SHARK NURSERY GROUNDS AND ESSENTIAL FISH HABITAT STUDIES

GULFSPAN GULF OF MEXICO-FY03
Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey

REPORT TO NOAA FISHERIES/HIGHLY MIGRATORY SPECIES OFFICE

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BACKGROUND

Identification and conservation of essential fish habitat are important components of providing adequate management and conservation for shark populations. This is of particular importance when attempting to understand the dynamics of sharks in coastal nursery areas. Over the last few years, attempts have been made at delineating shark nursery areas throughout the east coast of the United States through the Cooperative Atlantic States Shark Pupping and Nursery Survey (McCandless et al., 2002). A similar program was funded by NOAA Fisheries-Highly Migratory Species Office in 2003. This report describes results from the Cooperative Gulf of Mexico Shark Pupping and Nursery Project (GULFSPAN) for 2003.

METHODS

Surveys were modeled after those developed by Carlson and Brusher (1999) to provide a direct comparison of abundance among areas. A 186-m long gill net consisting of six different mesh size panels was utilized for sampling in all areas. Stretched mesh sizes ranged from 8.9 cm (3.5") to 14.0 cm (5.5") in steps of 1.27 cm (0.5"). The sampling gear was set at fixed stations or randomly set within each area based on depth strata and GPS location. Sharks captured were measured (precaudal, fork, total, stretched total length), sexed, and life history stage (young-of-the-year, juvenile, adult) recorded. Sharks that were in poor condition were sacrificed for life history studies and those in good condition were tagged with a nylon-head dart tag and released. Rays that were captured were measured in disc width and sexed. Because of the limited life history information for most species, a life history category for rays could not be assigned in the field. Temperature, salinity, dissolved oxygen, depth, water clarity (e.g. turbidity), and qualitative habitat type was recorded for each set of the gear.

RESULTS

1. Northwest Florida

Abundance trends

Sampling sites were located in four major areas along the northeastern portion of the Gulf of Mexico from Apalachicola Bay to St. Andrews Bay, FL (Figure 1). There was additional exploratory sampling along offshore areas between bays to test for movements of sharks between various bays and estuaries (see telemetry section).

Sampling was conducted from March to November. A total of 151 sets were made capturing 1,468 individuals from 9 species of sharks and 9 species of skates and rays. For sharks, most species captured were juveniles and young-of-the-year for sharks (Table 1).

Among sharks for all areas combined, the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, a member of the small coastal management group, was the most abundant shark captured, and the blacktip shark, *Carcharhinus limbatus*, was the most abundant species captured in the large coastal management group. The bonnethead shark, *Sphyrna tiburo*, was the second most abundant species captured in the small coastal group and overall was the third most encountered species. The remaining species commonly captured in decreasing abundance were the finetooth shark, *C. isodon*; spinner shark, *C. brevipinna*; blacknose shark, *C. acronotus;* scalloped hammerhead shark, *S. lewini*; and sandbar shark, *C. plumbeus.* Other species infrequently caught were bull shark, *C. leucas*; and great hammerhead shark, *S. mokarran*.

Cownose rays, *Rhinoptera bonasus*, were the most abundant ray captured. Other ray species captured in decreasing abundance were bluntnose stingray; *Dasyatis sayi*; smooth butterfly ray, *Gymnura micrura*; southern stingray, *Dasyatis americana*; guitarfish, *Rhinobatus lentiginosus*; manta ray, *Mobula hypostoma*; spotted eagle ray, *Aetobatus narinari*, roundel skate, Raja taxana; and spiny butterfly ray, *Gymnura altevela* (Table 2).

Comparison of abundance among areas

Overall species distribution varied by area (Table 1). For all combined life stages, blacktip, bonnethead, finetooth, sandbar, scalloped hammerhead, and spinner shark were most abundant in the Apalachicola bay system. Atlantic sharpnose sharks were most abundant in Crooked Island Sound and blacknose sharks in St. Joseph Bay. Although overall many species were abundant in Apalachicola Bay, certain life stages were more abundant in other areas. For example young-of-the-year and juvenile bonnethead had the highest CPUE in Crooked Island Sound. The difference in spatial distribution by life stage may reflect an attempt to avoid predation as all areas appear to have a high forage base. Crooked Island Sound is a small, semi-enclosed sound were few larger adult sharks are found. Thus, species with small young-of-the-year and juveniles like Atlantic sharpnose shark and bonnethead may be selecting this area as a nursery based on low predation levels.

Species Essential Fish Habitat Profiles

Information on essential fish habitat requirements (e.g. temperature, salinity, etc.) for sharks from northwest Florida have not changed considerably from that recently reported in Carlson (2002). Based on presence/absence data, updates to that information is provided in Tables 3-11.

Although not currently part of a management plan for the southeast, skates and rays are becoming increasing important as bycatch in a variety of trawl fisheries and in some cases are making up part of the directed catch (Dulvy et al. 2000). Information is being gathered on skates and rays in an attempt to have an essential fish habitat matrix should one be needed in the future. Based on presence/absence data, skates and rays were captured in water temperatures from 20-32º C, salinities averaging 27.6 ppt, and depths of 3.0 m (Table 12).

Predator-prey and trophic relationships

Several diet and trophic studies were initiated and/or completed in 2003. Stomach contents of early life stages of Atlantic sharpnose, blacktip, finetooth, and spinner sharks taken from Apalachicola Bay, Florida, were examined to test for resource competition. Atlantic sharpnose sharks exhibit an ontogenetic shift feeding mainly on shrimp as young-of-the-year, sciaenids (mostly *Micropogonias undulates*) as juveniles, and clupeids (primarily *Brevoortia* spp.) as adults. Young-of-the-year blacktip sharks also feed mainly on sciaenids, whereas juveniles feed on clupeids. The primary prey of young-of-the-year and juvenile finetooth and spinner sharks is clupeids. Eight of ten prey size-selectivity tests showed neutral selection. Compared to relative prey sizes published for teleost piscivores, Atlantic sharpnose and finetooth sharks consume relatively small-sized prey while blacktip sharks consume relatively large prey. Regardless of maturity state and species, diet overlap is high for species-life stage combinations that are similar in size; however, species-life stages did not show significant overlap in habitat use. Prey categories shared by similar-sized species may not be limiting, but competition may exist for available habitat resources. Results of this study are currently in press in the journal Marine Ecology Progress Series (Bethea et al. in press).

Diet was also examined for juvenile scalloped hammerhead shark within nursery areas from archived and samples obtained in 2003 (Bethea and Carlson, unpublished data). Items found in stomachs included arthropods (9 species representing 4 families in 3 orders), teleosts (15 species representing 12 families), molluscs (mostly O. Teuthoidea), annelids (polychete worms), and marine angiosperms (*Halodule spp.* and *Thalassia testudinum*). Of identifiable prey, penaeid and other decapod shrimp dominated the diet (36.2%IRI). Of the teleosts, sciaenids were of most importance (13.3%IRI, mostly *Bairdiella chrysoura* and *Stellifer lanceolatus*). Other important teleost prey included bothids (3.9%IRI) and clupeids (2.4%IRI).

Telemetry

Sonic transmitters were attached externally to the first dorsal fin of 6 blacktip sharks (mean size=75.7 cm FL) and 1 blacknose shark (102 cm FL). After release, sharks were tracked using a Vemco VR-60 acoustic receiver and hydrophone over several hours and found to remain in the immediate area of the sampling gear. To test for habitat residence time, we attempted to re-acquire sharks in the general area where they were released over the remainder of the sampling season. However, no sharks could be relocated. Attempts were made to locate sharks in adjacent areas between bays, but sharks could not be relocated. However, poor weather conditions during many of the tracks could have precluded locating acoustically tagged sharks. Preliminary evidence suggests juvenile blacktip sharks do not remain within the same bay system throughout the summer season. More research in this area is planned for 2004 using a sonic acoustic array system similar to that used by Heupel and Hueter (2002).

2. Mississippi/Alabama

Regrettably due to the delay and the timing in providing funds to Gulf Coast Research Laboratory, sampling began in August. A total of 42 sets at 8 stations were made from August to late October, 2003 (Figure 2). Four species of sharks were caught, most species captured were juveniles (Table 13). The blacktip shark was the most abundant species caught followed by finetooth, Atlantic sharpnose, and bull shark.

For all combined life stages, blacktip and finetooth sharks were most abundant off Horn Island while finetooth shark were most frequently caught off Round Island. Atlantic sharpnose sharks were only off Horn Island and bull sharks off Cat Island.

Species Essential Fish Habitat Profiles

Information on essential fish habitat requirements (e.g. temperature, salinity, etc.) for sharks from Mississippi sound have not changed considerably from that recently reported in Parsons (2002). Based on presence/absence data, updates to that information is provided in Tables 14-17.

3. Louisiana

Regrettably due to the delay and the timing in providing funds to Louisiana State University-Coastal Fisheries Institute, sampling could not begin in 2003. Once funds were provided, problems occurred with hiring field staff and traveling to the field sites. However, with funds provided in 2003, sampling will begin in February/March 2004 prior to a time when funds are usually allocated. Sampling this early in the season will allow for the examination of differences in recruitment between areas in the Gulf of Mexico. Preliminary evidence suggests bull sharks move into estuaries earlier off Louisiana which could be related to varying essential fish habitat requirements for this species (J. Neer, personal communication).

PRELIMINARY CONCLUSIONS

The similarity in gear type among the various areas allows for the comparison of abundance among areas, something that was not possible in the summary provided in McCandless et al., (2002). Although sampling was not performed over the entire season, preliminary evidence suggests northwest Florida has higher species diversity than areas in the Mississippi sound. However, blacktip and finetooth sharks are more abundant in the Mississippi Sound than in waters of northwest Florida. The highest CPUE for blacktip and finetooth sharks respectively was 5.37 sharks/net/hour and 2.58 sharks/net/hour for two areas in Mississippi while in northwest Florida CPUE was 0.40 and 0.48 sharks/net/hour. Yet, both species seem to prefer similar habitat characteristics based on presence/absence data. Blacktip and finetooth were captured in areas with high turbidity and over bottom types dominated by mud/silt/clay. Further refinement in these relationships will be explored in 2004 with the potential for comparing growth rates and predator-prey relationships of sharks among several proposed nursery areas. A species-life stage with a relatively low growth rate in one nursery may be experiencing higher competition for available resources compared to that same species with a relatively higher growth rate in another proposed nursery area. Quantifying the links among these sharks and the links between these sharks and resource species are critical for ecosystem modeling and a key step to a broader approach in fisheries management.

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Table 1. Summary of CPUE (number of sharks/net/hour) for sharks by life history stage and major area sampled. Mean values are presented and numbers is parentheses represent standard deviation. Young-of-the-year includes neonates. Species are listed alphabetically by common name.

Atlantic sharpnose shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	0.10 (0.35)	0.11 (0.43)	0.01 (0.12)	0.05 (0.29)
Juveniles	-	0.87 (2.55)	0.21 (0.81)	0.05 (0.31)
Adults	0.01 (0.03)	0.52 (1.31)	0.19 (0.63)	0.20 (0.70)
All	0.11 (0.35)	1.52 (3.77)	0.43 (1.21)	0.32 (1.04)

Blacknose shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	0.10 (0.35)	0.02 (0.13)	0.05 (0.31)	-
Juveniles	-	0.01 (0.07)	0.09 (0.38)	-
Adults	-	-	0.03 (0.13)	-
All	0.10 (0.35)	0.02 (0.15)	0.19 (0.61)	-

Blacktip shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	0.01 (0.05)	-	0.15 (0.61)
Juveniles	0.01 (0.03)	0.16 (0.55)	0.18 (0.86)	0.21 (0.77)
Adults	-	-	-	-
All	0.02 (0.07)	0.17 (0.55)	0.18 (0.86)	0.40 (1.13)

Bonnethead shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	0.17 (0.73)	0.18 (1.18)	0.07 (0.44)
Juveniles	0.01 (0.03)	0.27 (1.14)	0.04 (0.17)	0.05 (0.39)
Adults	0.08 (0.33)	0.09 (0.38)	0.10 (0.40)	0.87 (2.87)
All	0.09 (0.33)	0.56 (1.74)	0.34 (1.49)	1.02 (3.19)

Bull shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	-	-	-
Juveniles	-	-	-	-
Adults	-	0.02 (0.09)	-	-
All	-	0.02 (0.09)	-	-

Finetooth shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	-	-	0.14 (0.79)
Juveniles	-	0.08 (0.35)	0.05 (0.25)	0.23 (0.84)
Adults	-	0.06 (0.23)	0.02 (0.15)	0.07 (0.30)
All	-	0.14 (0.64)	0.07 (0.29)	0.48 (1.45)

Sandbar shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	-	-	0.01 (0.05)
Juveniles	-	-	-	0.06 (0.19)
Adults	-	-	-	-
All	-	-	-	0.07 (0.20)

Scalloped hammerhead shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	0.12 (0.47)	-	0.17 (0.83)
Juveniles	-	0.03 (0.11)	-	0.03 (0.17)
Adults	-	-	-	-
All	-	0.14 (0.53)	-	0.19 (0.84)

Spinner shark

Life stage	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Young-of-the-year	-	0.01 (0.11)	0.09 (0.69)	0.18 (0.83)
Juveniles	-	0.01 (0.14)	0.05 (0.22)	0.02 (0.19)
Adults	-	-	-	-
All	-	0.03 (0.21)	0.14 (0.86)	0.20 (0.86)

Table 2. Summary of CPUE (number of rays/net/hour) for rays by major area sampled. Mean values are presented and numbers is parentheses represent standard deviation. Species are listed alphabetically by common name.

Species	St. Andrew Bay	Crooked Island Sound	St. Joseph Bay	Apalachicola Bay
Atlantic guitarfish	-	0.01 (0.09)	-	-
Bluntnose stingray	-	0.03 (0.17)	0.06 (0.24)	-
Cownose ray	0.53 (1.63)	0.12 (0.71)	0.23 (0.98)	0.16 (0.70)
Devil ray	0.02 (0.10)	0.01 (0.09)	-	-
Smooth butterfly ray	0.04 (0.16)	0.02 (0.10)	-	-
Southern stingray	0.03 (0.15)	0.01 (0.06)	-	-
Spotted eagle ray	-	-	-	0.01 (0.12)

Table 3. Summary of the habitat associations for the Atlantic sharpnose shark, *Rhizoprionodon*

terraenovae, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	28.6 (24.1-31.2)	29.0 (26.1-30.8)	3.9 (0.8-5.0)	267.2 (80.0-400.0)	5.7 (3.5-6.6)	Mud/Sand/ Seagrass
Juveniles	28.2 (21.7-31.6)	29.6 (24.0-34.1)	3.7 (1.0-5.5)	230.4 (70.0-400.0)	5.7 (3.2-8.2)	Sand/Seagrass/ Mud
Adults	28.1 (21.6-31.7)	29.6 (20.3-34.8)	3.8 (1.0-5.9)	240.7 (20.0-400.0)	5.7 (2.0-8.2)	Equal Sand/ Mud/Seagrass

Table 4. Summary of the habitat associations for the blacknose shark, *Carcharhinus acronotus*, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	29.6 (26.7-31.4)	28.1 (22.2-30.0)	2.1 (0.8-4.0)	174.4 (80.0-210.0)	5.0 (3.5-6.2)	Sand/Seagrass/ Mud
Juveniles	28.0 (26.3-30.0)	31.5 (29.0-32.8)	3.0 (1.5-5.0)	276.7 (150.0-320.0)	5.7 (3.2-6.8)	Sand/Seagrass
Adults	25.9 (23.3-37.5)	32.3 (31.5-32.8)	2.7 (2.0-3.0)	266.7 (200.0-300.0)	6.4 (6.0-6.8)	Seagrass/Sand

Table 5. Summary of the habitat associations for the blacktip shark, *Carcharhinus limbatus*, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	29.1 (26.1-31.3)	27.9 (17.1-34.7)	3.7 (2.3-5.9)	158.9 (70.0-400.0)	5.1 (4.0-6.4)	Mud/Sand
Juveniles	28.5 (20.2-32.1)	30.4 (23.6-34.8)	3.5 (1.5-6.5)	153.0 (50.0-400.0)	5.6 (2.0-7.5)	Mud/Sand/ Seagrass
Adults	25.7 -	29.6 -	3.0 -	250.0 -	5.6 -	Mud/Seagrass

Table 6. Summary of the habitat associations for the bonnethead shark, *Sphyrna tiburo*, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	29.4 (25.5-31.6)	29.2 (26.1-34.8)	3.6 (1.5-6.5)	168.4 (70.0-220.0)	5.2 (3.2-6.6)	Sand/Seagrass/ Mud
Juveniles	27.9 (20.2-31.3)	30.7 (25.8-34.3)	3.6 (1.5-5.0)	199.0 (50.0-370.0)	5.8 (3.2-7.5)	Sand/Mud/ Seagrass
Adults	27.9 (22.2-30.5)	30.3 (26.1-24.8)	3.9 (1.5-6.5)	130.9 (50.0-400.0)	5.1 (3.2-6.6)	Mud/Sand/ Seagrass

Table 7. Summary of the habitat associations for the bull shark, *Carcharhinus leucas*, by life

stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	- -	- -	- -	- -	- -	-
Juveniles	30.1 (29.9-30.4)	27.0 (26.1-28.5)	3.0 -	165.0 (140.0-190.0)	5.6 (4.4-6.4)	Equal Sand/ Seagrass/Mud
Adults	- -	- -	- -	- -	- -	-

Table 8. Summary of the habitat associations for the finetooth shark, *Carcharhinus isodon*, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	28.8 (24.9-31.3)	26.2 (17.1-30.7)	3.5 (2.4-5.9)	95.0 (50.0-400.0)	5.2 (4.5-6.5)	Mud
Juveniles	27.6 (22.2-31.7)	29.8 (20.3-34.7)	3.7 (2.3-5.9)	185.2 (50.0-400.0)	5.5 (2.0-6.6)	Mud/Sand/ Seagrass
Adults	27.3 (22.2-31.0)	29.7 (26.3-34.8)	3.9 (2.1-6.5)	202.4 (20.0-400.0)	5.8 (4.5-6.8)	Mud/Sand/ Seagrass

Table 9. Summary of the habitat associations for the sandbar shark, *Carcharhinus plumbeus*, by

life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (^oC)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	30.5 -	29.8 -	3.0 -	85.0 -	4.5 -	Mud
Juveniles	27.7 (22.8-31.3)	29.6 (26.2-32.2)	3.7 (2.4-5.5)	80.0 (50.0-150.0)	5.1 (4.5-6.3)	Mud
Adults	- -	- -	- -	- -	- -	-

Table 10. Summary of the habitat associations for the scalloped hammerhead shark, *Sphyrna lewini*, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (^oC)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	29.2 (24.1-31.3)	29.2 (26.1-34.7)	4.1 (2.4-5.9)	161.3 (20.0-400.0)	5.5 (4.0-6.6)	Mud/Sand/ Seagrass
Juveniles	29.9 (29.4-31.0)	28.8 (27.4-33.2)	4.4 (3.2-5.0)	233.8 (95.0-340.0)	5.7 (5.1-6.3)	Sand/Mud
Adults	- -	- -	- -	- -	- -	-

Table 11. Summary of the habitat associations for the spinner shark, *Carcharhinus brevipinna*, by life stage. Young-of-the-year includes neonate life stage. Means are presented. Ranges are

in parentheses. Bottom type is presented in descending predominance unless otherwise stated.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	29.8 (26.1-36.1)	28.6 (17.1-32.1)	3.8 (2.4-5.9)	162.7 (70.0-400.0)	5.3 (4.5-6.4)	Mud/Sand/ Seagrass
Juveniles	29.3 (26.1-36.1)	29.6 (32.8-37.1)	4.6 (3.0-5.9)	300.0 (150.0-400.0)	5.8 (4.6-6.8)	Mud/Sand/ Seagrass
Adults	- -	- -	- -	- -	- -	-

Table 12. Summary of the habitat associations for skates and rays. Means are presented. Ranges are in parentheses. Bottom type is presented in descending predominance unless otherwise stated. Species are listed alphabetically by common name.

Species	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Atlantic guitarfish	24.3 (20.2-31.0)	32.0 (30.0-34.3)	1.3 (1.0-1.5)	166.7 (100.0-300.0)	7.1 (5.6-8.2)	Sand/Seagrass/ Mud
Atlantic stingray	28.5 (25.9-30.1)	26.7 (22.2-29.8)	2.7 (2.0-3.5)	175.0 (150.0-200.0)	5.3 (5.1-5.6)	Mud/Seagrass/ Sand
Bluntnose stingray	28.9 (23.2-30.8)	28.3 (24.0-31.5)	2.7 (0.8-5.0)	202.8 (80.0-250.0)	5.5 (3.5-6.3)	Sand/Mud/ Seagrass
Cownose ray	27.4 (20.2-32.2)	29.1 (17.1-34.8)	3.1 (1.0-6.5)	207.8 (50.0-350.0)	5.5 (2.3-8.2)	Mud/Seagrass/ Sand
Devil ray	25.9 (25.0-28.5)	25.4 (24.0-25.8)	2.8 (2.0-3.0)	260.0 -	6.1 -	Seagrass/Sand
Roundel skate	27.9 -	29.5 -	5.0 -	250.0 -	5.4 -	Mud
Smooth butterfly ray	29.4 (25.0-30.5)	25.1 (17.1-28.6)	3.2 (2.0-4.5)	170.0 (75.0-260.0)	5.7 (5.2-6.1)	Equal Sand/ Seagrass/Mud
Southern stingray	31.2 (30.1-32.2)	21.4 (20.5-22.2)	3.0 (2.0-4.0)	175.0 (150.0-200.0)	6.4 (5.2-7.5)	Equal Sand/ Seagrass/Mud
Spiny	29.0	30.9	3.2	220.0	5.5	Sand

butterfly ray	-	-	-	-	-	
Spotted eagle ray	29.5 (27.4-30.5)	20.4 (17.1-26.9)	2.6 (2.4-3.0)	100.0 (75.0-150.0)	5.6 -	Mud

Table 13. Summary of CPUE (number of sharks/net/hour) for sharks by life history stage and major area sampled in Mississippi Sound. Mean values are presented and numbers in parentheses represent standard deviation. Young-of-the-year includes neonates. Species are listed alphabetically by common name.

Atlantic sharpnose shark

Life stage	Round Island	Horn Island	Cat Island	Deer Island	Davis Bayou
Young-of-the-year	-	0.28 (0.39)	-	-	-
Juveniles	-	-	-	-	-
Adults	-	0.52 (0.30)	-	-	-
All	-	0.79 (0.68)	-	-	-

Blacktip shark

Life stage	Round Island	Horn Island	Cat Island	Deer Island	Davis Bayou
Young-of-the-year	-	4.92 (2.82)	0.87 (1.23)	-	-
Juveniles	-	0.46 (0.64)	0.35 (0.50)	-	-
Adults	-	-	-	-	-
All	-	5.37 (3.46)	1.22 (1.72)	-	-

Bull shark

Life stage	Round Island	Horn Island	Cat Island	Deer Island	Davis Bayou
Young-of-the-year	-	-	-	-	-
Juveniles	-	-	0.17	-	-
Adults	-	-	-	-	-
All	-	-	-	-	-

Finetooth shark

Life stage	Round Island	Horn Island	Cat Island	Deer Island	Davis Bayou
Young-of-the-year	4.19 (3.00)	-	-	-	-
Juveniles	0.49 (0.69)	0.41 (0.07)	-	-	-
Adults	-	-	-	-	-
All	2.58 (3.65)	0.41 (0.07)	-	-	-

Table 14. Summary of the habitat associations for Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, by life history stage sampled in Mississippi Sound. Mean values are presented and

numbers in parentheses represent minimum and maximum values measured. Young-of-the-year includes neonates.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	34.0 -	21.0 -	18.0 -	30.5 -	6.3 -	Silt/Clay
Juveniles	- -	- -	- -	- -	- -	-
Adults	31.9 (29.7-34.0)	21.5 (21.0-22.0)	4.5 (3.6-5.5)	106.7 (30.5-182.9)	6.6 (6.3-6.8)	Silt/Clay

Table 15. Summary of the habitat associations for blacktip sharks, *Carcharhinus limbatus*, by life history stage sampled in Mississippi Sound. Mean values are presented and numbers in parentheses represent minimum and maximum values measured. Young-of-the-year includes neonates.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	30.7 (28.3-34.0)	20.3 (18.0-22.0)	4.5 (3.6-5.5)	101.5 (30.5-182.9)	6.6 (6.3-6.8)	Silt/Clay/ Sand
Juveniles	31.2 (28.3-34.0)	19.5 (18.0-21.0)	5.0 (4.5-5.5)	61.0 (30.5-91.4)	6.5 (6.3-6.7)	Silt/Clay/ Sand
Adults	- -	- -	- -	- -	- -	-

Table 16. Summary of the habitat associations for bull sharks, *Carcharhinus leucas*, by life history stage sampled in Mississippi Sound. Mean values are presented and numbers in parentheses represent minimum and maximum values measured. Young-of-the-year includes neonates.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	- -	- -	- -	- -	- -	-
Juveniles	28.3 -	18.0 -	4.5 -	91.4 -	6.7 -	Silt/Clay
Adults	- -	- -	- -	- -	- -	-

Table 17. Summary of the habitat associations for finetooth sharks, *Carcharhinus isodon*, by life history stage sampled in Mississippi Sound. Mean values are presented and numbers in parentheses represent minimum and maximum values measured. Young-of-the-year includes neonates.

Life stage	Temperature (°C)	Salinity (ppt)	Depth (m)	Water clarity (cm)	Dissolved oxygen (mg l^{-1})	Bottom type
Young-of-the-year	28.5 -	21.0 -	12.0 -	91.4 -	9.7 -	Silt/Clay
Juveniles	30.7 (28.5-34.0)	21.3 (21.0-22.0)	4.2 (3.6-5.5)	101.5 (30.5-182.9)	7.6 (6.3-9.7)	Silt/Clay
Adults	- -	- -	- -	- -	- -	-

Figure 1. Locations of sets made in 2003 for areas in northwest Florida.

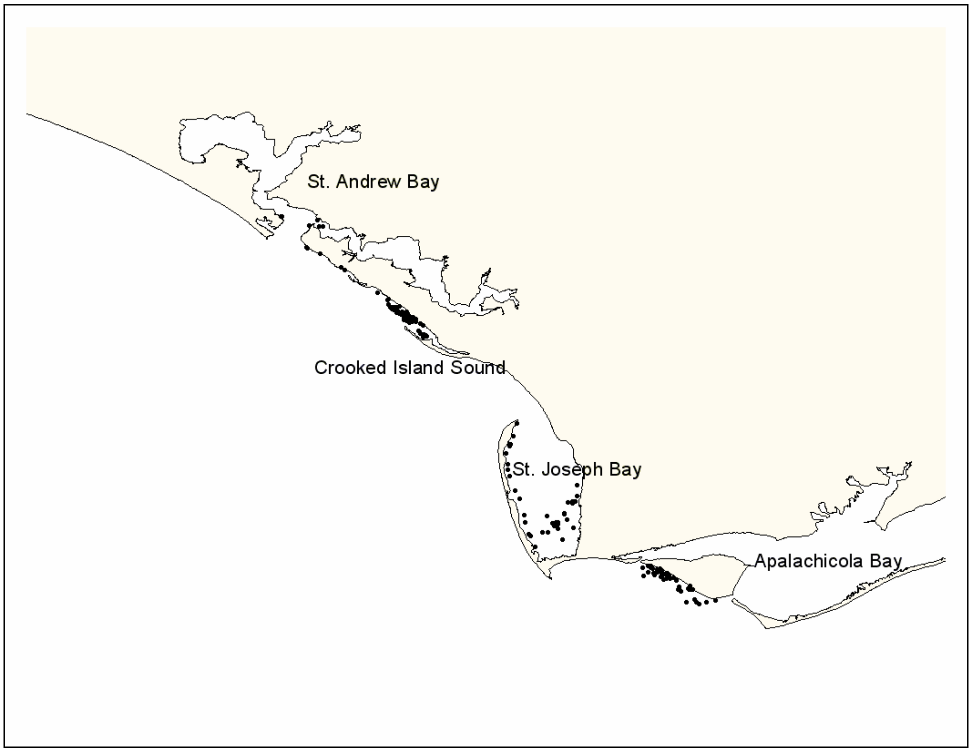

Figure 2. Locations of sampling stations in 2003 for areas in Mississippi.