3. ESSENTIAL FISH HABITAT

Section 303(a)(7) of the Magnuson-Stevens Act, 16 U.S.C. §§ 1801 *et seq*., as amended by the Sustainable Fisheries Act in 1996, requires that Fishery Management Plans (FMPs) describe and identify essential fish habitat (EFH) within the U.S. Exclusive Economic Zone (EEZ) for all life stages of each species in a fishery management unit. Available information should be interpreted with a risk-averse approach to ensure that adequate areas are protected as EFH for the managed species. The HMS FMP addresses EFH for species managed under that plan in Chapter 6; the Billfish Amendment provides a description of EFH and related issues in Chapter 4. The EFH regulations also specify that new EFH funding information should be reviewed as it becomes available, and reported as part of the SAFE report. The FMP EFH provisions should be revised or amended, as warranted, based on the available information.

3.1 Atlantic Sharks

Research funded primarily through the NMFS HMS Management Division extended the Mote Marine Laboratory Center for Shark Research (CSR) shark nursery studies in the eastern Gulf of Mexico from 1992-2001, allowing relatively continuous sampling of the juvenile sharks in these nurseries in the years between the two NMFS/MARFIN projects (1993-1995) as well as the years subsequent to MARFIN funding (1997-2001). This NMFS-sponsored research included exploratory surveys, standardized gill net collections, abundance studies, and conventional tagging and acoustic tracking of juvenile sharks in nursery areas of the Florida Gulf coast. Relative abundance of juvenile blacktip sharks in the nursery areas of Yankeetown and Charlotte Harbor, Florida, continued to be monitored in 1999 and 2000. Gill net surveys during those years resulted in the capture of seven shark species and 907 sharks, of which 435 were tagged and released.

A number of other studies have contributed to the body of 1991-2001 CSR data on shark nursery areas in the eastern Gulf of Mexico. These include: collaborative field collections and shark tagging with Florida Department of Environmental Protection; an ongoing study of juvenile blacktip shark movements and habitat using acoustic tracking (initially funded by NMFS/HMS, now supported primarily by the National Science Foundation); and studies of the endocrinology and reproduction of the bonnethead shark. Among these was a major U.S. Environmental Protection Agency-funded project on the mechanisms and effects of endocrine disruption in the bonnethead shark. This research involved extensive field work and collections of small sharks in eastern Gulf coastal waters from 1998-2000, resulting in the capture of 1,439 sharks of 8 species, with 772 being tagged and released.

An array of acoustic receivers deployed within Terra Ceia Bay, a known blacktip shark primary nursery area inside Tampa Bay, has been used to monitor the long-term movements and behavior patterns of young blacktip sharks. Over the course of three years, 91 neonate blacktip

sharks were fitted with acoustic transmitters and monitored for periods of 1-167 days. Data from these animals suggest three types of movement/behavior patterns: 1) animals that leave the nursery area after a relatively short duration and do not return; 2) animals that move into and out of the nursery area; and 3) animals that remain within the nursery area until the end of the summer when they leave to migrate south. The initial activity space of juvenile blacktip sharks inside Terra Ceia Bay is small and confined to one portion of the nursery area. However, habitat use increases over time as the sharks expand their home ranges and the proportions of the bay used. Temperature appears to provide a strong cue for animals to leave the nursery area as the colder fall months approach.

In addition to these various projects in the eastern Gulf, the CSR also has collected data on shark nursery areas along the east coast of Florida (in collaboration with the University of Central Florida), the Texas Gulf coast (in collaboration with the Texas Parks and Wildlife Department), and at a number of locations in Mexican coastal waters (in collaboration with Mexico's Instituto Nacional de la Pesca (INP). These activities have been largely supported by NMFS/HMS funding to the CSR. The Texas research is an ongoing effort to study the exchange rate of western Gulf sharks between the United States and Mexico. The work in Mexico with the INP is a long-term program, established in 1994, to understand the status of Mexican shark resources and distribution of shark nursery areas in Mexico.

A study of juvenile sharks in Apalachicola Bay is underway to examine resource partitioning, prey type and size selectivity, and habitat overlap for Atlantic sharpnose, blacktip, spinner, and finetooth sharks (Bethea et al. 2001). Preliminary diet analyses show teleost fish to be an important prey item for all four species, however, there is evidence of some resource partitioning (e.g., epibenthic vs pelagic teleost prey). Further quantification of habitat use by blacktip and spinner sharks will be examined using biotelemetry. Results will provide a better understanding of juvenile shark foraging ecology and habitat utilization.

2000 Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Survey (McCandless and Pratt, 2001)

Cooperation between federal and state governments in developing coordinated conservation measures is important to successful domestic management of coastal shark species because range, migrations and mating and pupping areas overlap some state and even federal jurisdictions. Many coastal species utilize highly productive bays and estuaries within state waters as nursery habitat (where parturition and young-of-the-year sharks occur) and/or secondary nursery habitat (utilized by juveniles, age 1+ only). Studies suggest that these inshore nursery grounds offer selective advantages of low predation rates and high forage abundance to juvenile sharks. Information on these areas is vital to understanding and managing sharks at this vulnerable stage where many sharks come closest to man's influence.

In 1998, the NMFS Apex Predators Program (APP) formed the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Survey. This is an alliance of NMFS and state cooperators conducting ongoing investigations of shark nursery grounds along the east coast of the United States. Results presented here are a summary of the work conducted in 2000, the third year of this five-year study. In subsequent years, the program will continue the delineation of shark nursery areas, develop relative indices of abundance of neonate and juvenile sharks in these nursery areas, use the environmental data and bycatch collected to determine habitat relationships, and use tag and recapture data to determine if sharks return to their natal nurseries and define the overwintering nursery grounds.

State cooperators in 2000 included the North Carolina Division of Marine Fisheries, the South Carolina Department of Natural Resources, and the University of Georgia Marine Extension service. Researchers from the NMFS APP and the University of Rhode Island conducted the COASTSPAN study in Delaware Bay. COASTSPAN is funded by the NMFS Highly Migratory Species Management Division.

COASTSPAN cooperators sampled a total of 2,132 sharks in 2000. Seven hundred and fifty-five of the sharks sampled were tagged with fin tags and released. Neonate and juvenile sharks caught by the cooperators included the following: Atlantic sharpnose, blacknose, blacktip, bonnethead, finetooth, lemon, nurse, sandbar, sand tiger, scalloped hammerhead, tiger, and spinner sharks.

DELAWARE BAY: COASTSPAN results show the importance of Delaware Bay as a pupping and nursery ground for sandbar sharks, and in the HMS FMP it has been designated EFH for the species. In addition, the middle and lower Bay has been designated a Habitat Area of Particular Concern for this species, consistent with provisions of the EFH regulations. Sandbar sharks in the Bay were captured from May through September of 2000 in waters with temperatures ranging from 15.5° to 26.0° C, salinity from 18.3 to 30.1 ppt, and depths from 1.6 to 23.0 m. Neonate and juvenile sandbar sharks were most abundant along the Bay's western shore from Pickering Beach to Broadkill Beach, with some localized abundance around shoals and ship wrecks on the New Jersey side of the Bay. Neonates were more abundant than juveniles, especially along the Delaware coast of the Bay, taking refuge in the shallow, protected (lower current) areas on both sides of the Bay. The less numerous juveniles appeared to be more evenly distributed throughout the Bay. Although present, neither neonates nor juveniles appeared to be abundant throughout the deeper waters in the center of the Bay. Sharks that were caught near the mouth of the Bay were only captured in late September. It is probable that their presence in the lower Bay is related to their fall migration south to the overwintering nursery grounds off North Carolina and South Carolina.

Sand tiger sharks, although far fewer in numbers than sandbar sharks, were also found in Delaware Bay, in water temperatures ranging from 19.0° to 26.0° C, salinity from 23.0 to 25.7

ppt, and depths from 2.8 to 7.0 m. The presence of these individuals, which were of juvenile size, suggest that the Bay may be a secondary nursery ground for this species.

NORTH CAROLINA: Sharks in North Carolina were sampled during June and July of 2000. Species composition consisted of Atlantic sharpnose, blacktip, finetooth, sandbar, scalloped hammerhead, and spinner sharks. Atlantic sharpnose sharks were the most commonly caught sharks sampled, followed by spinner and scalloped hammerhead sharks. With the exception of the Atlantic sharpnose sharks, most of which were adults, most of the sharks captured were neonates and juveniles. Water temperatures where the sharks were captured ranged from 19.4° to 29.3° C, and water depths from 3.0 to 14.2 m.

SOUTH CAROLINA: Sharks in South Carolina were sampled from April to November of 2000. Species composition consisted of Atlantic sharpnose, blacknose, blacktip, bonnethead, finetooth, lemon, nurse, sandbar, scalloped hammerhead, spinner, and tiger sharks. Atlantic sharpnose sharks were the most commonly caught sharks sampled, followed by blacknose and finetooth sharks. With the exception of the Atlantic sharpnose sharks, most of which were adults, most of the sharks captured were juveniles. Water temperatures where the sharks were captured ranged from 15.0° to 30.0° C, and water depths from 1 to 15 m.

GEORGIA: Sharks in Georgia waters were sampled from May to September of 2000, with effort focused in the St. Andrew, St. Simons, and Altamaha Sound systems. Species composition consisted of Atlantic sharpnose, blacktip, bonnethead, finetooth, sandbar, scalloped hammerhead, and spinner sharks. Atlantic sharpnose sharks were the most commonly caught sharks sampled, followed by bonnethead and blacktip sharks. Nearly all of the sharks captured were neonates and juveniles, with neonates outnumbering the juveniles. Water temperatures where the sharks were captured ranged from 26.4° to 30.8° C, salinity from 21.6 to 36.6 ppt, and water depths from 2.4 to 13.1 m.

3.2 Atlantic Billfish

Blue Marlin Spawning and Nursery Habitat Research (Serafy et. al., 2001)

Fishing has led to significant and continuing declines in billfish stocks, particularly those of the Atlantic blue and white marlin. A major barrier to effective management is the lack of fundamental biological knowledge of these highly migratory oceanic predators and the dynamics of their “blue water” environment. Data pertaining to their distribution, abundance, and seasonality are relatively rare. This, combined with the great difficulty in identifying young billfish to species, has limited our understanding of their distribution and abundance as well as the timing and location of spawning activity. Without knowledge of the spatio-temporal extent of spawning and nursery grounds, fishery managers cannot consider the use of measures such as time-area fishing closures and protecting critical habitats.

The SEFSC and the University of Miami are cooperatively undertaking a project that examines EFH for blue marlin focusing on Exuma Sound, a semi-enclosed body of water bounded by the islands of the Bahamas. Sampling for larval billfish was conducted in July of 2000 throughout the sound's surface waters and in adjacent, open waters of the Atlantic Ocean. The objectives of this effort were to explore the Sound's surface waters for early life stages of billfish, examine patterns of larval billfish occurrence, density and size, and to estimate when and where spawning likely occurred.

The study yielded very high numbers of larval blue marlin - of 99 billfish larvae collected, 90 were identified as blue marlin and three as sailfish. They were collected primarily in the eastern half of the Sound, with highest densities in areas where exchange with waters of the Atlantic is greatest. Surface water temperature ranged from 28.5° to 30.0° C, and salinity from 35.8 to 36.8 psu. Larval age estimates, distributional data, and surface transport information suggest that the larvae collected were the result of recent spawning - less than 18 days prior to sampling - at or near the mouth of Exuma Sound, and that this area may extend southeast beyond the mouth possibly as far as 200 km.

Results indicate that, clearly, this water body can function as a nursery area for blue marlin, and possibly other billfish species, at least during the summer. However, before the Sound's importance as blue marlin nursery habitat can be ascertained, further sampling is required to assess the frequency and magnitude of larval entrainment into the Sound and growth and survivorship rates of those entrained. Research of this type may represent a first step towards the ultimate protection of areas that appear important for blue marlin and possibly other highly migratory species.

3.3 Atlantic Bluefin Tuna

Movements and Environmental Preferences of Atlantic Bluefin Tuna

The cooperative Stanford University/NMFS study addressing the trans-Atlantic movements and thermal biology of Atlantic bluefin tuna has provided valuable information on the migratory and diving behavior of the species, and the environmental conditions it encounters (Block et. al., 2001). These studies, which were initiated in 1996, were conducted using pop-up archival satellite tags that download data to a computer via satellite once released from the fish and also archival tags that are implanted in the fish where they continuously record data. A total of 377 bluefin tuna have been tagged with one or both of these tags off the east coast of North America. In addition, 7065 bluefin tuna have been conventionally tagged in the winter Carolina fisheries. Eighteen percent of the archival tagged bluefin tuna and 4 percent of conventionally tagged bluefin tuna have been recaptured, and data has been acquired from 90 percent of the deployed pop-up tags. The information obtained from these sources has provided an insight into the seasonal movements and environmental preferences of the species. It has also provided

valuable information regarding the question of mixing of the western and eastern populations of the Atlantic bluefin tuna.

Bluefin tuna tagged in the west displayed four types of migratory behavior: (1) western Atlantic residency for one year or more without visiting known spawning areas, (2) western Atlantic residency for one year with Gulf of Mexico visitation during the breeding season, (3) trans-Atlantic movements to the east Atlantic and back in the same year, and (4) trans Atlantic movements from the west to the east Atlantic or Mediterranean Sea after 1 to 3 years of western residency. A significant finding of the study, however, is that western and eastern populations of bluefin tuna "mix" to a far greater degree than previously thought. The study concludes that there is a mixing of tuna in western and eastern feeding grounds, but that the fish may separate for spawning in either the Gulf of Mexico or Mediterranean Sea, the two known major breeding grounds for the bluefin tuna.

Most bluefin tuna tagged off the North Carolina coast remained there in the winter and proceeded offshore in the early spring. Offshore movements were along the Gulf Stream eastward toward Bermuda or southeast toward the Bahamas. The majority displayed a western residency track the year after release, moving from the Carolinas along the northern edge of the Gulf Stream in the spring and toward the New England and Canadian shelf in the summer, remaining there through the autumn while often ranging into the mid-North Atlantic, and returning to the Carolinas or Bahamas by winter. Western-tagged bluefin tuna are capable of moving from the continental shelf of North America to the eastern Atlantic in 40 days, migrating from the west to the east and back again in the same year, indicating that these bluefin tuna are vulnerable to fishing mortality from all Atlantic bluefin tuna fisheries.

Adolescent and mature western-tagged bluefin tuna display western residency for 1 to 3 years without moving to either breeding ground. Twelve archival-tagged bluefin tuna showed visitation to Gulf of Mexico breeding grounds during the spawning season, and exiting the Gulf in late June, traveling toward northern waters. Seven bluefin tuna were recaptured in the eastern Mediterranean Sea, south of Malta or north of Sicily, in mid-May and June. That west Atlantic bluefin tuna move to both the Gulf of Mexico and the eastern Mediterranean Sea during the breeding season emphasizes the need to protect both of these major spawning regions as they both directly affect the western fishery.

Archival tags also provided data on vertical movement patterns, environmental preferences, and thermal biology of the Atlantic bluefin tuna. Bluefin tuna most often occupy the upper 300 m of the water column and occasionally dive 1000 m to deep cold waters. Measurements of internal body temperature indicated large thermal gradients between ambient and internal temperatures can occur. Although individuals experienced a wide range of environmental temperatures, from 2.8˚ to 30.6˚ C, they maintained a relatively constant internal temperature of about 25˚ C. Maintaining a high stable body temperature may enhance muscle power, enabling the tuna to swim rapidly. Several mature bluefin tuna occupied waters warmer

than 23˚ C for short durations throughout the year. These included encounters in warm core rings off New England, Gulf stream waters off North Carolina, the Florida-Georgia Bight, the Bahamas, Bermuda, and the eastern Caribbean Sea.

Beginning in 1997, studies led by the New England Aquarium have implanted pop-up and pop-up archival satellite tags on northern Atlantic bluefin tuna. In the first year of the study, working with fishermen in the rod and reel, harpoon, and purse seine fisheries, researchers tagged and released 20 giant bluefin tuna with pop-up satellite tags (Lutcavage et. al., 1999). Seventeen tags jettisoned from the fish on schedule (late January through late July) and reported their locations. The 12 tags reporting during May-July were all located north of 33˚ N latitude, in a region of the mid-Atlantic Ocean bounded by Bermuda and the Azores. Their initial findings demonstrated the presence of adult bluefin tuna in the mid-Atlantic region during their presumed spawning period. This finding challenged one of the main assumptions underlying current management policies, that the western Atlantic stock of bluefin tuna spawn exclusively in the Gulf of Mexico.

Since 1998, working with NMFS and Canada's Department of Fisheries and Oceans scientists, the NW Atlantic tagging team led by the New England Aquarium deployed additional pop-up tags. Results from the 1998 season tags show a mid-Atlantic distribution of giant bluefin that is consistent with results from the previous year. In 1998, the team successfully tested the newly developed pop-up archival tags that record light levels, in order to provide a daily estimate of geolocation. A summary of pop-up satellite tagging of giant bluefin tuna in the joint United States/Canadian program in the Gulf of Maine and Canadian Atlantic Ocean was reported by Lutcavage et. al. (SCRS/00/95).

Tracking Adult and Juvenile Northern Bluefin Tuna using Ultrasonic Telemetry

Two recent studies used ultrasonic depth-sensitive transmitters to track the movements of adult (Lutcavage et. al., 2000) and juvenile (Brill et. al., in press) northern Atlantic bluefin tuna in the northwest Atlantic Ocean. The study on adult fish took place in the Gulf of Maine and the juvenile study tracked fish off the coast of Virginia.

In the study on adult fish, transmitters were attached to 11 free-swimming fish (136 to 340 kg estimated body mass) during the late summer and early fall of 1995-1997, and were each tracked for up to 48 hours. Mean swimming depth for all adult fish was 14 (+/- 4.7) m and maximum depth for individuals ranged from 22 to 215 m. All but one fish made their deepest descents at dawn and dusk. In general, adult bluefin tuna spent < 8 percent of their time at the surface (0 to 1 m), <19 percent in the top 4 m, but > 90 percent in the uppermost 30 m. Sea surface temperatures during tracking were 11.5 to 22.0 ° C, and minimum temperatures encountered by the fish ranged from 6.0 to 9.0 ° C. The tracked bluefin tuna and their schools frequented ocean fronts marked by mixed vertebrate feeding assemblages, which included seabirds, baleen whales, basking sharks, and other bluefin schools.

In the study on juvenile fish, transmitters were attached to 5 fish (6.8 to 18.7 kg estimated body mass) during the late spring and summer of 1998, and each were tracked for 30 to 48 hours. The fish spent the majority of their time over the continental shelf in relatively shallow water (generally > 40 m deep). They made use of the entire water column in spite of relatively steep vertical thermal gradients (≈24°C at the surface and ≈12C°at 40 m depth). The fish were found to spend the majority of their time (≈90 percent) above 15 m and in water warmer than 20°C. Their horizontal movements were uncorrelated with sea surface temperature. This most likely results from the inability of juvenile bluefin tuna to detect the relative minor horizontal temperature gradients (generally less then 0.5°C km^{-1}) due to the steep vertical temperature gradients (up to ≈0.6°C m^{-1}) they experience during their rapid vertical movements. In contrast, based on satellite-derived ocean color data, water clarity did appear to influence behavior. The fish remained in the intermediate water mass between the highly turbid and phytoplankton-rich plume exiting the Chesapeake Bay (and similar coastal waters) and the very clear oligotrophic water east of the continental shelf break.

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