Shark Nurseries in the Northeastern Gulf of Mexico

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Scope

Sharks were sampled by the National Marine Fisheries Service, Panama City Laboratory from March 1993-October 2000 as part of various studies on shark population dynamics and life history. All studies were directed towards sharks but focused on establishing a fishery independent index of abundance in the northeastern Gulf of Mexico; collecting information on age, growth, and reproduction; longline and gillnet selectivity; and feeding ecology. All studies were funded by NMFS/Highly Migratory Species Office, Washington, D.C.; Southeast Fisheries Science Center's Sustainable Fisheries Division; and the NMFS Panama City Facility.

Sampling Materials and Methods

Sampling for sharks took place April to October of each year, occasionally from November to March. Because funding was not continuous and sampling was directed at various objectives, the variability in sampling design and methodology precluded quantification of an index of abundance (i.e., CPUE) throughout the entire survey period. In general, gillnets were multi-paneled and ranged in length from 30.4 to 273.6 m. Stretched mesh sizes ranged from 5.1 cm to 20.3 cm. Panel depths when fishing were 1.5 to 3.1 m. Webbing for all panels, except for 20.3-cm, was of clear monofilament, double knotted and double selvaged. The 20.3-cm stretched mesh webbing was made of #28 multifilament nylon, single knotted, and double selvage. The nets when set were anchored at both ends and fished on the bottom.

The longline was constructed of a mainline made of 152-m lengths of 425.8 kg-test monofilament line. A 15.2-m length of 0.79-cm diameter braided polypropylene line connected each 152-m length. Depending on the number of hooks fished, the longline ranged in length from 152 to 608 m. Polyethylene floats or weights (1.3 kg) made of 1.5-m lengths of 136-kg test monofilament line with a snap were attached to the mainline every 30.4 m. Gangions were placed at 15.2-m intervals along the mainline. Gangions (136-kg test) were 0.9-1.8 m long and hooks were size Mustad #12/0 or #3/0. Bait was either menhaden (*Brevoortia* spp.) or Atlantic mackerel (*Scomber scombrus*). The mainline, when set, was tethered to an anchor on each end with a 30.4-m, 0.79-cm polypropylene rope between the anchor and the end of the mainline. A buoy (3.6-m aluminum pole with 1.8-kg weight and 50.8-cm poly float), with a strobe light and flag extended 2.4 m above the float, was attached at each end of the mainline.

Survey Design

For each survey period, the sampling gear was set randomly within each area or at a fixed station. Both random and fixed sets were designated on LORAN C coordinates. The nets and/or longlines were set over a 24 hr period at various times. In some surveys, the gillnets were checked and cleared of catch, or pulled and reset every 1.0-2.0 hr. In other surveys, gillnets were set at dusk, left to soak overnight, and hauled back the next day. For longlines, soak time ranged from 1.0-1.5 hr. Following each soak period, the longline was checked and all gangions that had caught sharks, been broken or damaged, or had damaged or lost baits, were removed from the mainline and a fresh-baited gangion attached. Sharks captured using either method were measured to the nearest cm for body lengths (precaudal, fork, total, and stretch total length) and data for sex and life history stage

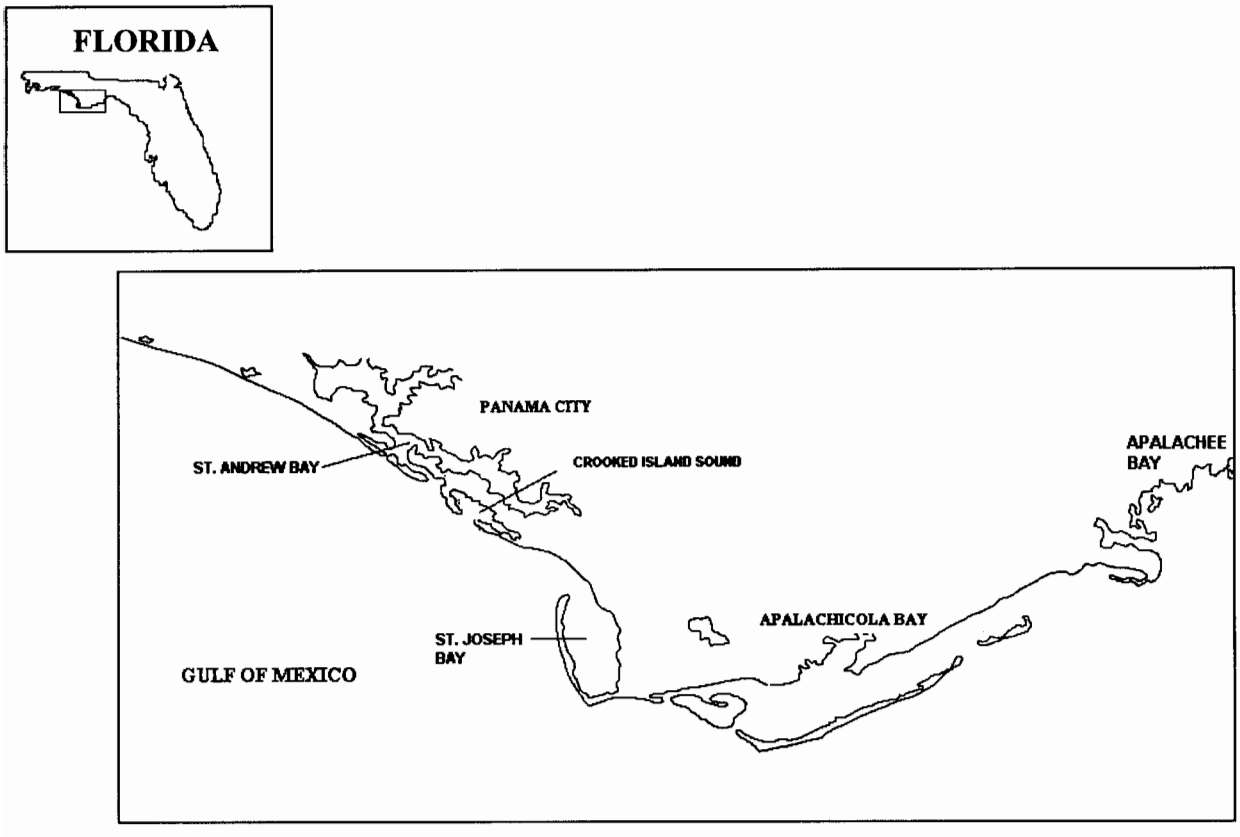


Figure 1. Map of study site illustrating major bay systems.

(neonate, young-of-the-year, juvenile, adult) were recorded. Sharks that were in poor condition were sacrificed for life history studies and those in good condition were released or tagged with a nylon-head dart tag and released.

Environmental data were collected prior to sampling. Mid-water temperature (°C), and dissolved oxygen (mg l^{-1}) was measured with a YSI Model 55 oxygen meter and light transmission (cm) was determined using a secci disk. Salinity (ppt) was measured with a refractometer. When possible, qualitative bottom type was recorded based on visual observation, sampling with a ponar grab, or visual inspection of the sediment type on the anchor.

Description of Study Areas

Sampling sites were located in five major areas along the northeastern portion of the Gulf of Mexico, Apalachee Bay to St. Andrews Bay, FL (Figure 1). Physical and chemical characteristics of each area are found in Table 1. The eastern part of this area has irregular coastline, few beaches and enclosed bay systems. Some bay systems contain large amounts of submergent, *Thalassia* spp., *Syringodium* spp and *Halodule* spp., and emergent vegetation, *Spartina* spp. and *Juncus* spp. The western part has numerous barrier islands and sand beaches and is composed of semi-enclosed bays. Tidal amplitude in the bays is highest in Apalachee Bay and generally decreases toward the west.

Apalachee Bay is an open ocean bay without barrier islands separating the area from the open Gulf of Mexico. The bay is broad, shallow (average 3 m), and extends about 15 km offshore. Salinity ranges from 22-36 ppt and tidal amplitude averages 1.1 m. Wave energy is low and the area has large areas of submerged vegetation.

Sampling in the Apalachicola Bay system occurred in the delta area between 0.5-3 km south of St. Vincent Island in the Gulf of Mexico where

Table 1. Environmental Characteristics of the Five Bay Systems. Numbers is parentheses represent minimum and maximum values observed.

System	Surface Area (acres)	Maximum Tidal Range (m)	Mean Water Depth (m)	Temperature (°C)	Salinity (ppt)	Light Transmission (cm)	Dissolved Oxygen (mg l^{-1})
Apalachee Bay	61,322	1.10	5.3 (4.5-8.0)	25.2 (19.0-31.0)	25.0 (23.0-26.0)	96.2 (68.0-108.0)	N/A
Apalachicola Delta	82,197	0.73	4.7 (2.1-10.0)	27.5 (19.5-31.4)	29.0 (19.0-39.0)	81.9 (15.0-200.0)	5.5 (3.6-7.3)
Crooked Island Sound	4,707	0.78	4.0 (1.7-8.7)	26.5 (16.0-31.2)	31.4 (21.0-38.0)	174.9 (10.0-450.0)	6.1 (4.6-8.3)
St. Andrew Bay	21,499	0.53	3.5 (1.0-5.2)	24.9 (16.5-31.0)	31.2 (22.0-38.0)	101.7 (0.0-250.0)	7.2 (5.4-8.1)
St. Joseph Bay	43,872	0.47	2.3 (0.7-6.2)	28.3 (20.0-33.6)	35.3 (30.0-38.0)	172.4 (8.3-300.0)	6.6 (2.0-8.3)

water depths average 5-10 m. The bay system surrounding this area is largely a line of barrier islands fronting the intersection of the Apalachicola delta. As a result of river discharge, there is little submergent vegetation due to high turbidity. Salinity fluctuates from 19-39 ppt and tidal range is 0.73 m.

St. Joseph Bay transcends from a broad, shallow, heavily, vegetated habitat to a relatively deep oceanic habitat. It is connected to the Gulf of Mexico by a deep navigation channel. The southern portion of the bay contains large expanses of *Thalassia* spp., *Halodule* spp., and *Syringodium* spp. The entire bay surface area covers approximately 43,000 acres and maximum tidal range is 0.47 m.

Crooked Island Sound (St. Andrew Sound) is a small semi-enclosed marine lagoon. It is about 14.5 km long and 0.2-2.0 km wide and has water depths from 3.5-4.5 m deep (mean high tide). This system also contains expanses of submergent vegetation but generally only along the edges of the bay where the water depth averages 1-2 m. Salinity ranges from 25-36 ppt and tidal amplitude averages 0.42 m. The sound exchanges water with the Gulf of Mexico through a pass 0.5-2.0 km wide.

St. Andrew Bay consists of several embayments, averages 1.9-5.7 m deep, and covers an area of about 21,500 acres. Because of its proximity to Panama City, FL this bay is subjected to much anthropogenic activity from commercial and recreational activity such as shipping traffic by commercial tankers, municipal and industrial discharge and tourism. Salinity ranges from 13-32 ppt and tidal amplitude averages 0.48 m. The system exchanges water with the Gulf of Mexico via a human-made pass at the western end.

Results

A total of 15 species of sharks were collected with gillnets and longlines. 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, using longlines and gillnets. 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 caught but not consistently captured were Florida smoothhound, *Mustelus norrisi;* bull shark, *C. leucas*; lemon shark, *Negaprion brevirostris*; nurse shark, *Ginglymostoma cirratum*; tiger shark, *Galeocerdo cuvieri*; dusky shark, *C. obscurus* and great hammerhead shark, *S. mokarran.*

Overall species distribution varied by area (Figure 2). The Atlantic sharpnose shark and bonnethead were the most abundant species captured in Crooked Island Sound. In Apalachee Bay, the Atlantic sharpnose and blacktip shark were the most frequently encountered. The bonnethead and Atlantic sharpnose shark were most commonly

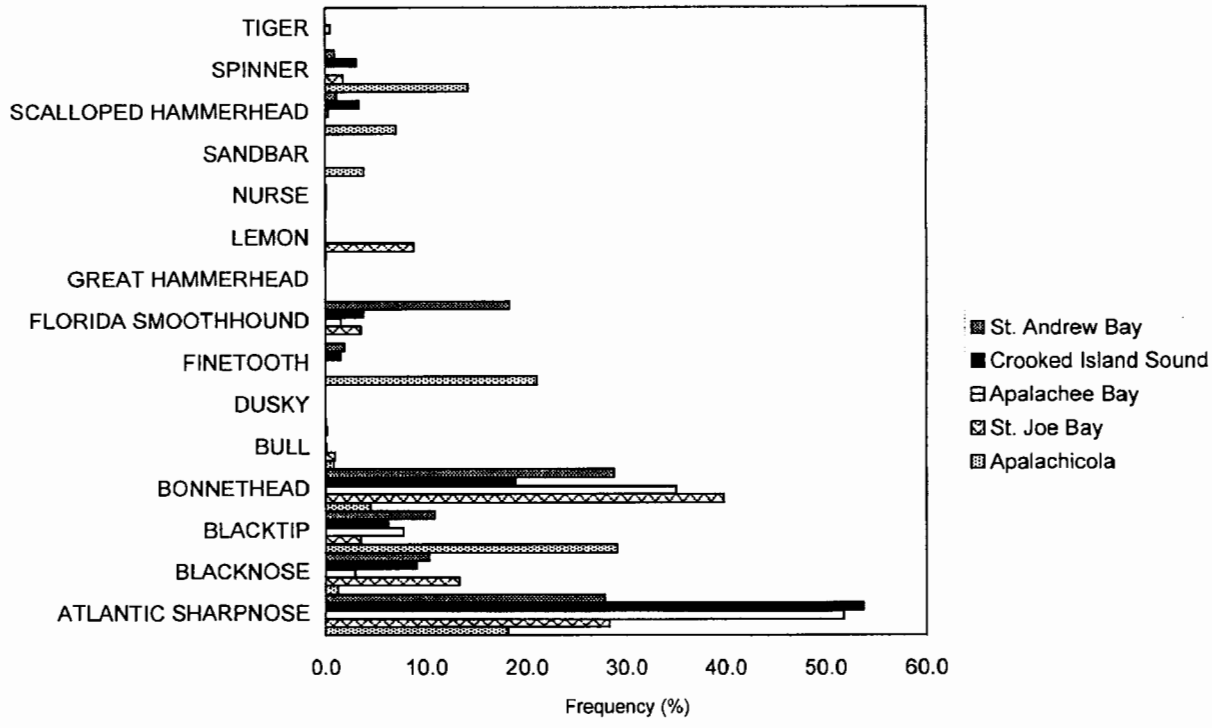


Figure 2. Frequency distribution of sharks within the major sampling areas.

caught in St. Joseph Bay and St. Andrew Bay. The blacktip and finetooth shark were the most abundant species found in Apalachicola.

Apalachee Bay

Sampling occurred in Apalachee Bay in 1993 and 1995. Sharks were captured in temperatures ranging from 19.0-31.0° C and salinities from 23.0-26.0 ppt. Nine species were encountered in this bay system with Atlantic sharpnose and bonnethead shark being the most commonly occurring (Table 2). With the exception of the bonnethead shark, juveniles were the dominant life stage captured (Figure 3). Other species captured were blacknose, blacktip, bull, Florida smoothhound, nurse, and scalloped hammerhead. Apalachee Bay is the only area surveyed where tiger sharks were encountered.

Apalachicola Delta

A total of 4,148 sharks were captured in the Apalachicola delta in 8 years of sampling. Because this system receives large amounts of freshwater from the Apalachicola River, sharks were captured over a broad range of salinities (19-39 ppt) and light transmission (15-200 cm). Of the 13 species found in this system, species with larger juveniles and young-of-the-year (>50 cm TL) were found most often (Table 3). These species were blacktip, spinner, sandbar, and finetooth sharks. Mostly adults were found in this area among species with smaller neonates and juveniles (e.g. Atlantic sharpnose, blacknose) (Figure 4). Within Apalachicola, neonate (open or partially healed umbilical scar) blacktip and finetooth sharks were first captured in May and June indicating parturition occurs for these species around this time. Following these species, neonate spinner and sandbar sharks were first encountered in July. Older juvenile blacktip and finetooth sharks immigrated into this area beginning in April or May depending on water temperature (>20° C) and juveniles of most other species were present by June. Almost all species present in this system usually emigrated out beginning in October. Of all bay systems surveyed, bull sharks were most often captured in Apalachicola and this is the only area where dusky sharks were encountered.

Table 2. Descriptive statistics of sharks captured using gillnets and longlines in Apalachee Bay. All measurements are in cm total length.

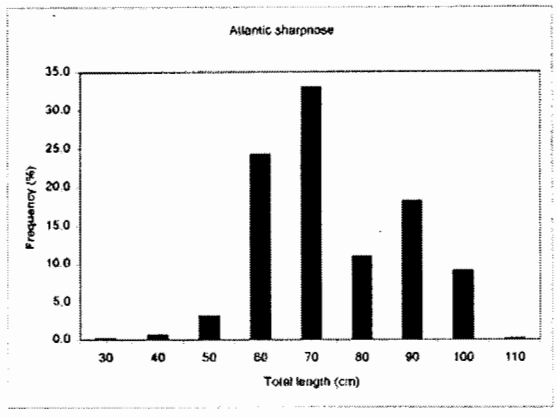
Species	Mean size captured	Standard deviation	Range	N
Atlantic sharpnose	69.2	13.6	29.3-102.0	472
Blacknose	82.4	21.0	43.1-114.4	26
Blacktip	104.9	24.5	72.3-174.0	70
Bonnethead	74.0	14.6	39.8-110.4	319
Bull	65.0	-	-	1
Florida smoothhound	65.0	6.0	45.8-71.0	14
Nurse	213.5	-	-	1
Scalloped hammerhead	99.8	33.4	73.1-137.2	3
Tiger	115.5	28.4	87.0-154.0	5

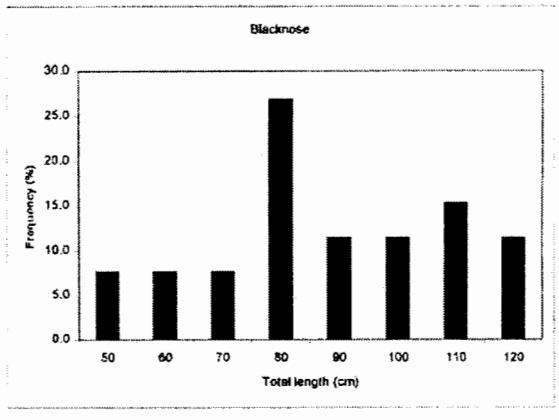
Table 3. Descriptive statistics of sharks captured using gillnets and longlines in Apalachicola delta. All measurements are in cm total length

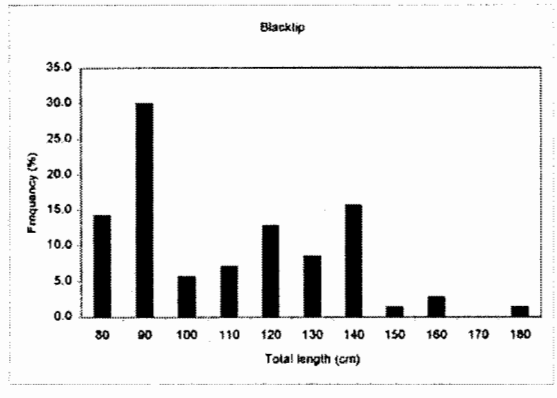
Species	Mean size captured	Standard deviation	Range	N
Atlantic sharpnose	74.4	23.0	30.0-111.5	752
Blacknose	110.9	15.2	53.2-134.0	52
Blacktip	96.7	22.4	51.2-181.0	1204
Bonnethead	88.5	14.0	49.0-122.0	186
Bull	185.0	61.4	67.0-267.0	31
Dusky	102.7	9.02	94.0-112.0	3
Finetooth	101.5	20.6	48.0-150.0	872
Great hammerhead	240	-	-	1
Lemon	170	-	170.0-170.0	3
Nurse	110.0	15.5	95.0-126.0	3
Sandbar	97.7	23.0	55.0-164.0	160
Scalloped hammerhead	58.6	16.6	37.2-238.0	291
Spinner	88.3	15.8	53.0-135.3	589

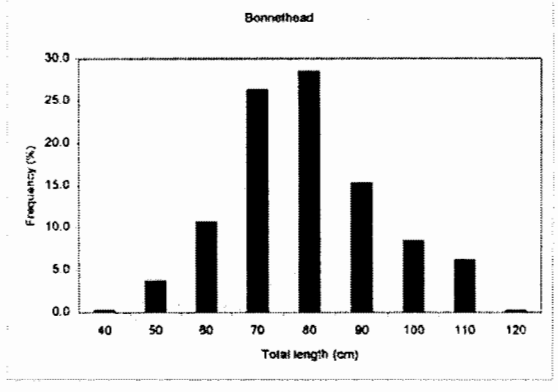
Table 4. Descriptive statistics of sharks captured using gillnets and longlines in St. Joseph Bay. All measurements are in cm total length.

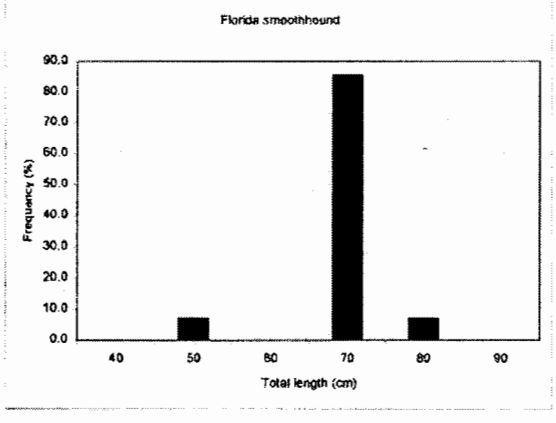
Species	Mean size captured	Standard deviation	Range	N
Atlantic sharpnose	78.2	13.9	38.0-99.0	32
Blacknose	59.3	20.6	43.0-118.0	15
Blacktip	91.0	23.0	66.0-116.0	4
Bonnethead	60.9	11.9	45.0-80.0	45
Bull	141	-	-	1
Florida smoothhound	67.8	4.6	62.0-72.0	4
Lemon	95.3	8.1	79.0-105.0	10
Spinner	101.5	21.9	86.0-117.0	2











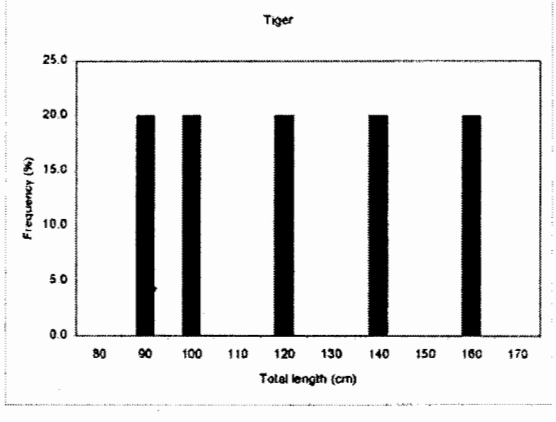


Figure 3. Length frequency distributions of the most abundant species captured in Apalachee Bay

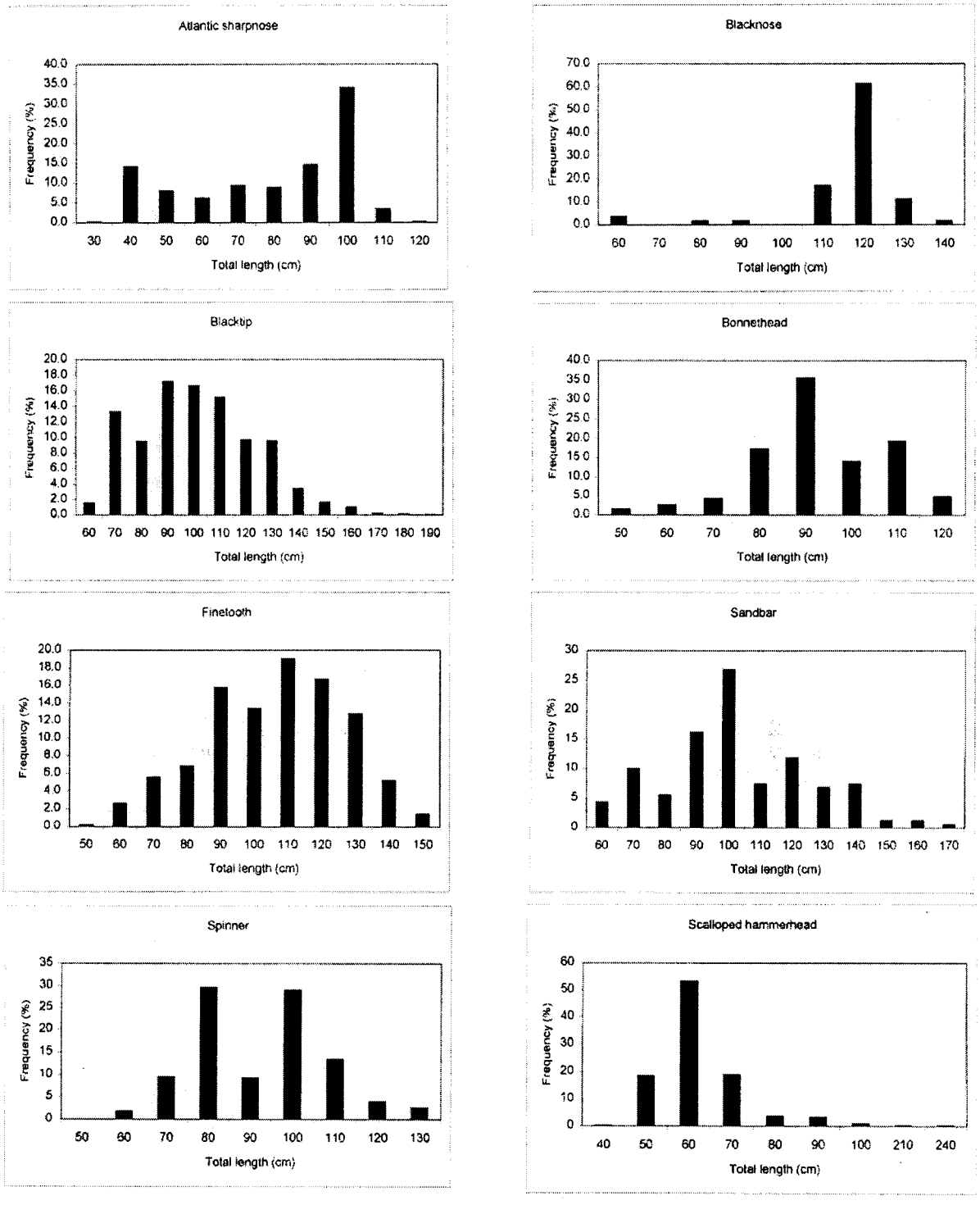


Figure 4. Length frequency distributions of the most abundant species captured in Apalachicola Bay

Table 5. Descriptive statistics of sharks captured using gillnets and longlines in Crooked Island Sound. All measurements are in cm total length.

Species	Mean size captured	Standard deviation	Range	N
Atlantic sharpnose	65.7	15.8	30.4-110.9	3015
Blacknose	61.4	18.9	39.5-132.1	511
Blacktip	90.0	19.9	48.5-148.0	348
Bonnethead	60.2	15.8	37.4-121.0	1058
Bull	151.0	1.4	150.0-152.0	2
Finetooth	110.1	19.9	55.3-141.0	85
Florida smoothhound	69.2	9.2	43.9-107.4	212
Great hammerhead	204.8	6.0	200.5-209.0	2
Nurse	154.7	8.0	150.0-167.6	7
Sandbar	83.5	16.3	72.0-95.0	2
Scalloped hammerhead	59.7	29.5	38.0-252.0	187
Spinner	81.4	14.8	55.1-124.1	176

St. Joseph Bay

St. Joseph Bay was surveyed from 1998-2000. A total of 113 sharks were captured in this bay system, the majority in shallow (2-3 m deep) areas over seagrass beds. Because this bay has little freshwater inflow, sharks were captured at higher salinities (30-38 ppt) than in other areas. Species such as blacknose and bonnethead, with smaller juveniles and young-of-the-year (<50 cm TL), were caught most often (Table 4). Adult Atlantic sharpnose and juvenile blacktip sharks were also found in St. Joseph Bay (Figure 5). St. Joseph Bay was the only bay system where young lemon sharks (~Age1-2; Brown and Gruber, 1988) were encountered. Lemon sharks were captured in a habitat type (shallow grass beds) that is similar to areas where lemon sharks are found in the Florida Bay ecosystem (E. Cortés, NMFS, SEFSC, Panama City, FL, pers. commun., 2000).

Crooked Island Sound

Sampling began in Crooked Island Sound in 1993 and has run continuous through 2000. A total of 5,605 sharks from 12 species have been captured in this area (Table 5). Generally, species with smaller neonates and juveniles (<50 cm TL) are most often captured in this system. Atlantic sharpnose, bonnethead, and blacknose sharks made up 82% of the sharks found.

Recruitment of young-of-the-year and/or pupping in this area followed a consistent pattern over most years sampled. Young-of-the-year bonnethead sharks recruited to the area beginning in April sometimes when water temperatures were recorded as low as 16° C. Neonate Atlantic sharpnose sharks were first observed in May when water temperatures approached 20-25° C followed by blacknose neonates and females with near-term pups in June. Gravid scalloped hammerhead sharks and neonates where captured in July. Additional recruitment of juvenile species such as blacktip, spinner, and finetooth shark occurred throughout June and July. Similar to Apalachicola, most species emigrated out of the bay system beginning in October. Florida smoothhound sharks were generally captured in cooler water temperatures (20° C) in March, April, and October.

St. Andrew Bay

A total of 464 sharks from 9 species were captured in St. Andrew Bay in 1993, 1998, and 1999. Species composition was fairly similar to that observed in Crooked Island Sound (Table 6). Most species observed were juvenile Atlantic sharpnose, bonnethead, and blacknose sharks (Figure 7). However, fewer neonates and gravid females were captured in this area than in Crooked Island Sound. Other species commonly observed within this bay system were juvenile blacktip and Florida smoothhound sharks. Other species caught but not consistently captured were finetooth, scalloped hammerhead, and spinner sharks.

Figure 5. **Length frequency distributions of the most abundant species captured in St. Joseph Bay**

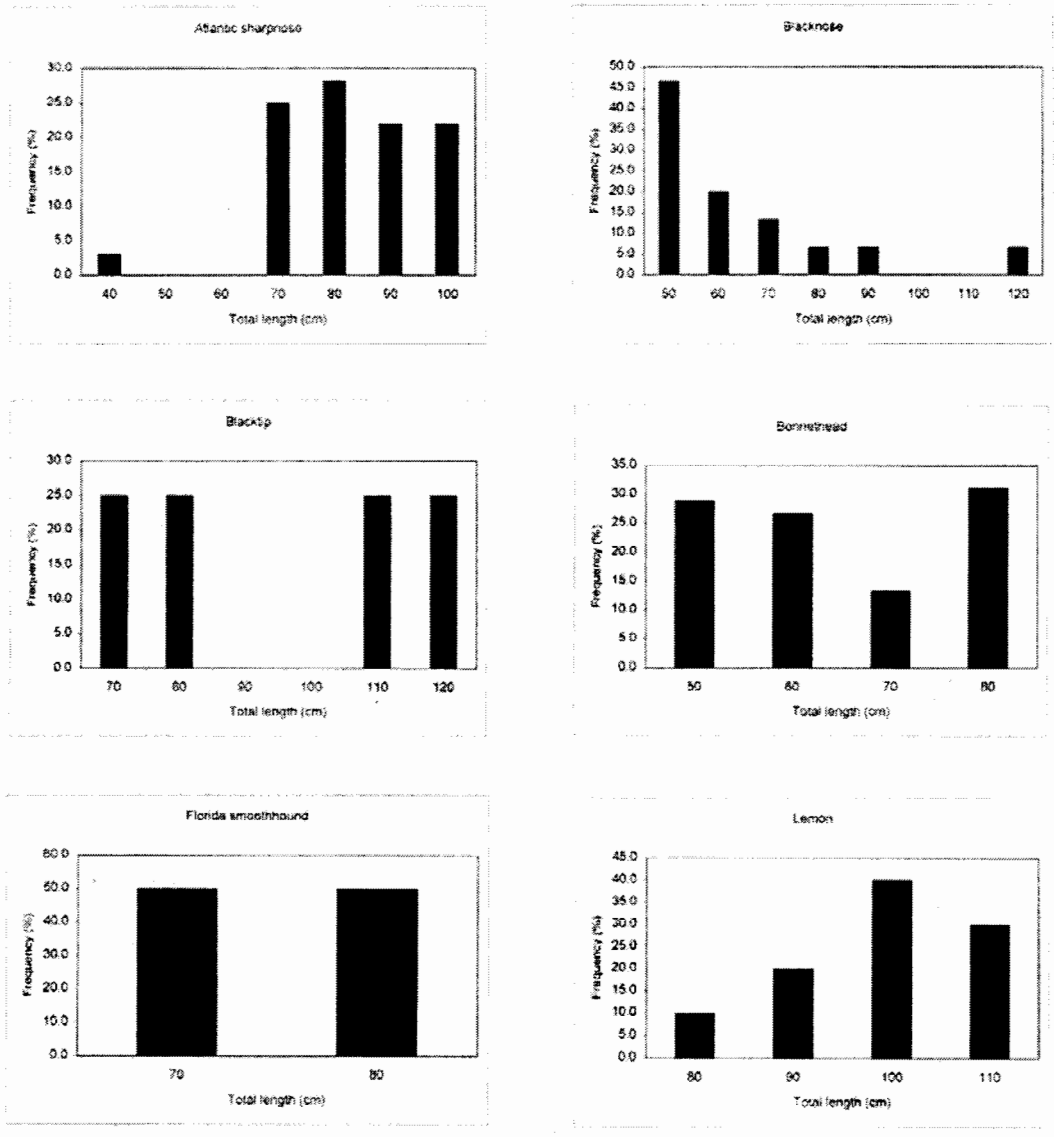


Table 6. **Descriptive statistics of sharks captured using gillnets and longlines in St. Andrew Bay. All measurements are in cm total length.**

Species	Mean size captured	Standard deviation	Range	N
Atlantic sharpnose	68.9	12.1	36.4-101.0	129
Blacknose	69.9	22.0	46.2-122.5	48
Blacktip	108.2	22.7	69.8-180.3	50
Bonnethead	62.5	12.5	42.0-92.8	133
Bull	200	-	-	1
Finetooth	109.4	14.8	102.0-148.2	9
Florida smoothhound	69.0	8.1	46.5-97.0	85
Scalloped hammerhead	88.6	90.7	48.0-250.8	5
Spinner	92.1	2.6	89.6-95.5	4

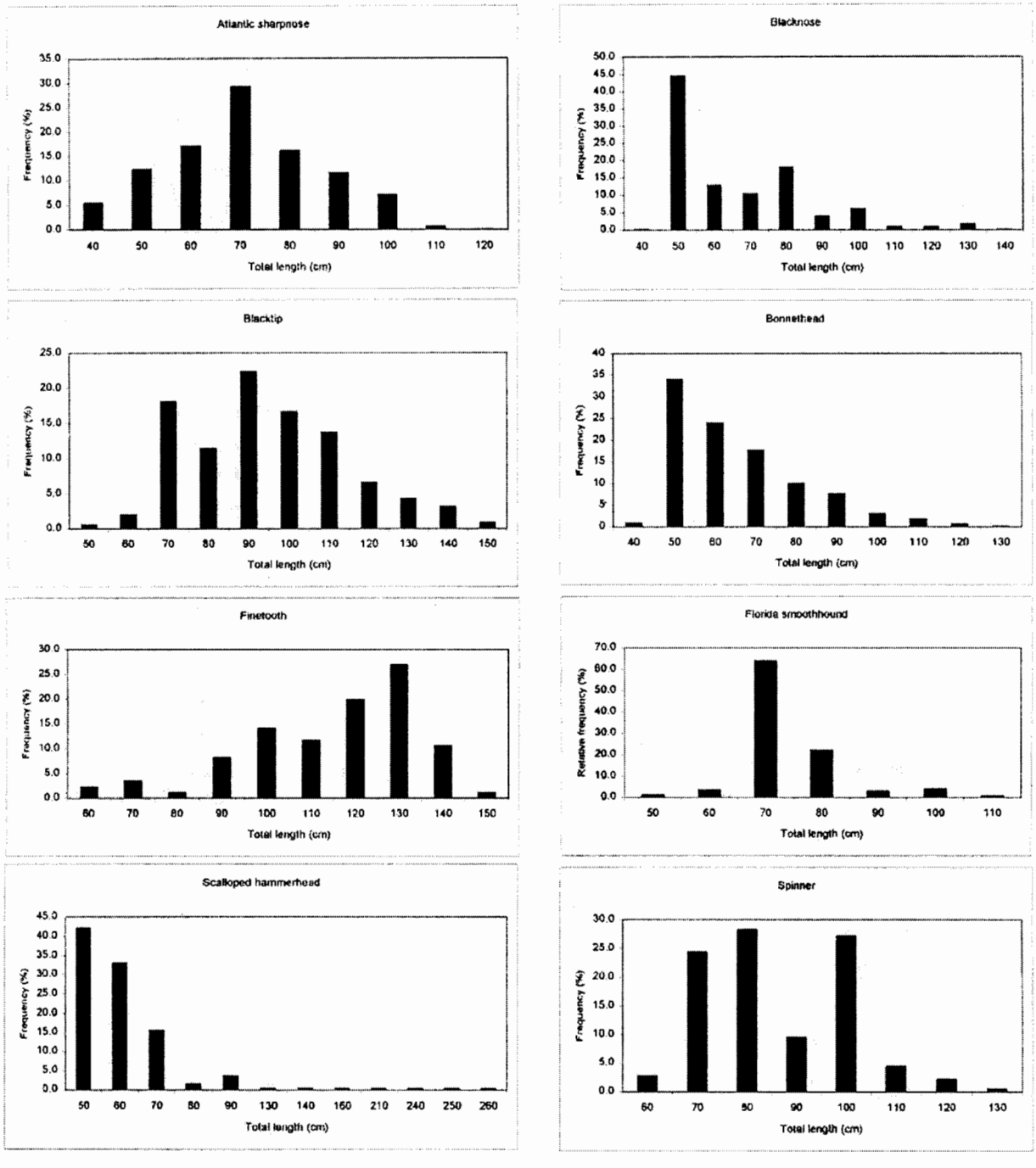


Figure 6. Length frequency distributions of the most abundant species captured in Crooked Island Sound

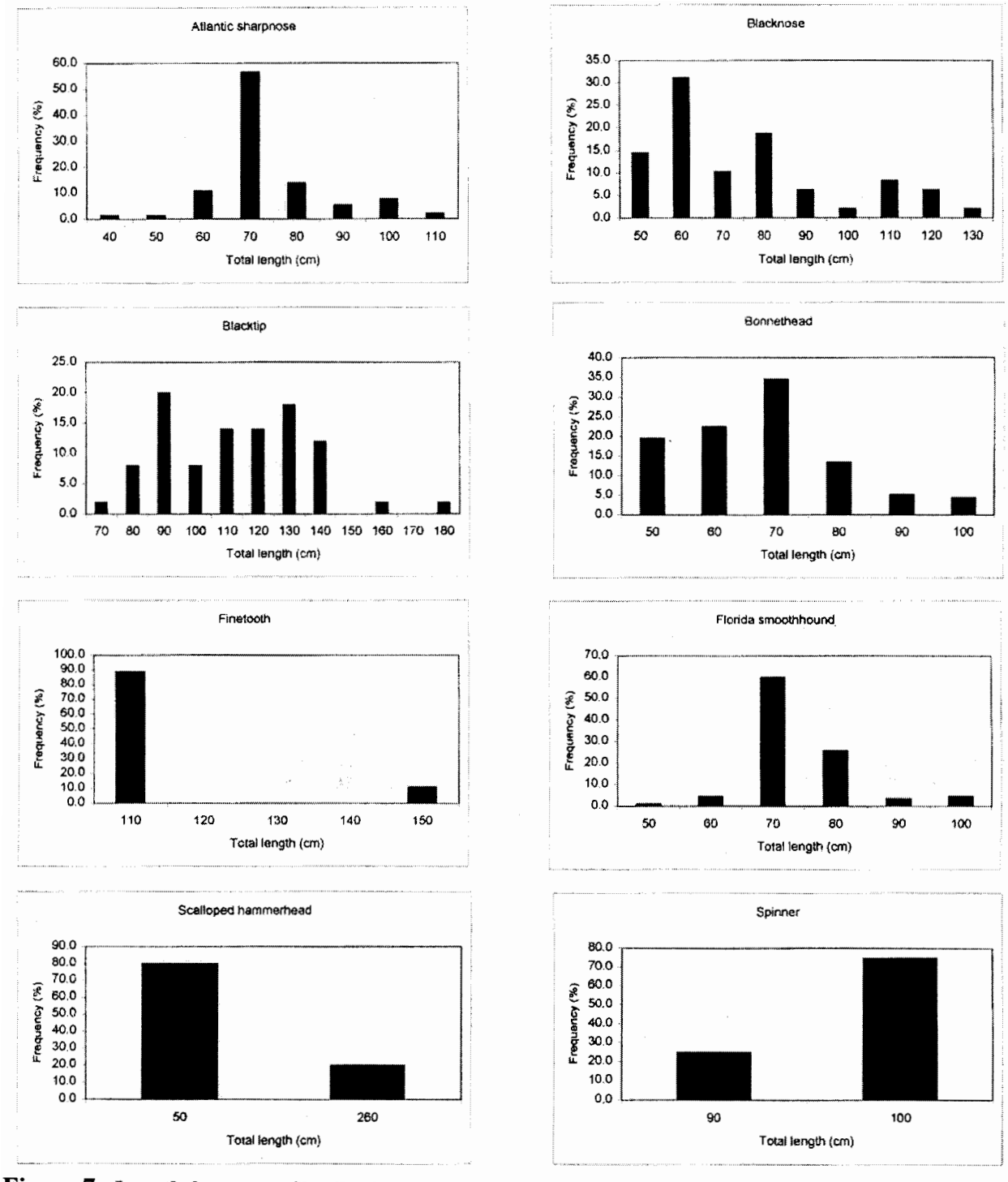


Figure 7. Length frequency distributions of the most abundant species captured in St. Andrew Bay

Tag/recaptures

A total of 1,117 sharks have been tagged and released since 1993 and 50 have been reported recaptured. This represents a recapture rate of 4.5%. The longest time at liberty was 2,461 days for an Atlantic sharpnose shark. This shark was recaptured in the same area, Crooked Island Sound, that it was originally tagged in. The largest distance traveled was for a blacktip shark that was recaptured offshore southwest of Tampa, FL. This shark traveled 205 nautical miles from Apalachicola Bay in 102 days.

Comparison of Abundance among Areas

Despite some apparent differences in abundance among the various sampling areas, caution should be taken when making inferences about the importance of one area over another (using abundance as a indicator) without considering the problem of sampling bias. Because funding was not continuous and sampling was directed at various objectives, prior to 1996 the sampling gear (gillnets and longlines) and sampling strategy varied. Since selectivity functions have not been calculated for all species with the respective gear types, it cannot ascertained whether some species are naturally low in abundance in some areas sampled or whether this is an artifact due to sampling bias.

Correlation of Abundance with Environmental Factors

When effort was standardized (see Carlson and Brusher 1999), correlations were examined among the most abundant species captured (log transformed CPUE) and environmental variables measured. Multiple linear regression was used to examine the relationship between shark abundance and temperature (°C), salinity (ppt), dissolved oxygen (mg l^{-1}), and light transmission (cm; measured as the depth of the photic zone). A significant relationship was found between abundance of spinner and scalloped hammerhead sharks and water temperature (spinner:r^2=0.19, p=0.02; scalloped hammerhead; r^2=0.16, p=0.03), but not with salinity, dissolved oxygen, or light transmission ($r^2$0.05). All remaining species had poor correlation coefficients and non-significant relationships (Table 7).

Species Profiles

Atlantic sharpnose shark, *Rhizoprionodon terraenovae*

A total of 4,400 Atlantic sharpnose sharks were captured from all areas sampled. Sharks ranged in size from 29.3-111.5 cm TL. Generally, sharks were captured in water temperatures from 26.6-28.0° C, salinities averaging 31.6 ppt, and depths of 4.1 m (Table 8). Atlantic sharpnose sharks were found over a variety of bottom types.

Blacknose shark, *Carcharhinus acronotus*

Blacknose sharks were captured in water temperatures from 20.8-33.6° C, salinities averaging 32.1 ppt, and depths of 3.7 m (Table 9). Blacknose sharks (n=652) caught ranged in size from 39.5-134 cm TL. Blacknose sharks were found over a variety of bottom types and tolerated dissolved oxygen levels to 2.0 mg l^{-1}.

Blacktip shark, *Carcharhinus limbatus*

Blacktip sharks captured (n=1676) ranged in size from 48.5-181 cm TL, but the majority of these were neonates and juveniles. Blacktip sharks appear to be a relatively tolerant species to a variety of habitat conditions, being found in water temperatures between 16.0-31.8° C, salinities of 19-38 ppt and depths of 2-7 m (Table 10). Similar to results of Grace and Henwood (1997), some blacktip sharks were captured in areas with low dissolved oxygen concentrations.

Bonnethead shark, *Sphyrna tiburo*

A total of 1,741 sharks were captured over the length of study. Bonnethead sharks ranged in size from 37.4-122 cm TL. Similar to blacktip shark, the bonnethead was found in a variety of habitat conditions (Table 11). Bonnethead sharks were collected in water temperatures between 16-32.5° C, salinities of 19-38 ppt, dissolved oxygen levels to 1.9 mg l^{-1} , and depths of 2-7 m. Preliminary

Table 7. Correlation coefficients and significance levels of between log transformed CPUE and temperature, salinity, light transmission and dissolved oxygen.

SPECIES	FACTOR	r^2	P
Atlantic sharpnose	Temperature	0.01	0.87
	Salinity	0.05	0.24
	Light transmission	0.01	0.49
	Dissolved oxygen	0.02	0.42
Blacknose	Temperature	0.07	0.16
	Salinity	0.04	0.33
	Light transmission	0.09	0.14
	Dissolved oxygen	0.11	0.66
Blacktip	Temperature	0.07	0.18
	Salinity	0.02	0.42
	Light transmission	0.01	0.85
	Dissolved oxygen	0.14	0.58
Bonnethead	Temperature	0.01	0.60
	Salinity	0.09	0.12
	Light transmission	0.03	0.40
	Dissolved oxygen	0.24	0.36
Finetooth	Temperature	0.02	0.51
	Salinity	0.10	0.10
	Light transmission	0.06	0.20
	Dissolved oxygen	0.06	0.69
Sandbar	Temperature	0.07	0.18
	Salinity	0.02	0.83
	Light transmission	0.01	0.85
	Dissolved oxygen	0.11	0.38
Scalloped hammerhead	Temperature	0.16	0.03
	Salinity	0.07	0.67
	Light transmission	0.08	0.65
	Dissolved oxygen	0.08	0.73
Spinner	Temperature	0.19	0.02
	Salinity	0.02	0.81
	Light transmission	0.07	0.68
	Dissolved oxygen	0.11	0.51

Table 8. Summary of the habitat associations for Atlantic sharpnose sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	28.0 (19.5-31.2)	31.8 (24.0-37.0)	4.0 (0.7-6.2)	128.7 (15.0-280.0)	5.8 (3.6-7.7)	Silt/clay Sand
Juveniles	27.0 (16.0-32.4)	32.5 (19.0-38.0)	4.1 (2.0-6.4)	208.5 (15.0-400.0)	6.2 (4.5-8.3)	Silt/clay Seagrass, Sand
Adults	26.6 (19.8-32.4)	30.5 (19.0-38.0)	4.1 (1.7-6.4)	156.5 (15.0-400.0)	6.2 (4.5-8.3)	Silt/clay Sand

Table 9. **Summary of the habitat associations for blacknose sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	27.6 (24.7-33.2)	33.1 (29.0-35.0)	3.6 (1.0-6.3)	201.0 (100.0-290.0)	5.9 (4.6-7.4)	Silt/clay Seagrass, Sand
Juveniles	28.0 (20.8-33.6)	32.1 (27.0-38.0)	3.5 (0.7-5.0)	196.9 (8.3-400.0)	6.8 (2.0-8.3)	Silt/clay Seagrass, Sand
Adults	26.0 (22.5-30.6)	31.2 (26.0-37.0)	4.2 (1.3-5.0)	119.1 (50.0-290.0)	5.7 (5.5-6.6)	Silt/clay Sand

Table 10. **Summary of the habitat associations for blacktip sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	28.4 (22.5-31.4)	29.8 (19.0-38.0)	4.1 (2.1-6.0)	97.0 (50.0-200.0)	5.1 (3.6-7.0)	Silt/clay Sand
Juveniles	27.8 (16.0-31.8)	30.1 (19.0-37.0)	4.1 (2.0-7.0)	128.9 (15.0-400.0)	5.7 (3.6-8.3)	Silt/clay Sand
Adults	28.3 (22.8-31.2)	31.9 (24.0-38.0)	3.9 (3.0-6.2)	119.5 (15.0-250.0)	5.5 (4.8-6.5)	Silt/clay Sand

Table 11. **Summary of the habitat associations for bonnethead sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	27.2 (16.0-32.5)	32.9 (19.0-38.0)	3.7 (0.7-6.4)	183.9 (25.0-365.0)	6.6 (1.9-8.3)	Seagrass Silt/clay, Sand
Juveniles	27.2 (16.0-32.5)	32.9 (19.0-38.0)	3.7 (0.7-6.4)	183.9 (25.0-365.0)	6.6 (1.9-8.3)	Seagrass Silt/clay, Sand
Adults	26.5 (16.0-31.4)	29.0 (19.0-38.0)	3.5 (1.0-6.4)	137.0 (25.0-365.0)	5.7 (4.5-8.1)	Sand Silt/clay

evidence suggests young-of-the-year bonnethead sharks prefer shallow sea grass beds while adults prefer deeper areas with a sand/clay bottom.

Bull shark, *Carcharhinus leucas*

Of all species collected, bull sharks seemed to prefer the most particular habitat type (Table 12). Bull sharks (n=36) ranging in size from 65-267 cm TL were only collected in areas with silt/clay sediment, high volumes of freshwater inflow, and high turbidities (water clarity from 66-103 cm). This species was found in water temperatures between 20.7-31.8° C, salinities of 25-36 ppt and depths of 2.5-5.3 m.

Finetooth shark, *Carcharhinus isodon*

A total of 966 finetooth sharks were captured from all areas sampled. Sharks ranged in size from 48-150 cm TL. Generally, sharks were captured in water temperatures averaging 27.3° C, salinities 27.9 ppt, and depths of 4.2 m (Table 13). Finetooth sharks were generally found in habitats with a predominately silt/clay sediment type.

Florida smoothhound shark, *Mustelus norrisi*

Florida smoothhound sharks (n=315) ranging in size from 43.9-107.4 were collected in cooler water temperatures averaging 20.5° C (Table 14). This species was found in depths from 1.7-5.0 m and in salinities from 27-36 ppt.

Nurse shark, *Ginglymostoma cirratum*

A total of 11 nurse sharks were captured ranging in size from 95-213.5 cm TL. Nurse sharks were found in temperatures from 22.6-28.1° C, salinities averaging 33.8 ppt and depths of 4.1 m (Table 15).

Lemon shark, *Negaprion brevirostris*

Lemon sharks were only captured in shallow protected areas with vast expanses of sea grass. Juveniles tended to prefer shallow depths (~1.1 m) where water temperatures averaged 30.9° C and salinities were 33.6 ppt (Table 16). Of the 14 lemon sharks captured (range 79-202 cm TL), most were younger juveniles (mean size=118 cm TL).

Sandbar shark, *Carcharhinus plumbeus*

Sandbar sharks were captured in water temperatures from 26.6-27.3° C, salinities averaging 34.0 ppt, and depths of 3.6 m (Table 17). Sandbar sharks (n=162) collected ranged in size from 55-164 cm TL. Sandbar sharks were found only over of bottom types of a silt/clay composition and in waters with low water clarity (40-107 cm).

Scalloped hammerhead shark, *Sphyrna lewini*

A total of 486 scalloped hammerhead shark were captured throughout the study period. Sharks ranged in size from 38.2-252 cm TL but the majority of these were juveniles. Generally, sharks were captured in water temperatures from 27.5-29.5° C, salinities averaging 32.2 ppt, and depths from 2.3-6.0 m (Table 18).

Spinner shark, *Carcharhinus brevipinna*

Spinner sharks captured (n=771) ranged in size from 53-135.3 cm TL. Spinner sharks were collected in water temperatures between 20.9-31.2° C, salinities of 19-38 ppt and depths of 2-6 m (Table 19). Spinner sharks were found over a variety of bottom types.

Preliminary Findings

Juveniles were the dominant life history stage captured in all areas sampled. It appears that species with larger juveniles and young-of-the-year (>50 cm TL) were found in Apalachicola. These species being blacktip, spinner and sandbar sharks. Species with smaller juveniles and young-of-the-year (<50 cm TL) (e.g. Atlantic sharpnose, bonnethead, and blacknose) were captured in more protected areas such as Crooked Island Sound and in the shallower areas of St. Joseph Bay and Apalachee Bay. The difference in spatial distribution among juveniles of different species may reflect an attempt to avoid predation (Springer, 1967; Branstetter, 1990) as all areas appear to have

Table 12. Summary of the habitat associations for bull sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	N/A	N/A	N/A	N/A	N/A	N/A
Juveniles	29.5 (20.7-31.8)	29.6 (25.0-36.0)	4.0 (2.5-5.0)	103.4 (30.0-200.0)	5.1 (4.5-6.6)	Silt/clay
Adults	24.6 (21.5-30.8)	25.7 (25.0-27.0)	5.2 (4.9-5.3)	66.7 (60.0-80.0)	N/A	Silt/clay

Table 13. Summary of the habitat associations for finetooth sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	27.9 (26.4-31.4)	26.1 (25.0-36.0)	4.2 (3.3-5.0)	73.5 (50.0-90.0)	5.0 (4.5-5.6)	Silt/clay
Juveniles	27.4 (19.5-31.4)	27.9 (19.0-38.0)	4.3 (2.3-5.3)	97.8 (15.0-365.0)	5.4 (3.6-6.8)	Silt/clay Sand
Adults	26.8 (19.5-30.3)	29.7 (19.0-38.0)	4.0 (2.6-6.0)	147.0 (15.0-365.0)	6.2 (4.8-7.0)	Silt/clay Sand

Table 14. Summary of the habitat associations for Florida smoothhound sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	N/A	N/A	N/A	N/A	N/A	N/A
Juveniles	20.5 (16.0-22.0)	30.2 (27.0-35.0)	3.5 (3.0-5.0)	252.9 (110.0-365.0)	7.5 (6.0-8.2)	Silt/clay Seagrass, Sand
Adults	20.3 (16.0-29.2)	31.1 (27.0-36.0)	3.8 (1.7-5.0)	230.7 (100.0-370.0)	7.5 (6.0-8.2)	Silt/clay Seagrass, Sand

Table 15. Summary of the habitat associations for nurse sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	N/A	N/A	N/A	N/A	N/A	N/A
Juveniles	25.8 (22.6-28.1)	33.8 (27.0-37.0)	4.1 (3.5-6.0)	158.8 (15.0-400.0)	6.3 (5.0-8.3)	Silt/clay Sand
Adults	N/A	N/A	N/A	N/A	N/A	N/A

Table 16. **Summary of the habitat associations for lemon sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	N/A	N/A	N/A	N/A	N/A	N/A
Juveniles	30.9 (27.2-34.0)	33.6 (26.0-39.0)	1.9 (0.7-6.3)	110.1 (8.3-300.0)	5.6 (2.0-8.1)	Seagrass
Adults	N/A	N/A	N/A	N/A	N/A	N/A

Table 17. **Summary of the habitat associations for sandbar sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	26.6 (26.6-30.8)	39.0 (19.0-39.0)	3.0 (3.0-5.2)	40.0 (40.0-265.0)	5.5 (5.0-7.3)	Silt/clay
Juveniles	27.3 (19.8-30.8)	29.4 (19.0-36.0)	4.2 (2.1-5.2)	106.9 (15.0-265.0)	5.5 (5.0-7.3)	Silt/clay
Adults	N/A	N/A	N/A	N/A	N/A	N/A

Table 18. **Summary of the habitat associations for scalloped hammerhead sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	29.3 (25.5-31.2)	33.4 (25.0-39.0)	3.8 (2.3-7.0)	116.9 (30.0-290.0)	5.9 (4.6-6.2)	Silt/clay Sand
Juveniles	29.5 (20.4-31.4)	32.1 (25.0-39.0)	4.2 (2.3-6.0)	140.6 (15.0-365.0)	5.9 (4.5-6.0)	Silt/clay Sand
Adults	27.5 (27.0-28.6)	31.3 (31.0-32.0)	3.8 (3.5-3.9)	203.3 (200.0-210.0)	N/A	Silt/clay Sand

Table 19. **Summary of the habitat associations for spinner sharks by life history stage. Mean values are presented and numbers is 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 O_2 (mg l^{-1})	Bottom type
Young-of-the-year	26.5 (22.5-30.5)	29.2 (25.0-35.0)	4.4 (2.7-5.0)	107.3 (50.0-280.0)	5.6 (5.4-6.0)	Silt/clay Seagrass
Juveniles	28.3 (20.9-31.2)	30.5 (19.0-38.0)	4.1 (2.0-6.0)	126.4 (15.0-400.0)	5.6 (4.9-8.3)	Silt/clay Sand
Adults	N/A	N/A	N/A	N/A	N/A	N/A

a high forage base. Crooked Island Sound is a small, semi-enclosed sound where few larger adult sharks were found. Thus, species with small neonates and juveniles may be selecting this area as a nursery based on low predation levels. Moreover, larger bull sharks were found in greatest abundance in Apalachicola and tiger sharks were captured only in the deeper areas of Apalachee Bay.

The poor relationship among environmental parameters and abundance suggest that additional environmental parameters not measured could be associated with habitat selection. Relationships may exist on multi-dimensions that would involve more robust statistical analysis that presented herein. Thus, more specific studies are needed to fully evaluate the interrelationships of abiotic and biotic factors and how they affect the abundance and distribution of sharks in nursery areas.

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NMFS INTERNAL REPORT TO NOAA'S HIGHLY MIGRATORY SPECIES OFFICE