2006 Report to Congress

Pursuant to the

Shark Finning Prohibition Act of 2000

(Public Law 106-557)

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

Prepared by the
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Executive Summary

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

Shark finning is the practice of taking a shark, removing the fin or fins from it, and returning the remainder of the shark to the sea. The Shark Finning Prohibition Act of 2000 prohibited the practice of shark finning for any person under U.S. jurisdiction. The Act requires the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) to promulgate regulations to implement the prohibitions of the Act, initiate discussion with other nations to develop international agreements on shark finning and data collection, and establish research programs. This report describes NMFS' efforts to carry out the Shark Finning Prohibition Act.

The Magnuson-Stevens Fishery Conservation and Management Act form the basis for fisheries management in federal waters, and requires NMFS and the eight regional fishery management councils to take specified actions. In the U.S. Atlantic Ocean, sharks and other highly migratory species 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. Additional information on shark management in the United States can be found on pages 4 through 15 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 June 2005, members of the Inter-American Tropical Tuna Commission adopted a binding resolution banning shark finning in the eastern Pacific Ocean. This resolution—cosponsored by the United States, European Union, Japan, and Nicaragua—bans shark finning and mandates the collection of information and advice on stock status of shark species as well as proposals for a comprehensive assessment of shark stocks in the Pacific Ocean. The resolution also requires all members establish and implement a national plan of action for conservation and management of shark stocks in accordance with the United Nations Food and Agriculture Organization (FAO) International Plan of Action for the Conservation and Management of Sharks.

Also in 2005, the North Atlantic Fisheries Organization (NAFO) Fisheries Commission adopted a ban on shark finning in all NAFO-managed fisheries and mandated the collection of information on shark catches. In addition, the United Nations General Assembly adopted a resolution on Oceans and the Law of the Sea, which recognizes the need for measures to promote long-term sustainability of shark populations and fisheries. This resolution, strongly supported by the United States, further encourages implementation of the FAO International Plan of Action for the Conservation and Management of Sharks. Further information on international efforts to advance the goals of the shark finning prohibition can be found on pages 21 to 26.

Numerous research studies undertaken by NMFS Science Centers have produced much valuable information on shark status, mobility, migration, habitat, ecology, and age and growth characteristics—all of which will be incorporated into effective shark fishery management decisions. A detailed description of NMFS' research efforts regarding sharks can be found on pages 27 through 51 of this report. Overall, compared with 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 have not traditionally been a major priority for fisheries management agencies, because the volume and value of shark landings were considerably lower than landings in commonly exploited commercial fishes. On a global level, however, shark catches are commonly underreported and in some coastal waters there is no requirement to report shark catches; therefore, actual landings may be much greater than previously surmised. Concern has grown over the past decade about the status of shark stocks and the sustainability of their exploitation in world fisheries, as demand for some shark species and shark products has increased and international fishing effort directed at sharks and evidence of overfishing have increased. 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 species in world fisheries.

Biology of Sharks

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, which can make them particularly vulnerable to overexploitation.

On December 21, 2000, President Clinton signed into law the Shark Finning Prohibition Act of 2000. Section 3 of this Act amended the Magnuson-Stevens Fishery Conservation and Management Act 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 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. Section 9 defines finning as the practice of taking a shark, removing the fin or fins from a shark, and returning the remainder of the shark to the sea.

The Shark Finning Prohibition Act requires NOAA's 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). This *Report to Congress* fulfills the requirements of Section 6 and describes NMFS' activities relative to other sections of the Act. This report also provides an update to last year's report, and includes complete information for 2005 activities.

Consistent with the provisions of Section 5 of the Act, the Department of Commerce and the Department of State have been active in promoting development of international agreements consistent with the Act. 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.

During 2005, there were several noteworthy and highly successful achievements toward advancing the provisions of Section 5 of the Act. In June 2005, members of the Inter-American Tropical Tuna Commission adopted a binding resolution banning shark finning in the eastern Pacific Ocean. This resolution—cosponsored by the United States, European Union, Japan, and Nicaragua—bans shark finning and mandates the collection of information and advice on stock status of shark species as well as proposals for a comprehensive assessment of shark stocks in the Pacific Ocean. The resolution also requires all members establish and implement a national plan of action for conservation and management of shark stocks in accordance with the United Nations Food and Agriculture Organization (FAO) International Plan of Action for the Conservation and Management of Sharks, and take measures to require their fishermen fully utilize any retained catches of sharks—defined as retention of all parts of the shark excepting head, guts, and skin—to the point of first landing.

Also in 2005, the North Atlantic Fisheries Organization (NAFO) Fisheries Commission adopted a ban on shark finning in all NAFO-managed fisheries and mandated the collection of information on shark catches. In addition, the United Nations General Assembly adopted a resolution on Oceans and the Law of the Sea, which recognizes the need for measures to promote long-term sustainability of shark populations and fisheries. This resolution, strongly supported by the United States, further encourages implementation of the FAO International Plan of Action for the Conservation and Management of Sharks.

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 NAFO, Inter-American Tropical Tuna Commission, International Commission for the Conservation of Atlantic Tuna, United Nations General Assembly, Asia Pacific Economic Cooperation, FAO, Convention on International Trade in Endangered Species of Wild Fauna and Flora, and International Union for Conservation of Nature and Natural Resources.

In addition, numerous research studies undertaken by NMFS Science Centers have produced much valuable information on shark status, mobility, migration, habitat, ecology, and age and growth characteristics—all of which will be incorporated into effective shark fishery management decisions. Overall, compared with 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.

Scalloped hammerhead captured in the Gulf of Mexico during 2006 bottom longline survey.
Source: NMFS Mississippi Laboratories, Shark Team

2. Management and Enforcement

2.1 Management Authority in the United States

Previous reports to Congress discussed the Magnuson-Stevens Act and other legal authorities for management entities governing U.S. fisheries in which sharks are directed catch, incidental catch, or bycatch. The Magnuson-Stevens 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 of Sharks in the Atlantic Ocean

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

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

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

On December 24, 2003, the final rule implementing Amendment 1 to the FMP for Atlantic Tunas, Swordfish, and Sharks was published in the *Federal Register* (68 FR 74746). This final rule revised the shark regulations based on the results of the 2002 stock assessments for SCS and LCS. In Amendment 1 to the 1999 FMP, NMFS revised the rebuilding timeframe for LCS to 26 years from 2004, and implemented several new regulatory changes. Management measures enacted in the amendment included: 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; imposing gear restrictions to reduce bycatch; 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.

Most of the regulations in Amendment 1 to the FMP for Atlantic Tunas, Swordfish, and Sharks became effective on February 1, 2004; however, the change in commercial quotas, removal of the commercial minimum size, establishment of regional quotas, and change in recreational bag limit became effective on December 30, 2003. The time/area closure off North Carolina and the trimester seasons became effective January 1, 2005. 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, are required to have a VMS installed and operating during the mid-Atlantic shark closure period (January 1–July 31). The VMS requirement was finalized on December 24, 2003 (68 FR 74746), and was delayed pending a type-approval notice, which was published on April 15, 2004 (69 FR 19979). The final rule announcing the effective date for the VMS requirement was published on August 17, 2004 (69 FR 51010).

On August 19, 2005, NMFS published a Draft Consolidated Atlantic HMS FMP and proposed rule (70 FR 48804). On October 2, 2006, the 1999 FMP was replaced with the final Consolidated Atlantic HMS FMP, which consolidates management of all Atlantic HMS under one plan, reviews current information on shark essential fish habitat, requires the second dorsal and anal fin to remain on shark carcasses through landing, requires shark dealers to attend shark identification workshops, and includes measures to address overfishing of finetooth sharks (71 FR 58058). This FMP manages several species of sharks (Table 2.2.1). The 2001–2004 commercial shark landings and the 2005 preliminary commercial shark landings are shown in tables 2.2.2 and 2.2.3, respectively.

Observer coverage in the shark bottom longline fishery began in 1994 on a voluntary basis. Since 2002, observer coverage has been mandatory for selected bottom longline vessels. In 2005, NMFS transferred the shark bottom longline observer program from the University of Florida to the NMFS Southeast Fisheries Science Center in Panama City, Florida. NMFS aims to obtain 5% observer coverage of the commercial effort and in doing so deploys approximately five to seven observers to monitor 300–400 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.

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. In June 1999, the Atlantic States Marine Fisheries Commission approved the development of an Interstate FMP for Spiny Dogfish. The Atlantic States Marine Fisheries Commission is now developing an interstate coastal shark FMP, as agreed to in 2005.

Table 2.2.1 U.S. Atlantic shark management units and shark species for which retention is prohibited.

Shark Species Managed under the Consolidated Atlantic HMS FMP			
Large Coastal Sharks (LCS)		Small Coastal Sharks (SCS)	
Sandbar	*Carcharhinus plumbeus*	Atlantic sharpnose	*Rhizoprionodon terraenovae*
Silky	*Carcharhinus falciformis*	Finetooth	*Carcharhinus isodon*
Tiger	*Galeocerdo cuvier*	Blacknose	*Carcharhinus acronotus*
Blacktip	*Carcharhinus limbatus*	Bonnethead	*Sphyrna tiburo*
Spinner	*Carcharhinus brevipinna*		
Bull	*Carcharhinus leucas*	Pelagic Sharks	
Lemon	*Negaprion brevirostris*	Shortfin mako	*Isurus oxyrinchus*
Nurse	*Ginglymostoma cirratum*	Common thresher	*Alopia vulpinus*
Scalloped hammerhead	*Sphyrna lewini*	Porbeagle	*Lamna nasus*
Great hammerhead	*Sphyrna mokarran*	Oceanic whitetip	*Carcharhinus longimanus*
Smooth hammerhead	*Sphyrna zygaena*	Blue	*Prionace glauca*
Prohibited Species			
Sand tiger	*Carcharias taurus*	Caribbean reef	*Carcharhinus perezi*
Bigeye sand tiger	*Odontaspis noronhai*	Narrowtooth	*Carcharhinus brachyurus*
Whale	*Rhincodon typus*	Caribbean sharpnose	*Rhizoprionodon porosus*
Basking	*Cetorhinus maximus*	Smalltail	*Carcharhinus porosus*
White	*Carcharodon carcharias*	Atlantic angel	*Squatina dumeril*
Dusky	*Carcharhinus obscurus*	Longfin mako	*Isurus paucus*
Bignose	*Carcharhinus altimus*	Bigeye thresher	*Alopias superciliosus*
Galapagos	*Carcharhinus galapagensis*	Sevengill	*Heptranchias perlo*
Night	*Carcharhinus signatus*	Sixgill	*Hexanchus griseus*
		Bigeye sixgill	*Hexanchus vitulus*

Table 2.2.2 Commercial landings for Atlantic large coastal, small coastal, and pelagic sharks in metric tons and dressed weight (mt dw), 2001–2004. Source: Cortés and Neer (2002); Cortés (2003); Cortés and Neer (2005).

2001–2004 Commercial Shark Landings				
Species Group	2001	2002	2003	2004
Large coastal sharks	1,560	1,948	2,017	1,454
Small coastal sharks	329	279	249	204
Pelagic sharks	162	212	281	307
Total	2,051	2,439	2,547	1,965

Table 2.2.3 Preliminary landings estimates in metric tons and dressed weight (mt dw) for the 2005 Atlantic shark commercial fisheries. Landings are based on the quota monitoring system.

2005 Preliminary Commercial Shark Landings					
Species Group	Region	First Season	Second Season	Third Season	Group Total
Large coastal sharks (i.e., sandbar, silky, tiger, blacktip, spinner, bull, lemon, nurse, and hammerheads)	Gulf of Mexico	110	123	118	**999**
	South Atlantic	131	169	271	
	North Atlantic	9	61	7	
Small coastal sharks (i.e., Atlantic sharpnose, finetooth, blacknose, bonnethead)	Gulf of Mexico	14	7	16	**246**
	South Atlantic	60	79	69	
	North Atlantic	0	<1	0	
Blue sharks	No regional quotas	0	0	0	**130**
Porbeagle sharks		0	3	1	
Pelagic sharks (other than blue or porbeagle)		23	81	22	
Total:		347	524	504	1,375

2.3 Current Management of Sharks in the Pacific Ocean

In the U.S. Pacific Ocean, three regional councils are responsible for developing fishery management plans: the Pacific Fishery Management Council (PFMC), the North Pacific Fishery Management Council (NPFMC), and the Western Pacific Fishery Management Council (WPFMC).

Pacific Fishery Management Council (PFMC)

The PFMC's area of jurisdiction is the Exclusive Economic Zone off the coasts of California, Oregon, and Washington. In late October 2002, the PFMC adopted its Fishery Management Plan (FMP) for U.S. West Coast Highly Migratory Species (HMS) Fisheries. This FMP's management area also covers adjacent high seas waters for fishing activity under the jurisdiction of the HMS FMP. The final rule implementing the HMS FMP was published in the *Federal Register* on April 7, 2004 (69 FR 18443). This FMP manages several sharks as part of the management unit (Table 2.3.1), including the common thresher (*Alopias vulpinus*) and shortfin mako (*Isurus oxyrinchus*) sharks valued but not primarily targeted in the West Coast–based fisheries, as well as blue sharks (*Prionace glauca*, a frequent bycatch species), bigeye thresher (*Alopias superciliosus*), and pelagic thresher (*Alopias pelagicus,* incidental catch) sharks. The HMS FMP also designated some shark species as prohibited because of their special status. If intercepted, these species—including great white, megamouth, and basking sharks—must be released immediately, unless other provisions for their disposition are established.

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

The Pacific Coast Groundfish FMP includes three shark species (e.g., leopard, soupfin, and spiny dogfish) in the groundfish management unit (Table 2.3.2). Under regulations promulgated for 2003 and likely to be in effect for some time, a "rockfish conservation area" has been established 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 harvest guideline for all "other fish," which includes sharks, skates, ratfish, morids, grenadiers, kelp greenling, and some other groundfish species. This harvest guideline is reduced by a precautionary adjustment of 50 percent from the acceptable biological catch. Table 2.3.3 lists landings (round weight equivalent in metric tons) for various sharks from fisheries off California, Oregon, and Washington from 1995 through 2005.

Table 2.3.1 Shark Species in the West Coast Highly Migratory Species Fishery Management Plan, including shark species for which retention is prohibited.

West Coast Highly Migratory Species FMP	
Sharks listed as management unit species	
Common thresher	*Alopias vulpinus*
Shortfin mako	*Isurus oxyrinchus*
Blue sharks	*Prionace glauca*
Bigeye thresher	*Alopias superciliosus*
Pelagic thresher	*Alopias pelagicus*
Prohibited species	
Great white	*Carcharodon carcharias*
Megamouth	*Megachasma pelagios*
Basking sharks	*Cetorhinus maximus*

Table 2.3.2 Shark species in the groundfish management unit of the Pacific Coast Groundfish Fishery Management Plan.

Pacific Coast Groundfish FMP	
Sharks listed as management unit species	
Leopard shark	*Triakis semifasciata*
Soupfin shark	*Galeorhinus zyopterus*
Spiny dogfish	*Squalus acanthias*

Table 2.3.3 Shark landings (mt) for California, Oregon, and Washington, 1995–2005, organized by species group.
Source: NWFSC fishticket data and the Pacific States Marine Fisheries Commission, PacFIN Database, Report # 307, August 2006, www.psmfc.org/pacfin/data

Shark Landings (mt) for California, Oregon, and Washington											
Species Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Bigeye thresher shark	31	20	32	11	6	5	2	--	5	5	10
Blue shark	5	1	1	3	<1	1	2	42	1	<1	1
Common thresher shark	270	319	320	361	320	295	373	301	294	115	179
Leopard shark	10	8	11	15	14	13	12	13	10	11	13
Other shark	1	2	3	5	6	5	38	4	20	3	5
Pelagic thresher shark	5	1	35	2	10	3	2	2	4	2	<1
Shortfin mako	95	96	132	100	63	80	46	82	69	54	33
Soupfin shark	44	65	63	54	75	48	45	32	35	27	26
Spiny dogfish	367	249	425	462	514	624	564	875	447	667	718
Unspecified shark	16	5	7	7	13	6	3	4	3	6	5
Pacific angel shark	18	16	31	50	48	34	28	22	17	13	12
Total	**862**	**782**	**1,060**	**1,070**	**1,070**	**1,114**	**1,115**	**1,377**	**905**	**904**	**1,003**

North Pacific Fishery Management Council (NPFMC)

The NPFMC manages fisheries in federal waters off Alaska. Sharks are managed under the “other species” category in the Gulf of Alaska (GOA) Groundfish Fishery Management Plan (FMP) and the Bering Sea/Aleutian Island (BSAI) 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. Aggregate catch of the whole category must be recorded and reported.

In the BSAI and GOA a survey is conducted biannually for the “other species” category, most recently in 2005. The BSAI Plan Team recommends to the Council annual overfishing levels and allowable biological catch amounts for the “other species” category based on the best available and most recent scientific information. The Council recommends Total Allowable Catch (TAC) levels for “other species” in the BSAI. In the GOA, because assessments for the “other species” category have not been regularly conducted, the GOA Plan Team does not recommend overfishing levels and allowable biological catch amounts for this category. At present, the annual TAC for the “other species” category in the GOA is set at 5 percent of the sum of all other TACs established for assessed species, or 13,856 mt in 2006.

In June 2005 the NPFMC selected its preferred alternative to amend the GOA FMP (Amendment 69) for setting the "other species" TAC in the GOA. The NPFMC recommended that as part of its annual groundfish harvest specification process, the TAC for the "other species" complex be set at less than or equal to 5 percent of the sum of all other target species TACs in the GOA. This action is intended as a short-term, proactive management measure to better conserve those stocks comprising the "other species" complex while the NPFMC develops a more comprehensive long-term approach for the management of the "other species" complex in both the GOA and BSAI.

Pending Secretarial approval of Amendment 69, in December 2005 the NPFMC recommended a reduction to 4,500 mt in the TAC for "other species" in the GOA for the 2006 and 2007 fishing years. 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, Advisory Panel, and the public. An annual TAC of 4,500 mt would meet incidental catch needs in the directed groundfish and halibut fisheries, and allow for a modest directed fishery for the "other species" complex of approximately 500 mt each year and the development of markets for these species.

Seven shark species have been identified during fishery surveys or observed during groundfish fishing in Alaskan waters (Table 2.3.4). The brown cat, basking, sixgill, and blue sharks are very rarely taken in any sport or commercial fishery and are not targeted for harvest. Pacific sleeper, salmon, and spiny dogfish sharks are taken incidentally in groundfish fisheries and are monitored in season by NMFS. Sharks are the only group in the complex consistently identified to species in catches by fishery observers. Most of the shark incidental catch occurs in the midwater trawl pollock fishery and in the hook-and-line fisheries for sablefish, Greenland turbot, and Pacific cod along the outer continental shelf and upper slope areas. The most recent estimates of the incidental catch of sharks in the GOA and BSAI are from 2005. These data are included in Appendix C to the November 2004 GOA Stock Assessment and Fishery Evaluation report, the November 2005 BSAI Stock Assessment and Fishery Evaluation report, and the NMFS catch accounting system. Estimates of the incidental catch of sharks in the GOA and BSAI groundfish fisheries from 2000 to 2005 have ranged from 418 to 1,117 mt and from 234 to 1,362 mt, respectively (Table 2.3.5). Due to limited catch reports on individual species and larger taxonomic groups in the "other species" category, estimates of the incidental catch of sharks in the GOA and BSAI are largely based on NMFS survey results and observer data.

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

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

Table 2.3.5 Incidental catch (in metric tons) of sharks in the Gulf of Alaska and Bering Sea/Aleutian Islands commercial groundfish fisheries.
Source: NMFS Survey and Observer data

Incidental Catch of Sharks							
Fishery	Species	2000	2001	2002	2003	2004	2005
Gulf of Alaska groundfish fishery	**Spiny dogfish**	397.6	494.0	117.0	386.6	175.6	415.5
	Pacific sleeper shark	608.2	249.0	225.6	292.5	232.3	454.2
	Salmon shark	37.8	32.8	58.2	35.7	21.6	52.7
	Unidentified shark	73.6	77.0	16.8	52.3	39.0	60.4
	Total	1,117.2	852.8	417.6	767.1	468.5	982.8
Bering Sea and Aleutian Islands groundfish fishery	**Spiny dogfish**	8.9	17.3	9.4	10.8	7.2	6.7
	Pacific sleeper shark	490.4	687.3	838.5	217.8	267.8	188.0
	Salmon shark	23.3	24.4	46.6	18.9	13.9	17.8
	Unidentified shark	67.6	35.0	467.8	32.1	57.5	21.9
	Total	590.2	764.0	1,362.3	279.6	346.4	234.4

The Alaska Department of Fish and Game manages the recreational fishery with a daily bag limit of one shark of any species per day, and a limit of two sharks of any species annually. The catch consists almost entirely of spiny dogfish and salmon shark. The vast majority of spiny dogfish are released, but there is a modest directed sport fishery for salmon sharks, especially in Prince William Sound. There were no reported incidents of sport-caught sharks being finned and discarded, and state regulations prohibit the intentional waste or destruction of any sport-caught species. The sport fishery in state and federal waters of Southeast and Southcentral regions of Alaska harvested an estimated 745 sharks of all species in 2004. No sport harvest of sharks was reported in the Arctic-Yukon-Kuskokwim region.

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 beginning in 2005. Sharks taken incidentally to commercial groundfish and salmon fisheries may be retained and sold provided the fish are fully utilized as described in 5 AAC 28.084. The state limits the amount of incidentally taken sharks that may be retained to 20 percent of the round weight of the directed species on board a vessel, except in the Southeast District where a hook-and-line or troll vessel may retain up to 35 percent round weight of sharks to round weight of the target species on board (5AAC 28.174 (1) and (2)). Also in the State's East Yakutat Section and the Icy Bay Subdistrict, salmon gill-netters may retain all spiny dogfish taken as bycatch during salmon gillnet operations (5AAC 28.174 (3)). All sharks landed must be recorded on an Alaska Department of Fish and Game fish ticket. To date, no permits have been issued 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 as less than three landings occurred.

Western Pacific Fishery Management Council (WPFMC)

In 2000, the WPFMC prepared an amendment to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region (Pelagics FMP) to conserve and manage sharks. Management options proposed in the amendment included restrictions on shark finning; harvest restrictions for shark species other than blue sharks; prohibitions on retention, landing, and domestic transshipping of shark fins; establishment of minimum and maximum harvest; prohibit harvest of female sharks; and requirements for more selective gear to minimize the mortality of released sharks. With the enactment of the Shark Finning Prohibition Act in 2000, the measure on shark finning became unnecessary. Other measures on shark conservation are pending WPFMC's revision to the 2000 Pelagics FMP amendment and its transmittal to the National Marine Fisheries Service for approval and implementation. There are nine species of sharks in the pelagic management unit (Table 2.3.6). Five species of coastal sharks are listed as currently harvested in the Coral Reef Fisheries Management Plan (Table 2.3.7).

The longline fisheries in the Western Pacific, in Hawaii and American Samoa, were responsible for the vast majority of the sharks landed. Shark landings (estimated whole weight) by the Hawaii-based longline fisheries peaked at about 2,870 mt in 1999, due largely to the finning of blue sharks (Table 2.3.8). A State of Hawaii law prohibiting landing shark fins without an associated carcass passed in mid-2000 (Hawaii Revised Statues 188.40-5). This law apparently decreased shark landings by almost 50 percent in 2000. With the subsequent enactment of federal Shark Finning Prohibition Act, shark landings from 2001 to 2005 were down by more the 93 percent from their peak. Today, sharks are marketed as fresh shark fillets and steaks in Hawaii supermarkets and restaurants, as well as exported to the U.S. mainland.

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

Table 2.3.6 Pacific Sharks in the pelagic management unit in the pelagic fisheries of the Western Pacific Region Fisheries Management Plan (as amended in March 2004).

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

Table 2.3.7 Five coastal sharks listed as management unit species in the Coral Reef Ecosystems Fishery Management Plan (CRE-FMP) and designated as currently harvested coral reef taxa. Other coastal sharks in the management unit of the CRE-FMP belonging to the Families: Alopiidae, Carcharhinidae, Sphyrnidae, and Lamnidae are designated as potentially harvested coral reef taxa.

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

Table 2.3.8 Shark landings (mt) from the Hawaii-based longline fishery and the American Samoa longline fishery, 1995–2005.
Source: Pacific Islands Fisheries Science Center's Fisheries Monitoring and Analysis Program and Western Pacific Fisheries Information Network

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

Shortfin mako caught on a longline vessel north of the Hawaiian Islands.
Source: NMFS Pacific Island Regional Office Observer Program

2.4 NMFS Enforcement Actions Pertaining to the Shark Finning Prohibition Act

Listed below are key cases initiated or concluded during 2005 by the NMFS Office for Law Enforcement involving the illegal finning of sharks, possession of prohibited shark species, or the unauthorized offload of shark fins into U.S. ports. Moreover, the NOAA Office of General Counsel for Enforcement and Litigation has instituted several enforcement actions for violations of the Shark Finning Prohibition Act. The following cases are highlighted as significant enforcement actions by NOAA:

- In January 2005, NMFS special agents from the Southeast Enforcement Division determined that a commercial fishing vessel that was required to have an operating VMS unit on board was not reporting. During a subsequent boarding of the vessel in Florida, a bag of shark fins was found hidden in the cabin in apparent violation of the Act. NOAA Office of General Counsel for Enforcement and Litigation issued a Notice of Violation and Assessment in the amount of $18,000 to the owner/operator of the vessel.

- In April 2005, NMFS special agents from the Southeast Enforcement Division developed information that a fishing vessel was landing commercial quantities of undersized grouper and shark fins without the appropriate number of carcasses. Florida Wildlife Conservation Commission officers, operating under a Joint Enforcement Agreement with the NOAA Office for Law Enforcement, boarded the subject fishing vessel and recovered several bags containing shark fins. A $43,000 Notice of Violation and Assessment was issued, and proceeds in the amount of $13,128.30 were seized. The owner/operator was also penalized by a Notice of Permit Sanction, and was prohibited from conducting fishing operations for 135 days.

- In October 2005, NOAA special agents from the Northeast Enforcement Division and New York Environmental Conservation Police officers executed an administrative inspection warrant at a local fish dealer in Brooklyn. The search revealed that the dealer purchased approximately 300,000 pounds of shark and shark fins over an approximate 2-year period, without a federal dealer permit. In June of 2006, the defendant corporation agreed to pay a civil penalty of $750,000, with an additional $250,000 penalty suspended, after admitting to unlawfully purchasing shark meat and fins, failing to report those purchases to federal authorities, and possessing fins from seven prohibited shark species, including basking and great white sharks. Penalties included the forfeiture of 1,000 pounds of dried shark fins valued at $80,000, including 230 pounds of fins from prohibited species.

Other pending cases of note are as follows:

- In July 2005, the U.S. Fish and Wildlife Service referred an investigative lead to a NOAA special agent from the Southeast Enforcement Division regarding a suspect shipment of fins exported from Atlanta, Georgia, to China. The shipment contained over 2,000 pounds of fins. Further investigation revealed that the exporting seafood dealer did not possess a valid federal dealer permit.

- In July 2005, a NMFS special agent from the Pacific Islands Enforcement Division initiated an investigation of a foreign-flagged vessel that offloaded a bag of dried shark fins without corresponding carcasses intended for sale in the Cook Islands. The captain of the vessel, a Cook Islands citizen, admitted he caught sharks for their fins and discarded their carcasses at sea. This case is currently under review with the Office of General Counsel for Enforcement and Litigation.

- In December 2005, a fishing vessel ran aground off the coast of the Big Island of Hawaii. During the subsequent rescue of the crew, U.S. Coast Guard personnel observed what were believed to be shark fins concealed in a bag taken from the vessel by crew members. Rescue personnel estimated the bag contained dozens of pieces of shark fin, weighing between 20 and 40 pounds. The bag of fins was left on shore by crew members while vessel personnel and their essential equipment were evacuated from the area. NOAA Special Agents determined that members of the crew caught and finned sharks, and intended to sell the fins in Honolulu. This case is currently under review with the Office of General Counsel.

2.5 Education and Outreach

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

1. Developed training tools and programs in elasmobranch identification (such as identification posters and color guidebooks).
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.
3. Attempted to raise awareness among the non-fishing public about the ecological benefits from elasmobranch populations, detrimental effects of habitat destruction (e.g., coastal development and coastal pollution), and appropriate conservation measures to avoid, minimize, or mitigate adverse effects on necessary habitats.

2.6 Fishing Capacity

Numerous management tools are in use 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). However, capacity reduction is still being investigated as an effective method for increasing the sustainability of elasmobranch fisheries. NMFS is currently assessing levels of fishing capacity in federally managed commercial fisheries in the United States as part of the U.S. National Plan of Action on the Management of Fishing Capacity. U.S. management entities are participating in this effort.

Blue shark (*Prionace glauca*)
Source: NMFS Pacific Island Regional Office Observer Program

3. U.S. Imports and Exports of Shark Fins

The summaries of annual U.S. imports and exports of shark fins appearing in Tables 3.1.1 and 3.2.1 are based on information submitted by importers and exporters to the U.S. Customs and Border Protection and U.S. Census Bureau as reported in the NMFS Trade database. Exports of shark fins far exceed imports in both weight and value. In 2005, import amounts exceeded those of the previous 2 years. In 2005, total exports of shark fins declined in weight and value compared to 2004.

3.1 Imports of Shark Fins

During 2005, imports of shark fins were entered through the following U.S. Customs and Border Protection districts: Los Angeles, New York City, San Francisco, Savannah, and Miami. In 2005, countries of origin in order of importance based on quantity were Philippines, Hong Kong, Brazil, Panama, Indonesia, Nicaragua, Australia, China, and Guatemala (Table 3.1.1). It should be noted that, due to the complexity of the shark fin trade, fins are not necessarily produced close to or even in the same country as those 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.

Table 3.1.1 Weight and value of dried shark fins imported into the United States, by country of origin.
Source: U.S. Bureau of the Census.

Country	2002 (kg)	2002 Value	2003 (kg)	2003 Value	2004 (kg)	2004 Value	2005 (kg)	2005 Value
Argentina	0	$0	450	$7,425	0	$0	0	$0
Australia	1,018	$12,232	475	$9,675	28	$2,592	192	$11,286
Bangladesh	52	$5,303	0	$0	0	$0	0	$0
Brazil	0	$0	353	$2,001	0	$0	2,269	$30,867
Canada	697	$39,879	0	$0	0	$0	0	$0
China	20,756	$578,052	0	$0	1,565	$19,211	150	$8,004
Costa Rica	110	$2,700	0	$0	0	$0	0	$0
Guatemala	0	$0	0	$0	0	$0	102	$2,120
Hong Kong	2,637	$144,746	1,157	$41,017	4,893	$106,573	7,124	$524,463
India	4,212	$22,292	5,686	$30,000	2,808	$16,500	0	$0
Indonesia	0	$0	0	$0	0	$0	524	$12,135
Japan	1,498	$108,104	0	$0	489	$28,013	0	$0
Madagascar	190	$7,441	0	$0	0	$0	0	$0
Mexico	2,760	$34,370	0	$0	0	$0	0	$0
Namibia	130	$7,450	0	$0	0	$0	0	$0
Nicaragua	0	$0	0	$0	0	$0	506	$23,130
Panama	0	$0	0	$0	4,119	$160,034	585	$72,975
Philippines	0	$0	998	$3,383	0	$0	15,866	$67,101
Singapore	5,081	$61,345	0	$0	0	$0	0	$0
Taiwan	0	$0	200	$4,796	0	$0	0	$0
Vietnam	0	$0	1,918	$11,849	551	$10,767	0	$0
Total	**39,141**	**$1,023,914**	**11,237**	**$110,146**	**14,453**	**$343,690**	**27,318**	**$752,081**

3.2 Exports of Shark Fins

The vast majority of shark fins exported in 2005 were sent from the United States to Hong Kong, Denmark, China, and Canada, and small amounts were sent to Mexico and Portugal (Table 3.2.1). The mean value per kilogram (kg) has been increasing since 2002, most notably in the Hong Kong market. Using data from Table 3.2.1, mean values of dried shark fins for all countries combined increased from approximately $28/kg in 2002 to approximately $84/kg in 2003, down to $52/kg in 2004 and back up to $59/kg in 2005. Hong Kong's significantly higher dollar value to quantity, as compared to shark fin trade with other countries, is associated with the higher quality demanded in Hong Kong's inelastic market, and historically high consumption patterns based on ethnic food consumption patterns.

Table 3.2.1 Weight and value of dried shark fins exported from the United States, by country of destination. Includes products of both domestic and foreign origin. Source: U.S. Bureau of the Census.

Country	2002 (kg)	2002 Value	2003 (kg)	2003 Value	2004 (kg)	2004 Value	2005 (kg)	2005 Value
Aruba	352	$4,156	0	$0	0	$0	0	$0
Canada	51,809	$395,252	4,723	$524,687	2,354	$270,387	1,687	$216,729
China	0	$0	0	$0	15,876	$150,000	2,350	$117,500
Colombia	0	$0	0	$0	377	$2,752	0	$0
Denmark	0	$0	0	$0	0	$0	2,804	$133,180
Hong Kong	45,173	$2,932,284	38,193	$3,441,436	61,242	$4,179,392	57,358	$3,390,495
Japan	2,400	$44,625	2,447	$42,150	0	$0	0	$0
Mexico	7,889	$55,120	1,334	$9,702	2,153	$86,049	937	$37,486
Portugal	0	$0	97	$3,029	100	$2,717	110	$2,988
South Korea	12,939	$28,525	809	$22,400	0	$0	0	$0
Taiwan	3,823	$25,513	1,041	$52,947	1,359	$69,292	0	$0
Thailand	0	$0	0	$0	9,381	$106,925	0	$0
Total	**124,385**	**$3,485,475**	**48,644**	**$4,096,351**	**92,842**	**$4,867,514**	**65,246**	**$3,898,378**

Shortfin mako (*Isurus oxyrhynchus*)
Source: NMFS Pacific Island Regional Office Observer Program

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

Consistent with the provisions of Section 5 of the Shark Finning Prohibition Act, the Department of Commerce and the Department of State have initiated ongoing consultation regarding the development of international agreements consistent with the Act. Discussions have focused on possible bilateral, multilateral, and regional agreements with other nations. The law calls for the United States to pursue an international ban on shark finning and to advocate improved data collection (including biological data, stock abundance, bycatch levels, and information on the nature and extent of shark finning and trade). Determining the nature and extent of shark finning is the first step toward reaching agreements to decrease the incidence of finning worldwide.

4.1 Bilateral Efforts

In 2005, NMFS participated in bilateral discussions with Canada, Chile, the European Union, Japan, Morocco, Taiwan, and Russia, which included the implementation of the Shark Finning Prohibition Act. 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 International Plan of Action for the Conservation and Management of Sharks, by finalizing their own national plans of action.

4.2 Regional Efforts

The U.S. Government will continue to work within regional fishery management bodies to facilitate shark research, monitoring, and management initiatives, as appropriate. Possible avenues for the development of international initiatives supporting the conservation of sharks include a number of regional fishery management organizations. Table 4.2.1 lists these regional fishery management organizations and regional programs, some with multilateral efforts. Of the list in Table 4.2.1, the activities or planning of four organizations are discussed below as a supplement to last year's report to Congress.

Table 4.2.1 Regional fishery management organizations and programs.

• Northwest Atlantic Fisheries Organization (NAFO)
• Inter-American Tropical Tunas Commission (IATTC)
• International Commission for the Conservation of Atlantic Tunas (ICCAT)
• Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (WCPFC)
• Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (South Pacific Tuna Treaty [SPTT])
• International Council for the Exploration of the Sea (ICES)
• Asia Pacific Economic Cooperation Forum (APEC) and the Convention on Migratory Species
• North Pacific Interim Scientific Committee for Tuna and Tuna-like Species (ISC)
• South East Atlantic Fisheries Organization
• Department of State Regional Environmental Hub Program

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) will be 13,500 metric tons, for each of the years 2005–2007. This total allowable catch was higher than the United States had initially sought, but the U.S. delegation ultimately joined the consensus of which this measure was a part. 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.

Inter-American Tropical Tunas Commission (IATTC)

At its 73rd meeting in June 2005, the IATTC adopted a "Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean." This resolution—cosponsored by the United States, European Union, Japan, and Nicaragua—bans shark finning and mandates the collection of information and advice on stock status of shark species as well as proposals for a comprehensive assessment of shark stocks in the Pacific Ocean.

The resolution also requires all members establish and implement a national plan of action for conservation and management of shark stocks in accordance with the FAO International Plan of Action for the Conservation and Management of Sharks; and take measures to require their fishermen fully utilize any retained catches of sharks—defined as retention of all parts of the shark excepting head, guts, and skin—to the point of first landing. By May 1 of each year, members must report data for catches, effort by gear type, landing and trade of sharks by species, where possible, and a progress report on implementation of this Resolution during the previous year.

International Commission for the Conservation of Atlantic Tunas (ICCAT)

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

In 2005, the Standing Committee on Research and Statistics (SCRS) reviewed the stock assessment of shortfin mako sharks, as well as the appropriateness of the 5 percent fin-to-carcass ratio. SCRS concluded the shortfin mako biomass in the North Atlantic may be below the biomass that can support maximum sustainable yield, as trends in catch per unit effort suggest depletions of 50 percent or more. The SCRS, therefore, recommended the Commission take actions to reduce fishing mortality if ICCAT wants to improve the status of the stock. SCRS noted reductions in fleet capacity and effective effort could provide the most direct benefit to the stock. At the 2005 ICCAT annual meeting, the Commission adopted a recommendation regarding shortfin mako sharks; but the recommendation does nothing more than press parties that have not yet implemented the 2004 ICCAT shark measure with respect to shortfin mako sharks to implement the measure and submit a report to the Commission. With regard to the 5 percent fin-to-carcass ratio, the SCRS concluded this ratio is not inappropriate with respect to mixed species shark fisheries that keep the primary fin set (first dorsal, two pectoral, and lower lobe of the caudal fin). The fin-to-carcass ratios are, however, highly variable depending on the species, fin set used, and fin cutting techniques. Other variables relate to how sharks are dressed and whether fins are dried on board. SCRS recommended that conversion factors between fins and body weights be developed and implemented on a species-specific and/or fleet-specific basis. The Commission did not consider alterations to the 5 percent fin-to-carcass ratio at its 2005 meeting.

__Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (WCPFC)__

The WCPFC held its second regular session in Pohnpei, Federated States of Micronesia, from December 12–16, 2005. Several draft resolutions on sharks were submitted but not passed. A resolution on non-target fish species was adopted. This resolution calls for encouragement of fisheries managed under the WCPFC to avoid to the extent practicable the capture of all non-target fish species that are not to be retained, and to promptly release any such fish to the water unharmed.

4.3 Multilateral Efforts

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

Table 4.3.1 Other multilateral fora.

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

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

In December 2005, a representative from NMFS attended an FAO Expert Consultation to Review Implementation of the International Plan of Action for Sharks (IPOA) at National Levels. The major conclusions/recommendations from this meeting were that the IPOA should continue. Recommendations of the Consultation include the following: countries with the expertise may take the initiative by offering assistance to countries that lack the expertise; appropriate international funding organizations (e.g., The Global Environmental Facility) could be formally approached by FAO to help developing countries get funding to aid in implementation; more coordination and involvement should be undertaken by Regional Fishery

Management Organizations; and FAO should hire a person specifically to assist countries in implementation. A report on the proceedings from this meeting is currently in press.

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

At the 12th Conference of the CITES Parties (Santiago, Chile, November 3–15, 2002), CITES listed two shark species in Appendix II—whale shark (*Rhincodon typus*) and basking shark (*Cetorhinus maximus*). The United States supported these proposals and a resolution encouraging continued monitoring of the FAO Shark IPOA process and further FAO/CITES coordination on sharks because it believes CITES offers numerous benefits for marine species conservation (e.g., enhanced and systematic trade monitoring, encouragement of national fishery management plans to foster sustainable trade, and regular reviews of trade patterns).

At its 13th Conference of the Parties (Bangkok, Thailand, October 2–14, 2004), Australia and Madagascar proposed to include the great white shark (*Carcharodon carcharias*) in Appendix II, including an annotation stating a zero annual export quota be established. The Conference of the Parties also determined it would be the responsibility of the CITES' Animals Committee to continue to study the biological and trade status of sharks and how CITES might contribute to their conservation. At the 21st Meeting of the Animals Committee (Geneva, Switzerland, May 20–25, 2005) decided to convene a technical workshop to discuss, among others, the following topics:

- Identification of shark species threatened by international trade.
- Identification of specific cases where trade is having an adverse impact on sharks, and those key shark species threatened in this way.
- Implementation issues related to sharks listed in the CITES Appendices.

Appendix I lists species in danger of extinction. All commercial trade in these species is prohibited. Appendix II includes species vulnerable to overexploitation for which commercial trade should be regulated so that they will not become threatened with extinction. Regulated trade of species listed in Appendix II is allowed if the exporting country has issued a permit that includes a finding the trade will not be detrimental to the survival of the species or its role in the ecosystem. Countries can unilaterally include species in their territory in Appendix III. This Appendix includes species for which a country needs the cooperation of other countries in order to control international trade to complement domestic regulation. International trade for these species requires an export permit from the listing country and a certificate of origin from all other countries.

United Nations General Assembly (UNGA)

In December 2005, the UNGA adopted by consensus a resolution on Oceans and the Law of the Sea: "Sustainable Fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments." The resolution, strongly supported by the United States, recognizes the importance and vulnerability of sharks and the need for measures to promote long-term sustainability of shark populations and fisheries. It confirms the role of relevant regional and subregional fisheries management organizations and arrangements in the conservation and management of sharks and encourages the implementation of the FAO International Plan of Action for Sharks. It further encourages the international community to increase the capacity of developing States to implement the FAO International Plan of Action for Sharks.

Shortfin mako caught on a longline vessel north of the Hawaiian Islands.
Source: NMFS Pacific Island Regional Office Observer Program

5. NMFS Research on Sharks

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

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

Fishery Data Collection

Market data from the PIFSC shoreside sampling program contains detailed biological and economic information on sharks in the Hawaii-based longline fishery dating from 1987. These data are primarily collected from fish dealers who are required to submit sales/transaction data to the State of Hawaii. The Western Pacific Fishery Information Network (WPacFIN) is a federal–state partnership collecting, processing, analyzing, sharing, and managing fisheries data on sharks and other species from American island territories and states in the Western Pacific. The WPacFIN program has also assisted other U.S. islands' fisheries agencies in American Samoa, Guam, and the Northern Mariana Islands to modify their data collecting procedures to collect bycatch information. These modifications have improved the documentation of shark interactions with fishing gear. Shark catches in the Hawaii-based longline fishery have been monitored by a logbook program since 1990, and by an observer program since 1994. In addition to catch statistics, biological samples are collected by the observer program. Tissue samples from pelagic and common thresher, and from longfin and shortfin mako sharks, are provided in support of NMFS' Southwest Fisheries Science Center research to identify genetically discrete stocks and to better understand basic shark biology and movement.

Biometrical Research on Catch Statistics

Funding for further biometrical research on shark bycatch issues has been received through the Pelagic Fisheries Research Program (PFRP, University of Hawaii). This work will use information from all three fishery data collection programs (market, logbook, and observer) to improve our understanding of shark catches in the Hawaii-based longline fishery. New analyses of shark catches will draw upon earlier published studies of blue shark and blue marlin (Walsh and Kleiber 2001; Walsh et al. 2002; Walsh et al. 2005) for methodology. The first two papers should prove applicable for estimating catches of species not retained (e.g., blue shark, oceanic whitetip shark, and silky shark), and the third paper should prove useful for estimating catches of mako and thresher sharks that are kept and have associated sales records. Hence, the analyses will assess both true bycatch (i.e., discarded and without economic value) and incidental catch (i.e., retained, non-target species with economic value) of sharks in this fishery. One concern in this study is several regulatory changes have been instituted in this fishery in recent years. Because shark catches include both true bycatch and incidentally caught species, changes in the logbook reporting behavior of fishermen may have stemmed from the regulatory changes and can be identified and described. The expectation is bycatch reporting could become less accurate after regulatory changes, whereas reporting of incidentally caught species can be checked against market sales records would remain largely unaffected. Also, NMFS is mandated to prepare an updated National Bycatch Report; and it is anticipated that results generated for this project may be incorporated there.

The objectives of this project are to:

1. Use the fishery observer catch data to describe and quantify the species composition of shark bycatch in this fishery. The underlying purpose is to avoid either over- or underestimating the number of these species taken by this fishery, because such errors could engender spurious ecological inferences.
2. Use the fishery observer catch data to investigate the condition and fate of the catch. Observers record the number of retained catch and discards that come up dead during longline haulback. Because other research suggests that most sharks released alive and intact do survive (discussed below), the number of dead sharks retained or discarded must be quantified.
3. Estimate catches and catch per unit effort for those sharks (blue shark, mako sharks, thresher sharks, and oceanic whitetip shark) specifically reported in Hawaii-based longline logbooks. This should generate updated results for blue shark (previously studied from March 1994 through December 1997) and comparable results for the other species that have yet not been studied.
4. Assess whether regulatory actions implemented for reasons unrelated to shark catch rates (e.g., time-area closures or gear restrictions intended to minimize interactions with sea turtles) tend to exacerbate problems with bias in the self-reported catch data. The underlying purpose of this objective is to elucidate the extent to which regulatory changes may elicit unexpected and undesirable consequences.

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 since 2000.

These estimates include surveys of:

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

To date, these surveys suggest sharks appear to be relatively abundant at most reefs in the Northwest Hawaiian Islands (NWHI) and Pacific Remote Island Areas, but are noticeably sparse and/or small-bodied at most reefs in the Main Hawaiian Islands (MHI), American Samoa, and Marianas Archipelago, especially in the southern islands.

One significant result to date at these locations has been the contrast in densities of sharks and other large-bodied apex predator fishes between the largely unfished NWHI and the heavily fished MHI. Surveys conducted in the NWHI and MHI during 2000 encountered apex predator stocks averaging 100-fold less dense in the MHI (Friedlander and DeMartini 2002). Observations made from 2001 to 2005 have generally affirmed the greater abundances of sharks and other apex predators in the NWHI relative to the MHI (Holzwarth et al. 2006).

Similarly, in surveys around 20 islands/shoals of the Marianas Archipelago, sharks were found to be at least an order of magnitude less dense around the southern inhabited islands (e.g., Guam and Saipan), compared to the remote northernmost islands (Schroeder et al. 2006).

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

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

Selective Removal of Large Sharks to Reduce Monk Seal Mortality:
Predation by Galapagos sharks (*Carcharhinus galapagensis*) is the single greatest mortality source for pre-weaned monk seal (*Monachus schauinslandi*) pups at French Frigate Shoals. PIFSC scientists hypothesized the predation involved a small number of sharks, as tested by direct monitoring and removal of limited numbers of active predators. Mortalities peaked from 1997 to 1999 and declined by more than 50 percent after monitoring and shark removal efforts began in 2000. The number of pup mortalities was relatively stable from 2000 to 2005, with 10 to 12 losses each year (15 to 21 percent of the annual cohort). Twelve sharks were removed and the number of patrolling sharks declined during diurnal hours. Most predation occurred at Trig Island, but it increased at other sites over time. We attribute these results to shark displacement away from Trig Island. 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 available data were sufficient to support the removal experiment.

***Stock Assessment of Pelagic Sharks*:**
Work was initiated in 2000 as a collaborative effort with scientists at the National Research Institute for Far Seas Fisheries (NRIFSF). A report was produced (Kleiber et al. 2001) but was not published in the peer-reviewed literature. The report indicated the stock was not being overfished. PIFSC and NRIFSF scientists have renewed this collaboration 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.

To accomplish this task, the following standardized data sets were created:

1. Hawaii longline—Catch and effort as reported in logbooks with catch modified based on observer and auction data. Size sample data were obtained from observers.
2. Japan longline—Effort from logbooks raised according to coverage rate. The data were "pre-processed" to select records with evident faithful reporting of shark catch. Catch per unit effort (CPUE) data were taken from selected sets, standardized, and used to calculate raised catch from the raised effort. Size sample data were taken from various sources including Japan's research and training vessels.
3. Taiwan/Korea/etc. longline—Effort is estimated by subtracting Japan's and the United States' effort from effort reported in the Secretariat of the Pacific Community 5X5 data base. The 5X5 database contains catch and effort summary data for the major fisheries of many major fishing nations within the Pacific region. Catch is then estimated from Japan's CPUE in item 2 above.
4. Driftnet catch, effort, and size data (Japan, Korea, Taiwan combined)—Data were gleaned from the literature. Squid net and large mesh data were kept separate.

In the new assessments, additional years of data are added to the end of the data time series. Catch estimates compiled from logbook CPUE and raised effort were found to be about twice the size of estimates based on the shark fin trade and Kleiber et al. (2001).

The analytical approach to stock assessment was to use several models and compare results. For the first model, catch and catch rate data, subset into shallow-set and deep-set series, were applied to a Bayesian surplus production model. The shallow series, which showed a trend of increasing CPUE at the end of the time period, could not be run in the model due to poor convergence diagnostics. The results for the deep series showed that current stock biomass is similar to stock biomass in the early 1970s and the current fishing mortality rate is less than the estimated maximum sustainable yield level. The stock status results were similar to Kleiber et al. (2001) and also consistent with a recent Commonwealth Scientific and Industrial Research Organization (CSIRO) study of blue sharks in the Southwest Pacific. The second approach used MULTIFAN-CL (size-based) models with a variety of structural assumptions. The results of the second approach confirmed the results of the production model and earlier MULTIFAN-CL results.

Before 1993, sharks were not recorded by species in the Japan logbook data. Since blue sharks make up the vast majority of the shark catch, earlier data were assumed to pertain to blue sharks. Because this assumption is not applicable to other shark species, no useful time series of data exists for those species. Investigation of the status of other shark species status may require creative modeling approaches and the use of such models to design tagging programs and other research to test model assumptions and predictions.

Other Assessment-Related Activity

PIFSC collaborative research scientist Mike Musyl (University of Hawaii, Joint Institute for Marine and Atmospheric Research) was a contributing coauthor on two papers critical of a published finding that some shark populations in the Northwest Atlantic have collapsed (Burgess et al. 2005a, 2005b).

Southwest Fisheries Science Center (SWFSC, La Jolla)

Juvenile Shark Survey

The 2005 shark survey was completed July 23, 2005. One to three fishing sets were conducted each day. A total of 5,719 hooks were fished at the 28 sampling stations in the Southern California Bight. Captured sharks were tagged with conventional spaghetti tags, satellite transmitting tags, and oxytetracycline (OTC). Catch included 80 mako, 101 blue, and two common thresher sharks, and 12 pelagic rays. The preliminary data indicate the overall catch rate was 0.369 per 100 hook-hours for mako and 0.443 per 100 hook-hours for blue sharks. The catch per-unit effort (CPUE) for both blue and mako sharks was slightly lower than in 2004 and continues a declining trend for both species.

In addition, 72 sharks were tagged with conventional tags for movement data and marked with OTC for age and growth studies, and 84 DNA samples were collected. One adult blue shark was tagged with a satellite transmitting tag in a cooperative Tagging of Pacific Pelagics project to define the physical habitat of Pacific blue sharks. Satellite pop-up tags and satellite transmitter tags were deployed on six mako sharks in a continuing series of habitat, migration, and condition studies. One common thresher shark was also tagged with satellite pop-up and transmitter tags. Results indicate blue and mako sharks surface regularly and data transmissions are providing tracks for periods of up to 2 years (www.toppcensus.org).

Shortfin mako shark being released with satellite transmitter tags. The shark was tagged during NMFS juvenile pelagic shark survey in the southern California Bight in order to study habitat use and migration patterns. Source: Southwest Fisheries Science Center Large Pelagics Group

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

Like many other sharks, the pups of the common thresher are found in nearshore waters. Such waters are Essential Fish Habitat (EFH) for this shark, but the extent of this habitat is poorly defined. The purposes of this EFH/Pup Abundance survey are to (1) determine the continuity of thresher pup distribution along the Southern California Bight coast and (2) develop a pup abundance index. The second series of surveys were completed June 2005. Sampling took place in inshore waters out to 200 fathoms from Point Conception south to San Diego, California. In 2005, survey efforts included 29 nearshore driftnet sets and 38 nearshore longline sets. Overall, 15 common threshers, 21 shortfin makos, and 20 blue sharks were caught. The majority of juvenile thresher sharks were tagged with conventional tags and OTC and then released. Four larger thresher sharks were tagged with five satellite tags (one animal was double tagged). In addition, three mako and one blue shark were tagged with satellite tags.

Movements of the common thresher shark obtained from the satellite tags were described in Baquero (2006). Compared to the mako and blue sharks, the threshers spent most of their time in nearshore waters. An analysis of diving behavior indicates a diurnal pattern of diving during the day and staying closer to the surface at night. These are the first detailed movement data from common thresher sharks in this area and, along with the survey data, will help define the common thresher shark's essential habitat.

Shark Feeding Habits

Recent studies into shark feeding habits have focused on a comparison of blue, shortfin mako, and common thresher shark diets when these species co-occur in California Current waters off California, Oregon, and Washington. By the end of 2005, 307 stomachs had been examined and distinct differences among the three shark species became apparent. For mako sharks, jumbo squid (*Dosidicus gigas*) and Pacific saury (*Cololabis saira*) were the two most important prey items. For blue shark, cephalopods of the *Argonauta* spp. and *Gonatus* spp. were the most important prey items. For thresher sharks, Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) were the two most important prey items. Comparing the first 12 prey items ranked by Geometric Index of Importance demonstrates that mako sharks fed on a combination of different teleosts and cephalopods, blue sharks fed primarily on squid, and threshers consumed mostly coastal pelagic teleosts. Analyses are ongoing of interannual differences and the influence of both prey availability and prevailing oceanographic conditions.

Mako and Thresher Ageing
Age and growth of mako and thresher sharks are being analyzed by ring formation in recaptured animals with OTC-marked vertebrae. Four hundred eighty-eight OTC-marked individuals have been released during the juvenile shark surveys. Recaptures will help validate the age-length relationship determined from examination of vertebrae. Accurate ageing is essential for understanding a shark's productivity and resilience to exploitation.

Preliminary results from shortfin mako vertebrae indicate juvenile and sub-adults lay down two bands of unequal size each year; however, as they mature and move offshore, the calcification pattern in the vertebrae appears to change with hyaline and calcified zones becoming narrower and more equal in relative size. This is an extremely interesting and important finding, because the question of whether the shortfin mako lays down one band or two bands per year has been an ongoing uncertainty, with two independent labs reporting conflicting results.

Thresher shark vertebrae are also being aged at the SWFSC using X-radiography techniques. The purpose is to expand and refine previous thresher shark ageing studies using a larger sample size from the driftnet fishery with accompanying information on sex and maturity stage. Preliminary results from common thresher sharks indicate that they lay down one band per year.

Harvest Guidelines for West Coast Common Thresher and Shortfin Mako Sharks
The SWFSC, working with the Pacific Fishery Management Council, estimates that 340 and 150 metric tons (round weight) of common thresher and shortfin mako, respectively, are precautionary harvest guidelines. The Council's Highly Migratory Species advisory bodies are trying to get a better handle on the thresher and mako shark recreational catch, which has been increasing in recent years, to determine whether a change in the harvest guidelines is necessary.

Bioaccumulation of Mercury in the Common Thresher and Shortfin Mako Shark
As apex predators, the common thresher and shortfin mako sharks have the potential to bioaccumulate high concentrations of methyl mercury in their tissues. Despite the potential human health risk, there are no comprehensive published studies of the mercury levels in these fish. A 1991 preliminary study in Hawaii found mean mercury levels in both shortfin mako (1.32 ppm) and pelagic and bigeye thresher sharks (mean = 1.02 ppm) to be higher than the 1.0 ppm recommended by the U.S. Food and Drug Administration. The goal of this study is to describe the bioaccumulation of mercury with size and sex for the shortfin mako and common thresher shark in the eastern North Pacific. We will also investigate for evidence of suspected ontogenetic diet shifts and the feasibility of using mercury level as an indicator of trophic status complementing the stable isotope study (described below). Preliminary analysis demonstrates low levels of mercury in the muscle tissue of small juvenile common thresher sharks. In contrast, the lone neonate shortfin mako analyzed to date shows a high mercury level (1.16 ppm) and three large adult makos had very high mercury levels (mean = 2.90 ppm).

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

Although common thresher and shortfin mako sharks are thought to undergo ontogenetic diet shifts, there is little quantitative evidence to support this. To complement the work with stomach content analysis, which provides only a snapshot-view of foraging, stable isotope studies are also under way. Stable isotope signatures reflect the overall diet in a predator and provide a cumulative record of the feeding events of an individual fish. The goal of this study is to infer aspects of the feeding ecology and trophic status of the common thresher and shortfin mako shark from the eastern North Pacific using stable isotope analysis of tissues and vertebral centra.

Population Structure of the Shortfin Mako

The shortfin mako is a wide-ranging pelagic shark caught globally in temperate and tropical waters. The stock structure within their broad range is poorly understood, especially in the Pacific. In the North Atlantic, where 608 conventional tags have been returned, not a single shark was recaptured south of 10°N, suggesting for the Atlantic, at a minimum, a northern and southern stock. Although the more limited conventional tag returns in the Pacific reveal movement across the North Pacific from California to as far as Japan, the potential separation between the North and South Pacific is not known. This study will use mitochondrial DNA analyses from samples around the Pacific to test the hypothesis that shortfin makos from the North and South Pacific are genetically distinct. In addition, this study will indicate philopatry (if females return to give birth in the same area) as seen in other shark species. A better understanding of stock structure is critical to developing accurate stock assessments and improving fisheries management. By the end of 2005, samples had been collected and processed from the northeastern and central Pacific.

Ocean Explorations: Eastern Tropical Pacific (ETP) Pelagic Shark Cruise

In March 2005, in collaboration with local scientists the second of two cruises for the Ocean Exploration project was undertaken in the waters off Costa Rica. Working with a local longline vessel, three species of shark were caught and tagged with two types of satellite tags: pop-up satellite archival tags and fin-mounted satellite transmitters. A total of 10 tags were deployed on seven silky sharks, one tag was deployed on a hammerhead shark, and three tags were deployed on two pelagic thresher sharks.

Movement, depth, and temperature data were obtained for both the silky sharks and one pelagic thresher. The fin-mounted satellite tags provided tracks of 5 to >15 months for the silky sharks. These sharks moved along the coast of Central America remaining primarily offshore off the continental shelf. One shark traveled from Costa Rican waters nearly 2,500 km to the mouth of the Gulf of California and back in 10 months, which highlights the need for international management. Depth data from the pop-up tags reveal that the silky sharks have little diurnal pattern, spending 99 percent of their time in the top 50 m of the water column both day and night. In contrast, the pelagic thresher showed a diurnal pattern with deeper dives to 300 m during the day. At night the pelagic thresher remained primarily above 50 m, similar to the silky sharks. Differences in temperatures between the two species reflect those in depth. The silky shark had a relatively narrow temperature range; more than 80 percent of their time was spent between 26 and 30°C. The pelagic thresher spent 70 percent of the daytime between 11 and

18^{o}C and during the night was primarily at temperatures between 24 and 30^{o}C. Both species are vulnerable to a range of fishing gear during both day and night.

Northwest Fisheries Science Center (NWFSC)

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 West Coast Groundfish Observer Program collects data on discards of all shark species on vessels selected for coverage by the program.

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

In addition to these monitoring activities, the NWFSC is assessing for the first time the population status of longnose skate, and is collaborating on an assessment of spiny dogfish being conducted by the Washington Department of Fish and Wildlife. These assessments are under way and will be presented and reviewed during the 2007 stock assessment review (STAR) process. The NWFSC coordinates the STAR panel review process for all such groundfish stock assessments provided as scientific advice to the Pacific Fishery Management Council.

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

Alaska Fishery Science Center (AKFSC, Auke Bay Laboratory)

Shark Research and Assessments

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

1. Collection of data to support stock assessments of shark species subject to incidental harvest in Alaskan waters.
2. Pacific sleeper shark predation of Steller sea lions.
3. Movement and diet of salmon sharks.
4. Tagging of Pacific sleeper sharks in Southeast Alaska.
5. Collaborative research with the University of Alaska and the University of Washington to investigate the population dynamics, life history, and ecological role of spiny dogfish in the Gulf of Alaska.

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. Stock assessment is currently limited to analysis of commercial bycatch relative to biomass 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 an appendix to the North Pacific Fishery Management Council (NPFMC) Stock Assessment and Fishery Evaluation Report available online (for example, see Courtney et al. 2005).

Pacific Sleeper Shark Predation of Steller Sea Lions

In August 2001 and May 2002, Auke Bay Laboratory scientists investigated the diet of Pacific sleeper sharks to test the hypothesis that sleeper sharks prey on Steller sea lions (*Eumetopia jubatus*). Scientists collected 198 stomach samples and found predominant prey items to be walleye pollock, octopus, unidentified teleost fish, Pacific salmon, and marine mammal tissue appearing to be from cetaceans. Stomach content analysis found no direct evidence of sea lion predation. In addition to the diet study, data on the vertical and geographic movement of sleeper sharks were collected by tagging for comparison with the vertical distribution of Steller sea lions. Thirty-three sleeper sharks were tagged with archival satellite tags designed to transmit depth data and location to polar orbiting Argos satellites. Data from 25 satellite tags have been recovered. Based on tag endpoint locations, the sharks typically moved less than 100 kilometers from the release locations. Archived depth data showed some sleeper sharks regularly traversed depths at rates of over 200 meters per hour and sometimes came to the surface at night. Two manuscripts have resulted from this study: Hulbert et al. (2006) and Sigler et al. (2006).

Movement and Diet of Salmon Sharks

During the summers of 1998–2001, scientists from the Auke Bay Laboratory investigated the movements and diet of salmon sharks aggregating in Prince William Sound (PWS), Alaska. During the study, 246 salmon sharks were tagged with conventional (spaghetti) tags and 16 with satellite transmitters. Movement data from satellite tag transmissions and conventional tag recoveries provided insights into the seasonal residency and movement patterns of salmon sharks in PWS and the northeast Pacific Ocean. Observations suggest salmon sharks were attracted by Pacific salmon (*Oncorhynchus spp.*) runs returning to the streams and hatcheries in PWS during summer months. In PWS, large salmon shark aggregations peaked with salmon spawning migrations during July and August. As the summer salmon runs declined in late summer, the sharks dispersed. Some continued to forage in PWS and the Gulf of Alaska into autumn and winter months, while others underwent rapid migrations hundreds to thousands of kilometers toward the west coasts of Canada and the United States. Fifty percent of the sharks tracked by this study traveled long distances.

Salmon shark diet included adult Pacific salmon—pink (*Oncorhynchus gorbuscha*), chum (*Oncorhynchus keta*), and coho (*Oncorhynchus kisutch*)— which were the principal prey as measured by both percent number (35 percent) and percent weight (76 percent). Even when adult salmon were locally abundant, salmon sharks had a varied diet including squid (*Teuthoidea spp*.), sablefish (*Anoplopoma fimbria*), Pacific herring (*Clupea pallasii*), rockfish (*Sebastes spp.*), eulachon (*Thaleichthes pacificus*), capelin (*Mallotus villosus*), spiny dogfish (*Squalus acanthias*), arrowtooth flounder (*Atheresthes stomias*), and cods (*Gadidae*). Salmon sharks consumed at least 263,000 kg of prey in Port Gravina during a 45-day period of peak salmon shark abundance in 2000. Assuming the sharks consumed equal proportions of pink and chum salmon by weight, the sharks would have consumed 116,000 pink salmon and 36,000 chum salmon. Based on Alaska Department of Fish and Game estimates of salmon escapement and commercial harvest for Port Gravina in 2000, the sharks would have consumed 12 percent and 29 percent of the pink and chum salmon runs, respectively. One manuscript has resulted from this study: Hulbert et al. 2005.

Tagging of Pacific Sleeper Sharks in Southeast Alaska
During the summers of 2003–2006, scientists from the Auke Bay Laboratory deployed 91 electronic archival tags, 24 acoustic tags, and eight satellite popup tags on Pacific sleeper sharks in the upper Chatham Strait region of Southeast Alaska. The recovery of temperature, depth, and movement data from the electronic archival and acoustic tags will aid in the identification of Pacific sleeper shark habitat utilization and distribution in Southeast Alaska, and identify the potential for interactions between Pacific sleeper sharks and other species in this region.

Collaborative Research of Spiny Dogfish in the Gulf of Alaska
The Auke Bay Laboratory has collaborated with the Juneau Center of the University of Alaska Fairbanks School of Fisheries and Ocean Sciences and with the University of Washington during 2004–2006 to investigate the population dynamics, life history, and ecological role of spiny dogfish in the Gulf of Alaska. As part of this study, Auke Bay Laboratory scientists deployed 100 electronic archival tags, 617 numerical tags, and one satellite popup tag on spiny dogfish in Yakutat Bay, Alaska. Data from tag recoveries will provide insights into the seasonal residency and movement patterns of spiny dogfish in Yakutat Bay and the northeast Pacific Ocean. The Auke Bay Laboratory has also provided shark bycatch data, biomass estimates, field and technical support, and a graduate student committee member in support of graduate student research. Results from graduate student research will be incorporated into annual stock assessments.

Northeast Fisheries Science Center (NEFSC)

SEDAR Process
Staff participated in the Southeast Data, Assessment, and Review (SEDAR) Data Workshop for the Large Coastal Shark Complex and contributed four SEDAR working papers. These

documents were on sandbar and blacktip mark/recapture data (Kohler et al. 2005), NEFSC historical longline surveys and biological sampling (Hoey et al. 2005), relative abundance trends for juvenile sandbar sharks in Delaware Bay (McCandless 2005), and catch rate information obtained from the NMFS northeast longline surveys (Natanson and McCandless 2005).

Age and Growth of Coastal and Pelagic Sharks

A comprehensive ageing and validation study was concluded for the shortfin mako (*Isurus oxyrinchus*) in conjunction with scientists at Moss Landing Marine Laboratories, California, using bomb carbon techniques. This study validated annual band pair periodicity for this species using tetracycline (OTC) and bomb carbon techniques. The two papers resulting from this work were presented at the American Elasmobranch Society (AES) meetings in July 2005 and submitted to the symposium for publication in *Environmental Biology of Fishes.*

Validation of ageing techniques for the tiger shark, (*Galeocerdo cuvier*) along with age estimates was concluded (with scientists at the University of New Hampshire) and has been finalized into thesis and publication format. Validation of ageing techniques for the Pacific white shark (*Carcharodon carcharias*) was inconclusive due to the behavior of this species in the Pacific. These efforts will continue on samples from the Atlantic, as data from stable isotope work conducted this year indicate the behavior of this species in the Atlantic is conducive to radiocarbon validation.

A study on the age and growth of the white shark was postponed due to lack for funding for bomb carbon work. An ageing study of the thresher shark (*Alopias vulpinus*) has been concluded as a Master’s thesis and has been formatted for publication. Ageing studies of the night shark (*Carcharhinus signatus*, with NMFS scientists at the SEFSC Panama City Laboratory), and the bull shark (*Carcharhinus leucas*, with scientists at the Florida Division of Natural Resources) are under way. Samples have been processed and are waiting photographing and reading of vertebrae. Additional sampling is continuing on these species. Age and growth of the smooth skate (in conjunction with the University of New Hampshire) was concluded. A note on methods used to elucidate the bands was submitted for publication in *Transactions of the American Fisheries Society*. Scalloped hammerhead (*Sphyrna lewini*) vertebrae were sectioned to be photographed for an intercalibration study with the SEFSC and University of Florida. Ageing of this species is in progress. In addition, collections of vertebrae took place at tournaments and fish were OTC-injected during fishing operations on board sport and commercial vessels.

Biology of the Thresher Shark

Life history studies of the thresher shark continued. In addition to the completion of the age and growth portion, food habits data were collected, and reproductive tissues sampled during the past several sampling seasons were processed. Attempts are ongoing to attach satellite transmitters to thresher sharks, with small threshers OTC-injected and tagged during this time. Four big-eye threshers have been tagged with satellite transmitters, as were two blue sharks. To date, three of the transmitters have reported on time.

Biology of the Torpedo Ray
A life history of the torpedo ray (*Torpedo nobiliana*) was initiated with researchers from the University of Rhode Island. Data collection and sampling began for age and growth, reproduction, and food habits studies.

Pelagic and Coastal Shark Diet and Feeding Ecology Studies
Construction of an electronic database of diet information for pelagic and coastal shark species was initiated. When completed, the database will contain over 5,000 samples from 29 species of shark and 11 species of teleost. The goals of this effort are to characterize the diet, analyze the diet relative to biotic and abiotic factors, compare diet overlap between species, examine the diet for temporal changes over decades, and determine gastric evacuation rates and daily rations.

***Morphometric Database*:**
A relational database (including nine length and multiple weight measurements) was created for 20 species of pelagic and coastal sharks. Analysis has begun for determining length-to-length and length-to-weight conversions and relationships.

Collection of Recreational Shark Fishing Data and Samples
Biological samples for age and growth, feeding ecology, and reproductive studies and catch data for pelagic sharks were collected at nine recreational fishing tournaments in the Northeast. This information will enhance ongoing biological studies and will be added to a long-term database of historic landings information from 1961–2005.

Cooperative Shark Tagging Program
The Cooperative Shark Tagging Program—involving more than 7,000 volunteer recreational and commercial fishermen, scientists, and fisheries observers since 1962—continued to tag large coastal and pelagic sharks and provide information to define essential fish habitat for shark species in U.S. Atlantic and Gulf of Mexico waters. Through 2005, a total of 195,000 sharks of more than 50 species were tagged and 11,600 sharks of 33 species were recaptured. In addition, the review and redesign of the shark mark/recapture database was initiated, including all input and auditing programs, forms, and outreach activities. This activity was coordinated with NEFSC staff toward integration with other Cooperative Tagging Programs (black sea bass, yellowtail flounder) with a goal of a centralized tagging infrastructure for the Northeast. Work has begun on tagging database designs to look at future system development and refinements in an attempt to support all groups and coordinate future activities.

Atlantic Blue Shark Life History and Assessment Studies
A collaborative program to examine the biology and population dynamics of the blue shark (*Prionace glauca)* in the North Atlantic is ongoing. A detailed reexamination of the reproductive parameters and feeding ecology of the blue shark continued, with collection of additional biological samples to determine if any changes have occurred since the 1970s. A manuscript is in press on blue shark stock structure based on tagging data detailing size composition and movements between Atlantic regions. Progress continued on the population dynamic study in the North Atlantic with the objectives of constructing a time series of blue shark catch rates from research surveys, estimation of blue shark migration and survival rates, and development of an integrated tagging and population dynamics model for the North Atlantic. This study—critical for use in stock assessment—is being

conducted in collaboration with scientists at the School of Aquatic and Fishery Sciences, University of Washington. Ongoing work includes general linear modeling analyses of blue shark catch rates to develop an index of abundance and preliminary analysis of survival and movement rates for blue sharks based on tag and release data from the NMFS Cooperative Shark Tagging Program. Coordination continued with the Irish Marine Institute and Central Fisheries Board for joint data analyses of mark-recapture databases.

Atlantic Shortfin Mako Life History and Assessment Studies
Updated manuscripts on age, growth, and diet were completed. Ongoing research includes examination of the reproductive parameters and estimation of shortfin mako survival rates using Cooperative Shark Tagging Program mark-recapture data and satellite tags with movements correlated with sea surface temperature data. The latter study is part of a collaborative program with students and scientists at the University of Rhode Island designed to examine the biology and population dynamics of the shortfin mako in the North Atlantic.

Coastal Shark Longline Studies
Work began on the recovery of data applicable to coastal shark analyses from research cruises occurring since the early 1960s. These efforts will include reconstructing the historic catch, size composition, and biological sampling data into a standardized format for time series analysis of catch rates and size to be used in future stock assessments for both species-specific and shark species complexes.

Cooperative Atlantic States Shark Pupping and Nursery Survey (COASTSPAN)
Apex Predators Investigation staff of NEFSC manage and coordinate this project using researchers in major coastal Atlantic states from Florida to Delaware to conduct a cooperative, comprehensive, and standardized investigation of valuable shark nursery areas. This research identifies which shark species use coastal zones as pupping and nursery grounds, gauges the relative importance of these areas, and determines migration and distribution patterns of neonate and juvenile sharks. Participants in the 2005 COASTSPAN survey included the North Carolina Division of Marine Fisheries, South Carolina Department of Natural Resources, Coastal Carolina University, University of Georgia’s Marine Extension Service with cooperation from the Georgia Department of Natural Resources, and the Florida Fish and Wildlife Conservation Commission. Researchers from the Apex Predators Investigation and the University of Rhode Island conducted the survey in Delaware Bay and the U.S. Virgin Islands.

Juvenile Shark Survey for Monitoring and Assessing Delaware Bay Sandbar Sharks
In July and August each year, NEFSC staff conduct this part of the COASTSPAN project for the juvenile sandbar shark population in Delaware Bay nursery grounds using monthly longline surveys. A random stratified sampling plan, based on depth and geographic location, is ongoing to assess and monitor the juvenile sandbar shark population during the nursery season. In addition, the tagging and recapture data from this project are being used to examine the temporal and spatial relative abundance and distribution of sandbar sharks in Delaware Bay. In 2005, a total of 897 sharks were caught in Delaware Bay, including 608 juvenile sandbar sharks, 288 smooth dogfish, and one large sandbar shark (likely an adult female) that broke free of the hook before she could be sampled. Six hundred and seven (68 percent) of the sharks sampled were tagged with fin tags and released. Time series data collected from this survey were used in the 2005/2006 SEDAR

Large Coastal Shark Stock Assessment Workshops to assess sandbar shark stocks. Catch per unit effort (CPUE) in number of sharks per 50-hook set per hour was used to examine the relative abundance of juvenile sandbar sharks in Delaware Bay between the summer nursery seasons from 2001 to 2005. The CPUE was standardized using an offset of the natural logarithm of the CPUE in a generalized linear model which took into account the effects of year, month, region, and depth strata. The CPUE was also standardized using a modified two-step approach based on a delta-lognormal model, and is a two-step approach that models the zero catch separately from the positive catch. Results from both standardization methods and the nominal CPUE values indicated the relative abundance of juvenile age 1+ and young of the year sandbar sharks during the summer nursery season in Delaware Bay from 2001 to 2005 has remained fairly constant, with only a significant drop in juvenile age 1+ abundance in 2002, which may be attributed to a large storm that passed through the Bay that year.

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

The food habits portion of the study characterizes the diet, feeding periodicity, and foraging habits of the sandbar shark, and examines the overlap in diet and distribution with the smooth dogfish shark (*Mustelus canis*). Stomachs from over 1,100 sandbar sharks and 350 smooth dogfish sharks were sampled for contents through a non-lethal lavage method and contained 44 percent and 98 percent food, respectively. Detailed dietary analysis using several diet indices will include ontogenetic changes, diel feeding, gear comparisons, diet overlap between species, and several abiotic factors. Acquired data will be coupled with environmental data, providing information on preferred habitat. This information contributes to our understanding of essential fish habitat and provides information necessary for nursery ground management and rebuilding of depleted shark populations. Gastric evacuation experiments were initiated in 2005 and are ongoing. These data will be used to provide estimates of consumption, and completion of this study will provide important ecological information for both of these common coastal shark species.

Habitat Utilization and Essential Fish Habitat of Delaware Bay Sandbar Sharks

A study was initiated with staff of Delaware State University and the University of Rhode Island to use automated acoustic telemetry to quantify residence time and fine-scale habitat use of juvenile sandbar sharks and to identify their most critical nursery habitats in Delaware Bay. Bottom monitors were deployed in known nursery areas and at opportunistic points throughout the bay, and neonate and juvenile sandbar sharks were implanted with transmitters. Funding was received through the NOAA Living Marine Resources Cooperative Science Center.

Ecosystems Modeling

Ecosystems modeling, focusing on the role of sharks as top predators, will be conducted using ECOPATH–ECOSIM models. The sandbar shark will be used as a model species and the ecological interactions between sandbar and smooth dogfish sharks in Delaware Bay will be examined upon completion of the diet, feeding ecology, and gastric evacuation studies.

Overview of Gulf and Atlantic Shark Nurseries

To better understand shark nursery habitat in U.S. coastal waters, NEFSC staff are serving as editors for an American Fisheries Society symposium proceedings volume on U.S. Atlantic and Gulf of Mexico coastal shark nursery ground and habitat studies.

Southeast Fisheries Science Center (SEFSC)

Stock Assessments of Large Coastal and Prohibited Sharks

The current assessment for the Large Coastal Shark (LCS) Complex was run, following the procedures of the Southeast Data, Assessment, and Review (SEDAR) process as closely as possible. The process involves three workshops: Data, Assessment, and Review. The Data Workshop for the LCS complex was held in Panama City, Florida, from October 31 to November 4, 2005 (Anon 2006). Initial data compilations and exploratory analyses for SEDAR assessments were requested from participants in the form of "working documents" to be submitted in advance and evaluated over the course of the workshop. Three working groups were established to address the quality and suitability of available data for stock assessment. The working groups covered (1) life history, (2) catch statistics, and (3) indices of relative abundance. Participants were initially assigned to one of the groups based on their expertise and the type of documents they were submitting; however, participants were allowed to participate in any working group they wished. Group rapporteurs reported issues and progress at Data Workshop plenary sessions several times during the week. Written reports from the life history and catch statistics working groups were substantially complete by week's end, whereas the indices group report was only in the preliminary stages. Editing of the reports and further analyses were completed after the Data Workshop.

Update on Catches of Atlantic Sharks

An update on catches of large and small coastal and pelagic sharks in U.S. Atlantic, Gulf of Mexico, and Caribbean waters was generated in October 2005 (Cortés and Neer 2005) and formed the basis of the catch scenarios included in the SEDAR Data Workshop report described above. Time series of commercial and recreational landings and discard estimates from several sources were compiled for the large coastal shark complex and sandbar and blacktip sharks. In addition, recent species-specific commercial and recreational landings were provided for sharks in the large coastal, small coastal, and pelagic groups. Species-specific information on the geographical distribution of commercial landings by gear type and geographical distribution of the recreational catches was also provided. Trends in length-frequency distributions and average weights and lengths of selected species reported from three separate recreational surveys and in the directed shark bottom-longline observer program were also included.

Observer Programs

Shark Longline Program

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

Shark Gillnet Program

Since 1993, an observer program has been under way 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 Fishery Management Plan for Highly Migratory Species. It was also created to obtain better data on catch, bycatch, and discards in the shark fishery. The Atlantic Large Whale Take Reduction Plan and the Biological Opinion issued under Section 7 of the Endangered Species Act mandate 100 percent observer coverage during the right whale calving season (November 15 to April 1). Outside the right whale calving season (April 1 to November 14), observer coverage equivalent to 38 percent of all trips is maintained. Similar to the shark longline observer program, all observers are required to attend a 1-week safety training and species identification course and while on board the vessel must record information on gear characteristics and all species caught, condition of the catch, and the final disposition of the catch.

Ecosystem Modeling–Reconstructing Ecosystem Dynamics in the Gulf of Mexico. An Assessment of the Trophic Impacts of Fishing and Its Effects on Keystone Predator Dynamics

Keystone species, such as sharks, can play a central role in the structure and function of marine communities. Conflicting views surround the ecological interactions between sharks and fisheries. One view suggests removals of keystone species cause a cascading trophic effect within the remaining community, which may involve changes in species composition among the prey or changes in the preferred prey of the predator. An alternate view suggests the high diversity of oceanic systems may oppose strong “top-down” effects. In light of the recent revelations on the reductions of higher trophic levels species and fishing down food webs, an improved understanding of the role of keystone predators in the Gulf of Mexico would be useful in evaluating the impacts of fishing on the marine ecosystem. An Ecopath with Ecosim model is being developed to model the Gulf of Mexico ecosystem dynamics. Hypotheses regarding the depletion of apex predators and their impact on predation mortality of major prey groups will be examined. Further, hypotheses regarding the role of complementary niches among sharks will be explored.

Elasmobranch Feeding Ecology and Shark Diet Database

The current Consolidated Atlantic Fishery Management Plan gives little consideration to ecosystem function because there is 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. Atlantic angel sharks (*Squatina dumerili*) have been collected for stomach content analysis from a trawl fishery in northeastern Florida since 2004. Evidence suggests angel sharks consumed mostly teleost fishes, with Atlantic croaker (*Micropogonias undulates*) being the most common fish species (Baremore et al. 2006). The diet of the roundel skate (*Raja texana*) from the northern Gulf of Mexico is also being examined (Bethea and Hale 2006). A database containing information on quantitative food and feeding studies of sharks conducted around the world has been in development for several years and presently includes over 200 studies. This fully searchable database will continue to be updated and fine-tuned in FY 2007 and will be used as part of a collaborative study with researchers from University of Washington, University of Wisconsin, and the Inter-American Tropical Tuna Commission.

Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey (Gulfspan)

The SEFSC Panama City Shark Population Assessment Group manages and coordinates a survey of coastal bays and estuaries between northwest Florida (Cedar Key–Pensacola) and Texas. Surveys identify the presence or absence of neonate and juvenile sharks and attempt to quantify the relative importance of each area as it pertains to essential fish habitat requirements for sharks. The Group also initiated a juvenile shark abundance index survey in 1996. The index is based on random, depth-stratified gillnet sets conducted throughout coastal bays and estuaries in northwest Florida monthly from April to October. The species targeted for the index of abundance are juvenile sharks in the large and small coastal management groups. This index has been used as an input to various stock assessment models.

Essential Fish Habitat

Conventional theory assumes shark nursery areas are habitats where female sharks give birth to young or lay eggs, or where juvenile sharks spend their first weeks, months, or years of life. The SEFSC Panama City Shark Population Assessment Group is currently testing a number of hypotheses regarding juvenile sharks and Essential Fish Habitat (EFH) that challenge this assumption. There are many bays and inlets along the Gulf of Mexico coastline that may serve as EFH for sharks. These habitats vary from near-oceanic conditions to shallow, enclosed estuarine areas. Following the research recommendations in Beck et al. (2001), the Group is determining which habitats provide a greater "nursery value" for a given species. A study using diet and bioenergetics concluded Crooked Island Sound provided a greater "nursery value" than Apalachicola Bay, Florida (Bethea et al. 2006).

Determining Differences in the Ratios of Fin to Carcass Weight among Sharks

Although many different species are harvested for their fins, the "5 percent rule" was established using data from only sandbar sharks due to a lack of data for other shark species. Using standardized data collated from state and federal databases, additional fin weight to body weight ratios were calculated for several commercially valuable shark species from coastal waters of the U.S. Atlantic Ocean and Gulf of Mexico. The wet fin to dressed carcass weight ratio of the sandbar shark (5.3 percent) was the largest of the 14 species examined, whereas the silky shark exhibited the lowest ratio at 2.5 percent. The fin to dressed weight ratio of the sandbar shark was significantly higher than most of the other large coastal species examined, and the bonnethead shark had a fin to weight ratio (4.9 percent) significantly higher than other small coastal species examined.

Life History Studies of Elasmobranchs

Biological samples are obtained through research surveys and cruises, recreational fishermen, and collection by onboard observers on commercial fishing vessels. Age and growth rates and other life history aspects of selected species are processed and the data analyzed following standard methodology. This information is vital as input to population models used to predict the productivity of the stocks and to ensure they are harvested at sustainable levels. Samples are obtained from commercial fishermen and fishery-independent surveys. Samples and preliminary analysis continue on determining life history parameters for skates in the Gulf of Mexico, a group of elasmobranchs often ignored despite being harvested as catch and bycatch in commercial fisheries.

Elemental Chemistry of Elasmobranch Vertebrae

Although numerous studies have used elemental analysis techniques for age determination in bony fishes, rarely have these procedures been used to verify age assessments or temporal periodicity of growth band formation in elasmobranchs. A study is underway to determine the potential of laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) to provide information on the seasonal deposition of elements in the vertebrae of the round stingray.

Cooperative Research—Habitat Utilization among Coastal Sharks

From 2004 to 2005, through a collaborative effort between the SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory, the use of coastal habitats by neonate and young-of-the-year blacktip and Atlantic sharpnose sharks has been monitored through an array of underwater acoustic receivers (VR2, Vemco Ltd.) placed throughout each study site. Movement patterns, home ranges, activity space, survival, and length of residence of individuals will be compared by species and area to provide information for better management of critical species and essential fish habitats.

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

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

Shark Assessment Research Surveys

The SEFSC Mississippi Laboratories have conducted bottom longline surveys in the Gulf of Mexico, Caribbean, and Southern North Atlantic since 1995 (21 surveys completed through 2005). The primary objective was assessment of the distribution and abundance of large and small coastal sharks across their known ranges in order to develop a time series for trend analysis. The surveys were designed to satisfy five important assessment principles: stockwide survey, synopticity, well-defined universe, controlling 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. and neighboring waters. Ancillary objectives were to collect biological and environmental data, and to tag-and-release sharks. Current surveys continue to address expanding fisheries management requirements for both elasmobranchs and teleosts and annual surveys include the U.S. Atlantic coast from Cape Hatteras to southern Florida and the U.S. Gulf of Mexico.

Smooth dogfish (*Mustelus canis*) tagged and released in the Gulf of Mexico during 2006 bottom longline survey. Source: NMFS Mississippi Laboratories, Shark Team

5.2 Incidental Catch Reduction

Pacific Islands Fisheries Science Center (PIFSC)

Reducing Longline Shark Bycatch

The resumption of the previously closed Hawaii shallow-set longline fishery for swordfish in late 2004 and continuing through 2006 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. Researchers at PIFSC have undertaken several projects to address shark bycatch on longlines.

Chemical Deterrents to Bycatch

One study under way since 2005 with funding from the National Bycatch Program seeks to test the use of chemical deterrents to reduce shark bycatch. Previous research by Eric Stroud at the SharkDefense LLC, Oak Ridge, New Jersey, laboratory was conducted to identify and isolate possible semiochemical compounds from decayed shark carcasses. Semiochemicals are chemical messengers or "clues" sharks may 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. Tonic immobility bioassay tests conducted in 2005 yielded two distinct classes of compounds: (1) those that terminate tonic immobility when introduced to a subject's nares (olfactory repellents), and (2) those that terminate tonic immobility when introduced into the mouth (gustatory compounds). Both sets of compounds were scaled up for field tests and shown to be effective against Caribbean reef shark, blacknose shark, lemon shark, nurse shark, and blacktip reef shark.

More limited testing was conducted on blue shark, bull shark, spotted wobbegong, and tiger shark. Food preference tests were conducted July 11–15, 2005, at the Achotines Laboratory, Las Tablas Provincia Los Santos, Republic of Panama, in which the behavior of captive tunas (longline target species) was observed in the presence of these repellents, and the results indicated no behavioral shift. Longline field testing of these chemicals is focusing on the gustatory compounds because of the ease and relative low cost of chemical synthesis when compared to olfactory compounds. The gustatory repellent will be tested using a low-weight, non-polluting time-release device. Each device may be deployed on each longline gangion, or at select points on a mainline.

Longline Gear Effects on Shark Bycatch

To explore operational differences in the longline fishery that might reduce shark bycatch, the observer database is being used to compare bycatch rates under different operational factors (e.g., hook type, branch line material, bait type, the presence of light sticks, soak time, etc.). A preliminary analysis has been completed that compare 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 within-set 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. Meanwhile, data from the first full year of the restored swordfish fishery in 2005 does not indicate the expected level of resurgence in shark bycatch, perhaps due to the requirement to use fish bait instead of squid.

Testing Deeper Sets

PIFSC researchers are also exploring the efficacy of an experimental deep setting longline technique, which eliminates shallow hooks, to reduce epipelagic bycatch and maximize the catch of target species such as bigeye tuna. Six-pound weights and 100 m floatlines will demarcate the start and end of each longline basket, which will be 50 m from the next basket, and so on. For example, the shallowest hooks could be designed to fish at 100 m. Data from pop-up satellite archival tags suggest bycatch of epipelagic sharks such as silky and oceanic white-tip, as well as marlin (blue and striped) in the Pacific could potentially be reduced by this technique, as they spend approximately 80 percent of their time—day and night—at depths less than 100 m. Several contracted commercial longline trips in the Hawaii-based fishery in 2006 will initiate the study, whereby the catch of deep experimental sets will be compared with control sets targeting the same species. Initial results from the first fishing trip indicate a 50 percent improved bigeye tuna catch rate with the deeper gear and about half the catch rate for all other species (billfishes, other incidental catches, sharks, and other bycatch combined).

Southeast Fisheries Science Center (SEFSC)

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

Funding is being sought through the NMFS Cooperative Research Program to examine alternative measures (such as reduced soak time, restrictions on gear length, and fishing depth restrictions) in the shark bottom longline fishery to reduce mortality on prohibited sharks.

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, are required to carry and use newly developed dehookers for removing hooks from sea turtles. These dehookers were reported to be effective in removing hooks from sharks in tests conducted by the NMFS in the Atlantic. The de-hooking device can be used to remove external hooks and ingested hooks from the mouth and upper digestive tract of fish, sea turtles, marine mammals, and sea birds, and could improve post-release survival and condition of released sharks.

Testing of the dehookers on sharks on research cruises aboard the NOAA R/V *Oscar Sette* has indicated removal of circle hooks from shark jaws with the dehookers can be quite difficult. The use of circle hooks in many fisheries reduces the likelihood of hooks being deeply ingested. The benefit that circle hooks are now primarily located externally or in the jaw is only somewhat offset by circle hooks being more difficult to dehook than other hook types. The reduction of deep hooking is probably more important. PIFSC is testing alternate styles of dehookers developed by the SEFSC for circle hooks and shark dehooking, and also is looking into the feasibility of barbless circle hooks for use on longlines. Preliminary research in the Hawaii shore fishery has indicated that barbless circle hooks catch as much as barbed hooks, but more data is needed. The situation may be very different with more passive gear like 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, so far indicate a substantial increase in bait loss using barbless hooks on longlines.

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 sports fisheries and commercial fisheries require information about long-term survival of released fish. Catch-and-release sports fishing and non-retention of commercially caught fish are justifiable management options only if there is a reasonable likelihood 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 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 sportfishing or longline gear. PIFSC researchers and collaborators from other agencies, academia, and the 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 pop-up satellite archival tag (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 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 pop-up satellite archival tags) based on analysis of small blood samples. Five parameters distinguished survivors from moribund sharks: plasma Mg^{2+} ($p<0.00001$), plasma lactate ($p<0.001$), erythrocyte Hsp70 mRNA ($p<0.005$), plasma Ca^{2+} ($p<0.005$) and plasma K^{+} ($p<0.05$). A logistic regression model incorporating a combination of Mg^{2+} and lactate successfully categorized 19 of 20 (95 percent) fish of known fate and predicted that 21 of 22 (96 percent) sharks of unknown fate would have survived upon release. These data suggest that a shark landed without obvious physical damage or physiological stress (the condition of 95 percent of the sharks they landed) would have a high probability of surviving upon release. The program has PSAT-tagged 32 blue shark, eight bigeye thresher sharks, 16 oceanic white-tip sharks, one shortfin mako, and 10 silky sharks. Of the 67 PSATs reporting from released sharks, in only one case was there an indication of mortality after release. These PSAT data complement the biochemical data indicating long-term survival after release from longline gear (Moyes et al. in press).

Electronic Tagging Studies and Movement Patterns

PIFSC scientists are using acoustic, archival, and PSATs to study vertical and horizontal movement patterns in commercially and ecologically important tuna, billfish, and shark species, as well as sea turtles. The work is part of a larger effort to determine the relationship of oceanographic conditions to fish and sea turtle behavior patterns. This information is intended for incorporation into population assessments, addressing fisheries interactions and allocation issues, as well as improving the overall management and conservation of commercially and recreationally important tuna and billfish species, sharks, and sea turtles. The research, sponsored by the Pelagic Fisheries Research Program and PIFSC, has shown some large pelagic fishes have much greater vertical mobility than others. More specifically, we have found 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. 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 (e.g., over 500 m). 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.

The PIFSC, in collaboration with Australian Institute for Marine Science and the Commonwealth Scientific and Industrial Research Organization have 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 deeper, below 1000 m, 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).

Pop-up Satellite Archival Tags (PSAT) Performance and Meta Data Analysis Project

The purpose of this study is to explore failure (or success) scenarios in PSATs attached to pelagic fish, sharks, and turtles. Shark species in the database include bigeye thresher, blue, shortfin mako, silky, oceanic white-tip, great white, and basking sharks. Other species include black, blue, and striped marlins; broadbill swordfish; bigeye, yellowfin, and bluefin tunas; tarpon; and green, loggerhead, and olive ridley turtles. To date, of 662 PSATs attached to sharks, billfish, tunas, and turtles, 520 (79 percent) reported data. Of the tags that recorded data, 87 (17 percent) hit their programmed pop-off date and 433 tags popped-off earlier than their program date. The 142 (21 percent) non-reporting tags are not assumed to reflect fish mortality. The meta data study is designed to look for explanatory variables related to tag performance by analyzing PSAT retention rates, percentage retrieved satellite data (i.e., depth, temperature, geolocations), 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 design. It is anticipated this study will examine information from more than 1,000 PSATs. Information derived from this study should allow an unprecedented and critical appraisal of the overall efficacy of the technology.

Northeast Fisheries Science Center

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

This ongoing cooperative research with the Massachusetts Division of Marine Fisheries is directed toward the sandbar shark (*Carcharhinus plumbeus*). The study uses blood and muscle sampling methods and acoustic tracking to obtain physiological profiles of individual sharks to characterize stamina and to determine ultimate post-release survival. These analyses are nearly complete and will be valuable in view of the extensive current catch-and-release management strategies for coastal and pelagic shark species.

This shortfin mako shark was caught in the California/Oregon drift gillnet fishery. In the upper left corner are fins from unidentified sharks. This photo was taken before shark fining became illegal. Source: NMFS Southwest Regional Office Observer Program

6. References

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Sandbar shark captured in the Gulf of Mexico during 2006 bottom longline survey.
Source: NMFS Mississippi Laboratories, Shark Team

Appendix 1: Internet Information Sources

Atlantic Ocean Shark Management

The 2006 Final Consolidated Atlantic HMS FMP; copies of Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks; and Atlantic commercial and recreational shark fishing regulations and brochures can be found on the Highly Migratory Species 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 Highly Migratory Species (HMS), which are also available on the website. The website includes links to current fishery regulations (50 CFR 635), shark landings updates, the U.S. National Plan of Action (NPOA) for Sharks, and the Atlantic HMS SAFE Reports.

Pacific Ocean Shark Management

The final Fishery Management Plan for U.S. West Coast Highly Migratory Species is currently available on the Pacific Fishery Management Council website: http://www.pcouncil.org/hms/hmsfmp.html.

Data reported in Table 2.3.3 (Shark landings (mt) for California, Oregon, and Washington, 1992–2005) was obtained from the Pacific States Marine Fisheries Commission's PacFIN Database, which may be found on their website at www.psmfc.org/pacfin/data.html.

Western Pacific Shark Management

The Western Pacific Fishery Information Network (WPacFIN) is a federal–state partnership collecting, processing, analyzing, sharing, and managing fisheries data from American island territories and states in the Western Pacific. http://www.pifsc.noaa.gov/wpacfin/

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

NOAA Fisheries Office of International Affairs
http://www.nmfs.noaa.gov/ia/

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

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

NAFO Article 13: Conservation and Management of Sharks
http://www.nafo.int/fisheries/frames/regulations.html

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

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

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

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

U.S. Imports and Exports of Shark Fins

Summaries of U.S. imports and exports of shark fins based on information submitted by importers and exporters to the U.S. Customs and Border Protection Data, and U.S. Census Bureau are reported in the NMFS Trade database:
http://www.st.nmfs.gov/st1/trade/index.html.

A neonatal common thresher shark caught during the NMFS juvenile pelagic shark survey.
The shark was injected with oxytetracycline for age and growth studies and was released.
Source: Southwest Fisheries Science Center Large Pelagics Group