ATLANTIC SHARKS

This information is taken from the 2005 Draft Consolidated Atlantic HMS FMP. For more information, please see that document.

3.1.1 Atlantic Sharks

3.1.1.1 Life History/Species Biology

Sharks belong to the class Chondrichthyes (cartilaginous fishes) that also includes rays, skates, and deepwater chimaeras (ratfishes). From an evolutionary perspective, sharks are an old group of fishes characterized by skeletons lacking true bones. The earliest known sharks have been identified from fossils from the Devonian period, over 400 million years ago. These primitive sharks were small creatures, about 60 to 100 cm long, that were preyed upon by larger armored fishes that dominated the seas. Sharks have survived competition for eons, evolving into the large and aggressive predators that dominate the seas today. The life span of sharks in the wild is not known, but it is believed that many species may live 30 to 40 years or longer.

Relative to other marine fish, sharks have a very low reproductive potential. Several important commercial species, including large coastal carcharhinids, such as sandbar (*Carcharhinus plumbeus)* (Casey and Hoey, 1985; Sminkey and Musick, 1995; Heist *et al*., 1995), lemon (*Negaprion brevirostris)* (Brown and Gruber, 1988), and bull sharks (Branstetter and Stiles, 1987), do not reach maturity until 12 to 18 years of age. Various factors determine this low reproductive rate: slow growth, late sexual maturity, one- to two-year reproductive cycles, a small number of young per brood, and specific requirements for nursery areas. These biological factors leave many species of sharks vulnerable to overfishing.

There is extreme diversity among the 350 species of sharks, ranging from tiny pygmy sharks of only 20 cm in length to the giant whale sharks, over 12 meters in length. There are fast moving, streamlined species such as mako (*Isurus spp.)* and thresher sharks (*Alopias spp*.), and sharks with flattened, ray-like bodies, such as angel sharks (*Squatina dumerili)*. The most commonly known sharks are large apex predators including the white (*Carchardodn carcharias*), mako, tiger (*Galeocerdo cuvier*), bull (*Carcharhinus leucas)*, and great hammerhead (*Sphyrna modarran*). Some shark species reproduce by laying eggs, others nourish their embryos through a placenta. Despite their diversity in size, feeding habits, behavior and reproduction, many of these adaptations has contributed greatly to the evolutionary success of sharks.

The most significant reproductive adaptations of sharks are internal fertilization and the production of fully developed young or “pups.” These pups are large at birth, effectively reducing the number of potential predators and enhancing their chances of survival. During mating, the male shark inseminates the female with copulatory organs, known as claspers that develop on the pelvic fins. In most species, the embryos spend their entire developmental period protected within their mother’s body, although some species lay eggs. The number of young produced by most shark species in each litter is

small, usually ranging from two to 25, although large females of some species can produce litters of 100 or more pups. The production of fully developed pups requires great amounts of nutrients to nourish the developing embryo. Traditionally, these adaptations have been grouped into three modes of reproduction: oviparity (eggs hatch outside body), ovoviviparity (eggs hatch inside body), and viviparity (live birth).

Adults usually congregate in specific areas to mate and females travel to specific nursery areas to pup. These nurseries are discrete geographic areas, usually in waters shallower than those inhabited by the adults. Frequently, the nursery areas are in highly productive coastal or estuarine waters where abundant small fishes and crustaceans provide food for the growing pups. These areas also may have fewer large predators, thus enhancing the chances of survival of the young sharks. In temperate zones, the young leave the nursery with the onset of winter; in tropical areas, young sharks may stay in the nursery area for a few years.

Shark habitat can be described in four broad categories: (1) coastal, (2) pelagic, (3) coastal - pelagic, and (4) deep-dwelling. Coastal species inhabit estuaries, the nearshore and waters of the continental shelves, *e.g.*, blacktip (*Carcharhinus limbatus*), finetooth, bull, lemon, and sharpnose sharks (*Rhizoprinondon terraenaovae*). Pelagic species, on the other hand, range widely in the upper zones of the oceans, often traveling over entire ocean basins. Examples include shortfin mako (*Isurus oxyrinchus*), blue (*Prionace glauca*), and oceanic whitetip (*Carcharhinus longimanus*) sharks. Coastal-pelagic species are intermediate in that they occur both inshore and beyond the continental shelves, but have not demonstrated mid-ocean or transoceanic movements. Sandbar, scalloped hammerhead (*Sphyrna lewini*), and dusky sharks (*Carcharhinus obscurus*) are examples of coastal-pelagic species. Deep-dwelling species, *e.g.*, most cat sharks (*Apristurus spp*.) and gulper sharks (*Centrophorus spp*.), inhabit the dark, cold waters of the continental slopes and deeper waters of the ocean basins.

Seventy-three species of sharks are known to inhabit the waters along the U.S. Atlantic coast, including the Gulf of Mexico and the waters around Puerto Rico and the U.S. Virgin Islands. HMS manages seventy-two species; spiny dogfish also occur along the U.S. coast, however management for this species is under the authority of the Atlantic States Marine Fisheries Commission as well as the New England and Mid-Atlantic Fishery Management Councils. Based on a combination of ecology and fishery dynamics the sharks in the management unit have been divided into four species groups for management: (1) large coastal species, (2) small coastal species, (3) pelagic species, and (4) prohibited species (Table Error! **No text of specified style in document..1**).

Table Error! No text of specified style in document..**1** **Common names of shark species included within the four species management units under the purview of the HMS management division.**

Management Unit	Shark Species Included
Large Coastal Sharks (11)	Sandbar, silky, tiger, blacktip, bull, spinner, lemon, nurse, smooth hammerhead, scalloped hammerhead, and great hammerhead sharks

Small Coastal Sharks (4)	Atlantic sharpnose, blacknose, finetooth, and bonnethead sharks
Pelagic Sharks (5)	Shortfin mako, thresher, oceanic whitetip, porbeagle, and blue sharks
Prohibited Species (19)	Whale, basking, sandtiger, bigeye sandtiger, white, dusky, night, bignose, Galapagos, Caribbean reef, narrowtooth, longfin mako, bigeye thresher, sevengill, sixgill, bigeye sixgill, Caribbean sharpnose, smalltail, and Atlantic angel sharks

3.1.1.2 Status of the Stocks

NMFS is responsible for conducting stock assessments for the Large and Small Coastal Shark complexes (LCS and SCS) (Cortes, 2002; Cortes *et al*., 2002). ICCAT and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) have recently conducted assessments of three pelagic shark species. Stock assessments were conducted for the Large and Small Coastal Shark complexes (LCS and SCS) in 2002. Species-specific assessments for blacktip and sandbar sharks within the LCS complex and finetooth sharks, Atlantic sharpnose sharks, blacknose sharks (*Carcharhinus acronotus*), and bonnethead sharks (*Sphyrna tiburo*) within the SCS complex, were also conducted in 2002. The conclusions of these assessments are summarized in Table Error! **No text of specified style in document..2** and Table Error! **No text of specified style in document..3** and are fully described in Amendment 1 to the 1999 Atlantic Tunas, Swordfish, and Sharks FMP. Summaries of recent stock assessments and reports on several species of pelagic sharks (blue sharks, shortfin mako sharks, and porbeagle sharks (*Lamna nasus*) by COSEWIC and ICCAT are also included in this section.

3.1.1.3 Finetooth Sharks

Finetooth sharks inhabit shallow coastal waters to depths of 10 m (32.8 feet) near river mouths in the Gulf of Mexico and South Atlantic Ocean between Texas and North Carolina. These fish often form large schools and migrate to warmer waters when water temperatures drop below 20°C (68°F). Finetooth sharks are relatively productive compared to other sharks as fish are sexually mature at 3.9 (TL = 118 cm (46 inches)) and 4.3 (TL = 123 cm (48 inches)) years for males and females, respectively (Carlson *et al*., 2003). Reproduction in finetooth sharks is viviparous with yolk sac placenta and embryos nourished through a placental connection. Females move into the nursery areas in late May and gestation is approximately 12 months. Each litter can have 1-6 pups with individuals measuring 51 - 64 cm (20 - 25 inches) in length. The finetooth shark feeds primarily on mullet, Spanish mackerel, spot, Atlantic menhaden, cephalopods, and crustacean (Bester and Burgess, 2004).

In 2002, NMFS conducted a stock assessment for all SCS, including finetooth sharks. Five catch rate series were used, including fishery-independent and -dependent data. The fishery-independent data sources included the NMFS Pascagoula and Panama City Laboratory longline surveys (NMFS SE LL and NMFS LL PC), and the NMFS Panama City Laboratory Gillnet Survey (NMFS GN). Fishery–dependent catch series

data were included from the combined recreational series and the Directed Shark Gillnet Fishery Observer Program (DSGFOP). This catch rate series data were combined with life history information for finetooth sharks and evaluated with several stock assessment models. There were four models utilized for the assessment and numerous scenarios within each model, producing a range of point estimates for fishing mortality, relative fishing mortality, biomass, relative stock biomass, maximum fishing mortality threshold, minimum stock size threshold, and other parameters.

Of the catch series data used in the analysis, three of the five showed a positive trend (*i.e.*, had positive slopes) in catch over time, suggesting an increase in finetooth shark abundance. The catch series data showing positive trends were DSGFOP (0.03), NMFS SE LL (0.34), and NMFS LL PC (0.04); however only the slope for the DSGFOP catch series data was statistically significant different from zero ($P = 0.03$). However, it should be noted that data were missing from some years in the NMFS SE LL and the DSGFOP catch series data; therefore, one cannot necessarily assume that finetooth sharks are increasing in abundance. The other two datasets, NMFS LL PC and NMFS GN PC, had negative trends in catch over time as indicated by their negative slopes (-0.24 and -0.11, respectively) but neither trend was statistically significant from zero. Overall, the slopes for the small coastal shark (SCS) complex as a whole and other individual species were relatively flat, indicating that the relative abundance of the stocks remained fairly stable during the exploitation phase (Cortés, 2002).

Four different stock assessment models were used to evaluate the status of SCS using Bayesian statistical techniques. Results of both surplus production models and the Lagged Recruitment Survival and Growth State Space model (LRSG) (using several different scenarios) indicate that the current level of removals is sustainable for the SCS aggregate and the individual species within the complex. Relative stock biomass and fishing mortality trajectories obtained with the Bayesian state-space Schaefer surplus production model (SPM) for the small coastal aggregate and the Atlantic sharpnose sharks followed similar trends, since the catches were dominated by these species. The model predicted that the stock biomass for the small coastal shark complex in any given year from 1972 - 2000 exceeded the biomass producing MSY. Relative fishing mortality (F/F_{MSY}) was generally below one for the SCS complex, but for finetooth sharks, the final five values of F in the series (1996 - 2002) estimated by the model were above the level of F corresponding to MSY.

Results for finetooth sharks were directly influenced by the catch series used, which did not include any bycatch estimates, and this, in turn, influenced certain parameters of the Bayesian models (specifically, the priors chosen for K, which describes uncertainty in assessment models) (Cortés, 2002). The lack of bycatch data in the catch series data lead to low values of MSY predicted for finetooth sharks in the SCS stock assessment (especially those obtained through the SPM models). This lack of bycatch data and shorter catch and catch per unit effort (CPUE) series, coupled with no catches reported in some years, led to some uncertainty in the stock assessment for finetooth sharks. In the case of finetooth sharks, model estimates of recent F levels are above F_{MSY}, indicating that recent levels of effort directed at this species, if continued, could

result in an overfished status in the relatively near future. The various stock assessments models used and sensitivity analyses run support these general conclusions (Cortés, 2002). Future work should continue to monitor the status of this individual species (Cortés, 2002).

Currently, there are a number of issues that make the management of finetooth problematic. First, in order to reduce fishing mortality on finetooth sharks, NMFS needs to identify a target fishing mortality. However, the large ranges for F_{2000} (0.13 - 1.50) and F_{MSY} (0.03 - 0.44) make it difficult to discern to what extent fishing mortality (*i.e.*, F_{2000}) needs to be reduced (*i.e.*, it is difficult to identify the fishing mortality target). The large ranges in the stock assessment output for finetooth sharks are due to the fact that for finetooth sharks there were shorter catch and CPUE series, lack of bycatch estimates, and no catches reported in some years (Cortes, 2002). Since bycatch mortality was not included in the 2002 stock assessment for finetooth sharks, NMFS does not currently have an accurate estimate of bycatch fishing mortality. Furthermore, the majority of fishing mortality may be occurring in fisheries that may not be targeting finetooth sharks and/or are not reporting their landings. For instance, finetooth sharks are generally a coastal species that occur in shallow, inshore waters under states' jurisdiction (Bester and Burgess, 2004). NMFS is currently investigating recreational and commercial landings in state waters.

Management efforts are further complicated by the fact that the DSGFOP catch series data included landings data from only five vessels with directed shark permits, targeting sharks with gillnet gear. These vessels account for less than 10 percent of the landings depending on the year. These landings equate to approximately one percent of finetooth landings reported to the General Canvass during the same time period. While observer coverage is extensive (100 percent from November 15 – April 1), it does not include all finetooth shark landings in this fishery outside the right whale calving season (April 2 – November 14) when observer coverage is reduced to approximately 30 percent. The majority of the commercial landings reported via the general canvass (dealer) logbooks are being caught by other gillnet fisheries in the South Atlantic managed by states, fishery management councils, or fisheries that are not currently managed. These vessels are not currently included in the DSGFOP because they are not "targeting" sharks, however, since they possess shark permits they are able to keep the finetooth sharks they harvest. Finetooth sharks are susceptible to any type of gillnet gear, even those with a slightly different mesh size than the driftnets or strikenets employed by vessels in the observer program.

Landings of finetooth sharks in other fisheries are extensive; however, catch series data from these fisheries are currently unavailable. The inclusion of such data in future stock assessments will provide better information on both fishing effort and estimates of MSY. Thus, it may be prudent to continue to investigate other sources of fishing mortality before initiating a particular set of management actions. In order to capture additional catch series data on fisheries contributing to finetooth fishing mortality, NMFS is expanding observer programs to include DSGFOP observers on all boats that have directed or incidental shark permits to determine if these gillnet vessels in

the South Atlantic are contributing to the majority of fishing mortality. A continuation of a pilot program initiated in the spring of 2005 that placed observers on board additional gillnet vessels targeting other fish species will improve data collection efforts. Furthermore, contacting regional Fishery Management Councils and Interstate Marine Fisheries Commissions to determine sources of mortality occurring under other fishery management plans, and having finetooth sharks included as a select species for sub-sampling of bycatch in the Gulf of Mexico Shrimp Trawl Observer Program will provide additional landings data necessary for appropriate management and conservation actions in the future.

Table Error! No text of specified style in document..**2 Summary Table of Biomass and Fishing Mortality for Small Coastal Sharks (SCS)** Source: Cortes, 2002.

Species/Complex	MSY	2001 Relative Biomass Level (B_{2001}/B_{MSY})	Minimum Stock Size Threshold MSST = (0.5)B_{MSY} if M>=0.5 MSST = (1-M)Bmsy if M<0.5	Fishing Mortality Rate (F_{2000})	Maximum Fishing Mortality Threshold (F_{MSY})	Outlook
Small Coastal Sharks (SCS)	7.0-2.2 mill lb dw	1.38-2.39	16.2-50.2	0.03-0.24	0.04-0.28	Not overfished; No overfishing occuring
Finetooth Sharks	0.26-0.05 mill lb dw	1.39-2.37	0.4-1.4	0.13-1.50	0.03-0.44	Not overfished; Overfishing is occuring
Bonnethead Sharks	1.8-0.5 mill lb dw	1.46-2.78	2.3-7.3	0.03-0.18	0.05-0.53	Not overfished; No overfishing occuring
Atlantic Sharpnose Sharks	7.8-1.9 mill lb dw	1.69-3.16	11.5-33.4	0.02-0.06	0.04-0.42	Not overfished; No overfishing occuring
Blacknose Sharks	0.8-0.2 mill lb dw	1.92-3.15	1.6-4.5	0.02-0.19	0.03-0.32	Not overfished; No overfishing occuring

Table Error! No text of specified style in document..**3 Summary Table of Biomass and Fishing Mortality for Large Coastal Sharks (LCS).** Source: Cortes *et al*., 2002

Species/Complex	2001 Biomass (N_{2001})	2001 Relative Biomass (N_{2001}/N_{MSY})	Fishing Mortality Rate (F_{2001})	Maximum Fishing Mortality Threshold (F_{MSY})	Outlook
Large Coastal Complex	2,940-10,156	0.46-1.18	0.07-0.21	0.05-0.10	Overfished; Overfishing is occurring
Sandbar Sharks	1,027-4.86 E-8	3.25E4-2.22	0.0001-0.70	0.05-0.46	Not overfished; Overfishing is occurring
Blacktip Sharks	5,587-3.16 E7	0.79-1.66	0.01-0.21	0.06-0.18	Not overfished; No overfishing occurring

ICCAT Stock Assessment on Blue and Shortfin Mako Sharks

At the 2004 ICCAT annual meeting in New Orleans the commission adopted a recommendation concerning the conservation of sharks caught in association with fisheries managed by ICCAT. This is the first binding measure passed by ICCAT dealing specifically with sharks. This recommendation includes, among other measures: reporting of shark catch data by Contracting Parties, a ban on shark finning, a request for Contracting Parties to live-release sharks that are caught incidentally, a review of management alternatives from the 2004 assessment on blue and shortfin mako sharks, and a commitment to conduct another stock assessment of selected pelagic shark species no later than 2007.

At the 2004 Inter-Sessional Meeting of the ICCAT Subcommittee on bycatch, stock assessments for Atlantic blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*) were conducted. This work included a review of their biology, a description of the fisheries, analyses of the state of the stocks and outlook, analyses of the effects of current regulations, and recommendations for statistics and research. The assessment indicated that the current biomass of North and South Atlantic blue shark seems to be above MSY ($B>B_{MSY}$), however, these results are conditional and based on assumptions that were made by the committee. These assumptions indicate that blue sharks are not currently overfished, again, this conclusion is conditional and based on limited landings data. The committee estimates that between 82,000 and 114,000 mt ww (180,779,054 - 251,326,978 lb) of blue shark are harvested from the Atlantic Ocean each year.

The North Atlantic shortfin mako population has experienced some level of stock depletion as suggested by the historical CPUE trend and model outputs. The current stock may be below MSY ($B<B_{MSY}$), suggesting that the species may be overfished. Overfishing may also be occurring as between 13,000 and 18,000 mt ww (28,660,094 – 39,683,207 lb) of shortfin mako are harvested in the Atlantic Ocean annually. South Atlantic stocks of shortfin mako shark are likely fully exploited as well, but depletion rates are less severe than in the North Atlantic.

The results of both of these assessments should be considered preliminary in nature due to limitations on quality and quantity of catch data available (SCRS, 2004). The subcommittee stated that catch data currently being reported to ICCAT does not represent the total catch actually landed, and are very limited with regard to size, age, and sex of shark harvested or caught incidentally. In order to attain a more accurate estimate of total landings, and improve future stock assessments, the committee made several recommendations, including: increase the infrastructure investment for monitoring the overall catch composition of sharks, standardize catch per unit effort (CPUE) from major fishing fleets, expand use of trade statitistics (fins) to extend historical time series, and include scientists from all Contracting Parties with significant blue and shortfin mako catches in future assessments (SCRS, 2004).

COSEWIC Stock Assessment on Porbeagle

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) conducted a species report and assessment for porbeagle in 2004. They suggest that significant declines in porbeagle abundance have occurred as a result of overexploitation in fisheries. In 2001, porbeagle biomass was estimated at 4,409 mt ww (9,720,181 lb), a decline of 89 percent from the pre-fishing biomass in 1961 (COSEWIC, 2004). The model employed predicts that populations declined precipitously after the fishery was developed in 1961, recovered slightly in the 1980s, and then declined again to the current level. Porbeagle quotas have been reduced significantly for Canadian fisheries. NMFS is interested in working with the Canadian government to address concerns raised by the COSEWIC report. Currently, NMFS has a species-specific quota of 92 mt dw (202,823 lb) for porbeagle. These fish are generally harvested incidentally in the pelagic longline fisheries. Between 2000 and 2003, landings of porbeagle were approximately 3.4 mt dw for the four fishing years combined.

3.1.1.4 Ongoing Research

Northeast Fisheries Science Center

Fishery Independent Survey for Coastal Sharks

The biannual fishery independent survey of Atlantic large and small coastal sharks in US waters from Florida to Delaware was conducted from April 19 to June 1, 2004. The goals of this survey are to: 1) monitor the species composition, distribution, and abundance of sharks in the coastal Atlantic; 2) tag sharks for migration and age validation studies; 3) collect biological samples for age and growth, feeding ecology, and reproductive studies; and 4) collect morphometric data for other studies. Results from this 2004 survey included 557 sharks representing eight species caught on 69 longline sets. The time series of abundance indices from this survey are critical to the evaluation of coastal Atlantic shark species.

Age and Growth of Coastal and Pelagic Sharks

A comprehensive aging and validation study for the shortfin mako (*Isurus oxyrinchus)*, continued in conjunction with scientists at Moss Landing Marine Laboratories, California using bomb carbon techniques. Additional validation studies have begun on the sandbar shark, (*Carcharhinus plumbeus),* dusky shark, (*Carcharhinus obscurus),* tiger shark, (*Galeocerdo cuvieri),* and white shark, (*Carcharodon carcharias).* Age and growth studies on the tiger shark (with scientists at the University of New Hampshire), thresher shark, (*Alopias vulpinus)* (with scientists at the University of Rhode Island), night shark, (*Carcharhinus signatus)* (with NMFS scientists at the SEFSC Panama City Laboratory), and the bull shark, (*Carcharhinus leucas)* (with scientists with the Florida Division of Natural Resources) are underway. Collection, processing, photographing, and reading of samples are in various stages for these species including intercalibration of techniques, criteria, and band readings. This intercalibration process involves sharing samples and comparing counts between researchers including a

researcher from the Natal Sharks Board, South Africa for joint work on shortfin mako, blue, and basking shark band periodicity. Collections of vertebra took place at tournaments and on the biannual research cruise with 285 sharks injected with OTC for validation. Night and dusky sharks were prepared with gross sectioning to determine the best method for reading and all processing was initiated using histology. Readings were completed on the thresher and tiger sharks towards intercalibration to generate bias graphs. Vertebrae, length-frequency data, and tag/recapture data collected from 1962 to present are being analyzed on each of these species to obtain growth parameters.

Biology of the Thresher Shark

Life history studies of the thresher shark continued. Data collection was augmented to include reproductive and food habits, in addition to age and growth information.

Biology of the Porbeagle Shark

A cooperative U.S./Canada research program continued on the life history of the porbeagle shark, (*Lamna nasus)* with preliminary analysis of porbeagle tagging and recapture data using information from U.S., Canadian, and Norwegian sources.

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 recreational fishing tournaments in the Northeast. Analysis of these tournament landings data was initiated by creating a database of historic information (1961 - 2004) and producing preliminary summaries of one long term tournament. The collection and analysis of these data are critical for input into species and age specific population and demographic models for shark management

Cooperative Shark Tagging Program (CSTP)

The Cooperative Shark Tagging Program involving over 6,500 volunteer recreational and commercial fishermen, scientists, and fisheries observers conducted 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. Since its inception, the CSTP has tagged over 128,000 sharks representing 40 species.

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. Research on the food and feeding ecology of the blue shark is being conducted cooperatively with University of Rhode Island staff with additional samples collected and a manuscript under revision. A detailed reexamination of the reproductive parameters of the blue shark continued with collection of additional biological samples to determine if any changes have occurred since the 1970s. A manuscript on blue shark stock structure based on tagging data was completed detailing size composition and movements between Atlantic regions.

Additionally, a research focus on the population dynamics in the North Atlantic with the objectives of constructing a time series of blue shark catch rates (CPUE) from research surveys, estimation of blue shark migration and survival rates, and the development of an integrated tagging and population dynamics model for the North Atlantic for use in stock assessment continued in collaboration between NEFSC scientists and scientists at the School of Aquatic and Fishery Sciences, University of Washington. Progress to date includes the preliminary recovery of historical research survey catch data, size composition, and biological sampling data on pelagic sharks and preliminary analysis of survival and movement rates for blue sharks based on tag and release data from the NMFS CSTP. Preparation of standardized catch rate and size composition data compatible with pelagic longline observer data continued with a resulting ICCAT submission. As part of this comprehensive program, cooperative research continued with the Irish Marine Institute and Central Fisheries Board on mark-recapture databases including coordination of formats and programs with the NMFS CSTP for joint data analyses.

Atlantic Shortfin Mako Life History and Assessment Studies

A collaborative program with students and scientists at the University of Rhode Island to examine the biology and population dynamics of the shortfin mako in the North Atlantic was continued. Ongoing research included an update on age and growth and reproductive parameters and an examination of the predator-prey relationships between the shortfin mako and its primary prey, bluefish (*Pomatomus saltatrix).* A manuscript was completed comparing contemporary and historic levels of bluefish predation. Future research includes the estimation of shortfin mako migration rates and patterns and survival rates using CSTP mark/recapture data and satellite tags with movements correlated with Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature data. Toward these goals, two shortfin mako sharks were tagged with pop-up archival transmitting tags.

Blacktip Shark Migrations

Analysis of movements of the blacktip shark (*Carcharhinus limbatus)* in the western North Atlantic and Gulf of Mexico based on release and recapture data is ongoing with the examination of general migration patterns and exchange between and within regions of U.S. and Mexican waters. Release and recapture data were analyzed for evidence of Atlantic and Gulf primary and secondary blacktip nursery grounds.

Cooperative Atlantic States Shark Pupping and Nursery Survey (COASTSPAN)

NEFSC Apex Predators Program staff manage and coordinate this project that uses 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 utilize 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. This program is described in further detail in Section **Error! Reference source not found.** of this document.

Juvenile Shark Survey for Monitoring and Assessing Delaware Bay Sandbar Sharks

NEFSC staff conduct this part of the COASTSPAN monitor and assessment project for the juvenile sandbar shark population in the Delaware Bay nursery grounds using monthly longline surveys from June to September each year. 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.

Habitat Utilization, Food Habits, and Essential Fish Habitat 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 as well as examine the overlap in diet and distribution with the smooth dogfish shark (*Mustelus canis)*. Stomachs from over 800 sandbar sharks and over 200 smooth dogfish sharks have been sampled for contents through a non-lethal lavage method. Acquired data will be coupled with environmental data, providing information on preferred habitat. This information is an important contribution towards understanding essential fish habitat and provides information necessary for nursery ground management and rebuilding of depleted shark populations.

Ecosystems Modeling

Ecosystem modeling, focusing on the role of sharks as top predators, will be conducted using ECOPATH - ECOSIM models, using the sandbar shark as a model species and examining the ecological interactions between sandbar and smooth dogfish sharks in Delaware Bay.

Overview of Gulf and Atlantic Shark Nurseries

Due to the requirement for a better understanding of shark nursery habitat in U.S. coastal waters, NEFSC staff are editors for an American Fisheries Society symposium proceedings volume on U.S. Atlantic and Gulf of Mexico coastal shark nursery ground and habitat studies.

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

This ongoing research is directed towards the sandbar shark (*Carcharhinus plumbeus)*, and is being conducted cooperatively with Massachusetts Division of Marine Fisheries biologists. The study utilizes blood and muscle sampling methods in addition to acoustic tracking to obtain physiological profiles of individual sharks to characterize stamina and to determine ultimate post release survival. These analyses are requisite in view of the extensive current and proposed catch-and-release management strategies for coastal and pelagic shark species.

Southeast Fisheries Science Center

Stock Assessments of Pelagic, Large Coastal, and Prohibited Sharks

The ICCAT Subcommittee on Bycatches conducted a stock assessment of blue sharks and shortfin makos in Tokyo, Japan, in June 2004. All information available on biology, fisheries, stock identity, catch, CPUE, and size of these species was reviewed and an evaluation of the status of stocks conducted using surplus production, age-structured, and catch-free stock assessment models. U.S. scientists contributed eight working documents for this meeting on various aspects of shark biology and methods to assess stock status; SEFSC scientists participated in the assessment process and authored or co-authored six of those documents. A stock assessment of dusky shark, a prohibited species under the shark FMP and candidate for listing under the ESA, is under way with expected completion in summer of 2005. Biological and fishery information available for this species is being synthesized and stock status will be evaluated using multiple stock assessment methodologies. The next assessment of large coastal sharks is planned for FY06, but data collection, synthesis, analysis, and preliminary stock evaluations will begin in late FY05.

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 FY04 for inclusion in the 2004 SAFE Annual Report and future shark stock assessments. 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. Additionally, 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. Another update on catches of Atlantic sharks will be generated in FY05.

Ecosystem Modeling

A dynamic mass-balance ecosystem model was used to investigate how relative changes in fishing mortality on sharks can affect the structure and function of Apalachicola Bay, Florida, a coastal marine ecosystem. Simulations were run for 25 years wherein fishing mortality rates from recreational and trawl fisheries were doubled for 10 years and then decreased to initial levels. Effect of time/area closures on ecosystem components were also tested by eliminating recreational fishing mortality on juvenile blacktip sharks. Simulations indicated biomass of sharks declined up to 57 percent when recreational fishing mortality was doubled. Simulating a time/area closure for juvenile blacktip sharks caused increases in their biomass but decreases in juvenile coastal shark biomass, a competing multispecies assemblage that is the apparent

competitor. In general, reduction of targeted sharks did not cause strong top-down cascades. Another update on catches of Atlantic sharks was generated in FY05

Elasmobranch Feeding Ecology and Shark Diet Database

The 1999 Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks 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. Given this, several studies are currently underway describing the diet and foraging ecology, habitat use, and predator-prey interactions of elasmobranchs in various communities. In 2004, the diet of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) was compared in two marine embayments of the northeast Gulf of Mexico. Results indicate that variations in diet composition between areas and ontogenetic diet shifts within each location are likely due to differences in overall habitat structure and availability of potential prey species. A manuscript is currently in review. 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 FY05. The goal is to make this tool available to researchers in the relatively near future.

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 the Panhandle of Florida and Texas. Surveys identify the presence/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 SEFSC Panama City Shark Population Assessment 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. More information on this program can be found in Section **Error! Reference source not found.** of this document.

Angel Shark Life History

The Atlantic Angel Shark is a benthic species inhabiting deep waters of the Gulf of Mexico and the Atlantic Ocean. This species is listed as prohibited by the 1999 Fisheries Management Plan for Atlantic Tunas, Swordfish, and Sharks due to the lack of biological data and a precautionary approach for species thought to be highly susceptible to exploitation. Life history studies began in 2003. Samples are obtained from commercial fishers and fishery-independent surveys. Preliminary reproductive parameters were determined in 2004 and results presented at the annual American Elasmobranch Society meeting held in Norman, Oklahoma, in May 2004.

Life History Studies of Elasmobranchs

Biological samples are obtained through research surveys and cruises, recreational fishers, and through collection by onboard observers on commercial fishing vessels. Age and growth rates and other life history aspects of selected species are processed and data analyzed following standard methodology. This information is vital as input to population models incorporating variation and uncertainty in estimates of life-history traits to predict the productivity of the stocks and ensure that they are harvested at sustainable levels. The age and growth parameters of bull shark (*Carcharhinus leucas*) and spinner shark (*C. brevipinna*) were completed and submitted for publication in 2004.

Cooperative Research-Definition of Winter Habitats for Blacktip Sharks in the Eastern Gulf of Mexico

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory is underway to define essential winter habitats for blacktip sharks (*Carcharhinus limbatus*). Deployment of archival Pop-up Archival Transmitting (PAT) tags on sharks during January - February of FY05 in the Florida Keys and north Florida will be executed with the cooperation of the charterboat industry. PAT tags will be programmed to detach from individuals during late spring and early summer when sharks have recruited to coastal areas.

Cooperative Research-Habitat Utilization among Coastal Sharks

Through a collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory, the utilization of coastal habitats by neonate and young-of-the-year blacktip and Atlantic sharpnose sharks will be 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 to better manage critical species and essential fish habitats.

Cooperative Research-Characterization of Bycatch in the Gulf Butterfish, (*Peprilus burti*), Trawl Fishery, with an Emphasis on Identification of Life History Parameters for several Potentially High-Risk Species

A proposal with the SEFSC Panama City Shark Population Assessment Group and the University of Florida was submitted to MARFIN to quantify and qualify the elasmobranch bycatch in the butterfish, (*Peprilus triacanthus)*, trawl fishery in the Gulf of Mexico. Determination of life history parameters for the roundel skate, (*R. texana),* the clearnose skate, (*R. eglanteria),* the spreadfin skate (*Dipturus olseni),* and the Atlantic angel shark, (*Squatina dumerili)* will be developed ultimately for the estimation of vital rates. Vital rate information will be used to determine the productivity of the stocks and ensure that they are harvested at sustainable levels.

Coastal Shark Assessment Research Surveys

The SEFSC Mississippi Laboratories in Pascagoula have been operating annual research cruises aboard NOAA vessels since 1995. The objectives of this program are to conduct bottom longline surveys to assess the distribution and relative abundance of coastal sharks along U.S. and Mexican waters of the Gulf of Mexico and the U.S. eastern seaboard. This is the only long-term, nearly stock-wide, fishery-independent survey of Atlantic sharks conducted in U.S. and neighboring waters. Ancillary objectives are to collect biological and environmental data, and to tag-and-release sharks. Starting in 2001 and under the auspices of the Mex-US-Gulf Program, the Pascagoula Laboratories have provided logistical and technical support to Mexico's Instituto Nacional de la Pesca to conduct a cooperative research cruise aboard the Mexican research vessel Onjuku in Mexican waters of the Gulf of Mexico. The cruise also took place in 2002, but was suspended in 2003 and 2004 because of mechanical problems with the research vessel and other issues.

Cooperative Research--The capture depth, time, and hooked survival rate for bottom longline- caught large coastal sharks

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and the University of Florida to examine alternative measures in the shark bottom longline fishery to reduce mortality on prohibited sharks such as reduced soak time, restrictions on the length of gear, and fishing depth restrictions will be tested using hook timers. Funding is being sought through the NMFS Cooperative Research Program.