survey results were incorporated into the Stock Assessment and Fishery

[7] 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.
[8] For the most up-to-date report of shark landings, check the PacFIN website: http://pacfin.psmfc.org/pacfin_pub/data.php, as the data may continue to be updated.
[9] 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.

Evaluation (SAFE) reports for "other species" in the BSAI and GOA available from the NPFMC. A NMFS survey of "other species" is scheduled for 2010 in the BSAI and 2011 in the GOA. The results will be incorporated in the 2010 and 2011 SAFE reports.

Each year the BSAI and GOA Plan Teams recommend to the NPFMC an overfishing level (OFL) and an allowable biological catch (ABC) amount for the "other species" category based on the best available and most recent scientific information. The Council recommends a total allowable catch (TAC) level for "other species" in the BSAI and GOA. The OFL and ABC for "other species" are based on the sum of the assessments for the major taxonomic groups in the "other species" category. In recent years the NPFMC has recommended a TAC for these species in the BSAI sufficient to meet incidental catch amounts in other directed groundfish fisheries but not sufficient to allow for a directed fishery on these species. The most recent assessments for sharks are in Chapter 18b to the SAFE reports for the BSAI and GOA.

Beginning in 2008, with the implementation of Amendment 79 to the Fishery Management Plan for Groundfish of the Gulf of Alaska (GOA FMP), the GOA Plan Team recommended aggregate OFL and ABC levels for the "other species" category in the GOA. The Alaska Fisheries Science Center (AFSC) prepared stock assessments for the "other species" category in the GOA in 2009 for the 2010 and 2011 groundfish fisheries. Amendment 79 requires the NPFMC to set aggregate OFL and ABC levels for the "other species" category each year as part of the annual groundfish harvest specification process. This amendment allows the NPFMC to incorporate the best and most recent scientific and socio-economic information as well as public testimony in its recommendation for an annual "other species" TAC. The purpose of the amendment is to provide a sound biological basis for the setting of "other species" TAC and to provide for an annual review of the stock status of the "other species" category to further reduce the risk of overfishing these species. Previously the NPFMC only recommended 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 NPFMC 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 (SSC), Advisory Panel (AP), and 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.

At its April 2010 meeting the NPFMC recommended amendments to the BSAI and GOA FMPs to comply with the requirements of the Magnuson-Stevens Act to end and prevent overfishing, rebuild overfished stocks, achieve optimum yield, and to comply with statutory requirements for annual catch limits (ACLs) and accountability measures (AMs). The NPFMC recommendations include that the "other species" category be dissolved and that separate OFLs, ABCs, and TACs be set annually for sharks (BSAI and GOA), skates (BSAI), squid (GOA), sculpins (BSAI and GOA), and octopi (BSAI and GOA). NMFS intends to implement these amendments for the 2011 fishing year.

Seven shark species have been identified during fishery surveys or observed during groundfish fishing in the 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 "other species" category 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 BSAI and GOA are from 2009. These data are included in Chapter 18b in the 2009 BSAI and GOA SAFE reports and the NMFS catch accounting system. Estimates of the incidental catch of sharks in the BSAI and GOA and BSAI groundfish fisheries from 2000 through 2009 have ranged from 418-1,603 mt in the GOA and from 140-1,362 mt in the BSAI (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 GOA and BSAI in the earlier years (2000 to 2002) are largely based on NMFS survey results, observer data, and the NMFS Catch Accounting System data in the later years (2003 and onward).

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

Sharks in Alaskan groundfish fisheries	
Common Name	Scientific 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	*Hexanchus griseus*
Blue shark	*Prionace glauca*

Very few of the sharks incidentally taken in the groundfish fisheries in the GOA and BSAI are retained. Table 2.3.6 lists the amounts of sharks discarded and retained between 2005 and 2009 in the GOA and BSAI. The amount of sharks retained during the period range from 3.2 to 6.8 percent of the total incidental catch in the GOA, and 4.4 to 9.9 percent in the BSAI. 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 ADF&G for use in State waters. The catches of these vessels is confidential but catches of sharks were very low in amount, effort was very short-lived, and deemed unsuccessful by the participants. Since 2006 there has been no effort targeting sharks in the GOA or BSAI.

Table 2.3.5 Incidental catch (in metric tons) of sharks in the Gulf of Alaska and Bering Sea/Aleutian Islands commercial groundfish fisheries, 2000–2009.
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	2008	2009
GOA Groundfish	Spiny dogfish	398	494	117	362	204	485	1,232	849	534	859
	Pacific sleeper shark	608	249	226	298	286	486	254	297	66	48
	Salmon shark	38	33	58	37	41	60	34	135	7	10
	Unidentified shark	74	77	16.8	54	40	70	83	107	12	24
	Total	**1,117**	**853**	**418**	**751**	**571**	**1,101**	**1,603**	**1,388**	**619**	**941**
BSAI Groundfish	Spiny dogfish	9	17	9	11	9	11	7	3	17	19
	Pacific sleeper shark	490	687	838	280	420	333	313	256	120	44
	Salmon shark	23	24	47	196	26	47	63	44	42	70
	Unidentified shark	68	35	468	33	60	26	305	28	7	6
	Total	**590**	**764**	**1,362**	**520**	**515**	**418**	**689**	**331**	**186**	**140**

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, 2005–2009.
Source: Observer Data and NMFS Catch Accounting System Data

Utilization of Sharks (mt)						
		2005	2006	2007	2008	2009
GOA Groundfish Fishery	Retained	36	62	45	42	58
	Discarded	1065	1541	1343	577	883
	Total	1101	1603	1388	619	941
	% Retained	**3.2**	**3.9**	**3.3**	**6.8**	**6.2**
BSAI Groundfish Fishery	Retained	20	27	33	13	6
	Discarded	397	663	299	173	134
	Total	418	689	331	186	140
	% Retained	**4.9**	**3.9**	**9.9**	**7.0**	**4.4**

Recreational shark fisheries

The ADF&G manages the recreational shark fishery in State and Federal waters under the statewide Sport Shark Fishery Management Plan (5 AAC 75.012), in effect since 1998. Until 2010, the plan stipulated 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. In March 2010 the Alaska Board of Fisheries amended the plan to increase daily bag and possession limit for spiny dogfish only to five fish, with no annual limit. Demand for spiny dogfish is low and liberalization of the bag limit is not expected to result in a significant increase in harvest. 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.

Recreational harvest of all shark species combined is estimated through a mail survey of sport fishing license holders. About 917 sharks of all species were harvested by the sport fishery in state and federal waters of Southeast and Southcentral Alaska in 2008 (most recent mail survey estimate). The highest harvests were in Prince William Sound, and no sport harvest of sharks was reported in western Alaska. 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 directed recreational fishery for salmon sharks in Prince William Sound involving a small number of charter boats. Salmon sharks are also taken incidentally by halibut anglers.

Harvest of salmon sharks by guided anglers is required to be reported in mandatory charter fishing logbooks. Charter boats reported harvests of 244 sharks in 2007, 94 sharks in 2008, and 63 sharks in 2009. 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.

Commercial shark fishing in State waters

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 that 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% of the round weight of the target species on board a vessel except in the Southeast District where a vessel using longline or troll gear may retain up to 35% round weight of sharks to round weight of the target species on board (5AAC 28.174 (1) and (2)). Also 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. Since 2006 no permits have been issued.

Western Pacific Fishery Management Council (WPFMC)

The WPFMC's area of jurisdiction is the EEZ around Hawaii, American Samoa, Guam, the Northern Mariana Islands, and the Pacific Remote Islands Areas (PRIA). The NMFS Pacific Islands Regional Office in Honolulu, Hawaii, implements the fishing regulations and other management measures and policies. In the western Pacific, the conservation of sharks is governed under the provisions of the five fishery ecosystem plans, and 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 Ecosystem Plan for Western Pacific Pelagic Fisheries identifies nine sharks as management unit species (Table 2.3.7). Five species of coastal sharks are listed in the fishery ecosystem plans for American Samoa, Hawaii, the Marianas Archipelago, and the Pacific Remote Islands Areas (Table 2.3.8) as currently harvested.[10]

Table 2.3.7 Sharks in the management unit of the Fishery Ecosystem Plan for Western Pacific Pelagic Fisheries (December 2009, as amended).

Western Pacific Pelagic Fisheries FEP	
Shark Species in the Pelagic Management Unit	
Blue shark	*Prionace glauca*
Shortfin mako shark	*Isurus oxyrinchus*
Longfin mako shark	*Isurus paucus*
Oceanic whitetip 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*

The longline fisheries in the western Pacific, mostly 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. 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 2009 were down by more

[10] In 2009, the WPFMC's Crustaceans, Bottomfish & Seamount Groundfish, Precious Corals, and Coral Reef Ecosystem FMPs were replaced by fishery ecosystem plans (FEP) for American Samoa, Hawaii, the Mariana Archipelago (Guam and the Northern Mariana Islands, and the Pacific Remote Island Areas. The western Pacific Pelagics FMP was converted to the Pelagics FEP.

than 93 percent from their peak (Table 2.3.9). Landings in 2009 (preliminary data) were 146 mt; about the same as in the past eight years. 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 lands a small amount of sharks compared to Hawaii's longline fishery (Table 2.3.9). The pattern of shark landings by the American Samoa longline fishery was similar to shark landings by the Hawaii-based longline fishery. Landings increased to 13 mt in 1999, followed by a decline. The decline in shark landings by the American Samoa longline fishery is attributed to the Shark Finning Prohibition Act.

Table 2.3.8 Five coastal sharks listed as management unit species in the four western Pacific Archipelagic Fishery Ecosystem Plans for Western Pacific Fisheries. Other coastal sharks in the management unit of the FEP belonging to the families Carcharhinidae and Sphyrnidae are designated as potentially harvested coral reef taxa.

Coral Reef Ecosystems of the Western Pacific Fishery Management Plan					
Sharks Listed as Management Unit Species and Designated as Currently Harvested Coral Reef Taxa					
Common Name	*Scientific Name*	American Samoa FEP	Hawaii FEP	Marianus FEP	PRIA FEP
Grey reef shark	*Carcharhinus amblyrhynchos*	*X*	*X*	*X*	*X*
Silvertip shark	*Carcharhinus albimarginatus*	*X*	-	*X*	*X*
Galapagos shark	*Carcharhinus galapagenis*	*X*	*X*	*X*	*X*
Blacktip reef shark	*Carcharhinus melanopterus*	*X*	*X*	*X*	*X*
Whitetip reef shark	*Triaenodon obesus*	*X*	*X*	*X*	*X*

Table 2.3.9 Shark landings (in metric tons) from the Hawaii-based and American Samoa pelagic longline fisheries, 2000-2009.
Source: Pacific Islands Fisheries Science Center, Fisheries Monitoring and Analysis Program, and Western Pacific Fisheries Information Network (WPacFin).

Shark Landings (mt)											
Fishery	Species	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hawaii-based Longline Fishery	Blue shark	1,200	30	30	20	60	30	12	6	7	9
	Mako shark	80	60	80	90	70	110	95	119	109	103
	Thresher shark	100	50	50	50	60	30	33	42	39	29
	Misc. shark	70	10	20	10	10	-	11	7	4	6
	Total shark landings	**1,450**	**150**	**180**	**170**	**200**	**170**	**151**	**174**	**159**	**146**
American Samoa Longline Fishery	**Total shark landings**	**4**	**1**	**3**	**4**	**1**	**<1**	**1**	**2**	**1**	**1**

2.4 NOAA Enforcement of the Shark Finning Prohibition Act

NOAA Office for Law Enforcement (OLE) has responsibility for enforcing the Shark Finning Prohibition Act (SFPA) and its implementing regulations. During calendar year 2009, most violations of the SFPA were detected, investigated, and prosecuted in the Southeast, Alaska, and Pacific Islands Enforcement Divisions. In addition, during 2009, the United States Coast Guard (USCG) detected several violations of the Shark Finning Prohibition Act and referred them to NOAA for further disposition. Violations which were investigated included finning, the unauthorized feeding of sharks, as prohibited by the Magnuson-Stevens Fishery Conservation and Management Act, and exceeding recreational catch limits.

- In the waters off of Texas in July of 2008, personnel from the U.S. Coast Guard intercepted a commercial fishing vessel at sea. During the approach for boarding and inspection, officers observed the operator discard four shark fins over the side of the vessel. The vessel operator was cited for this offense, as well as for conducting shrimp fishing operations during a seasonal closure. The vessel's catch was seized and this matter subsequently investigated by OLE's Southeast Enforcement Division. In November 2008, the Office of General Counsel for Enforcement and Litigation (GCEL) assessed the respondent an administrative penalty in the amount of $15,000 through a Notice of Violation and Assessment (NOVA)

- While conducting patrols in Alaska during October 2008, a boarding team from the U.S. Coast Guard Cutter ACUSHNET performed a routine inspection of a commercial fishing vessel and discovered a shark fin in the fish hold; however, the shark carcass had not been retained. The shark fin was seized and the matter was investigated by the Alaska Enforcement Division of the NOAA OLE. In September of 2009, the NOAA GCEL assessed a penalty in the amount $750.

- In the Southeast during February 2009, personnel from the U.S. Coast Guard boarded a commercial fishing vessel at sea and located two shark fins and one undersized shark in the vessel's hold. The vessel operator was issued a Summary Settlement citation in the amount of for $1750 for shark finning and for improper Turtle Excluder Device spacing in the fishing nets.

- In the Southeast Division, personnel from the USCG boarded a commercial fishing vessel at sea. During the boarding and inspection, three shark fins were located in the vessel's hold. The vessel operator was issued a Summary Settlement citation in the amount of $100 for shark finning.

- In June 2009, personnel from the USCG boarded a commercial fishing vessel at sea. During the boarding, 24 shark fins were located in the vessel's hold. The vessel operator was issued a Summary Settlement for $600 for shark finning.

- During May 2009, officers from the Florida Fish and Wildlife Commission boarded a commercial fishing vessel at sea. During the boarding, 89 shark fins without associated shark carcasses were located onboard the vessel. The vessel's catch was seized and the case is under review by GCEL.

- On June 12, 2009, defendant Mark Harrison plead guilty in U.S. District Court in Atlanta to violating the Lacey Act for illegally dealing in shark fins and not reporting their landing as required by law. According to the charges and other information presented in court, Harrison allegedly represented himself to be the nation's largest shark fin buyer, purchasing "millions" of shark fins since he had been in business, beginning in 1989. On August 19, 2009, Harrison was sentenced in U.S. District Court to a probationary term of five years, ordered to pay a fine of $5,000, and was required to perform 150 hours of community service. Harrison was also ordered to take out an advertisement in a publication of wide circulation within the fishing industry regarding compliance with shark fin reporting requirements. His corporation, Harrison International, was also fined $5,000 and was placed on probation for five years.

- In November 2009, a Special Agent from OLE's Alaska Division and Alaska State Troopers, boarded and inspected a Kodiak-based fishing vessel. During the boarding, the special agent observed a Salmon Shark tail fin on the vessel; however the carcass had not been retained. The NOAA special agent explained the requirements of the SFPA and gave a warning to the vessel operator. The tail fin was seized as contraband.

- In April of 2009, the U.S. Coast Guard was conducting a routine patrol when they encountered a commercial fishing vessel returning to port in Honolulu. A subsequent inspection of the Hawaii-based pelagic longline vessel revealed a bag of 17 shark fins without the corresponding carcasses. NOAA special agents in Hawaii responded and conducted an investigation. Subsequently, GCEL issued a NOVA to the owners in the amount of $7,500.

While we have taken enforcement action as appropriate for violations of the shark finning prohibitions, we take this opportunity to note the disparity between the enforcement scheme under the Magnuson-Stevens Act, as amended by the SFPA, and most other U.S. environmental statutes. Most of our nation's major environmental statutes empower the United States, in the event of a violation, (1) to bring an administrative action for penalties, (2) to file in federal court a civil action seeking penalties and appropriate injunctive relief, or (3) in the most egregious cases, to file in federal court a criminal action seeking criminal sanctions.

For most violations, however, including those related to shark finning, the Magnuson-Stevens Act only authorizes the United States to bring civil administrative actions for penalties or permit sanctions. The absence of the full range of enforcement options in the Magnuson-Stevens Act makes it more difficult for the United States to address shark finning violations of varying degrees of severity through similarly varying degrees of sanctions, including the possibility of criminal prosecution.

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 entities have:

1. Developed training tools and programs in elasmobranch identification (such as identification posters and color guidebooks). For example, the 2006 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 ASMFC Interstate Coastal Shark FMP now requires that all state shark dealers must obtain a Federal shark dealer permit and therefore must attend the Atlantic Shark Identification Workshop. The objective of these workshops is to reduce the number of unknown and improperly identified sharks reported on 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:
   - Staff from NMFS NEFSC attend Northeast U.S. recreational shark fishing tournaments captains meetings to inform participants on current shark management

regulations and discuss and answer questions on current research. Tags, tagging information, length and weight conversions, identification guides and placards, research results, as well as management and regulation pamphlets are made available to the fishing public. Feedback is given to tournament officials on historic tournament landings to apply further shark conservation measures and to facilitate better catch and release practices and encourage catch and release prizes.

- Dr. Lisa Natanson, staff at NMFS NEFSC was recently shown in episodes of the Discovery Channel series 'Swords: Life on the Line'. These episodes highlighted Dr. Natanson's pelagic shark nursery ground research, movements, and abundance studies in conjunction with the U.S. high seas commercial longline fleet. This collaborative work offers a unique opportunity to sample and tag blue sharks (*Prionace glauca*) and shortfin makos (*Isurus oxyrinchus*) in a potential nursery area on the Grand Banks, to collect length-frequency data and biological samples, and to conduct conventional and electronic tagging of these species.
- 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. In addition, in 2008, in conjunction with Amendment 2 to the Consolidated HMS FMP, and in 2009 in conjunction with Amendment 3 to the Consolidated HMS FMP, NMFS developed and distributed recreational placards that show recreational fishermen which Atlantic sharks could be legally retained.
- Also, staff from NMFS' Southwest Region Sustainable Fisheries Division appeared as an in-studio guest on the popular Southern California fishing radio show "Lets Talk Hook-up" to discuss and answer questions 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 addition, the NMFS Southwest Region Sustainable Fisheries Division, Southwest Fisheries Science Center, and the Pfleger Institute of Environmental Research sponsored three informational thresher shark seminar series in Southern California during 2009. The primary goal of the seminars was 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. An outreach brochure developed in 2008 (see figure 2.5.1) was distributed at the seminars and at various fishing shows in 2009 (e.g., at the Fred Hall Fishing and Tackle Shows in Long Beach and Del Mar, California, which annually attracts in excess of 50,000 participants).
- Dr. Michael Musyl, staff at NMFS Pacific Island Fisheries Science Center (PIFSC), was recently highlighted on an episode of *Pacific Expeditions* television series on the VS network where he was filmed placing electronic tags on blue marlin in the Marshall Island in February 2009. On the episode, Dr. Musyl discussed his overall research which includes documenting the excellent post-release survival rate of marlins (virtually 100%) and pelagic sharks (>95%) released from sports fishing gear and longline gear, respectively. Dr. Musyl and colleagues from PIFSC also annually present results on their research activities on pelagic fishes and sharks to the Hawaiian International Billfish Symposium.

- The United States has worked cooperatively with Governments in the Eastern Pacific Ocean (EPO) to hold a series of regional workshops aimed at improving shark conservation and management efforts in the EPO. Two workshops occurred in 2008, one in Ecuador and the other in Mexico. A third workshop is planned for 2010 in Ecuador. See section 4.2 for more information on this effort.

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.
    - As part of the joint relationship between NMFS and the Shelby Center for Ecosystem based Management in Dauphin Island, Alabama, three scientists from the Southeast Fisheries Center taught a 2-week summer course on the biology of sharks for the second year in a row. The course is open to upper level undergraduates from a number of Alabama Universities. The course is a comprehensive, interdisciplinary introduction to the evolution, biology, ecology, and conservation of elasmobranch fishes. Subsequent focus is considered from both an organismal (form and function), and an ecological (population dynamics, their habitats and interactions with each other and their environment) perspective. The impact of fisheries on elasmobranchs from a population and conservation standpoint is also considered. The course consists of lectures, laboratories, and field trips.

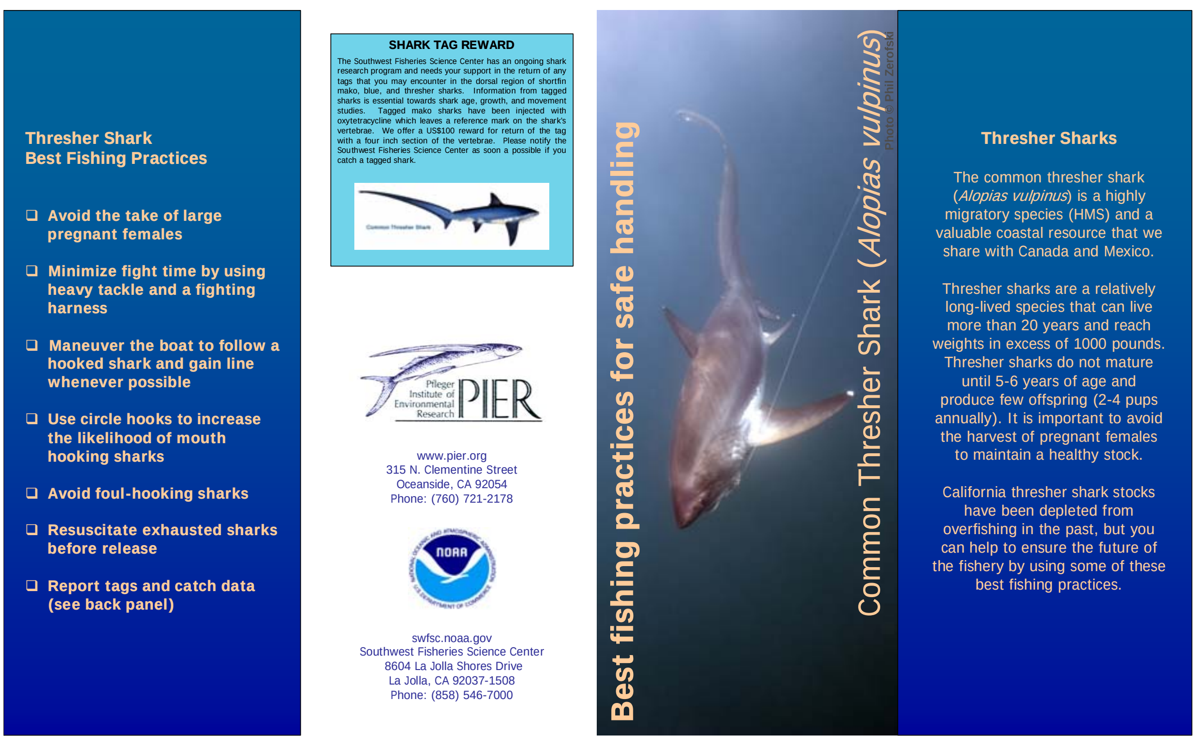

Fig. 2.5.1. Page 1 of informational brochure on best fishing practices for safe release of common thresher shark captured in the southern California recreational fishery.

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. Current regulatory measures in this fishery include time/area closures to protect near shore shark pupping and nursery grounds and HMS bycatch limits (including sharks) for selected non-HMS gears. In addition, a Pacific Leatherback Conservation Area was established in 2001 that closed off a substantial portion of the historic U.S. West Coast Swordfish/Thresher Shark Drift Gillnet fishing grounds (north of Point Conception to an area near the Columbia River, Oregon) during the months of August-November. 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 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 Consolidated HMS FMP targets tunas, swordfish, sharks, and billfish; and 2) the West Coast HMS FMP mainly targets tuna, swordfish, 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 Consolidated HMS FMP, the capacity problem seems to be most serious in the fleets that fish large coastal sharks. The West Coast HMS FMP has relatively low overcapacity in the shark fisheries and declining levels of capacity in the swordfish and thresher shark large mesh drift gill net fishery along with stabilized or slightly declining albacore and coastal purse seine 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 finalized a rule on June 24, 2008 (73 FR 35778, corrected on July 15, 2008, 73 FR 40658), amending the Consolidated Atlantic HMS FMP as discussed previously in Section 2.2.

The North Pacific Fishery Management Council (NPFMC) has adopted multiple programs aimed at reducing overall fishing capacity; including implementing a licensing program to limit access to the Pacific cod fishery in the Gulf of Alaska (GOA), removing groundfish trawl licenses that had not been in recent use, implementing four exclusive quota programs, and implementing vessel buyback programs in the Bering Sea and Aleutian Islands (BSAI) crab fisheries and the longline catcher processor subsector of the BSAI non-pollock groundfish fishery.

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. In recent years, exports of shark fins exceed imports in both weight and value. The total weight and value of imports remained steady or increased every year between 2005 and 2008, but dropped by more than 25% in 2009. Conversely, the total weight of exports showed a large increase in 2009 after three years of decreases.

3.1 U.S. Imports of Shark Fins

During 2009, imports of shark fins entered through the following U.S. Customs and Border Protection districts: Los Angeles, New York City, San Francisco, Miami, Seattle and Portland, ME. In 2009, countries of origin (in order of importance based on quantity) were Hong Kong, China, New Zealand and Canada (Table 3.1.1). The mean value of imports per metric ton (mt) increased from $28,000/mt in 2005 to $59,000/mt in 2008 with a decrease to $46,000/mt in 2009. 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 2009 were sent from the United States to Hong Kong, China, Canada and Poland, with small amounts going to Panama, South Korea, Indonesia, Germany, Portugal and Egypt (Table 3.2.1). The mean value of exports per metric ton (mt) has decreased from $81,000/mt in 2006 to $49,039/mt in 2009, the lowest value since 2005 with the second largest quantity of 77 mt. Using data from Table 3.2.1, mean values of dried shark fins for all countries combined has fluctuated between $49,039/mt and $81,000/mt from 2005 to 2009.

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 of 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. Reported global imports of shark fins have fluctuated between 13,800 mt and 17,126 mt from 2004 to 2007, while the reported global exports of shark fins have fluctuated between 9,911 mt and 15,598 mt from 2004 to 2007. The level of both imports and exports was lower in 2007 than in any other year in the period 2004-2006. Hong Kong remains 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	2005		2006		2007		2008		2009	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Australia	(1)	11	0	0	1	13	0	0	0	0
Brazil	2	31	0	0	0	0	0	0	0	0
Canada	0	0	(1)	5	2	11	(1)	20	(1)	2
China	(1)	8	4	132	5	656	1	59	6	200
China, Hong Kong	7	524	16	1053	20	954	23	1522	11	706
Colombia	0	0	0	0	0	0	(1)	4	0	0
Guatemala	(1)	2	0	0	0	0	0	0	0	0
Indonesia	1	12	0	0	(1)	7	(1)	8	0	0
Japan	0	0	0	0	0	0	2	82	0	0
Mexico	0	0	(1)	4	0	0	0	0	0	0
New Zealand	0	0	1	26	0	0	1	14	3	57
Nicaragua	1	23	(1)	22	0	0	0	0	0	0
Panama	1	73	7	139	0	0	(1)	4	0	0
Peru	0	0	0	0	2	36	0	0	0	0
Philippines	16	67	0	0	0	0	0	0	0	0
South Korea	0	0	0	0	0	0	2	19	0	0
Vietnam	0	0	0	0	0	0	(1)	6	0	0
Total	**27**	**752**	**29**	**1382**	**29**	**1677**	**29**	**1738**	**21**	**966**
Mean value	**$28,000/mt**		**$48,000/mt**		**$58,000/mt**		**$59,000/mt**		**$46,000/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 (may include products of both domestic and foreign origin) and re-exports (commodities that have entered the U.S. as imports and not sold, which, at the time of re-export, are in substantially the same condition as when imported). (1) means that the weight was less than 500 kilograms.

Source: U.S. Census Bureau

Country	2005		2006		2007		2008		2009	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Australia	0	0	0	0	0	0	1	13	0	0
Canada	2	217	2	246	3	238	1	164	2	277
China	2	118	0	0	0	0	1	112	3	495
China, Hong Kong	57	3390	42	3536	32	2347	30	1531	71	2948
China,Taipei	0	0	0	0	0	0	(1)	35	0	0
Denmark	3	133	0	0	0	0	0	0	0	0
Egypt	0	0	0	0	0	0	0	0	(1)	3
Finland	0	0	0	0	1	33	0	0	0	0
Germany	0	0	3	91	0	0	0	0	(1)	3
Indonesia	0	0	0	0	0	0	0	0	(1)	5
Japan	0	0	2	35	0	0	4	204	0	0
Mexico	1	37	(1)	17	(1)	21	0	0	0	0
Netherlands	0	0	1	22	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	(1)	21
Poland	0	0	0	0	0	0	0	0	1	15
Portugal	(1)	3	0	0	(1)	3	0	0	0	3
South Korea	0	0	0	0	0	0	0	0	0	6
Total	**65**	**3898**	**49**	**3945**	**36**	**2642**	**37**	**2059**	**77**	**3776**
Mean value	**$60,000/mt**		**$81,000/mt**		**$73,000/mt**		**$56,000/mt**		**$49,000/mt**	

Table 3.3.1 Weight and value of shark fins imported by countries other than the United States.
Note: (1) means that the weight was less than 500 kilograms.
Source: Food and Agriculture Organization of the United Nations, FishStat database, www.fao.org

Country	2004		2005		2006		2007		2008	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Australia	0	0	9	1,056	7	891	11	1182	7	1351
Brazil	4	20	2	8	0	0	0	0	0	0
Brunei Darussalam	2	3	0	0	0	0	0	0	0	0
Cambodia	0	0	1	12	4	186	1	38	0	0
Canada	69	5,134	112	5,261	110	5,480	94	4,994	118	6,508
Chile	(1)	11	0	0	0	0	0	0	0	0
China	4,776	27,523	3,338	17,758	2,662	13,882	2,542	11,991	2,005	10,777
China, Hong Kong	11,040	329,778	10,348	306,968	9,363	253,427	10,183	276,302	9,950	287,510
China, Macao	96	2,831	120	3,324	106	3,728	118	5,306	122	5,911
China, Taipei	525	4,052	434	4,658	708	4,141	564	6,223	792	8,710
Djibouti	0	0	(1)	15	0	0	0	0	0	0
India	0	0	2	8	0	0	0	0	0	0
Indonesia	193	2,407	332	2,486	293	1,274	84	366	220	1,515
Laos	0	0	(1)	5	(1)	6	0	0	0	0
Malaysia	293	480	93	311	145	585	163	653	0	0
Maldives	(1)	1	0	0	0	0	0	0	0	0
North Korea	1	268	1	331	2	1,222	2	1,084	1	579
Peru	1	4	1	4	8	52	2	12	28	141
Singapore	566	25,524	437	20,673	489	23,434	446	20,638	396	22,632
South Korea	5	268	2	109	6	157	2	82	4	167
Thailand	121	1,256	113	1,317	102	1,141	82	877	66	748
United Arab Emirates	0	0	0	0	(1)	15	0	0	0	0
Total	**17,692**	**399,560**	**15,345**	**364,304**	**14,005**	**309,621**	**14,294**	**329,748**	**13,709**	**346,549**
Mean value	**$22,584/mt**		**$23,741/mt**		**$22,108/mt**		**$23,069/mt**		**$25,279/mt**	

Table 3.3.2 Weight and value of shark fins exported by countries other than the United States.
Note: Data are for "total exports," which is a combination of domestic exports (may include products of both domestic and foreign origin) and re-exports (commodities that have entered into a country as imports and not sold, which, at the time of re-export, are in substantially the same conditions as when imported). (1) means that the weight < 500 kg.
Source: Food and Agriculture Organization of the United Nations, FishStat database, www.fao.org

Country	2004		2005		2006		2007		2008	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Angola	5	249	4	265	4	224	3	179	2	149
Argentina	4	133	9	504	9	656	11	503	99	3,019
Bahrain	0	0	0	0	0	0	0	0	(1)	9
Bangladesh	166	689	0	0	195	623	351	1,407	17	403
Brazil	179	2,405	157	2,292	118	1,894	131	2,313	113	2,825
Brunei Darussalam	0	0	12	82	0	0	4	21	0	0
Burma	0	0	2	23	0	0	0	0	0	0
Cambodia	0	0	(1)	5	0	0	0	0	0	0
Chile	54	2,474	39	1,639	13	570	4	158	0	0
China	2,476	40,966	1,349	20,753	381	5,306	409	6,712	347	5,898
China, Hong Kong	8,560	138,005	7,134	127,102	5,962	103,818	5,670	97,074	5,294	100,877
China, Macao	0	0	0	0	29	800	23	711	7	410
China, Taipei	1,241	4,259	1,141	8,875	974	9,514	903	8,082	846	7,910
Colombia	17	1,130	14	1,034	17	1,132	19	1,146	16	1,074
Congo, Dem. Rep. of the	0	0	1	53	(1)	20	0	0	(1)	10
Congo, Republic of	14	430	18	848	10	246	10	314	15	509
Costa Rica	6	123	0	0	0	0	10	69	0	0
Côte d'Ivoire	(1)	1	0	0	0	0	0	0	0	0
Djibouti	0	0	0	0	2	47	0	0	0	0
Ecuador	102	2,243	(1)	8	1	5	12	257	124	2,526
Gabon	0	0	0	0	0	0	5	298	20	470
Guinea	(1)	4	47	2,163	47	1,872	35	1,613	0	0
Guinea-Bissau	0	0	3	110	0	0	5	276	0	0
India	218	4,513	104	3,663	145	5,037	96	3,879	95	7,496
Indonesia	943	10,936	1,554	8,065	1,073	9,174	801	7,303	1,320	7,047
Iran	0	0	0	0	0	0	(1)	2	(1)	14
Japan	205	10,262	168	8,140	181	9,091	197	8,735	163	8,457
Kiribati	(1)	25	1	70	1	111	1	69	(1)	30
Kuwait	0	0	0	0	(1)	9	1	91	2	78

Table 3.3.2 Continued

Country	2004		2005		2006		2007		2008	
	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)	Metric ton	Value ($1000)
Liberia	0	0	3	296	3	271	3	253	4	310
Libya	1	27	1	59	1	52	0	0	0	0
Malaysia	463	565	37	196	50	239	107	554	0	0
Maldives	57	647	43	598	16	192	15	107	9	70
Marshall Islands	1	52	0	0	0	0	55	825	17	305
Nigeria	0	0	1	25	0	0	0	0	0	0
Panama	103	3,860	97	3,544	78	2,600	66	4,836	61	2,615
Papua New Guinea	12	271	9	652	10	495	17	1,412	17	1,526
Philippines	54	411	0	0	0	0	77	948	38	130
Saint Pierre & Miquelon	0	0	0	0	0	0	2	10	0	0
Saudi Arabia	0	0	0	0	0	0	0	0	5	122
Senegal	72	2,537	2	8	48	2,678	2	14	0	0
Seychelles	5	33	7	56	6	67	9	86	2	29
Singapore	453	25,965	333	17,253	410	21,394	374	20,296	380	22,703
Solomon Islands	0	0	0	0	0	0	0	0	3	78
Somalia	0	0	0	0	0	0	(1)	3	0	0
South Korea	5	293	7	357	9	438	7	224	16	610
Suriname	6	218	7	312	8	487	4	260	4	243
Thailand	29	1,036	44	1,916	18	772	74	763	20	866
Togo	0	0	0	0	24	207	0	0	25	193
Tonga	0	0	0	0	0	0	0	0	8	470
United Arab Emirates	468	10,149	539	14,381	427	13,592	472	13,965	515	16,220
Uruguay	38	977	39	570	27	509	21	324	22	335
Vanuatu	0	0	0	0	0	0	0	0	40	179
Venezuela	40	874	20	351	7	21	2	21	0	0
Yemen	156	5,434	179	5,846	284	8,442	351	11,333	228	10,760
Total	**16,153**	**272,196**	**13,125**	**232,114**	**10,588**	**202,605**	**10,359**	**197,446**	**9,894**	**206,975**
Mean value	**$16,851/mt**		**$17,685/mt**		**$19,764/mt**		**$19,922/mt**		**$20,919/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	2004	2005	2006	2007	2008
Bangladesh	4	1	4	0	17
Brazil	179	157	118	131	226
China, Hong Kong SAR	NA	NA	NA	NA	NA
China, Taipei	134	137	117	36	89
Ecuador	59	NA	1	12	124
El Salvador	136	149	194	44	40
Fiji Islands	175	160	160	0	0
Guyana	82	151	123	125	131
India	827	1,926	270	172	1,232
Indonesia	943	1,554	1,073	1,360	1,320
Korea, Republic of	5	7	33	7	16
Madagascar	NA	NA	NA	NA	NA
Maldives	20	13	11	11	9
Pakistan	68	81	62	69	78
Philippines	54	84	71	78	38
Senegal	33	34	27	16	22
Singapore	246	320	120	170	260
Sri Lanka	110	80	80	80	50
Uruguay	35	43	0	7	25
Yemen	156	179	284	351	228
TOTAL (mt)	**3,266**	**5,076**	**2,748**	**2,669**	**3,905**

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 ongoing consultations regarding the development of international agreements consistent with the Act. Discussions have focused on possible bilateral, multilateral, and regional work 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

NMFS has participated in bilateral discussions with a number of entities (including Canada, Chile, Colombia, Japan, Taiwan, Uruguay, and the European Union), which included issues relating to international shark conservation and management. 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 International Plan of Action (IPOA) for the Conservation and Management of Sharks by finalizing and implementing their own National Plans of Action.

4.2 Regional Efforts

The U.S. Government continues to work within regional fishery management organizations (RFMOs) and other regional entities to facilitate shark research, data collection, monitoring, and management initiatives, as appropriate. In recent years, the United States has successfully led efforts to ban shark finning and implement shark conservation and management measures within a number of such organizations. Table 4.2.1 lists RFMOs and regional/multilateral programs in which the United States has worked to address shark conservation and management. Of the list in Table 4.2.1, ICCAT, NAFO, WCPFC, and the IATTC have adopted finning prohibitions. Other RFMOs the United States is not a Party to also have adopted finning prohibitions, such as

IOTC, GFCM, SEAFO, and NEAFC. Further activities or planning of the RFMOS that the U.S. is a Party to 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)
• Indian Ocean Tuna Commission (IOTC)
• International Council for the Exploration of the Sea (ICES)
• Asia Pacific Economic Cooperation Forum and the Convention on Migratory Species (APEC)
• South East Atlantic Fisheries Organization (SEAFO)
• General Fisheries Commission for the Mediterranean (GFCM)
• North East Atlantic Fisheries Commission (NEAFC)
• Commission for the Conservation of Southern Bluefin Tuna (CCSBT)
• 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

North Atlantic Fisheries Organization (NAFO)

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 and subsequently set at the same level for 2009. 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.-Japan 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. 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 November 2009, the IATTC convened a shark stock assessment workshop to discuss technical aspects of scientific models that might be used for stock assessments of shark species. Several current shark stock assessments were also reviewed, including an assessment of eastern Pacific Ocean silky sharks that is under development by the IATTC. An IATTC technical meeting on sharks is planned for August 30, 2010 in La Jolla, CA. Sessions are planned to promote discussions on stock assessment methods, life-history studies, fishery data from national and regional programs, bycatch mitigation methods, and data collection standardization.

International Commission for the Conservation of Atlantic Tunas (ICCAT)

New assessments of shortfin mako and blue sharks were completed in 2008 by the Standing Committee on Research and Statistics (SCRS). The assessment findings, characterized by high levels of uncertainty due to data limitations, indicated that blue sharks in the North and South Atlantic are not overfished and overfishing is not occurring. Separate assessments were conducted for North and South Atlantic shortfin mako sharks. With respect to North Atlantic shortfin mako sharks, assessment results indicated that there is a non-negligible probability that this stock could be below the biomass that could support MSY and above the fishing mortality rate associated with MSY. Recent biological data show decreased productivity for this species. Therefore, given the results of this assessment, NMFS has determined that North Atlantic shortfin mako is not overfished, but is approaching an overfished status and is experiencing overfishing. The status of South Atlantic shortfin mako sharks remains unknown as the SCRS was unable to obtain plausible estimates of stock abundance.

In 2008, the SCRS also conducted productivity-susceptibility analyses (ecological risk assessments) for ten shark species and one stingray species based on biological productivity and potential susceptibility to ICCAT longline fisheries. The results of these analyses indicated that most Atlantic pelagic sharks have exceptionally limited biological productivity and can be overfished even at very low levels of fishing mortality. Bigeye thresher, longfin mako, and shortfin mako sharks have the highest biological vulnerability of the shark species examined. The SCRS asserted that all species considered in the ecological risk assessments are in need of improved biological data to evaluate biological productivity more accurately. The SCRS recommended that precautionary measures be considered for shark stocks with the greatest biological vulnerability and for which there is limited data and that management measures be species-specific whenever possible.

At ICCAT's 2008 annual meeting, several shark-related proposals were presented and two were adopted. The first proposal called for ICCAT and the International Council for the Exploration of the Sea (ICES) to coordinate the assessment of porbeagle sharks, which occurred in June 2009, in Copenhagen, Denmark (see below). The measure also contemplated that a meeting of concerned RFMO Chairs be convened just after the joint assessment to consider compatible management measures for the species. At the time of this writing, this meeting had not yet been scheduled. The second measure adopted by ICCAT in 2008 requires the release of bigeye thresher sharks caught in association with fisheries managed by ICCAT and that are still alive when brought to the vessel, as well as the recording and reporting to ICCAT of incidental catches and live releases of this species.

In 2009, the United States went to ICCAT seeking a reduction of mortality of North Atlantic shortfin mako sharks. While a U.S. proposal to cap shortfin mako landings from pelagic longline vessels received broad support, it did not achieve consensus. Some parties wanted to exempt mako sharks taken as bycatch despite the fact that bycatch is the primary cause of mortality on this species. No management measures were adopted for shortfin mako at the 2009 ICCAT meeting, but the matter is being discussed intersessionally by interested parties and is expected to be considered at the 2010 ICCAT meeting.

Belize, Brazil and the United States submitted a proposal to require that all sharks be landed with their fins naturally attached. There was support for this proposal from several ICCAT members but consensus on the proposal could not be reached, as some parties noted such a significant change in management required additional research. The issue is being discussed intersessionally and is expected to be reconsidered at ICCAT's 2010 annual meeting.

The SCRS and ICES conducted a joint assessment of porbeagle shark in 2009. Four stocks were considered for assessment: northwest, northeast, southwest, and southeast Atlantic. Assessments found that porbeagle sharks in the northwest Atlantic are overfished, but that overfishing is not occurring. Despite the improving status of the stock, the Canadian assessment projected that stock rebuilding will take decades due to the low productivity of this stock. No conclusions on the status of the two south Atlantic stocks could be drawn due to data limitations. While the conclusions for the northeast Atlantic stock were also characterized by uncertainty due to data limitations, it was estimated that the stock was overfished and that overfishing was occurring or close to occurring. It was predicted that stock recovery would take between 15 and 34 years under a no fishing scenario. Canada and the EU submitted a porbeagle proposal for the Northeast Atlantic and Northwest Atlantic stocks at ICCAT's 2009 annual meeting. Several ICCAT parties, including the United States, expressed concerns that the measures in the proposal were not in line with scientific advice and that porbeagle measures should be coordinated with other relevant RFMOs. Consensus on the porbeagle proposal was not achieved at ICCAT's 2009 annual meeting.

ICCAT did adopt a recommendation prohibiting retention of bigeye thresher sharks in all fisheries with the exception of a small-scale Mexican coastal fishery, which is allowed to retain 110 bigeye thresher sharks. The original EU proposal would also have prohibited the retention of other thresher shark species (genus *Alopias spp*) but consensus on the broader proposal could not be reached. The final agreement, however, does include a requirement to submit catch and effort data for *Alopias* species other than bigeye thresher. It also mandates that the number of discards and releases of bigeye threshers be recorded with the indication of status (dead or alive) and reported to ICCAT. The 2009 measure replaced the bigeye thresher measure adopted in 2008.

Western and Central Pacific Fisheries Commission (WCPFC)

At its 5th Regular Session in December 2008, the Parties to WCPFC adopted a U.S. proposal to modify and strengthen a 2006 measure for the conservation and management of sharks. The revised measure applies to all vessels regardless of size or gear type. Commission Members, Cooperating non-Members, and participating Territories (CMMs) must report annually regarding their retention and discards of total shark catches as well as their annual catch and effort by gear type for key shark species. The 2008 measure identified blue shark, oceanic whitetip shark, mako shark, and thresher shark as key species. At the annual meeting in December 2009, the Commission amended the 2008 measure to include silky shark on the list of key species. The Commission tasked the 6th regular meeting of the WCPFC Science Committee to consider whether porbeagle and hammerhead sharks should be added to the list of key shark species.

At the 5th Regular Meeting of the WCPFC Northern Committee acknowledged the importance of shark issues and an intention to study northern shark species and report to the Commission in future.

Joint Meeting of Tuna Regional Fisheries Management Organizations

The European Community organized and hosted the Second Joint Meeting of Tuna RFMOs from June 29 to July 3, 2009 in San Sebastian, Spain. The Participants of the Second Joint Tuna RFMOs Meeting agreed to call on RFMOs, consistent with the FAO IPOA-Sharks, to establish precautionary, science-based conservation and management measures for sharks taken in fisheries within the convention areas of each tuna RFMO, including as appropriate:

- Measures to improve the enforcement of existing finning bans;
- Prohibitions on retention of particularly vulnerable or depleted shark species, based on advice from scientists and experts;
- Concrete management measures in line with best available scientific advice with priority given to overfished populations;
- Precautionary fishing controls on a provisional basis for shark species for which there is no scientific advice; and
- Measures to improve the provision of data on sharks in all fisheries and by all gears.

Eastern Pacific Ocean (EPO) Regional Workshops

The United States has worked cooperatively with Governments in the Eastern Pacific Ocean to hold a series of regional workshops aimed at improving shark conservation and management efforts in the EPO. The first workshop was held in Manta, Ecuador, July 9-11, 2008, and was co-hosted by the United States, Ecuador, and IUCN. National attendance was strong with representatives from nearly every country along the Eastern Pacific including Mexico, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Peru, and Chile. The workshop brought together a broad swath of stakeholders including commercial and artisanal fishermen, fisheries managers, scientists, (NGO's) and policymakers. As a result, a lively interactive discussion identified gaps and opportunities for capacity building and began a dialogue on developing regional cooperative measures for conserving and sustaining shark stocks in the Eastern Pacific. Presentations reviewed each country's National Plan of Action for shark conservation (NPOA), import/export trends in the shark fin trade, national laws prohibiting finning, and the latest science and forensic techniques used to identify species populations and enforce wildlife trafficking laws.

On December 3-5, 2008, the Government of Mexico hosted in Mazatlan, Mexico, the second workshop. It was organized by Mexico's National Commission of Fisheries and Aquaculture (CONAPESCA) with support from the International Union for the Conservation of Nature (IUCN), and the U.S. Government. The Mazatlan workshop continued the dialogue undertaken in Ecuador to identify gaps and sampling needs along with assessing opportunities for capacity building efforts to conserve and sustain shark stocks in the EPO. The theme of the Mazatlan workshop focused on identifying what data exist and what data still need to be collected in order to develop some rudimentary stock assessment estimates for several key shark species including: silky shark *Carcharhinus falciformis*, scalloped hammerhead shark *Sphyrna lewini,* shortfin mako shark *Isurus oxyrinchus*, pelagic thresher shark *Alopias pelagicus*, and blue shark *Prionace* *glauca*. The workshop also addressed the production of a regional shark guide for the Eastern Pacific in order to facilitate shark stock assessments.

The workshop also included a session for administrators, government representatives and regional fisheries organizations to discuss regional cooperation in shark management and conservation. The objective was to define regional activities that would be consistent with the FAO's International Plan of Action for Conservation and Management of Sharks (IPOA-SHARKS). Participants concluded that there was a need to establish a mechanism to strengthen regional cooperation in both the short-term and the long-term. Priority themes for cooperation include research, development of human resources, regulations and an exchange of technology and experience. Long-term activities include the development of a proposal to be presented to international donors that would provide funds for the themes described above. A third workshop is scheduled to take place in 2010 in Manta, Ecuador.

4.3 Multilateral Efforts

The U.S. Government continued work within other multilateral fora to facilitate shark research, data collection, 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 four 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)
• Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Convention on International Trade in Endangered Species of Wild Fauna and Flora (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 CITES Resolution Conf. 12.6 on conservation and management of sharks, the Animals Committee is directed to examine information provided by range states in shark assessment reports and other available relevant documents, with a view to identify key species and examine these for consideration and possible listing under CITES. The Animals Committee made species-specific recommendations at the 13th and 14th meetings of the Conference of the Parties for improving the conservation status of sharks and the regulation of international trade in these species. Decision 14.107 states that the Animals Committee shall continue these activities, including collaborating with FAO to refine the list of shark species of concern. The United States led an intersessional group on the implementation of Decision 14.107 and presented a paper for discussion at the 24th Animals Committee, which included progress on previous recommendations and prioritized future actions for species of concern. The working group identified shark species whose status is affected by poor fisheries management and trade, which were also identified by a 2008 FAO workshop as priority species for monitoring fisheries and trade. The Working Group recommended Parties improve data collection, management and conservation, which could be implemented, enhanced and enforced through domestic, bilateral, Regional Fisheries Management Organizations (RFMO), or other international measures. The Shark Working Group also discussed document AC24 Doc. 14.2, the interim draft report of the freshwater stingray workshop and recommended Range States take note of the workshop's findings and conclusions, and increase their efforts to improve data collection on the scale and impact of the threats facing stingray species and populations from collection for ornamental trade, commercial fisheries for food, and habitat damage. The Shark Working Group also recommended continued research to improve understanding of the situation and identify the linkages between international trade in shark fins and meat, and IUU fishing. In 2010, CITES will convene the 15th Conference of the Parties, where additional species can be proposed for listing on Appendix I, II and/or III. The US developed proposals to add the oceanic whitetip shark, *Carcharhinus longimanus*, and scalloped hammerhead shark, *Sphyrna lewini* and look-alike species to Appendix II.

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: Argentina, Australia, Canada, Ecuador, Japan, Malaysia, Mexico, Seychelles, Taiwan, the United Kingdom, the United States, and Uruguay.

FAO convened an Ad Hoc Expert Panel in December 2009 to assess proposals to amend Appendices I and II of CITES concerning commercially-exploited aquatic species (FAO 2004;

2007). The Panel was convened in response to an agreement by the twenty-fifth and twenty-sixth sessions of the FAO Committee on Fisheries (COFI) that FAO should convene panels to review any proposals to CITES Conferences of Parties for listing or de-listing commercially-exploited marine `species. The Terms of Reference for the ad hoc expert advisory panels for assessment of proposals were elaborated by the twenty-fifth session of COFI in 2003. The objective of the Panel was to assess proposals from a scientific perspective in accordance with the CITES listing criteria and recent recommendations from FAO to CITES on the criteria, and to comment on biological, ecological, trade and management issues raised by the proposals, as well as the likely effectiveness for conservation. A representative from NOAA Fisheries Service attended this workshop and presented the US CITES proposals to add the oceanic whitetip shark, *Carcharhinus longimanus*, and scalloped hammerhead shark, *Sphyrna lewini*, to Appendix II.

United Nations General Assembly (UNGA)

In December 2005, the UNGA adopted by consensus a resolution on "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, recognized the importance and vulnerability of sharks and the need for measures to promote long-term sustainability of shark populations and fisheries. It confirmed the role of relevant regional and subregional fisheries management organizations and arrangements in the conservation and management of sharks and encouraged the implementation of the FAO IPOA for the Conservation and Management of Sharks. It further encouraged 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 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."*

Further, the 2009 resolution called upon RFMOs with the competence to regulate highly migratory species, "*to strengthen or establish precautionary, science-based conservation and management measures, as appropriate, for sharks taken in fisheries within their convention areas consistent with the International Plan of Action for the Conservation and Management of*

Sharks, taking into account the Course of Actions adopted at the second joint meeting of tuna regional fisheries management organizations and arrangements, held in San Sebastian, Spain, from 29 June to 3 July 2009" (see section 4.2).

The United States intends to build on the success achieved at the UNGA by promoting shark conservation in other appropriate multilateral fora.

Convention on the Conservation of Migratory Species of Wild Animals (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, including a possible new global shark instrument.

Conference of the Parties
CMS convened the Ninth Meeting of the Conference of the Parties (COP) to the Convention from 1-5 December 2008 in Rome, Italy. Two representatives from NOAA attended the COP under Observer status. The COP considered proposals for listing four new shark species under Appendix II of CMS. Migratory species that have an unfavorable conservation status or would benefit significantly from international cooperation are listed in Appendix II to the Convention. Further, CMS encourages State parties to conclude global or regional instruments for the listed species. The European Commission put forward proposals for the inclusion of *Squalus acanthias* (spiny dogfish) and *Lamna nasus* (porbeagle shark) and Croatia put forward proposals for the inclusion of *Isurus oxyrinchus* and *Isurus paucus* (longfin and shortfin mako sharks). Since the United States is not party to CMS, we are not able to vote in favor or against listing any new species under the Convention, however, we were able to participate in the discussions under our Observer status at the meeting. These proposals were intensely debated due to many Southern Hemisphere countries opposing the listings based on the premise that southern populations of the stocks being proposed were in better shape than northern populations. The COP agreed to list longfin and shortfin mako sharks, porbeagle shark, and Northern Hemisphere populations of spiny dogfish on Appendix II. Since we are not party to CMS, the listings do not have any direct impact on the United States, except that these listings will have implications on the species considered for listing under the new global shark instrument currently under negotiation and, which to date, had only tentatively agreed to focus on the previously listed species of whale sharks, basking shark, and great white shark.

Intergovernmental Meeting for a New Global Shark Instrument
Following on from the first intergovernmental meeting held in December 2007 to identify and elaborate on an option for international cooperation on conserving migratory sharks under CMS, the CMS Secretariat convened the second meeting on International Cooperation on Migratory Sharks (SHARKS II) from 6-8 December 2008, directly following the COP. The meeting participants discussed a range of options for a potential CMS instrument, including the type of instrument desired, the species to be covered, the desired geographical scope and issues that should be addressed in an associated plan of action.

Regarding the type of instrument desired, participants centered their discussions around two drafts texts, one of a legally binding instrument or Agreement (Agreement) and one of a non-legally binding instrument or Memorandum of Understanding (MOU), prepared by the CMS Secretariat, in consultation with an Intersessional Steering Group on Migratory Sharks (ISGMS), on which NOAA participated. Meeting participants agreed to develop a non-legally binding MOU that would be global in scope. The MOU will have a Plan of Action that sets out activities that the signatories will progressively strive to undertake in relation to sharks, and assign priority to these activities.

Among the meeting's most contentious issues was species to be covered by the MOU. The discussion centered on whether to limit the scope of the MOU to the basking, great white, and whale sharks that initially triggered interest in the instrument in 2005 or to include the Northern Hemisphere populations of the spiny dogfish, porbeagle, shortfin mako, and longfin mako sharks that were recently listed on the CMS Appendix II at its 9th COP held the week prior to SHARKS II. No final decisions were made on what species would be listed initially nor a mechanism for adding additional species in the future. During the meeting, participants agreed to form an informal intersessional drafting group, led by the United States, which would work by correspondence, to further develop a draft Plan of Action.

The U.S. approach at SHARKS II meeting was to explore ways that CMS may be able to add value to existing international efforts aimed at the conservation and management of sharks, including the FAO IPOA for the Conservation and Management of Sharks and work underway in various RFMOs. The U.S. primary areas of focus included: 1) strengthening shark management in U.S. waters; 2) working with other nations, particularly developing nations to build capacity for shark conservation and management; 3) working through RFMOs to fulfill their mandates for sharks; and 4) improve enforcement of shark finning bans. The United States also 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 Philippines offered to host SHARKS III in early 2010.

5. NOAA Research on Sharks

Large predators such as sharks are a valuable part of marine ecosystems. Many shark species are vulnerable to overfishing because they are long-lived, take many years to mature, and only have a few young at a time. In order to manage sharks sustainably, we need information on their biology and the numbers caught (either as target species or bycatch) to make sure their populations are not depleted. NMFS Science Centers are investigating shark catch, abundance, age, growth, diet, migration, fecundity, and habitat requirements. Additional research aims to identify fishing methods that minimize the incidental catch of sharks and/or maximize the survival of captured sharks after release.

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

Pacific Islands Fisheries Science Center (PIFSC)

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 (Hamm et al. 2009). 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

Biometrical research on shark bycatch issues funded by the Pelagic Fisheries Research Program (University of Hawaii) was documented in Walsh et al. (2009). This work was based on analyses of shark catch data from the Pacific Islands Regional Observer Program. The results included a detailed description of the taxonomic composition of the shark catch, as well as additional information pertinent to either the management (e.g., nominal catch rates; disposition of caught sharks; distributions of shark catches relative to those of target species) or basic biology (e.g., mean sizes; sex ratios) of the common species. The results indicated that blue shark in particular, which comprises approximately 85 percent of the shark bycatch, exhibits a high rate of survival (about 95 percent) to the time of release. On the basis of these very low minimum mortality estimates, it was concluded that this fishery has made substantial progress in reducing bycatch mortality compared to the period before the shark finning ban.

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 (CRED) since 2000.

These estimates include surveys of:

- 10 major shallow reefs in the Northwestern Hawaiian Islands (2000, 2001, 2002, 2003, 2004, 2006, 2008).
- The Main Hawaiian Islands (2005, 2006, 2008).
- 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, 2008).
- Guam, and the Commonwealth of the Northern Marianas Islands (2003, 2005, 2007, 2009), Johnston Atoll (2004, 2006, 2008), and at Wake Atoll (2005, 2007, 2009).

To date, these surveys suggest that shallow (<30m) inshore water shark populations appear to be relatively abundant at most reefs in the Northwestern Hawaiian Islands (NWHI), Pacific Remote Island Areas, and the Northern Mariana Islands, but are noticeably sparse and/or small-bodied at most reefs in the Main Hawaiian Islands (MHI), American Samoa, and the Southern Mariana Islands. CRED is currently working on a scientific article pertaining to these observations. Preliminary results were presented at the 11th International Coral Reefs Symposium in 2008.

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

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

In brief, five species of sharks are typically recorded in sufficient frequency by towed-divers to allow meaningful statistical analyses: grey reef shark (*Carcharhinus amblyrhynchos*), Galapagos shark (*Carcharhinus galapagensis*), whitetip reef shark (*Triaenodon obesus*), blacktip reef shark (*Carcharhinus melanopterus*), and tawny nurse shark (*Nebrius ferrugineus*). Analyses show a highly significant negative relationship between grey reef and Galapagos shark densities and proximity to human population centers (e.g., proxy for potential fishing pressure and other human impacts). Average combined numerical density for these two species near population centers is less than 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.

Although the CRED time series is still relatively short (<9 years), certain temporal trends in reef shark densities are starting to appear. In brief, CRED has noticed apparent declines in reef shark densities in the Northwestern Hawaiian Islands and in the Northern Mariana Islands. Possible explanations for these patterns are currently being investigated.

Shark Predation Mitigation on Hawaiian Monk Seals at French Frigate Shoals

Galapagos shark predation has become the dominant mortality source for nursing and recently weaned endangered Hawaiian monk seal pups at French Frigate Shoals (FFS), 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 (17-32 percent of the annual cohort) were documented each year from 1997 to 1999. 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 2008 (12–21 percent of the annual cohort). Sharks were removed using a combination of shore-based handline fishing, boat fishing, and hand-held harpoon. Removal attempts were unsuccessful in 2005 and 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 has increased at other sites in the atoll over time. We attribute these results in part to shark displacement away from Trig Island due to applied fishing, harassment, and deterrence efforts at Trig 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 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). For the 2009 pupping season, an expanded deterrent study is being conducted, which includes a comparison of deterrents versus increased human presence at pupping sites. Also, a remote camera system is currently in place at Trig with the aim of capturing shark activity and incidents on pups this season. Results from the 2008-2009 deterrent research will be used to determine which, if any, of these deterrent methods are effective in reducing predation levels, and to assess whether shark removals will be necessary in future years.

NOAA's Hawaiian Monk Seal Research Program is also financially and logistically supporting a shark movement research project being conducted by the Hawaiian Institute of Marine Biology. To date, 46 Galapagos and 19 tiger sharks were captured and fitted with acoustic transmitters. With 18 deployed underwater receivers, the activity of these tagged sharks are detectable around four major pupping sites within the FFS atoll, as well as deep water locations outside of the FFS breaking reef. The research will help characterize the segment of the Galapagos shark population likely involved in predation of pre-weaned monk seal pups.

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) that indicated that the blue shark stock was not being overfished. PIFSC and NRIFSF subsequently renewed this collaboration, along with scientists from 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—were found to be in general agreement even though they represent opposite ends of the spectrum in terms of data needs (Kleiber et al. 2009). The trends in abundance in the production model and all alternate runs of the integrated model show the same 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. There was an increasing trend in total effort expanded by longline fisheries toward the end of the time series, and this trend may have continued thereafter. 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 pop-up satellite archival tags (PSATs)[11] 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 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). PIFSC is finishing manuscripts detailing the movements of pelagic sharks in relation to oceanographic conditions (Musyl et al. in review). In a review paper, Bernal et al. (2009) summarizes the eco-physiology of large pelagic sharks while Sibert et al. (2009) report on the error structure of light-based geolocation estimates afforded by PSATs and Nielsen et al. (2009) show how reconstructed PSAT tracks can be optimized. A figure from Bernal et al. (2009) [Figure 5.1.1], indicates a possible vertical niche pelagic fish structure based on physiology and thermal biology.

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,

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[11] PSAT tags record measurements such as temperature, pressure (depth), and ambient light-level irradiance (some model tags also have the ability to measure salinity). At a preset time, an electronic link is activated that dissolves the tag's nosecone attachment, allowing the tag to float to the surface where it sends its broadcast of data to satellites under three conditions: (1) meets set pop-up date, (2) exceeds threshold depth (~1200-1500 m; can tell shed tag from mortality), and (3) remains stationary at a depth above the threshold depth for (usually) 4 consecutive days.

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; Wilson et al. 2007).

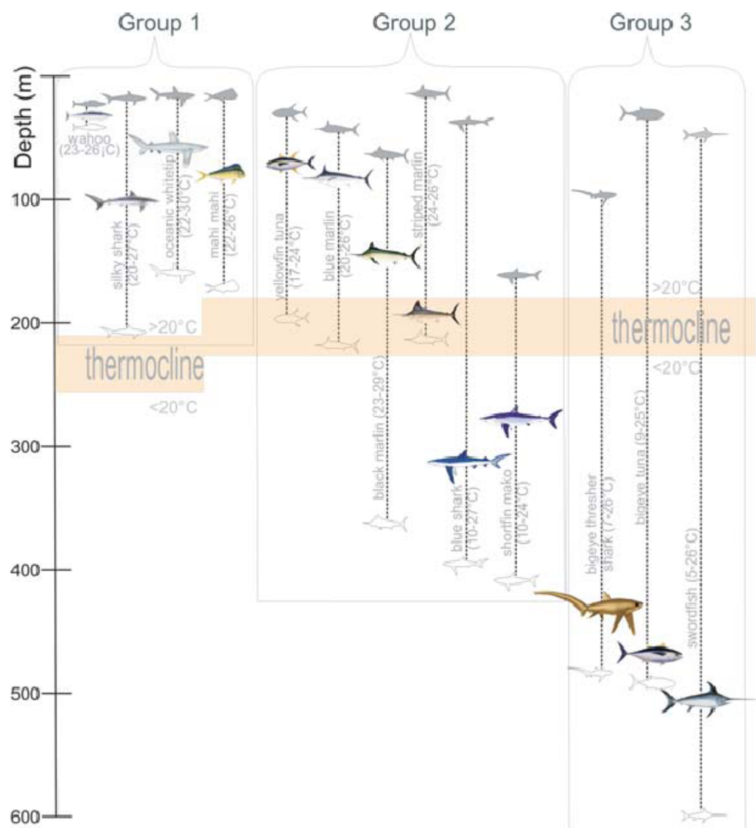

Fig. 14.1 Representative vertical movement patterns for pelagic fishes. Fish images represent the average depth (combined night and day) for each species. Gray-filled fish outlines represent the depth at which each species spent 95% of the time during the night. Open outlines represent the depth at which each species spent 95% of the time during the day. Values next to the common name show the temperature ranges encountered by each species. Orange shaded bar represents the thermocline, defined as depth range in which the water column is separated into the upper uniformed-temperature surface layer (i.e., water above 20ºC) and the cooler deeper waters (i.e., below 20ºC). Group 1: Fishes that spend the majority of their time in the upper uniformed-temperature surface layer. Group 2: Fishes that undertake short excursions below the thermocline. Group 3: Fishes that make frequent excursions below the thermocline. Fig. modified from Musyl *et al.* (2004). Wahoo[1] (*Acanthocybium solandri*), silky shark[2] (*Carcharhinus falciformis*), oceanic whitetip[2] (*Carcharhinus longimanus*), mahimahi[2] (*Coryphaena hippurus*), yellowfin tuna[3] (*Thunnus albacares*), blue marlin[4] (*Makaira nigricans*), black marlin[5] (*M. indica*), striped marlin[6] (*Tetrapturus audax*), blue shark[7] (*Prionace glauca*), shortfin mako shark[8] (*Isurus oxyrinchus*), bigeye thresher shark[9] (*Alopias superciliosus*), the bigeye tuna[10] (*Thunnus obesus*), and swordfish[11] (*Xiphias gladius*).
[1]C. Sepulveda, S. Aalbers, D. Bernal, unpublished; [2]M. Musyl and R. Brill, unpublished; [3]Schaefer *et al.* (2007); [4] Block *et al.* (1992); [5]Gunn *et al.* (2003), Pepperell and Davies (1999); [6]Brill *et al.* (1993), Holts and Bedford (1990); [7]Carey and Scharold (1990); [8]Holts and Bedford (1993), Sepulveda *et al.* (2004); [9]Nakano *et al.* (2003), Weng and Block (2004); [10]Schaefer and Fuller (2002), Holland *et al.* (1992); [11]Carey and Robinson (1981), Carey (1990).

Figure 5.1.1. Possible vertical niches of pelagic fishes. Source: Bernal et al. (2009)

Southwest Fisheries Science Center (SWFSC)

Abundance Surveys

The blue, shortfin mako, and thresher sharks are all taken in regional commercial and recreational fisheries. Common thresher and mako sharks have the greatest commercial value and are also specifically targeted by sportfishers, especially off southern California. Although the blue shark is targeted in Mexico, it has little market importance in the U.S. but is a leading bycatch species in the west coast drift gillnet and high-seas longline fisheries. Although catches of adult blue, thresher, and shortfin mako sharks do occur, the commercial and sport catch of these species off southern California consists largely of juvenile sharks. To track trends in the abundance of juvenile and sub-adult blue, shortfin mako, and common thresher shark, surveys are carried out in the Southern California Bight (SCB) each summer.

Juvenile Pelagic Shark Survey

The SCB is 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 July and August of 2009. A total of 5,575 hooks were fished during 27 daytime sets. Catch included 100 shortfin mako sharks, 67 blue sharks, 31 pelagic rays (*Pteroplatytrygon violacea)*, and seven moon fish *(Lampris guttatus)*. The overall survey catch rate was 0.453 mako sharks per 100 hook-hours and 0.314 blue sharks per 100 hook-hours. The nominal CPUE for blue sharks dropped substantially from 2008 and was the second lowest in the survey's history. There is a declining trend in nominal CPUE for both species over the time series of the survey (Figure 5.1.2).

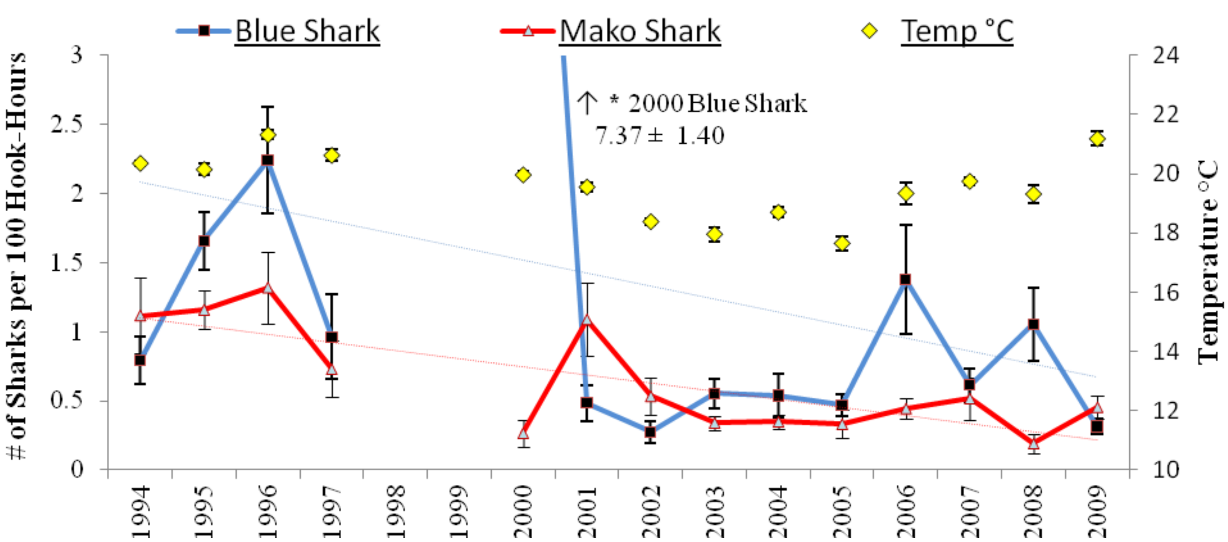

Figure 5.1.2. Average (± standard error) survey temperature and catch per 100 hook-hr for shortfin mako and blue sharks, 1994 – 2009. No data were collected in 1998 and 1999.

In conjunction with the fisheries-independent survey, additional biological studies were also conducted during the 2009 cruise. Most mako and blue sharks caught were tagged with conventional tags, marked with oxytetracycline (OTC) for age validation and growth studies, and DNA samples were taken for studies of population dynamics. To obtain more detailed information on movements and define habitat, satellite tags were deployed on both blue and mako sharks (see below). Finally, an experiment directed by collaborators from the University of Hawaii and PIFSC examined the potential for using rare earth metals to reduce shark bycatch (see section 5.2).

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 SCB. These waters are considered EFH for thresher shark pups, but the extent of this habitat is poorly defined. In 2003, the SWFSC began a survey to develop a pup abundance index and determine the continuity of thresher pup distribution along the coast of the SCB. In 2009, the seventh year of sampling took place. The SWFSC team worked with the F/V *Outer Banks* to sample from Point Conception to the Mexico border. Fifty longline sets were made in relatively shallow, near-shore waters. Over the 18-day cruise the research team caught 216 common thresher sharks, 11 soupfin sharks (*Galeorhinus galeus*), seven shortfin mako, three spiny dogfish (*Squalus acanthias*), one leopard shark (*Triakis semifasciata*), and one Pacific angel shark (*Squatina californica*). 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 17 thresher sharks by colleagues from Scripps Institute of Oceanography.

While it is still too early to develop a pre-recruit index, a number of patterns are emerging. 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 Dr. Graham of Scripps Institution of Oceanography and Dr. 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. Based on tag recoveries and satellite tracks, it is clear that the thresher shark nursery spans the waters of both countries.

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 (DFO), Pacific Biological Station. The specific goals of the satellite tagging program are to document and compare the movements and behaviors of these species in different portions of the California Current, and to link these data to physical and biological oceanography. This approach will allow us to characterize the habitats sharks most frequently utilize or prefer and, subsequently, to better understand how populations might shift in response to changes in environmental conditions.

During the juvenile shark abundance surveys conducted in the summer of 2009, 14 shortfin mako sharks, 10 blue sharks and one hammerhead shark were tagged with PSAT tags and/or SPOT tags, which are radio-linked satellite tags that provide position estimates using Argos

[12] newborn

system satellites. Since 1999, a total of 91 makos, 76 blue sharks, 27 common threshers and two hammerheads have been satellite tagged through these collaborative projects.

SPOT tag deployments from 2009 have provided relatively long-term records for three blue and 12 mako sharks whose tags were still transmitting in early 2010. Two satellite tags deployed in 2008 on mako sharks were also still reporting. These longer-term and multi-year records provide an opportunity to examine seasonal movement patterns and regional fidelity. An ongoing analysis of blue shark habitat use reveals a range of patterns. A number of these patterns are apparent in one blue shark for which the PSAT tag was recovered and the minute by minute data on temperature depth and light were obtained (Figure 5.1.3). This shark moved offshore from July through October. As the track progressed and sea surface temperature warmed, the swimming depth increased. This is seen both in the overall record as well as in a one-week representation of the detailed archival data. The archival record also reveals the distinct diel pattern with substantially deeper depths attained during the day than at night. The regular timing of the individual dives is consistent with behavioral thermoregulation; the shark returns to the surface mixed layer between foraging bouts to warm. The diel shift in depth distribution and increase in depth as sharks moved offshore is consistent with daytime foraging on organisms associated with the SSL and similar to what has been observed for swordfish. The depth of the SSL increases offshore due to the increased penetration of light in more oligotrophic waters.

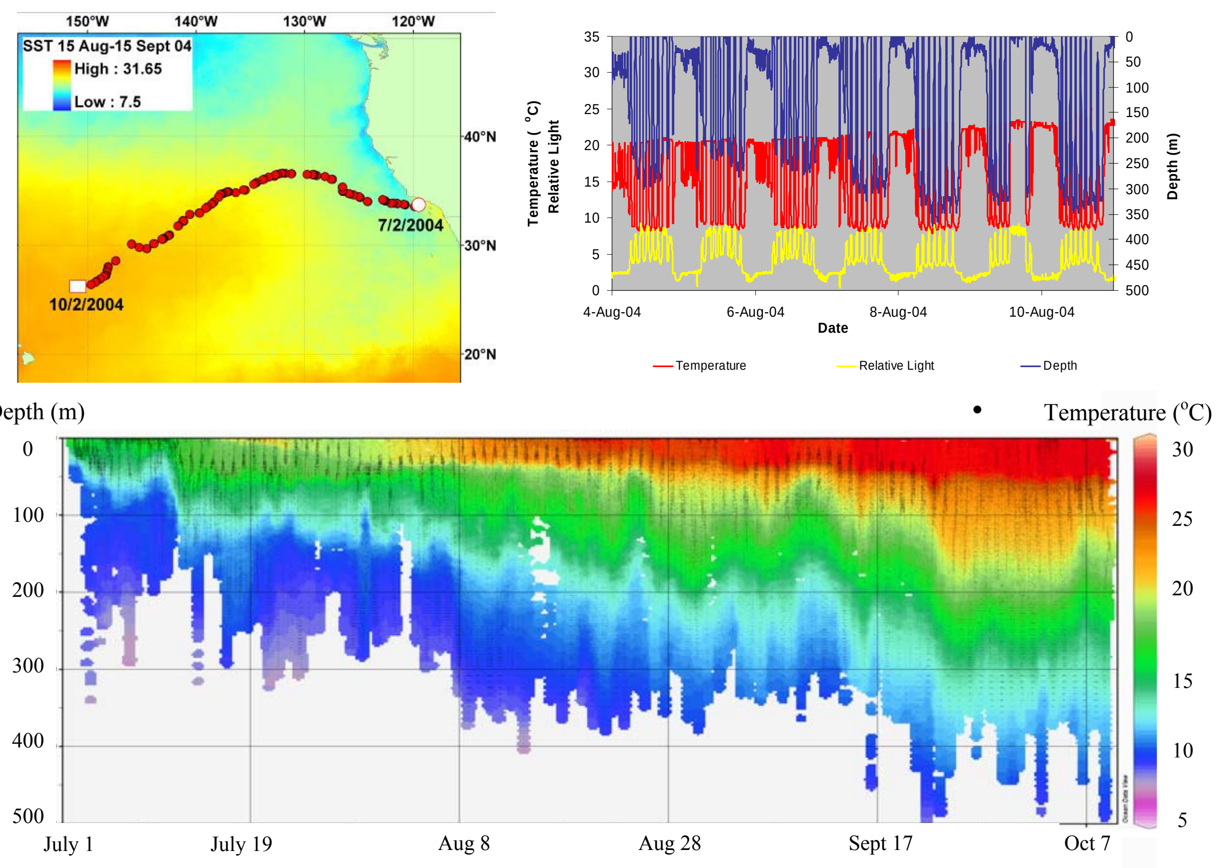

Figure 5.1.3. Top left; Argos track from the SPOT tag of a 157 cm FL male blue shark. Top right; Seven days of temperature (red), depth (dark blue) and light (yellow) data for the same blue shark. Bottom; depth color-coded by temperature over the duration of the archival record.

Pelagic Shark Feeding Ecology

With the recent reauthorization of the MSA, there is a move towards ecosystems management. This approach requires information on ecological relationships among species, one of the most important being trophic links. To determine the trophic relationships in the SCB, the SWFSC has been investigating the foraging ecology of a range of shark species since 1999. Species examined in 2009 include blue, shortfin mako, and common thresher. Distinct diet differences among the species and across years have been identified. To date a total of 713 stomachs have been collected and analyzed. Stomach contents were identified to the lowest taxonomic level. Analytical approaches to characterize prey composition and examine inter- and intra- specific patterns include both univariate and multivariate methods.

Of the 330 shortfin mako shark stomachs examined (sizes 53 to 248 cm FL), 238 contained 43 prey taxa. Jumbo squid (GII=46.0) and Pacific saury (*Cololabis saira*, GII=25.5) were the most important prey. Of the 158 blue shark stomachs examined (sizes 76 to 248 cm FL), 114 contained 38 prey taxa. Jumbo (GII=33.9) and *Gonatus* spp. squids (GII=33.6) were the most important prey. Of the 225 thresher shark stomachs examined (sizes 108 to 228 cm FL), 157 stomachs contained 18 prey taxa. Northern anchovy (*Engraulis mordax,* GII=68.4) and Pacific sardine (*Sardinops sagax*, GII=48.5) were the most important prey.

The statistical analyses reveal a number of interesting patterns. Results show that blue and mako shark diets were most similar, while dietary overlap was lowest between blue and thresher sharks. Inter-annual variation in diet was greatest for blue sharks. Overall, results reveal that mako sharks have the most diverse diet, feeding on a range of teleosts and cephalopods; blue sharks generally prefer cephalopods; thresher sharks are more specialized, feeding primarily on coastal pelagic teleosts. Despite similarities in life history characteristics and spatial and temporal overlap, diets of the three species are distinct.

Genetic Population Structure

<u>Shortfin Mako Shark (*Isurus oxyrinchus*)</u>

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. Amber Michaud's recent master's thesis, completed as a collaboration between the University of San Diego and SWFSC, provided evidence of regional stock structure within the Pacific. Her study, using mitochondrial haplotype data, showed a strong subdivision between northern and southern hemisphere populations, with additional subdivision between SE and SW Pacific populations. Unfortunately, insufficient samples were available from the NW Pacific to evaluate whether a subdivision exists between NE and NW Pacific populations.

In a second project on shortfin mako shark population structure, Dovi Kacev, a Ph.D. student at U.C. Davis and San Diego State University, has been developing a suite of nuclear microsatellite markers to further refine the spatial and temporal resolution of shortfin mako stocks within the Pacific. In addition to studies of stock structure, these markers will be used to develop estimates of effective population size within the California Current region. This is a collaborative project with SWFSC, and the application of these markers will commence this year.

Common Thresher Shark (*Alopias vulpinus*)
Common threshers are commonly encountered in temperate coastal marine fisheries but little is known about regional connectivity. In recent years they have become part of an increasingly important recreational fishery in southern California in addition to being an important component of local drift gillnet fisheries. In order to better understand population connectivity, Dovi Kacev has been developing nuclear microsatellite markers for this species as well. Application of these markers will also commence this year.

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 oxytetracycline (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 determined. In 2009, OTC validation studies on mako, blue, and thresher sharks continued.

Since the beginning of the program in 1997, over 2,000 OTC-marked individuals have been released during juvenile shark surveys. In 2009, 184 mako, 114 blue, and 186 common thresher sharks were tagged and marked with OTC. As of March 2010, recaptured OTC-marked sharks included 81 mako, 56 common thresher, and 56 blue sharks. Vertebrae have been returned for roughly 60 percent of the recaptured sharks. Time at liberty ranged from one to 1,938 days, and the maximum net movement for an individual shark was 3,410 nmi. An analysis of mako shark band deposition patterns is now nearly complete and a manuscript is being drafted.

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.

Basking Shark (Cetorhinus maximus): Species of Concern
In 2009, the SWFSC, in collaboration with the Pacific Shark Research Center at Moss Landing Marine Laboratories, began assimilating information necessary to promote basking sharks as a NOAA "Species of Concern' in the Pacific. This effort was motivated by three main observations: 1) sightings and fisheries data of basking sharks both off Canada and coastal California suggest dramatic declines in the Northeast Pacific population from the 1920's, 40's and 50's when animals were targeted in both countries. In locations where 100's to 1000's of sharks were sighted, now only a few if any individuals are seen. 2) Despite decades with no directed fishing pressure there is no apparent recovery in population numbers. Given their low reproductive rates, even low levels of fisheries mortality may prevent a rebound. While no longer targeted in the U.S. or Canada, basking sharks are still caught incidentally in a range of fishing gear and may also be taken in high-seas fisheries. 3) Finally, very little is known about basic aspects of their life history including age at first reproduction, age and growth, nursery grounds, geographic range and population structure or dynamics. It is critical that additional information be acquired to assess contemporary risks to the population and to facilitate the development of a recovery plan. In spring 2010, basking shark was added to NOAA's Species of Concern List. Efforts to fill data gaps and develop a management strategy will begin in 2010.

Other International Collaboration

The SWFSC provides guidance to RFMO's on the conservation and management of sharks throughout the Pacific. As an example, SWFSC scientists participate in the Bycatch Working Group and the newly established Shark Assessment Taskforce of the International Scientific Committee (ISC) and work collaboratively with the Inter-American Tropical Tuna Commission (IATTC) on the development of shark and ray bycatch reduction techniques. SWFSC staff also work collaboratively with scientists of the Instituto Nacional de la Pesca through the bilateral partnership, MexUS-Pacifico. While no collaborative activities were carried out during 2009 through MexUS-Pacifico, planned projects include joint abundance surveys and tagging of large pelagic sharks and collaborative shark assessment efforts. The group met early in 2009 and reiterated their commitments to the projects. In addition, SWFSC staff participate in the Northeast Pacific International Union for Conservation of Nature (IUCN) shark specialist group and have provided input regarding shark conservation and management through a number of other international fora. In addition to the work listed above, the SWFSC is collaborating with the DFO in Canada and CICESE in Baja California Norte, Mexico on a basking shark recovery plan.

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 conducted the first assessment for longnose skate in 2007. This assessment was reviewed during the 2007 stock assessment review (STAR) process, and was adopted by the PFMC for use in management. The NWFSC is planning to conduct an assessment of spiny dogfish along the Pacific coast of the United States in 2011.

Movement studies

The NWFSC, in collaboration with Washington Department of Fish and Wildlife (WDFW) and the Seattle Aquarium, recently completed a study 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 at their capture site. Automated listening stations were used to detect the 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. In particular, the researchers found that Puget Sound is an important habitat for pupping and provides a nursery ground for the juveniles. The adults return to the coast after pupping, while the juveniles stay in Puget Sound for several years until they mature, and then move out to the coast. Biological data (e.g., genetic samples, blood samples, gut contents, and length/weight) were also collected and used by the WDFW to support management of these species.

Alaska Fishery Science Center (AFSC), Auke Bay Laboratories(ABL)

Shark Research and Assessments

Research efforts at the Alaska Fishery Science Center's Auke Bay Laboratories (ABL) are focused on:

1. Collection of data to support stock assessments of shark species subject to incidental harvest in waters off Alaska.
2. Migration and habitat use of Pacific sleeper sharks.
3. Migration and habitat use of spiny dogfish in the Gulf of Alaska (GOA).
4. Estimation of incidental catch of sharks in unobserved fisheries.
5. Development and validation of improved aging methods for spiny dogfish and Pacific sleeper sharks.
6. Collaborative research with the University of Alaska Fairbanks (UAF), the University of Washington (UW) and the Alaska Department of Fish and Game (ADF&G):
    a. Life history, reproduction and general ecology
    b. Demography, and
    c. Feeding ecology and stable isotopes.

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

Species currently assessed include Pacific sleeper sharks (*Somniosus pacificus*), spiny dogfish (*Squalus acanthias*), and salmon sharks (*Lamna ditropis*), which are 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 the North Pacific Fishery Management Council's (NPFMC) Stock Assessment and Fishery Evaluation (SAFE) Report available online (i.e., see Tribuzio et al. 2009a and 2009b).

Migration and habitat use of Pacific sleeper sharks

During the summers of 2003–2006, scientists from the ABL deployed 138 numerical Floy tags, 91 electronic archival tags, 24 electronic acoustic tags, and 17 electronic satellite pop-up 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. Analysis of tagging data is ongoing.

Migration and habitat use of spiny dogfish in the Gulf of Alaska (GOA)

In the summer of 2009, scientists from ABL deployed in Yakutat Bay 15 pop-off archival tags on spiny dogfish and will deploy 20 more in the summer of 2010. Data include depth and temperature as well as a geolocation. Data from the first 15 tags is slowly being collected as the tags pop-off and transmit their stored data, as of June 10, 2010, a total of 4 tags have been retrieved. Results will indicate habitat preference with respect to depth and temperature, which may play a role in examining the effects of climate changes in the North Pacific. Further, the geolocation data will elucidate the degree to which GOA spiny dogfish populations mix with those populations in British Columbia, Canada, and the U.S. Pacific Coast. Preliminary results suggest a westward movement from Yakutat Bay towards Cook Inlet and Kodiak Island between August and December and also show that dogfish tend to have a strong daily migration between deeper and shallower waters.

Estimation of shark bycatch from unobserved fisheries

In the GOA, some fisheries fall outside of the groundfish observer program (e.g. halibut individual fishing quota fishery) and data on the bycatch of shark and skate species from those fisheries does not exist. Scientists at ABL are working with others from the Alaska Fisheries Science Center, Alaska Department of Fish and Game and the International Pacific Halibut Commission to determine a method for using existing survey data to estimate the bycatch of elasmobranch species. This project will build off work reported in the 2006 shark assessment (Courtney et al. 2006). The goal of the working group is to develop a method to estimate catch of all non-halibut species in the IFQ fishery and methods will be reported to the NPFMC's Science and Statistical Committee for approval before implementation for the 2011 stock assessment cycle.

Age and Growth Methods

Scientists at ABL and the AFSC age and growth lab are collaborating with researchers at the University of New England to conduct a study examining a potential new method for aging of spiny dogfish. Traditional methods of aging used the dorsal fin spine, which can be worn or broken over time, thus introducing a source of uncertainty in the aging estimation process (Tribuzio et al. 2010). A new method which uses the vertebrae and histological staining has been applied to spiny dogfish in the U.S. east coast in efforts to reduce the uncertainty of age estimates. This project will compare the results of both aging methods to determine if the vertebrae method is appropriate for GOA spiny dogfish. The second purpose of this study is to establish a method for aging Pacific sleeper sharks, which have not been successfully aged. This histological method has been successful on deep sea Squaloid sharks in the North Atlantic, and there is some suggestion that it will work for Pacific sleeper sharks. Scientists at ABL are also working to establish a captive population of spiny dogfish which will be used to validate the histological aging methods. Captive sharks will be injected with oxytetracycline (OTC) on an annual basis for up to 5 years. OTC binds with calcium and leaves a distinct mark on the hard structures that are used for aging. The improved age-at-length data will be used to re-estimate growth models used in stock assessments.

Other spiny dogfish research

Through the collaborative work, scientists were able to collect dogfish data from many regions within the GOA, using multiple gear types throughout most of the year. The data is being examined for trends in seasonal abundance; gear biases; sex, size and age distributions; and reproductive information. Preliminary results suggest that the spiny dogfish has a low fecundity and slow reproductive cycle. They mature at a large size relative to the overall maximum size and at a late age. These are indicators of species that are susceptible to overfishing. This project is also examining historical commercial and survey data for abundance trends by regions. One goal is to determine if seasonal abundances coincide with abundances of other species (i.e. prey availability) or environmental factors.

Growth model results (Tribuzio et al. 2010) were used to construct two demographic models of spiny dogfish in the GOA: an age based and a stage based model. The stage based model had 5 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>=0.3, all simulated populations went extinct in 20 years or less. A manuscript detailing this research is under review (Tribuzio and Kruse, in review).

Feeding Ecology and Stable Isotopes

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 towards certain prey groups. A manuscript detailing the diet analysis is in preparation (Tribuzio et al. in prep).

Additional collaborations between NMFS and UAF used stable isotope analysis to investigate the feeding ecology of spiny dogfish and Pacific sleeper shark in the GOA. In the spiny dogfish study, 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 that different size classes of spiny dogfish have in the GOA.

Pacific sleeper shark stable isotope ratios of nitrogen and carbon were compared among regions and to other species in the northeast Pacific Ocean and eastern Bering Sea. Results show that Pacific sleeper sharks have significantly different stable isotope ratios between regions (Bering Sea and Aleutian Islands vs. Gulf of Alaska vs. Southeast Alaska), between large and small sharks (≥ 180.5 cm vs. < 180.5 cm TL) and between shallow caught and deep caught sharks (≥ 200 m vs. < 200 m). Sleeper shark trophic level determined from Δ 15N was consistently below pinnipeds in the Bering Sea and Gulf of Alaska, about the same as large sized fish and squid in the GOA, and above small sized fish and squid in the GOA. Our results suggest that Pacific sleeper sharks in the northeast Pacific Ocean may be feeding at approximately one trophic level below what diet studies based on stomach contents alone would appear to indicate. Refined data on Pacific sleeper shark trophic position will help inform ecosystem models and provide a base for understanding the expected role of this large predatory species in the ecosystem.

Northeast Fisheries Science Center (NEFSC)

Fishery Independent Surveys and Recreational Monitoring of Coastal and Pelagic Sharks

Fishery Independent Coastal Shark Bottom Longline Survey

The fishery independent survey of Atlantic large and small coastal sharks is conducted bi-annually in U.S. waters (see Figure 5.1.4). Its primary objective is to conduct a standardized, systematic survey of the shark populations to provide unbiased indices of relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. It also provides an opportunity to tag sharks with conventional and electronic tags as part of the NEFSC Cooperative Shark Tagging Program (CSTP, see below), inject with oxytetracyline (OTC) for age validation studies, and to collect biological samples and data used in analyses of life history characteristics (age, growth, reproductive biology, trophic ecology, etc.) and other research including the collection of morphometric data for size conversions. The time series of abundance indices from this survey is critical to the evaluation of coastal Atlantic shark species. Fish captured in the 2009 survey included 1,686 fish (1,676 sharks) representing 19 species. Sharks represented 99% of the total catch of which sandbar sharks were the most common, followed by dusky and tiger sharks. As part of this survey, bottom longline sets were conducted in the closed area off North Carolina. Cooperative work included sample collections of blood, heart and other tissues for post-release survivorship, parasite, toxicology, and ribosomal DNA species identification marker studies. These results represent the highest catches of sharks from any previous survey to date.

Figure 5.1.4. Bringing in a sandbar shark during the NEFSC Coastal Shark Bottom Longline Survey. Source: Peter Cooper / NMFS photo.

Fishery Independent Pelagic Shark Longline Survey

NMFS and its predecessor agencies conducted periodic longline surveys for swordfish, tunas, and sharks off the east coast of the United States starting in the early 1950's. Surveys first targeted tunas and swordfish along the edge of the continental shelf, and subsequently focused on pelagic and coastal sharks over a variety of depths, including inshore bays and estuaries. The last large-scale pelagic fishing trip was conducted in 1985; however, the NEFSC Narragansett Laboratory completed a pilot survey in the spring of 2006 and conducted pelagic sets subsequent to the 2007 fishery independent coastal shark survey. Goals of this research are to initiate a 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 (*Carcharhinus plumbeus*)
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) program (see below). A random stratified longline sampling plan, based on depth and geographic location, was developed in 2001 to assess and monitor the juvenile sandbar shark population during the nursery season. In 2009, a total of 228 sandbar sharks were caught, with 96% released with tags. The juvenile index of abundance from this standardized survey has been used as an input into various stock assessment models and the mark-recapture data has been used to examine the temporal and spatial relative abundance and distribution of sandbar sharks in Delaware Bay. The sand tiger bycatch from this survey was used along with other information to update the status of the sand tiger in the northwest Atlantic Ocean (Carlson et al. 2009) and was presented at the 2009 American Elasmobranch Society Meeting. Results of cooperative genetic research with the Virginia Institute of Marine Science (Portnoy et al. 2009) provided a calculation for the effective number of breeders and effective population size for adults of Delaware Bay and the Eastern Shore of Virginia by genotyping 902 animals across five cohorts at eight microsatellite loci. Estimates of the effective number of breeders and effective population size were compared to estimates of Delaware Bay census size. The estimated ratios were 0.45 or higher, which is similar to that found in marine and terrestrial mammals, and is in contrast to estimated ratios in other exploited marine fishes that are several orders of magnitude smaller.

Delaware Bay Sand Tiger (*Carcharias taurus*) Survey
A survey targeting the sand tiger shark was initiated in 2006 to identify essential fish habitat (EFH) and collect data for future stock assessments, continued in 2009 (see Figure 5.1.5). 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 2009, a total of 68 sand tigers were caught and 63 (93%) released with conventional tags.

Figure 5.1.5. Measuring a sand tiger during the NEFSC Delaware Bay Sand Tiger Survey. Souce: Corey Eddy/NMFS photo.

Collection of Recreational Shark Fishing Data and Samples
Historically, species-specific landings data from recreational fisheries is lacking for sharks. In an effort to fix this, the NEFSC has been attending recreational shark tournaments continuously since 1961 collecting data; in some cases, for over 45 years. These tournaments provide information on species sex and size composition as well as provide a source of biological samples for pelagic and some coastal sharks. Analysis of tournament landings data was initiated by creating a database of historic information (1961-2009) and producing preliminary summaries of one long-term tournament. The collection and analysis of these data are critical for input into species and age specific population and demographic models. In 2009, catch, morphometric data,

and biological samples for more than 200 pelagic sharks were collected at 10 fishing tournaments in the northeastern United States. Information from shark tournaments is very valuable as a monitoring tool to provide long-term data that can detect trends in species and size composition, provide valuable specimens and tissue for life history and genetic studies, provide outreach opportunities for recreational fishermen and the public, and finally, to provide additional information on movements that complement the NMFS Cooperative Shark Tagging Program (CSTP).

NEFSC Historical Longline Survey Database

The NEFSC recently recovered the shark species catch per set data from the exploratory shark longline surveys conducted by the Sandy Hook and Narragansett Laboratories from 1961 to 1991. In addition, scientific staff have been working with the University of North Carolina (UNC) to electronically recover the data from an ongoing coastal shark survey in Onslow Bay that began in 1972. These surveys provide a valuable historical perspective for evaluating the stock status of Atlantic sharks. This data recovery process is part of a larger, systematic effort to electronically recover and archive historical longline surveys and biological observations of large marine predators (swordfish, sharks, tunas, and billfishes) in the North Atlantic. When completed, these efforts will include reconstructing the historic catch, size composition, and biological sampling data into a standardized format for time series analysis of CPUE and size. Standardized indices of abundance developed for sharks caught during these longline surveys have been and will continue to be used in stock assessments as part of the Southeast data, assessment, and review (SEDAR) process. A poster summarizing these results to date was presented at the NEFSC 9^{th} Science Symposium in 2009. In addition, analyses of trends in sand tiger abundance from the NEFSC exploratory shark longline surveys were an integral part of a recent study using all currently available information to determine the status of the United States population of this species (Carlson et al. 2009) and were presented at the 2009 American Elasmobranch Society Meeting. Based on results of this study, it was recommended that sand tigers be retained on the Species of Concern list, because of their low productivity and the high uncertainty in the parameter estimates (due to low sample sizes). Work 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. Analyzing the temporal, spatial and operational characteristics of NEFSC surveys and commercial operations, as well as the associated multi-species catch will also provide an opportunity to better understand seasonal distribution patterns and relative vulnerability of various species to different fishing practices.

Essential Fish Habitat

Pelagic Nursery Grounds

Pelagic shark biology, movements, and abundance studies continued in 2009 with further investigations of pelagic nursery grounds in conjunction with the high seas commercial longline fleet. This collaborative work offers a unique opportunity to sample and tag blue sharks (*Prionace glauca*) and shortfin makos (*Isurus oxyrinchus*) in a potential nursery area on the Grand Banks, to collect length-frequency data and biological samples, and to conduct conventional and electronic tagging of these species. To date, over 1,800 sharks have been tagged with 83 recaptured. These fish were primarily blue sharks that were recovered by commercial fishermen working in the mid-Atlantic Ocean. In addition, 250 blue sharks were double tagged to help evaluate tag-shedding rates used in sensitivity analyses for population estimates and to calculate fishing mortality and movement rates for this pelagic shark species. This research is being filmed by Original Productions as part of a television series called 'Swords: Life on the Line' which first aired on the Discovery Channel in 2009. In 2006 and 2008, two real-time satellite (SPOT) tags and five PSAT tags were deployed on shortfin makos and one PSAT tag was deployed on a blue shark. Data from these tags were analyzed in 2009 to determine the horizontal and vertical movements of these fish; three (1 blue, 2 mako) of the tags did not report.

Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Program

COASTSPAN surveys conduct cooperative, comprehensive, and standardized investigations of coastal shark nursery habitat from Florida to Massachusetts and in the U.S. Virgin Islands (USVI). The surveys use longline and gillnet sampling and mark-recapture data to describe the species composition of shark nursery habitat, to describe habitat preferences, and to determine the relative abundance, distribution, and migration of shark species (see Figure 5.1.6). Standardized indices of abundance from several COASTPAN surveys are used in the stock assessments for large and small coastal sharks and data from all surveys are used to update and refine EFH designations for juvenile life stages of managed coastal shark species. The NEFSC manages and coordinates this program; participants in 2009 were the Georgia Department of Natural Resources, the South Carolina Department of Natural Resources, Coastal Carolina University, the North Carolina Division of Marine Fisheries, and the University of North Florida. The NEFSC staff conducts the survey in Narragansett and Delaware Bays and additional sampling in the USVI and Massachusetts in conjunction with the Massachusetts Division of Marine Fisheries (MDMF).

Figure 5.1.6. Tagging a juvenile sandbar shark during the NEFSC COASTSPAN Program Survey. Source: W. David McElroy / NMFS photo.

In collaboration with MDMF and NMFS (Galveston, TX; Silver Spring, MD), a study was initiated to investigate the spatial and temporal use of nursery habitat by neonatal blacktip (*Carcharhinus limbatus*) and lemon (*Negaprion brevirostris*) sharks in St. John, USVI. In December 2005, active acoustic tracking of lemon and blacktip sharks was conducted in Fish Bay, a productive shark nursery, for 10 days with students from the Boston University Marine Program. This cooperative USVI survey is the first comprehensive survey of elasmobranchs in the USVI and has resulted in the identification of critical shark nursery habitat for blacktip and lemon sharks in Fish Bay. Building on this work, 33 acoustic transmitters were surgically implanted in 28 blacktip and 20 lemon sharks from 2006 to 2009; their long-term movements are currently being monitored using passive acoustic telemetry. Additional tags will be deployed in 2010.

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 a multi-year cooperative research project with staff from Delaware State University and the University of Rhode Island on habitat use, depth selection, and the timing of residency for sand tigers in Delaware Bay. Sand tigers were implanted with 69 standard acoustic or depth-sensing transmitters to monitor their movements and habitat use during the summer months from

2006–2008. Males and females were segregated, with males more commonly found in the lower salinity middle portion of the bay and in shallower waters, whereas females were more common in deeper, higher salinity waters near the mouth of the Bay. Habitat use varied between years with significantly shallower depths used in 2007 than in 2008. The importance of Delaware Bay as summer habitat for sand tigers is demonstrated by relatively high interannual site fidelity with 50 percent of sharks tagged in 2006 returning in 2007, and 60 percent tagged in 2007 were detected in the Bay the summer of 2008. These results were presented at the 2009 American Elasmobranch Society Meeting.

Essential Fish Habitat (EFH) Designations

NEFSC staff participated in a working group with the NMFS HMS Division and SEFSC to update and refine the EFH designations for managed shark species. This process was ongoing in 2009 and entailed providing data for smooth dogfish caught during the COASTSPAN surveys, and reviewing the smooth dogfish EFH designation resulting from all contributed data.

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 and from strandings. In recent years, studies have concentrated on a complete life history for a species to obtain a total picture for management. This comprehensive life history approach encompasses studies on age and growth rates and validation, diet and trophic ecology, and reproductive biology essential to estimate parameters for demographic, fisheries, and ecosystem models.

Atlantic Blue Shark (*Prionace glauca*) and Shortfin Mako (*Isurus oxyrinchus*) 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—have resulted in fishery-independent demographic and risk analysis results for the blue shark for use in conservation and management with the construction of an age-structured matrix population model in which the vital rates are stochastic. 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. Estimates of survival were generated with the computer software MARK and 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 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.

From samples provided from recreational fishing tournaments and on research cruises, a genetic approach for identifying pelagic shark tissues was streamlined and simplified by researchers at NOVA Southeastern University, facilitating rapid and unambiguous species identification. The result is a rapid, accurate, and relatively inexpensive genetic assay for identifying tissues and body parts from the shortfin mako and four other shark species (silky, dusky, sandbar, and longfin mako).

Efforts were initiated in 2005 with Massachusetts Division of Marine Fisheries (MDMF) researchers to tag shortfin makos and blue sharks with PSAT and SPOT tags. In October 2005, two blue sharks were tagged and released south of Massachusetts; both fish were blood sampled for stress physiology studies. The tags detached from the sharks in February, 2006 and data analysis is ongoing. In addition, two real-time satellite (SPOT) tags and five PSAT tags were deployed on shortfin makos in 2006 and 2008, respectively, from a longliner while fishing on the Grand Banks. In addition, one PSAT tag was deployed on a blue shark (see pelagic nursery section above).

Regional sizes, sex ratios, maturation, and movement patterns were analyzed for 91,450 blue sharks tagged by members of the NMFS Cooperative Shark Tagging Program (CSTP) in the North Atlantic Ocean from 1962-2000. Of these, 5,410 were recaptured for an overall recapture rate of 5.9%. Blue sharks made frequent trans-Atlantic crossings from the western to eastern regions, and were shown to move between most areas; the mean distance traveled was 857 km, and the mean time at liberty between tagging and recapture was 0.9 year. North Atlantic blue sharks are believed to constitute a single stock, and a better understanding of their complex movements, life-history strategies, and population structure is needed to develop informed management of this open ocean species.

Utilizing this blue shark tag-recovery data from the NMFS CSTP (1965–2004), a spatially structured tagging model was used to estimate blue shark movement and fishing mortality rates in the North Atlantic Ocean (Aires-da-Silva et al. 2009). Four major geographical regions (two on each side of the ocean) were assumed with the blue shark fishing mortality rates (F) found to be heterogeneous across the four regions. While the estimates of F obtained for the western North Atlantic Ocean were historically lower than 0.1 year^{-1}, the F estimates over the most recent decade (1990's) in the eastern side of the ocean are rapidly approaching 0.2 year^{-1}. Because of the particular life-history of the blue shark, these results suggest careful monitoring of the fishery as the juvenile and pregnant female segments of the stock are highly vulnerable to exploitation in the eastern North Atlantic Ocean.

The blue shark has been subject to bycatch fishing mortality for almost a half-century and has even become the target species in pelagic longline fisheries in the North Atlantic Ocean. Nevertheless, stock status is ambiguous and improved input data are needed for stock assessments. It is particularly important to obtain reliable indices of abundance because of the uncertainty in estimates of bycatch. An index of relative abundance (catch-per-unit effort, CPUE) was developed for western North Atlantic blue sharks, starting from the mid-1950s, when industrial pelagic longline tuna fisheries began. Longline catch and effort records from recent observer programs (1980–1990s) were linked with longline survey records from both historical archives and recent cruises (1950–1990s). Generalized linear models were used to remove the effects of diverse fishing target practices, and geographical and seasonal variability that affect blue shark catch rates. The analysis revealed a decline in blue shark CPUE of approximately 30% in the western North Atlantic from 1957 to 2000. The magnitude of this CPUE decline was less than other recently published estimates and seems reasonable in light of the high productivity of the blue shark revealed by life-history studies and preliminary stock assessments.

Biology of the Thresher Shark (*Alopias vulpinus*)
Life history studies of the thresher shark in the western North Atlantic continued with analysis of age and reproductive parameters. Reproductive organs from 134 male and 257 female thresher sharks were examined to determine size at maturity and reproductive cycle. Males ranged in size from 78 to 237 cm fork length (FL) and females ranged from 62 to 263 cm FL. Reproductive tissues were processed and sectioned using histological techniques. Male maturity was best described by an inflection in the relationship of clasper length to FL when combined with clasper calcification. In females, most reproductive organ measurements related to body length showed a strong inflection around the size of maturity. 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 centimeters fork length. These results will be combined with the morphological reproductive data to determine sexual sizes at maturity for this species. A summary was presented at the NEFSC 9th Science Symposium in 2009.

Biology of the Atlantic Torpedo (*Torpedo nobiliana*)
Atlantic torpedo samples for age and growth, reproduction, and food habits were obtained from the bycatch of bottom trawl, trap net and gillnet fisheries operating primarily out of Pt. Judith, Rhode Island. A total of 170 rays (124 female, 46 male) were collected from February 2006 through March 2008. Males ranged in size from 60.4 cm to 111.2 cm total length (TL) while females ranged in size from 69.1 cm to 151.7 cm TL. Vertebrae from 45 males and 122 females were processed using histology and image analysis. Criteria for the identification of bands was unable to be defined due to the variety of banding patterns throughout the vertebral samples and attempts to calibrate the band pair readings using a subsample of vertebrae were unsuccessful. Due to these difficulties, this work is still in progress. Electric rays (family Torpedinidae) are distinguished from other batoids by the possession of kidney-shaped electric organs along the anterior-lateral portion of their disks. There are approximately 21 validated species in the genus *Torpedo*, of which only the Atlantic torpedo, *Torpedo nobiliana*, is believed to be found in the Northwest Atlantic Ocean. However, as an indirect result of this study, the population of electric rays off the coast of Rhode Island is being examined to determine if the rays may be of the species *Torpedo occidentalis* rather than, or in addition to, *Torpedo nobiliana*. This research is part of a University of Rhode Island graduate student masters thesis and a presentation was given at the NEFSC 9th Science Symposium in January 2009 summarizing these data.

Biology of the Smooth Skate (*Malacoraja senta*)
The smooth skate is one of the smallest (<70 cm TL; <2.0 kg wet weight) species of skate endemic to the western North Atlantic and has a relatively broad geographic distribution, ranging from Newfoundland and southern Gulf of St. Lawrence in Canada to New Jersey in the United States. Age and growth estimates for the smooth skate were derived from 306 vertebral centra from skates caught in the North Atlantic off the coast of New Hampshire and Massachusetts

(Natanson et al. 2009). Males and females were aged to 15 and 14 years, respectively. Male and female growth diverged at both ends of the data range but both sexes were best described by a von Bertalanffy growth curve with parameters of L_o=11 cm TL, L_∞=75.4 cm TL, and K=0.12 for males and L_o=10 cm TL, L_∞=69.6 cm TL, and K=0.12 for females.

Age and size at sexual maturity was determined for 185 male and 96 female smooth skates (ranging in size from 370 to 680 mm total length), collected from the western Gulf of Maine (Sulikowski et al. 2009). The best estimate suggests that 50% maturity occurs between 9 and 10 years (560 mm TL) for males and at 9 years (540 mm TL) for females.

Northeast Skate Complex

The goal of this research is to sample the skate complex landed for use in the Rhode Island lobster bait industry. Sampling includes identification to species level, collection of data on size, sex, and reproductive condition, recording catch locations, and collection of vertebrae and stomach samples for subsequent analysis. These data will contribute to the FMP objectives to collect information critical for improving knowledge of skate fisheries by species and for monitoring the status of skate fisheries, resources, and related markets, as well as improve the effectiveness of skate management approaches.

Atlantic Angel Shark (*Squatena dumeril*)

The Atlantic angel shark is among 20 species of sharks that are prohibited from both commercial and recreational fisheries. However, off the northeast coast of the U.S., this species is encountered in several commercial fisheries including the bottom otter trawl and gillnet fisheries. Northeast Fisheries Observer Program observers and NEFSC survey vessel staff have collected 54 angel sharks to date. Dissections of these specimens have resulted in preliminary maturity estimates of greater than 100 cm fork length for both male and female angel sharks. Preliminary age determination estimates from the vertebrae are similar to results from angel sharks from the Gulf of Mexico and Pacific; there does not appear to be any correlation between band periodicity and time. Further work is required to determine band periodicity in this species. A presentation was given at the NEFSC 9th Science Symposium in January 2009 summarizing these data. DNA samples from the western North Atlantic population have also been collected. This study will examine the angel shark evolutionary history and population structure using mitochondrial DNA control region sequences from the northwest Atlantic, and western and eastern populations from the Gulf of Mexico. Further investigations into angel shark life history studies are ongoing including examinations of the distribution and food habits.

Age and Growth of Elasmobranchs

Tiger Shark (*Galeocerdo cuvier*)

Age and growth estimates for the tiger shark in the western North Atlantic were derived from band counts of 238 sectioned vertebral centra. Two- and three-parameter von Bertalanffy and Gompertz growth functions fit to length at age data demonstrated that growth rates were similar for males and females up to approximately 200 cm fork length after which male growth slowed. Both sexes appear to reach maturity at age 10. Males and females were aged to 20 and 22 years, respectively, although longevity estimates predict maximum ages of 27 and 29 years, respectively. Bomb radiocarbon analysis of ten band pairs extracted from four vertebral sections suggested that band pairs are deposited annually up to age 20. This study provides a rigorous description of tiger shark age and growth in the western North Atlantic and further demonstrates the utility of bomb radiocarbon as an age validation tool for elasmobranch fishes.

Basking Shark (*Cetorhinus maximus*)
Age and growth of the basking shark was examined using vertebral samples from 13 females (261 to 856 cm TL), 16 males (311 to 840 cm TL) and 11 specimens of unknown sex (376 to 853 cm TL). Vertebral samples were obtained worldwide from museums and institutional and private collections. Examination of multiple vertebrae from along the vertebral column of 10 specimens indicated that vertebral morphology and band pair (alternating opaque and translucent bands) counts changed dramatically along an individual column. Smaller sharks had similar band pair counts along the length of the vertebral column while large sharks had a difference of up to 24 band pairs between the highest and lowest counts. Evidence indicates that band pair deposition may be related to growth and not time in this species and thus the basking shark cannot be directly aged using vertebral band pair counts.

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. A summary of the results was presented at the 2009 International Otolith Symposium.

Elasmobranch Feeding Ecology

Sandbar shark (*Carcharhinus plumbeus*)
The Delaware Bay estuary supports substantial populations of several shark species including juvenile sandbar sharks. During June, July, and August from 2003-2005 non-lethal diet methods were utilized to sample 1,169 sandbar shark stomachs, of which 56% contained prey items. Sexual differences in feeding were not found. Significant ontogenetic changes in diet composition were identified among young of the year (YOY), small juvenile, and large juvenile size classes, which may reduce intra-specific competition while in the Bay. Overall, sandbar sharks fed principally on teleosts, with crustaceans (chiefly majid, pagurid, and portunid crabs) important to young sharks and elasmobranchs an increasing component of the diet of larger sharks. Smaller fish prey, e.g. *Ophidion marginatum* and *Anchoa mitchilli*, were consumed more frequently by smaller sharks; whereas larger teleost prey, e.g. *Brevoortia tyrannus*, *Micropogonias undulatus*, and *Trinectes maculatus*, became progressively more common in the larger sizes. Short term changes were exhibited in feeding between the summer months. Early in the summer YOY had less stomach contents (both in frequency of vacuity and mass of contents), and consumed predominately less mobile prey types. YOY in August were similar in diet composition to small juveniles from June and July, and small juveniles by August had a diet more consistent with large juveniles. These dramatic monthly changes in feeding by YOY suggested improvement in hunting capability by late summer, with some shifts to larger or more mobile prey continuing in the juveniles. Shifts in monthly consumption of some prey were consistent with reported times of peak abundance for those species, and suggested a generally opportunistic feeding strategy. An intermittent feeding pattern, diverse diet, and occasional consumption of large meals were typical for all three size classes. The dietary results will be compared with morphometric data being compiled to evaluate changes in growth and condition.

This will provide insight into the quality and importance of the nursery habitat, and potential information regarding physiological changes in condition, survival, and the impact of migration and winter habitat. This research was completed as part of a graduate student Ph.D. Dissertation (McElroy, 2009) and a poster was presented at the NEFSC 9th Science Symposium in 2009.

Smooth dogfish (*Mustelus canis*)
In collaboration with MDMF and the University of Massachusetts, staff are working to examine the feeding ecology of smooth dogfish off Massachusetts. Cape Cod, Massachusetts is generally regarded as a natural barrier to the northern range of smooth dogfish although they have been observed farther north. This study was designed to characterize the diet of smooth dogfish where there is significant overlap with higher densities of American lobster, *Homarus americanus*. Consumption of lobster by predators such as smooth dogfish is thought to be extensive in this area, and may have led to the drastic decline in local abundance of the lobster over the last decade. A survey was conducted from May through October of 2008 in Buzzards Bay, Massachusetts. Stomach contents of all dogfish were everted and analyzed. The diet of the smooth dogfish consisted mostly of crustaceans, with lobster, rock crab *Cancer irroratus*, common spider crab *Libinia spp.* and mantis shrimp *Squilla empusa*, among the most common prey items. Preliminary analysis suggest that smooth dogfish may be an underestimated predator of the American lobster population in Buzzards Bay, but the extent to which they impact the lobster population remains to be determined. This research is part of a graduate student masters thesis and a poster was presented at the NEFSC 9th Science Symposium in January 2009.

Shortfin mako (*Isurus oxyrinchus*)
The diet and daily ration of the shortfin mako in the inshore waters of the western North Atlantic were re-examined to determine whether fluctuations in prey abundance and availability are reflected in these two biological variables (Wood et al. 2009). During the summers of 2001 and 2002, stomach content data were collected from fishing tournaments along the northeast coast of the United States. These data were quantified by using four diet indices and were compared to index calculations from historical diet data collected from 1972 to 1983. Bluefish (*Pomatomus saltatrix*) were the predominant prey in the 1972–83 and 2001–02 diets, accounting for 92.6% of the current diet by weight and 86.9% of the historical diet by volume. From the 2001– 02 diet data, daily ration was estimated and it indicated that shortfin makos must consume roughly 4.6% of their body weight per day to fulfill energetic demands. The daily energetic requirement was broken down by using a calculated energy content for the current diet of 4909 KJ/kg. Based on the proportional energy of bluefish in the diet by weight, an average shortfin mako could consume roughly 500 kg of bluefish per year off the northeast coast of the United States.

Scalloped Hammerhead (*Sphryna lewini*)
The role of the scalloped hammerhead in the western North Atlantic food web is being examined by quantitatively characterizing the stomach contents from sharks caught by research and commercial vessels, and at recreational fishing tournaments using three types of gear: longline, rod and reel, and gillnet. A total of 314 samples were collected from 1975 to 2009 with 188 (60%) containing food. Geographic area had the strongest influence on diet. Sharks occurring in inshore waters fed primarily on fish (both less active demersal and pelagic species) while cephalopods were by far the largest food group found in the stomachs of sharks caught offshore. There were fewer empty stomachs found in the offshore sample than in the inshore sample but

the volume of stomach contents in those with food was higher inshore. Season also played a significant role in their feeding ecology. The lowest percent empty, the largest average stomach content volume, and the largest average number of prey items per stomach occurred in the summer. Shark sex, state of maturity, decade caught and gear type had little or no significant influences on diet. A poster was presented at the NEFSC 9th Science Symposium in January 2009 summarizing these results.

Sable Island Seal Predation

An investigation into shark predation on five species of seals on Sable Island, Nova Scotia, Canada, is ongoing. 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.

Movements and Migrations using conventional and electronic tag technology

Cooperative Shark Tagging Program (CSTP)

The Cooperative Shark Tagging Program 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. In 2009, information was received on 7,250 tagged and 325 recaptured fish bringing the total numbers tagged to 216,000 sharks of more than 50 species and 12,850 sharks recaptured of 33 species. To improve the quality of data collected through the CSTP, the Guide to Sharks, Tunas, & Billfishes of the US Atlantic and Gulf of Mexico has been reprinted and made available to recreational and commercial fishermen through the Rhode Island Sea Grant as well as identification placards for coastal and pelagic shark species. A toll-free number has been established as well as online reporting to collect information on recaptures for all species.

Alternative tag testing is underway utilizing recreational tag and release tournaments; the most recent in February of 2009. These events offer an opportunity to investigate the use of two new dart tags on coastal and pelagic sharks. Many of these events have 100% observer coverage on the recreational boats and observers alternatively using each tag type and recording tag data, release condition, and total catch and effort. This will allow an initial evaluation of these tags by getting feedback from the participants on how easy each tag is to handle, how well they stay on the tagging needle, and how easily the dart head penetrates the shark skin. This feedback on tag use and subsequent recaptures will enable us to begin to evaluate these tag types for future use.

Integrated Mark-Recapture Database Management System (I-MARK)

The NEFSC Integrated Mark-Recapture Database System (I-MARK) provides a platform to keep multi-species tagging data in a common format for management and analysis. Initiated by the Cooperative Research Program, the database design and application were developed collaboratively by the shark, yellowtail flounder, black sea bass, and scup tagging programs, and Data Management Systems. I-MARK was designed to track fish and tags independently. It consists of several web application modules including inventory of tags, initial release events, subsequent recapture events, bulk data entry of cruise releases, contact name and address information, map display, reports and statistical queries. Fate of animal, fate of tag, double tags, and multiple recaptures can be accommodated within the database. Extensive quality control is achieved using the web application to enter and maintain the I-MARK data. These audits can be applied to data for all fisheries or a specific fishery and encompass standard audits such as checking data type, land locations, and allowable values as well as more complex validations which check relationships between the fate of animal, fate of tag and event type. A constituent release recapture letter is generated by the web application with a map, size, location, time at liberty and distance traveled information. A poster was presented at the NEFSC 9th Science Symposium in January 2009 summarizing these results.

Porbeagle (*Lamna nasus*) Movement Patterns

A study on the movement patterns, habitat utilization, and post-release survivorship of porbeagles 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. 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 (Skomal et al. 2009). The sharks, ten males and ten females ranging from 128-154 cm fork length, were tagged and released from a commercial longliner on the northwestern edge of Georges Bank. Based on known and derived geopositions, the porbeagles exhibited broad seasonally-dependent horizontal (77-870 km) and vertical (surface to 1300 m) movements. All of the sharks remained in the western North Atlantic from the Gulf of St. Lawrence and the coast of Nova Scotia to Georges Bank and oceanic and shelf waters south to North Carolina. In general, the population appears to contract during the summer and fall with more expansive radiation in the winter and spring. Although sharks moved through temperatures ranging from 2-26 °C, the bulk of their time (77%) was spent in water ranging from 8-16 °C. In the spring and summer months, the sharks remained in the upper 200 m of the water column. In the late fall and winter months, some of the porbeagles (n=10) moved deeper (200-1000 m). Temperature records indicate that these fish were likely associated with the Gulf Stream. Additional analyses, which include the integration of these data with those from the long-term conventional tag-recapture database, are ongoing. Since none of these fish moved to the NE Atlantic, this work also supports the two stock hypotheses for the North Atlantic.

Tiger Shark (*Galeocerdo cuvier*) Movement Patterns

In cooperation with researchers from the Monterey Bay Aquarium and MDMF, three tiger sharks were tagged with PSAT's off the coast of North Carolina during the NEFSC fishery independent bottom longline survey in April, 2007. The tags provided viable data on the horizontal and vertical movements of these fish. Given that these sharks were also blood sampled at capture, these tags generate additional information on post-release survivorship and behavior of longline-stressed tiger sharks. Data analyses are ongoing in 2009.

<u>Southeast Fisheries Science Center (SEFSC)</u>

Stock Assessments of Pelagic and Prohibited Sharks

SEFSC scientists actively participated in the ICCAT intersessional assessment of blue and shortfin mako stocks described in section 4.2. Specifically, SEFSC staff prepared 5 documents for the stock assessment workshop held in Spain in 2008, in addition to being centrally involved in conducting the actual stock assessments (ICCAT 2008). SEFSC staff also developed two Ecological Risk Assessments (ERAs) of pelagic sharks for the 2008 ICCAT stock assessment meeting (see ERA section below). In 2009, SEFSC staff also actively participated in the joint ICCAT/ICES porbeagle shark stock assessment held in Denmark, conducting some of the assessments and preparing 2 documents for the assessment meeting.

Ecological Risk Assessments (ERA) of Atlantic sharks

SEFSC staff conducted several ERAs of Atlantic sharks in 2008. These analyses evaluate the productivity of a stock and its susceptibility to the fisheries exploiting it, which allow for an assessment of the potential vulnerability of the stock. Two ERAs were carried out for stocks in the Atlantic shark complex, one as part of activities by the NMFS Vulnerability Evaluation Working Group (for more information see Patrick et al. 2009 and http://www.nmfs.noaa.gov/msa2007/vulnerability.htm), the other for presentation at the American Elasmobranch Society 24th annual meeting (Cortés et al. 2008a). Additionally, two ERAs were conducted in support of ICCAT's 2008 assessment activities for pelagic sharks (Cortés et al. 2008b; Simpfendorfer et al. 2008). Results of these analyses provided categorizations of the relative vulnerability and associated risk of the different stocks to being overfished.

Observer Programs

<u>Shark Longline Program</u>

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. 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.). Recent amendments to the Consolidated Atlantic HMS FMP based on updated stock assessments have eliminated the major directed shark fishery in the U.S. Atlantic. The amendments implement a shark research fishery, which allows NMFS to select a limited number of commercial shark vessels on an annual basis to collect life history data and catch data for future stock assessments. Furthermore, the revised measures drastically reduce quotas and retention limits, and modify the authorized species in commercial shark fisheries. Specifically, commercial shark fishers not participating in the research fishery are no longer allowed to land sandbar sharks, *Carcharhinus plumbeus*, which have been the main target species. Outside the research fishery, fishers are permitted to land 33 non-sandbar large coastal sharks. In 2008, NMFS announced its request for applications for the shark research fishery from commercial shark fishers with a directed or incidental permit. Based on the temporal and spatial needs of the research objectives, and the available quota, 11 qualified applicants were selected for observer coverage in 2008, 7 in 2009, and 9 in 2010. These vessels carried observers on 100 percent of trips. Outside the research fishery, vessels targeting shark and possessing current valid directed shark fishing permits were randomly selected for coverage with a target coverage level of 4-6 percent. From June 2005 to December 2009, a total of 273 trips on 65 vessels with a total of 879 hauls were observed.

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[13] 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. All observers must record information on all gear characteristics, species caught, condition of the catch, and the final disposition of the catch. A total of 12 drift gillnet vessels were observed making 225 sets on 43 trips in 2009. Vessels targeted one or more of the following species: Spanish mackerel, king mackerel, or small coastal shark species including blacknose *Carcharhinus acronotus*, Atlantic sharpnose *Rhizoprionodon terraenovae*, and finetooth *Carcharhinus isodon*, sharks. Three vessels making a total of 4 trips and 6 sets were observed fishing gillnets in a strike fashion in 2009. Target species included king mackerel, Spanish mackerel, and blacktip shark *Carcharhinus limbatus*. A total of 38 trips making 190 sink-net sets on 14 vessels were observed in 2009. Trips were made targeting one or more of the following species: shark, Spanish mackerel, king mackerel, Southern kingfish, *Menticirrhus americanus*, Atlantic croaker *Micropogonias undulatus*, bluefish, weakfish *Cynoscion regalis*, blacknose shark, and finetooth shark.

Determination of critical habitat for the conservation of dusky shark (Carcharhinus obscurus) using satellite archival tags

In an attempt to improve the conservation status of dusky shark, NMFS established a time-area closure off North Carolina from January to July to reduce bycatch of neonate and juvenile dusky sharks. Although neonate and juvenile dusky sharks have been documented in abundance in this locality during the winter months, current knowledge of the overwintering area of this population is derived entirely from fishery-dependent data (tag returns and commercial fishery longline data; NMFS 2003). Thus, these data may be a more accurate reflection of the distribution of the

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[13] 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.

fishery rather than the distribution of the population. To examine the utility of the closed area on the conservation and recovery of dusky shark, satellite archival tags are being used to examine habitat utilization and movement patterns of juvenile dusky shark. Information gathered through this study will verify the utilization of the closed area by dusky shark and also provide information on daily and seasonal movement patterns such as migration corridors that could aid in developing additional critical habitat information. Data are also being obtained on preferred depth and habitat, which may help reduce further fishery interactions through bycatch mitigation. To date, 4 dusky sharks have been tagged with PSAT tags.

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 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 recently 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 2009, 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.

A comparison of the foraging ecology and bioenergetics of two sympatric juvenile hammerhead sharks

Juvenile scalloped hammerheads, *Sphyrna lewini* (30-60 cm FL; mean FL= 41.5 cm; n=208), were collected in northwest Florida to examine foraging ecology, bioenergetics, and trophic level. Diet was quantified using five indices, and daily ration was estimated using a bioenergetic approach. Diet composition and bioenergetics were compared to already published information for the bonnethead shark, *S. tiburo*, from the same region and trophic level was calculated for both species using stomach contents and stable isotope analysis. Diet overlap was low between species because juvenile *S. lewini* are largely piscivorous, feeding mostly on relatively small benthic teleosts (bothids and sciaenids) and penaeid shrimp while *S. tiburo* feed mostly on crabs and other crustaceans and plant material. Plant material contributed little to the diet of *S. lewini*. *S. lewini* estimated daily ration was higher (4.58 % BW d^{-1}) than *S. tiburo*. Trophic level was calculated at 4.0 for *S. lewini* and 2.6 for *S. tiburo*. *S. lewini* was significantly enriched in $d^{15}N$ and significantly depleted in $d^{13}C$ when compared to *S. tiburo*. Further studies need to be conducted to better determine the relative influence of plant material on the trophic level and bioenergetic differences.

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). 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 was updated and fine-tuned in fiscal year 2008 with hopes to have it online and searchable by all participants in fiscal year 2010.

Monitoring the Recovery of Smalltooth Sawfish (Pristis pectinata)

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

The completion of the Smalltooth Sawfish Recovery Plan in early 2007 brought about a new phase of research and management for the U.S. population of smalltooth sawfish. Research and monitoring priorities identified in the Recovery Plan are now being implemented. Field work is underway to gather information on determining critical habitat and monitoring the population. This information will evaluate the effectiveness of protective and recovery measures and help determine if the population is rebounding or, at the very least, stabilizing.

One of the high priority research areas is monitoring of the number of juvenile sawfish in various regions throughout Florida to provide a baseline and time series of abundance. One of the more important regions for smalltooth sawfish identified in previous research is the section of coast from Marco Island to Florida Bay, FL. This region encompasses the coast of the Ten Thousand Islands National Wildlife Refuge and Everglades National Park. Scientists from the Panama City Laboratory conduct monthly surveys in southwest Florida to capture, collect biological information, tag and then release smalltooth sawfish. Preliminary results indicate that juvenile sawfish are highly specific to certain areas and that they may return to the same specific mangrove habitat. Genetic identification of recaptured individuals indicates that sawfish caught on the same mudflat, for example, are siblings and a single adult female sawfish may give birth on that same mudflat year after year. Determination of critical habitat and movement and migration corridors for larger juvenile and adult sawfish is being undertaken using PSAT and SPOT tags. Preliminary results indicate sawfish are found at greater depths than originally anticipated and may be found in offshore aggregations in specific areas of the Gulf of Mexico.

Life History Studies of Elasmobranchs

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

Sandbar Shark (*Carcharhinus plumbeus)*

Sandbar shark age, growth, and reproduction was investigated following recommendations from SEDAR 11. A total of 1194 (701 females, 493 males) sandbar sharks were examined. Size (and age) at 50% maturity for males was 151.6 cm FL (13.1 years) and 154.9 cm FL (14.1 years) for females, while the size at which 50% of females were in reproductive condition was 162.6 cm FL (15.5 years). Males and females showed distinct seasonal reproduction patterns, with peak mating and parturition occurring from April through June. Female fecundity averaged 8.0 pups; there was a weakly significant increase in fecundity with size and a significant increase in fecundity with age. Results suggest that sandbar sharks may have a triennial reproductive cycle. Age and growth analysis of the sandbar shark from the Gulf of Mexico and southern Atlantic Ocean was completed with vertebral samples primarily gathered from the sandbar shark research fishery (n = 1194). Three parameter von Bertalanffy growth curves were run for male and female sandbar sharks separately and growth parameters were estimated as a male $L_\infty = 172.97 \pm 1.30$ cm FL, female $L_\infty = 181.15 \pm 1.45$ cm FL, male $k = 0.15 \pm 0.005$, female $k = 0.12 \pm 0.004$, male $t_0 = -2.33 \pm 0.19$, and female $t_0 = -3.09 \pm 0.16$. The oldest aged sandbar shark was a 27 year old female. This study represented a concerted effort to collect current samples from the commercial shark bottom longline fishery to better describe the age structure of the sandbar shark population.

Great hammerhead shark (*Sphyrna mokarran)*

The great hammerhead shark is a cosmopolitan species that is caught in a variety of fisheries throughout much of its range. The apparent decline of great hammerhead shark populations has reinforced the need for accurate biological data to enhance fishery management plans. To this end, age and growth estimates for the great hammerhead were determined from sharks (n = 216) ranging in size from 54 to 315 cm fork length (FL) captured in the Gulf of Mexico and northwestern Atlantic Ocean. The von Bertalanffy growth model was the best fitting model with resulting growth parameters of $L\infty$= 264.2 cm FL, k= 0.16 year-1, to= -1.99 year for males and $L\infty$= 307.8 cm FL, k= 0.11 year-1, to= -2.86 year for females. Annual band pair deposition was confirmed through marginal increment analysis and a concurrent bomb radiocarbon validation study (see below). Great hammerheads have one of the oldest reported ages for any elasmobranch (44 years) but grow at relatively similar rates (based on von Bertalanffy k value) to other large hammerhead species from this region. This study is the first to provide vertebral ages for great hammerheads.

Bomb radiocarbon validation

Preliminary validation of annual growth band deposition in vertebrae of great hammerhead shark, *Sphyrna mokarran*, was conducted using bomb radiocarbon analysis. Adult specimens (n = 2) were collected and thin sections of vertebral centra removed for visual ageing and radiocarbon assays. Vertebral band counts were used to estimate age, and year of formation was assigned to each growth band via subtraction from year of capture. Samples for radiocarbon analysis were extracted from 10 individual bands. Calculated $\Delta 14C$ values from dated bands were compared to known-age reference chronologies, and resulting trends indicate annual periodicity of growth bands up to 42 years. Patterns of $\Delta 14C$ across time in individual specimens indicate that radiocarbon is conserved through time and that habitat and diet may influence $\Delta 14C$ levels in elasmobranchs. Results of this study are limited to a partial validation of age due to low sample size and narrow age range of individuals sampled. However, they do represent the first evidence of age validation in *S. mokarran*, further illustrating the usefulness of bomb radiocarbon analysis as a tool for life history studies in elasmobranchs.

Habitat use and movement patterns of bull sharks (Carcharhinus leucas) determined using pop-up satellite archival tags

Habitat use, movement and residency of bull sharks were determined using satellite pop-up archival transmitting (PAT) tags throughout coastal areas in the Gulf of Mexico and waters off the southeast US. From 2005-2007, eighteen bull sharks (mean size=164 cm LF) were tagged over all seasons. Sharks retained tags for up to 85 days (median= 30 days). Based on geolocation data from initial tagging location to pop-off location, sharks generally traveled about 5-6 km day-1 and traveled an average of 143·6 km. Overall, mean proportions of time at depth revealed bull sharks spent the majority of their time in waters less than 20 m. Bull sharks exhibited significant differences among depths but were not found at a particular depth regardless of diurnal period. Most bull sharks occupied temperatures around 32° C with individuals found mostly between 26° C and 33° C. Geolocation data for bull sharks were generally poor and varied considerably but tracks for two individuals revealed long distance movements. One bull shark traveled from the southeast coast of the US to coastal Texas near Galveston while another moved up the east coast of the US to South Carolina. Data on bull shark movements indicated that they are found primarily in shallower waters and tend to remain in the same location over long periods. While some individuals made large-scale movements over open ocean areas, the results emphasize the importance of the coastal zone for this species as potential essential fish habitat, particularly in areas of high freshwater inflow.

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

A cooperative shark research project between Brazil (Universidade Federal Rural de Pernambuco) and the U.S. (NMFS SEFSC Panama City Laboratory and the University of Florida's Florida Museum of Natural History) was initiated in 2007. The main goal of this cooperative project is to conduct simultaneous research on pelagic sharks in the North and South Atlantic Ocean. Central to conducting the research is development of fisheries research capacity in Brazil through graduate student training and of stronger scientific cooperation between the U.S. and Brazil. Electronic equipment (hook-timer recorders [HTR] and temperature and depth recorders [TDRs]) was sent from the U.S. to Brazil for deployment aboard commercial longline fishing vessels to investigate preferential feeding times of pelagic sharks and associated fishing depths and temperatures for potential use in habitat-based models and estimation of catchability. To date, one fishing survey has been conducted, with 17 sets on a commercial pelagic longline fishing vessel during April and May 2009; each set made use of 300 HTRs. In this first survey only HTRs were used; the deployment of the TDRs is scheduled for the next survey. A total of 772 individuals, represented by 22 species were caught. The target species, swordfish (*Xiphias gladius*), was the most commonly fish caught, (n = 297, 38.5%). Sharks (*Carcharhinus longimanus* (n = 7), *Prionace glauca* (n = 23), *Sphyrna* spp. (n = 5), *Isurus oxyrinchus* (n = 4), *Alopias* spp. (n = 3), *Carcharhinus signatus* (n = 2), and *Pseudocarcharias kamoharai* (n = 7)) represented 6.6% of the total catch. A total of 415 activated HTRs were recovered with fish (or identifiable fish parts) on the leader. Time at hooking varied among species. Almost all blue sharks (96%) were hooked at night, and all shortfin makos and crocodile sharks caught on leaders with HTRs were caught at night. Thresher and hammerhead sharks showed no clear preference between daylight and nighttime feeding. Only one oceanic whitetip shark was caught during the night, and this animal was hooked just prior to sunrise. Future work will consist of another 15 surveys in 2009 and 2010 to collect fishery TDR and HTR data. Additionally, the use of pop-up satellite archival tags (PSATs) on blue, shortfin mako, and other pelagic sharks is intended to provide critical knowledge on daily horizontal and vertical movement patterns, depth distribution, and effects of oceanographic conditions on the vulnerability of these pelagic sharks to pelagic longline fishing gear. Six pop-off satellite archival tags have been deployed to date (2 oceanic whitetip sharks, 3 bigeye threshers and 1 longfin mako) in U.S. Atlantic waters. Archival satellite pop-up tags were also attached to three female blue sharks and two female shortfin mako sharks by pelagic longline fishing vessels in the Southwestern Atlantic Ocean. Data collected by these tags are still being analyzed; however, preliminary findings will be presented at regional and national conferences.

As part of the training component of this cooperative Brazil-US research project, an international course entitled: “A practical course in demographic methods and ecological risk assessment using spreadsheets” was taught by Dr. Enric Cortés at the Florida Museum of Natural History, University of Florida, Gainesville, July 13-17, 2009. The course included students mostly from Brazil, but also from Argentina, Colombia, Venezuela, Uruguay, Portugal, Spain, and the USA.

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

As part of a project entitled “Sustainable fisheries and bycatch reduction of pelagic sharks in the Atlantic Ocean: a collaborative project between Uruguay and the USA”, the SEFSC and Uruguay’s fisheries agency (DINARA) aim to advance knowledge on the productivity and susceptibility of pelagic sharks to longline fisheries in the western South Atlantic Ocean, aspects which are largely unknown for pelagic sharks in the southern hemisphere. To that end, six satellite transmitters (4 PSATs and 2 SPOTs) obtained through a grant awarded to conduct this project, have been successfully deployed on blue sharks to date. At least two additional satellite tags will be deployed to continue to characterize spatio-temporal habitat use in pelagic sharks. Staff from DINARA and the SEFSC are also working cooperatively on the creation of an identification guide for sharks of the Atlantic Ocean for ICCAT.

Shark Assessment Research Surveys

Figure 5.1.7. Scalloped hammerhead captured in the Gulf of Mexico during a bottom longline survey.
Source: NMFS Mississippi Laboratories, Shark Team

The SEFSC Mississippi Laboratories have conducted bottom longline surveys in the Gulf of Mexico (see Figure 5.1.7), Caribbean, and Southern North Atlantic since 1995 (27 surveys have been completed through 2009). The primary objective is assessment of the distribution and abundance of large and small coastal sharks across their known ranges in order to develop a time series for trend analysis. The surveys, which are conducted at depths between 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 (9.1 meters) to examine seasonality and abundance of sharks in inshore waters of the northern Gulf of Mexico and to determine what species and size classes are outside of the range of the sampling regime of the long-term survey. This work is being done in cooperation with 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.

<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.

5.2 Incidental Catch Reduction

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

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 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 of 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 bait in the presence of the metal (metal approximately the same size as a 60g lead fishing weight).

Initial experiments to examine the effects on shark catch rates on modified longlines are also being conducted. This is being accomplished through a collaboration with Dr. Kim Holland of the University of Hawaii's Hawaii Institute of Marine Biology (HIMB) located on Coconut Island in Kaneohe Bay. We have initiated two experiments, one focusing on the effects of Nd/Pr (Neodymiun/Praseodymium) alloy on the catch rates of sharks on bottom set longline gear and the other examining the effects of Nd/Pr alloy and other lanthanide alloys on the feeding and swimming behavior of scalloped hammerhead (*Sphyrna lewini)* and sandbar *(Carcharhinus plumbeus)* sharks. Preliminary results from longline field trials in Kaneohe Bay, Hawaii suggest that catch rates of juvenile scalloped hammerhead sharks are reduced by 63 percent on branchlines with the Nd/Pr alloy attached as compared to lead weight-controls (Figure 5.2.1). Sharks for behavioral experiments are being collected, experimental observation arenas are being prepared for behavioral experiments, and initial behavioral experiments examining effects on swimming behavior have been initiated (Wang et al. 2009; Brill et al. 2009).

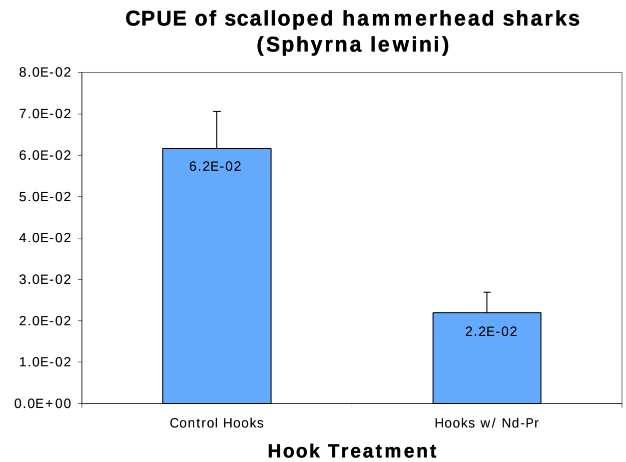

Figure 5.2.1. Catch per unit effort of scalloped hammerhead sharks on longlines with Nd/Pr alloy attached versus control hooks.

In addition, field trials on pelagic sharks are being initiated. Collaborating with the SWFSC, experiments examining the effects of the metals on the catch rates of mako and blue sharks were conducted during the annual SWFSC pelagic shark surveys off California in the summer of 2009. Analysis of catch data is ongoing, though initial results indicate no difference in the catch rates of blue and mako sharks between control branchlines and branchlines with Nd/Pr metal. The data are being further examined based on size, sex, and other potential factors before drawing final conclusions. A pilot study in the Ecuadorian mahi-mahi longline fisheries was also conducted.

<u>Longline Gear Effects on Shark Bycatch</u>

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. There was no significant difference in the catch of the target species, bigeye tuna (*Thunnus obesus*) by hook type. However, results showed strong statistical evidence that the use of large circle hooks would reduce the catch of incidental species such as billfish, pelagic sharks, opah, and dolphinfish in the Hawaii-based tuna longline fishery (Curran and Bigelow, 2010).

Testing Deeper Sets

An experiment with deeper-set longline gear conducted in 2006 has been analyzed and has been published (Beverley et al. 2009). 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.

Southwest Fisheries Science Center (SWFSC)

Incidental Take of Blue Sharks in the U.S. West Coast Drift Gillnet and Longline Fisheries for Swordfish

Blue sharks are one of the most common bycatch species in a number of pelagic fisheries. In the Hawaii shallow-set longline fishery for swordfish they are the most commonly caught non-target species and in the California drift gillnet fishery they are the second most common bycatch species behind the ocean sunfish, *Mola mola*. A better understanding of the temporal and spatial patterns in bycatch should help in the development of bycatch reduction methods.

With funding from the NOAA Bycatch Reduction Engineering Program (BREP), SWFSC scientists have been analyzing observer and logbook data to characterize the catch of blue sharks and to identify seasons, areas and gear configurations that yield the lowest blue shark to swordfish catches ratios. To compare catch ratios for drift gillnet and longline fisheries, over 250,000 sets from logbooks and over 100,000 observed sets have been compiled for the CA drift gillnet and longline fisheries, and the HI longline fishery. The ratio of blue shark catch to swordfish catch per set was analyzed with respect to a range of factors related to fishing methods, temporal and spatial patterns as well as regional oceanography. Preliminary results show that on average the drift gillnet fishery has a lower blue shark to swordfish catch ratio than the CA and HI longline fisheries combined; however, significant differences were apparent between the logbook and observer data for each of the fisheries, likely due to under reporting of blue shark catch in the logbooks. For example, the median ratios of blue shark to swordfish catch for the drift gillnet logbook and observer datasets are 0.0, and 0.4, respectively, whereas those for the CA longline logbook and observer datasets are 0.34 and 0.52, respectively. Lower blue shark to swordfish ratios were observed during the month of August for both fisheries. Additional analyses using multivariate statistical methods are currently underway to tease apart the complex relationships between the environment, location, data type and gear type.

Southeast Fisheries Science Center (SEFSC)

Cooperative Research—Capture time, size and hooking mortality of bottom longline-caught sharks

The primary gear type used to harvest coastal sharks in the U.S. Atlantic shark fishery is bottom longline. Recent stock assessments have found several species of coastal sharks in US Atlantic Ocean waters have declined from 60-80% of virgin levels. To aid in stock rebuilding, alternative gear restriction measures such as reduced soak time, restrictions on the length of gear, and fishing depth restrictions have been considered but not implemented. In order to evaluate the effectiveness of some of these management measures, controlled experiments were performed using hook timers and time depth recorders, assessing the factors affecting mortality during longline capture for the four most abundant species that incurred at-vessel mortality: sandbar (*Carcharhinus plumbeus*), blacktip (*C. limbatus*), bull (*C. leucas*), and blacknose (*C. acronotus*). Our results indicate that as hook time and shark size increased, mortality rates for the sandbar and blacktip sharks increased. Predicted models indicated mortality rates increased steadily for the three species but appeared to increase the most after 10, 6, and 1 h on the hook for sandbar, blacktip and blacknose shark, respectively. Sandbar sharks larger than approximately 170 cm FL are more susceptible to hooking mortality. Blacknose shark mortality rates increased as hook time increased but bull shark mortality rates were not affected by any factor. The probability of a hook being bitten increased the most between 5 to 12 h after the fishing gear had been set and the mean amount of time hooks were in the water prior to being bitten was 4, 5 and 9 h. for sandbar and blacknose sharks, blacktip, and bull sharks, respectively. A significant difference was found between these means for sandbar and bull sharks and between blacknose and bull sharks. Shark species were commonly caught at different temperature and depth ranges. These results could be used by fisheries management to implement restrictions of fishing depth and soak time to aid in the recovery of coastal sharks species.

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 Mg2+, plasma lactate, erythrocyte Hsp70 mRNA, plasma Ca2+, and plasma K+. A logistic regression model incorporating a combination of Mg2+ 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 (Moyes et al. 2006).

In the second approach, five species of pelagic sharks (bigeye thresher, n=8; blue shark, n=32; oceanic whitetip, n=16; short fin mako, n=5; and silky shark, n=10) released from longline gear were tagged with PSATs. Of 44 PSATs reporting (62 percent reporting rate, 95% CI, 50 to 73 percent), there was definitive data for post-release mortality in only 2 cases (male blue shark after 7days, female oceanic whitetip after 9 days) for an overall mortality estimate of 4.5 percent (95 percent bootstrap CI, 0 to 11 percent). Non-reporting tags are not synonymous with mortality as Musyl et al. (in review) can demonstrate that species' depth patterns (pressure/temperature), tag manufacturer and pop-up year significantly influence PSAT reporting rates in logistic regression models. Other researchers have similarly surmised that you can not make the assumption that non-reporting tags are cases of mortality due to many factors that could cause electronic tag failure in the marine environment. The case for mortality in the blue shark sample (1 mortality in 16 tags, 95 percent bootstrap CI, 0 to 19 percent) must be viewed with skepticism. For example, morbidity in this case was perhaps unwittingly influenced by scientific sampling (see Moyes et al. 2006). This was the first shark hauled and tagged on board in the study and there were problems obtaining a blood sample (i.e., no blood sample was taken after repeated trials). In the second case (1 mortality in 13 tags, 95% bootstrap CI, 0 to 23 percent), the oceanic whitetip shark did not make any notable descents after release and languished near the surface before it apparently succumbed and sank, thereby jettisoning the tag to the surface about 9 days after capture. Antecedent stress variables to explain mortality have been examined (i.e., capture temperature, soak time, etc.) but we could not conclusively demonstrate association with any of the variables and mortality in these two instances. These combined biochemical and PSAT analyses suggest that sharks landed in an apparently healthy condition are likely to survive long term if released (95 percent survival based on biochemical analyses [blue shark]; >95 percent based on PSATs [all sharks studied]). In summary, our studies demonstrate a high rate of post-release survival of pelagic sharks captured and released from longline gear fished with circle hooks. These tagging results are also used to chronicle these pelagic species in terms of migration routes, distribution patterns and habitat association as well as developing bycatch mitigation methods (Musyl et al. 2009; Beverley et al. 2009).

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. We quantify these issues by analyzing reporting rates, retention times, and data return from 27 pelagic species from 2164 deployments [731 PSAT deployments from 19 species in the authors' database, and in 1433 PSAT deployments from 24 species summarized from 53 published articles]. Shark species in the database include bigeye thresher, blue, shortfin mako, silky, oceanic whitetip, 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. PSATs in the database had an overall reporting rate of 0.79 which was not significantly different ($p = 0.13$) from the PSAT reporting rate of 0.76 in the meta-analysis. Logistic regression models showed that reporting rates have improved significantly over recent years, are lower in species undertaking large vertical excursions with a significant interaction between species' depth class (i.e., littoral, epi-pelagic, meso-pelagic, bathy-pelagic) and tag manufacturer. Information derived from this study should allow an unprecedented and critical appraisal of the overall efficacy of the technology (Musyl et al. in review).

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 (SCB). 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 SWRO have been working on a project to determine the survivorship of blue sharks caught and released alive from the California drift gillnet fishery. This fishery targets swordfish in the California Current with the majority of the recent effort focused in the SCB. With the exception of ocean sunfish, blue sharks are caught in greater numbers than any other finfish species taken in this fishery. Nearly all blue shark are discarded at sea due to lack of market value. A 2009 analysis of the 1990-2008 observer data reveals that 32% of blue sharks captured were released alive, and an additional 5% were discarded with their disposition unknown. The remaining 63% were discarded dead.

In 2007, the SWFSC and SWRO began deploying PSAT tags on sharks released from the drift gillnet fishery to assess survivorship. The goal was to tag sharks such that the sex ratio, range of sizes, and condition at release are comparable to those released from the fishery. To document condition at release, a set of criteria were developed to characterize sharks in good, fair or poor condition.

Since initiating the study in 2007, 11 blue sharks (100-200 cm FL, median 155 cm) have been tagged by fishery observers; one shark was tagged during the 2009-2010 season. Nine of these animals were male, and the sex of two animals was unknown. Three of the 11 sharks were released in "good" condition while the remaining eight were released in "fair" condition. Satellite tag records suggest that all animals survived the acute effects of capture; temperature, depth and movement data demonstrated behavior of blue sharks that was similar to that reported in other studies.

To meet the goal of matching the general composition of the catch, additional tag deployments are necessary to better match shark size and gender and release condition. To date no sharks in poor condition have been tagged. In the fishery, 27% of blue sharks released during the 2007-2008 and 2008-2009 seasons (the only seasons for which this information has yet been collected and compiled) were released in poor condition. For seasons 1990-2008, the median overall FL of blue sharks caught was 112 cm, and 61% were female. Tagging efforts during the 2010-2011 season will focus on smaller sharks, females and animals released in poor condition.

Survival of Common Thresher Sharks (*Alopias vulpinus*) Released from the Recreational Fishery

A recreational fishery for thresher sharks has become increasingly popular off Southern California. Anglers often hook the tails of thresher sharks and pull the fish backwards to the boat. This technique has the potential to prevent sufficient oxygenation as thresher sharks are obligate ram ventilators. When the fight time is long, the fish may be exhausted by the time it reaches the boat and survivorship may be reduced.

Figure 5.3.1. One of twenty common thresher sharks captured and tagged with a PSAT tag to assess catch-and-release survivorship

To document survivorship for tail-hooked sharks, a collaborative project funded through the NOAA Bycatch Reduction Engineering Program (BREP) was initiated by the SWFSC, SWRO Sustainable Fisheries Division, and the Pfleger Institute of Environmental Research (PIER). For the survivorship study, 20 thresher sharks were hooked in the tail and pulled to the boat using standard recreational tackle (see Figure 5.3.1). PSAT tags were deployed on 18 of the adult and subadult sharks and two sharks died before they could be tagged. The tags were programmed to release after 10 days to determine survivability. The records from the 17 PSAT tags that reported to satellite indicated that three additional sharks died following release (one tag did not report). Our findings suggest a hooking mortality rate of 26%, with a post-release mortality estimate of 17% for adult and subadult thresher sharks. All individuals with fight times less than 85 minutes survived the acute effects of capture as determined by the PSAT records. All sharks sustaining fight times of greater than 85 minutes died. The longest fight times were recorded for the largest individuals that tend to be harder to bring to the boat. Consequently, mortality due to capture stress is likely higher for larger individuals. Further tagging is planned for the 2010 season to increase the sample size and experiment with alternative fishing techniques, including teasers with drop-back bait, and corrosive links to reduce trailing gear.

Blood chemistry was analyzed to assess the stress response associated with tail-hook capture. Eight blood and plasma parameters were examined (Na^+, Cl^-, K^+, Ca^{++}, Mg^{++}, glucose, lactate, and hematocrit). Blood was drawn from nine thresher sharks that were not included in the tagging study; six of these were tail-hooked. The two parameters that showed a significant increase with fight time were lactate and hematocrit.

In an effort to educate the recreational fishermen about the biology and conservation of the thresher sharks and to promote responsible fishing techniques, an outreach brochure was developed and distributed among the community (see Figure 2.5.1). Outreach included seminars and presentations at sportfishing club meetings, tournaments, and fishing/boating shows. Public education about effective catch and release methodologies and gear innovations to increase post-release survivorship will continue through the 2010 season.

Northeast Fisheries Science Center

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

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

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Appendix 1: Internet Information Sources

Atlantic Ocean Shark Management

Copies of the 2006 Consolidated Atlantic HMS FMP and its Amendments 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 metric tons) for California, Oregon, and Washington, 1998–2008) was obtained from the Pacific States Marine Fisheries Commission's PacFIN Database, which may be found on their website at: http://pacfin.psmfc.org/pacfin_pub/data.php.

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

Data reported in Table 2.3.9 (Shark landings (mt) from the Hawaii-based longline fishery and the American Samoa longline fishery, 1998-2008) 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 Conservation and Enforcement Measures
http://www.nafo.int/fisheries/frames/regulations.html

IATTC
http://iattc.org/HomeENG.htm

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

WCPFC
http://www.wcpfc.int/

UNGA
http://www.un.org/en/law/

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

Appendix 2: Species Index