SHARKS OF THE CENTRAL GULF COAST OF FLORIDA

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ABSTRACT

From January 1955 to April 1964, 762 sharks and 842 embryos of 16 species of sharks from the central west coast of Florida were examined. Included in order of abundance in our catches are: *Carcharhinus leucas* (135 specimens), *C. milberti* (109), *Negaprion brevirostris* (76), *Carcharhinus limbatus* (64), *Sphyrna tiburo* (63), *Carcharhinus acronotus* (61), *Galeocerdo cuvieri* (60), *Ginglymostoma cirratum* (58), *Carcharhinus obscurus* (49), *Scoliodon terraenovae* (22), *Sphyrna mokarran* (21), *Carcharhinus maculipinnis* (20), *Mustelus norrisi* (17), *Sphyrna lewini* (5), *Aprionodon isodon* (1), and *Carcharias taurus* (1). Measurements, seasonal distribution, embryonic development, maturity, and reproductive habits are discussed.

INTRODUCTION

This report is based essentially on nine years of shark collecting, January 1955 through December 1963, in shallow water on the central west coast of Florida by the Cape Haze Marine Laboratory. During the preparation of this manuscript some information was added on catches from January through April 1964.

On 7 January 1955, the Cape Haze Marine Laboratory was opened in Placida, Florida. Shark fishing began soon after and the first sharks were caught on 27 January on a 16-hook trot line set 3 miles off Gasparilla Pass in the Gulf of Mexico. For five years sharks were obtained in the area of Placida, Englewood, and Boca Grande, with the Laboratory's trot line, by hook and line, and from commercial fishermen, especially stopnetters working in Lemon Bay, confluent with Gasparilla Sound, on which the Laboratory was located.

In January 1960, the Laboratory was moved 30 miles north of Placida to Sarasota. The location on the south end of Siesta Key gave ready access to the Gulf through Midnight Pass. More than half the sharks included in this report were caught in the Sarasota area. Some specimens were obtained from commercial fishermen and anglers. Most were caught on trot lines set in the Gulf within 6 miles of Midnight Pass.

In the literature, mainly from numerous studies by Stewart Springer (1938, *et seq.*), 19 species of sharks are known from the littoral zone of western Florida. We have collected and examined 762 specimens (and 842 embryos) of 16 of these species (Table 2). In addition, this report lists species of doubtful occurrence and those which possibly occur but have not yet been recorded. There are probably at least 23 species of sharks on the wide continental shelf of western Florida.

The material presented in this report was at first accumulated only incidental to other studies. Originally sharks were collected for anatomical studies and experimentation. As many research workers came to use the facilities for collecting and keeping sharks, fishing activities were increased to accommodate the growing interest of staff and visitors. We then became more interested in gathering data for analyses of seasonal distribution, time of mating, parturition, and growth of embryos and young. Our early records were not always complete. Only in the last two years, since plans for summarizing our collection data took form, were more extensive data taken.

Acknowledgments

We are grateful to the excellent staff collectors of the Cape Haze Marine Laboratory: Beryl Chadwick (1955-1957), Oley Farver (1957-1961), and John Strong (1961-present). These fine fishermen have operated the boats and shark lines, taken care of feeding and handling the sharks studied in captivity, helped in the weighing, measuring, and dissection of sharks, and kept contact with local commercial and sportfishermen for additional specimens. Many of the small sharks were obtained through the cooperation of the commercial net fishermen, especially H. B. Alderman, Herbert Downing, John Fulton, Wes Godwin, and Z. P. Lewkowsky.

Many others have given us valuable help in our efforts to secure, examine, and study shark specimens: Frederick Aronson, Lester R. Aronson, Barbara and John F. Bass III, Elsie and John Bracken, Mary Braden, Harvey Bullis, Jr., R. L. Carmichael, Jr., Robert Friedman, William Gray, Erwin Gremli II, Jon Hamlin, Palmer Hanson, Thomas Harvey, Christopher Heller, Mary and John H. Heller, Robert Jackson, Allen Moody, the late E. R. Parkinson, Henri Pauchey, Robert Pelham, Lawrence Penner and family, Anthony Perks, Elver Raffield, the late Thomas Romans, William R. Royal, Milton Sanders, William M. Stephens, Charles Sundin, Donald Wilson, Warren J. Wisby, Timothy Wright, Thomas Young, and Richard Youngstrand. Sara Page helped in the preparation of tabular data; Marion Suss, Jeanne Houck, and Mary Eastridge assisted in keeping records, and Eric von Schmidt advised us in preparing some of the figures. Mary Eastridge and R. L. Carmichael, Jr. have greatly helped in many ways during the preparation of this manuscript.

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Material and Methods

Although this report covers mainly data from sharks caught from 1955 through 1963, in the cases of *Mustelus norrisi, Scoliodon terraenovae, Sphyrna tiburo,* and *S. mokarran,* data are included on specimens caught January through April 1964, as noted later. Specimens were obtained from the shallow coastal waters extending 48 miles along the central west coast of Florida from Longboat Key, Sarasota, south to Boca Grande Pass. This included the bays, passes, and Gulf waters to a maximum depth of 14 meters, about 6 miles off shore.

Data from a few exceptional records of sharks from outside this area are included in some of the analyses to assist the interpretations. We believe there is no noticeable difference in the shark population in the Placida, Englewood, and Sarasota areas and therefore we have grouped the data on specimens from these nearby areas for this report.

Whenever feasible each specimen was weighed, up to 42 measurements taken, stomach contents, gonads, embryos examined, and other pertinent data recorded. Parasites, jaws, vertebrae, dermal denticle samples, whole embryos, and parts of sharks were preserved as part of Cape Haze Marine Laboratory reference collection. Analytical studies have been made on samples of blood (Phillips, 1959; Urist, 1962) and liver (Heller *et al.,* 1957; 1963). In many cases specimens were kept alive in pens adjacent to the Laboratory grounds and used for behavioral studies.

In analyzing the data collected, especially such a factor as seasonal distribution, the methods used in obtaining specimens proved to be important. Weather conditions and the schedule of visiting investigators using shark material affected the frequency of the fishing operations. Table 1 and Figure 1 show the seasonal variation in our fishing operations. The weather in spring is generally the most favorable to these operations. In the summer there are more frequent rains, in the fall the winds are often too high to work the set lines, and in winter the low temperatures in shallow water drive away or cause less feeding activity among the species which live well in captivity (lemon, bull, and nurse sharks) and are used for experimentation. The spring months also are advantageous, as several species have nearly full-term embryos at this time and young sometimes can be delivered alive from a dying gravid female or they are born in the pens. A special, shallow "maternity pen" is used at this time of year to isolate gravid females from other large sharks in the main pen, which readily eat the newborn. The problems of maintaining sharks in these pens have been discussed by Clark (1962, 1963a,c). Descriptions and illustrations of these pens are given in Davies *et al.* (1963).

All lengths of sharks are total lengths (T.L.) unless otherwise indicated. Measurements are given in cm or mm except when quoting sources where measurements were taken in feet and inches and in the discussions of

large sharks (over 100 cm) where total length is given in both feet and cm for purposes of comparing our data with the literature

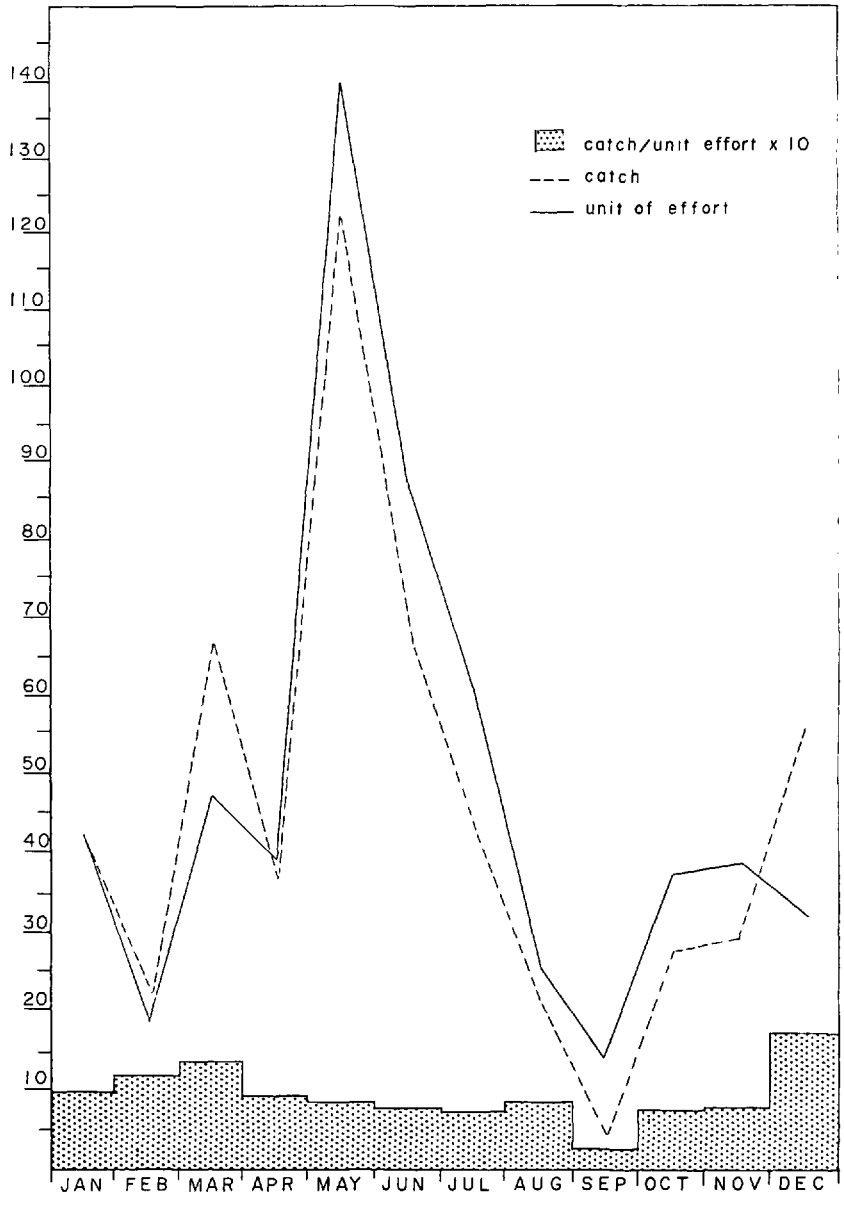

FIGURE 1. Monthly totals of shark catch and units of effort on CHML set lines, 1955-1963.

TABLE 1

MONTHLY TOTALS OF SHARKS CAUGHT ON CHML SET LINES, UNIT OF EFFORT, AND CATCH PER UNIT EFFORT 1955-1963[1]

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Year's Total		
	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C/E
1955	7	2	3	2	7	4	4	4																	21	12	1.75
1957																					0	2	13	4	13	6	2.16
1958	0	1			29	16	12	9	14	12	4	3	1	4											60	45	1.33
1959	4	5	7	3	2	2	5	3	3	6					14	4					7	3	6	2	48	28	1.71
1960	7	9	1	2	7	5	3	5	4	11	15	19	0	1					5	3					42	55	0.76
1961					22	16	2	3	20	23	12	14	27	28	4	4	4	7	7	10	3	5	10	3	111	113	0.98
1962	12	6	9	6			11	15	52	25	3	3	10	11	3	15			1	6	8	17	3	11	112	115	0.95
1963	11	19	2	5	0	4			29	63	34	48	5	17	0	2	0	7	14	18	11	11	23	12	129	206	0.63
Totals	41	42	22	18	67	47	37	39	122	140	68	87	43	61	21	25	4	14	27	37	29	38	55	32	536	580	
C/E	0.98		1.22		1.42		0.95		0.87		0.78		0.70		0.84		0.28		0.73		0.76		1.72				0.93

[1]C=Catch (number of sharks).
E=Unit of effort (one unit = one line of 15 to 18 hooks fished for an average of 24 hours).

TABLE 2

TOTAL NUMBERS OF EACH SPECIES AND SEX OF SHARKS FROM THE CENTRAL WEST COAST OF FLORIDA EXAMINED AT THE CAPE HAZE MARINE LABORATORY, JANUARY 1955 TO DECEMBER 1963[1]

Common name	Scientific name	Sex			
		♂ ♂	♀ ♀	Unknown	Total
1. Bull shark	*Carcharhinus leucas* (Valenciennes)	62	63	10	135
2. Sandbar shark	*Carcharhinus milberti* (Valenciennes)	15	91	3	109
3. Lemon shark	*Negaprion brevirostris* (Poey)	25	48	3	76
4. Bonnethead	*Sphyrna tiburo* (Linnaeus)	43	18	2	63
5. Blacktip shark	*Carcharhinus limbatus* (Valenciennes)	19	38	7	64
6. Blacknose shark	*Carcharhinus acronotus* (Poey)	21	16	24	61
7. Tiger shark	*Galeocerdo cuvieri* (Peron and Lesueur)	17	41	2	60
8. Nurse shark	*Ginglymostoma cirratum* (Bonnaterre)	37	8	13	58
9. Dusky shark	*Carcharhinus obscurus* (Lesueur)	2	47	0	49
10. Atlantic sharpnose shark	*Scoliodon terraenovae* (Richardson)	16	6	0	22
11. Great hammerhead	*Sphyrna mokarran* (Rüppell)	1	15	5	21
12. Spinner shark	*Carcharhinus maculipinnis* (Poey)	10	4	6	20
13. Florida smoothhound	*Mustelus norrisi* Springer	12	5	0	17
14. Scalloped hammerhead	*Sphyrna lewini* (Griffith)	4	0	1	5
15. Finetooth shark	*Aprionodon isodon* (Valenciennes)	0	1	0	1
16. Sand shark	*Carcharias taurus* Rafinesque	0	1	0	1
Total		284	402	76	762

[1]Except for specimens of *Mustelus*, *Scoliodon*, and *Sphyrna tiburo* caught January through April 1964, and one exceptionally large specimen of *Sphyrna mokarran*.

General Results

This report covers 762 sharks examined (Table 2). These figures include all local sharks, including those obtained by methods other than with set lines. The analyses of the seasonal distribution (by months) of individual species also include all local specimens regardless of how they were caught. (Figs. 2-5), with Figure 5 showing the winter species.

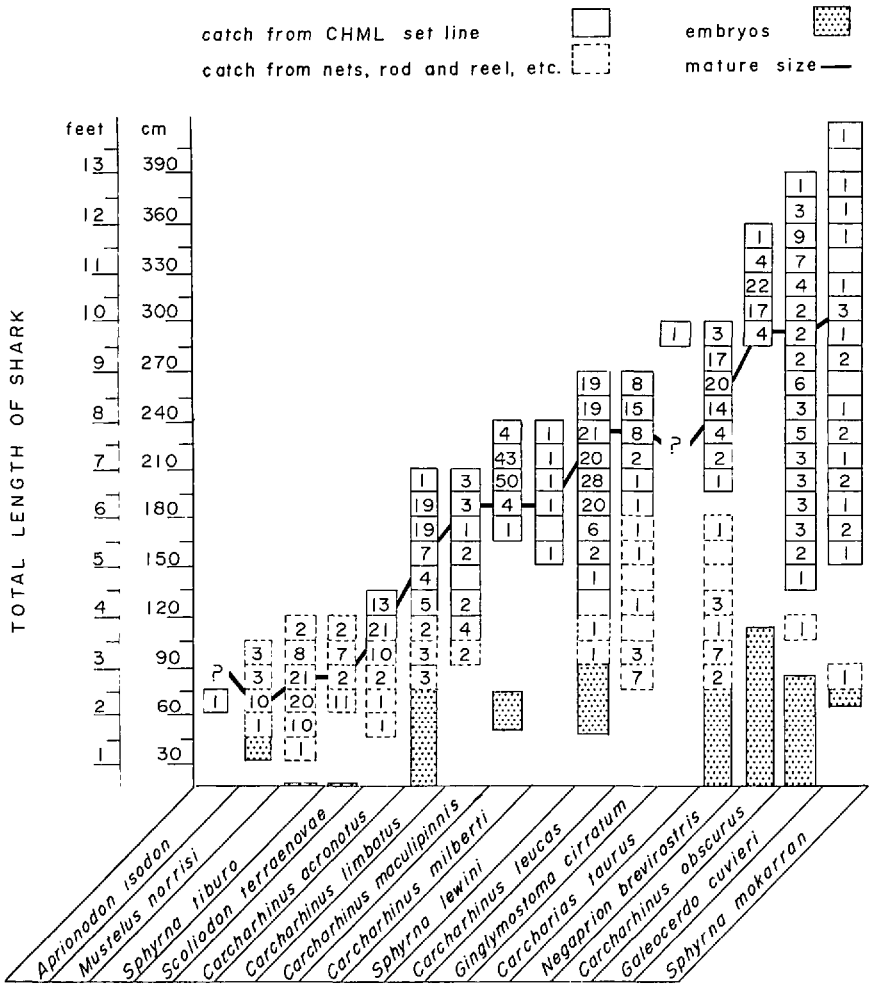

FIGURE 2. Length-frequency of sharks examined at CHML 1955 through 1963, plus additional data on *Mustelus norrisi, Scoliodon terraenovae, Sphyrna tiburo,* and the largest specimen of *S. mokarran* through April 1964. Free-swimming specimens measured to nearest 15 cm. Embryos measured to nearest 2.5 cm.

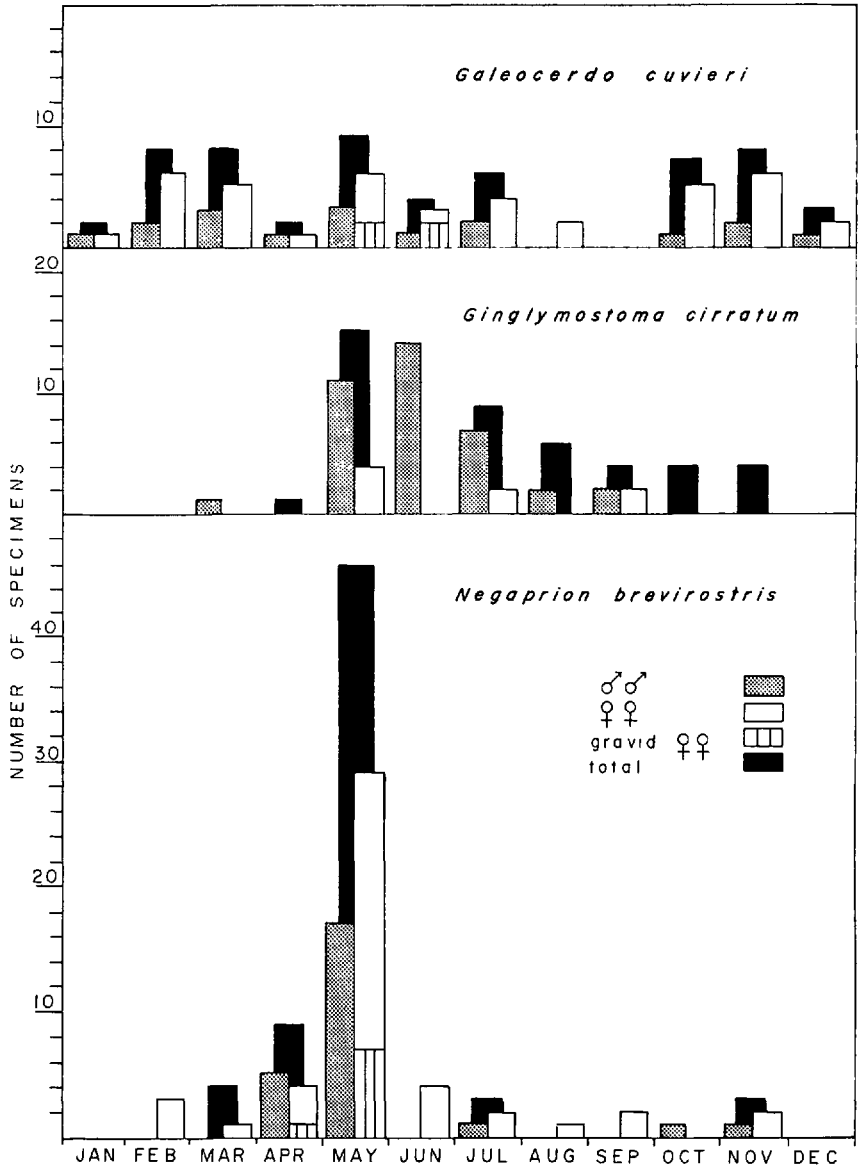

FIGURE 3. Seasonal distribution of *Galeocerdo cuvieri*, *Ginglymostoma cirratum*, and *Negaprion brevirostris* examined at CHML, 1959 to 1963. Specimens of unknown sex are included in the total.

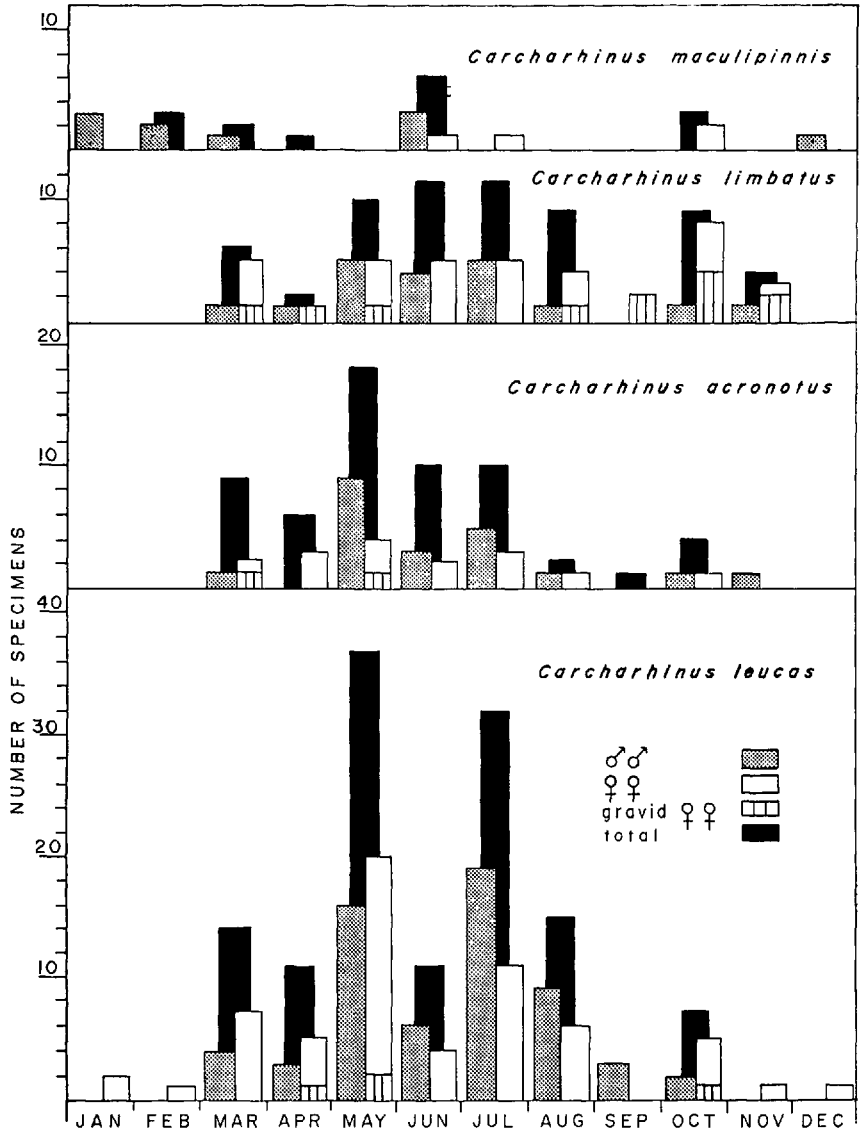

FIGURE 4. Seasonal distribution of *Carcharhinus maculipinnis, C. limbatus, C. acronotus,* and *C. leucas* examined at CHML, 1959 to 1963. Specimens of unknown sex are included in the total.

Family CARCHARIIDAE
Sand Sharks

Carcharias taurus Rafinesque — Sand Shark

A single specimen, a female 296 cm (9′9″), 514 lbs, was caught off Big Gasparilla Pass in 6 meters of water, on 24 February 1960. The ovary, approximately 40 cm diameter, contained thousands of eggs under 1 cm diameter. The uteri were highly elastic and had a vascular lining suggesting

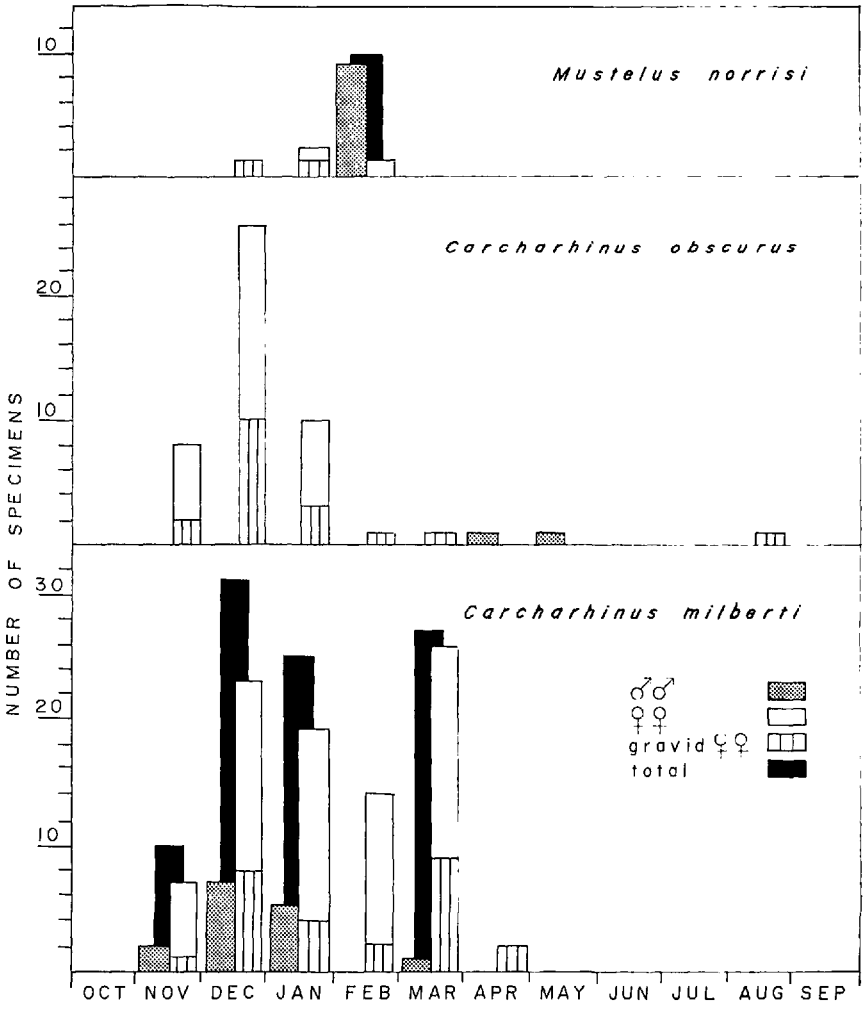

FIGURE 5. Seasonal distribution of *Mustelus norrisi*, *Carcharhinus obscurus*, and *C. milberti* examined at CHML, 1959 to 1963. (*M. norrisi* records of Jan., Feb. 1964 are included). Specimens of unknown sex are included in the total.

recent parturition. Stomach contents included *Brevoortia* sp., *Pogonias cromis, Bagre marinus,* and *Chaetodipterus faber.*

Bigelow & Schroeder (1948) believed this species occurs in the Gulf as a stray only. None of the extensive Gulf shark collections of the vessel OREGON (Springer & Bullis, 1956) includes records of this species. Springer (1939b) reported catching two adult females (9′2″ and 10′5″) off Englewood, in February and March. Springer (1948) also reported several adult females, one of which was carrying oviphagous embryos, caught off Louisiana in July. Other specimens from the Gulf of Mexico have been reported at the mouth of the Mississippi (Springer, 1960) and off Pass-a-Grille, Florida (Springer & Woodburn, 1960).

Family LAMNIDAE
Mackerel Sharks

Alopias superciliosus (Lowe) Bigeye thresher

Bigelow & Schroeder (1948:167) reported this species from Englewood, Florida. The specimen to which they refer (Springer, 1943) was actually from Salerno. We have found no records of thresher sharks from this area except as erroneous identifications in newspapers which included photographs of sharks obviously not this species.

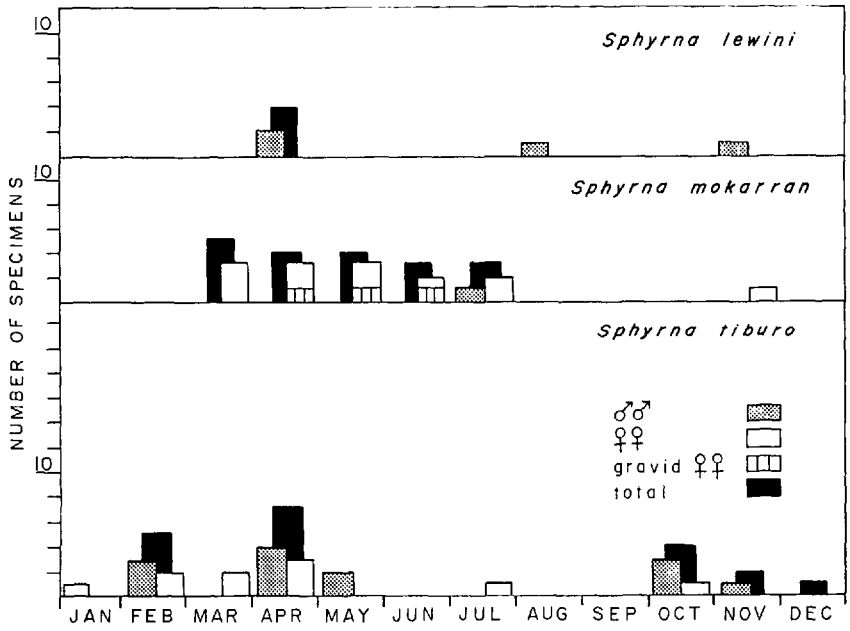

FIGURE 6. Seasonal distribution of *Sphyrna lewini, S. mokarran,* and *S. tiburo* examined at CHML, 1959 to 1963.

Alopias vulpinus (Bonnaterre) Thresher shark

Bigelow & Schroeder (1948) suggested that western Florida is included in the range of this species but no actual records exist.

Carcharodon carcharias (Linnaeus) White Shark

None has been seen by us. Springer (1939a) reported a 15½-ft immature female specimen caught in the Gulf 8 miles off Englewood, 1 February 1939 and another female, approximately 15 ft, caught near Sarasota the previous winter.

A third specimen (14′7″) from this area was caught by commercial fishermen, Milton Sanders and W. K. Weinhold, in 30 meters of water 30 to 40 miles off Sarasota, in January or February 1943. The sex was not noted and cannot be determined from the photograph (Fig. 7). The liver weighed 455 lbs and the weight of the shark was estimated at over a ton. Capt. Sanders told us that this was the largest of about a dozen white sharks he had caught during ten years of shark fishing in the eastern Gulf of Mexico and the only specimen from the Sarasota area.

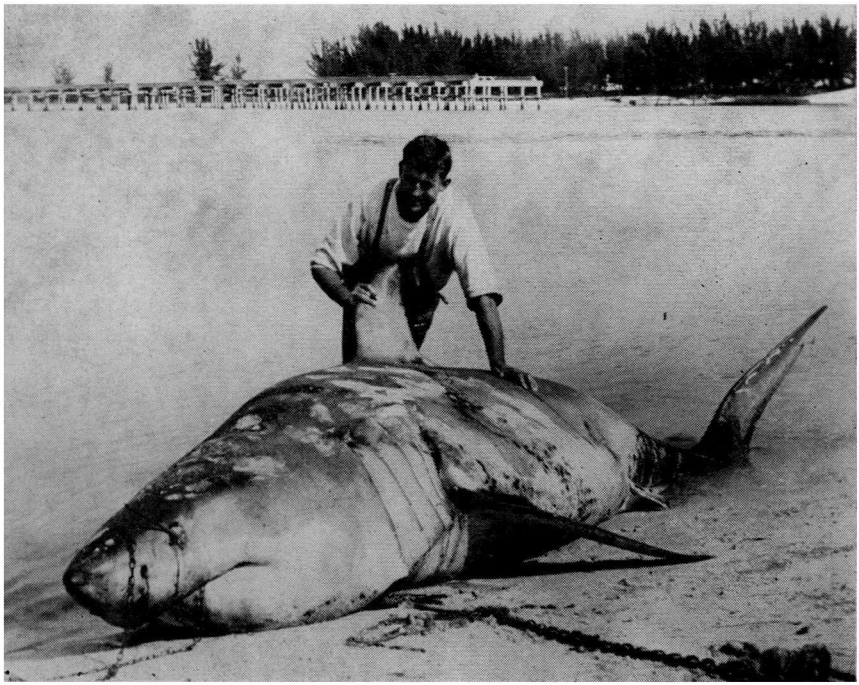

FIGURE 7. *Carcharodon carcharias,* 14′7″, caught off Sarasota 1943.

Isurus oxyrinchus Rafinesque Mako

Bigelow & Schroeder (1948) listed western Florida in the range of this species. Springer & Woodburn (1960) reported a 10½-ft specimen taken off St. Petersburg and a 6½-ft female taken in February, 80 miles southwest of Egmont Key. We have no other records from this area.

Family Orectolobidae
Nurse Sharks

Ginglymostoma cirratum (Bonnaterre) Nurse shark

Studies on the life history of the nurse shark were made at the Dry Tortugas by Gudger (1912, 1921, 1942). This is one of the most abundant and easily observed sharks in Florida. It lives well in captivity and has been kept alive in public aquariums for over 25 years (Clark, 1963c).

Experiments in instrumental conditioning of nurse sharks have been attempted at this Laboratory (Clark, 1963c) and have been found to be more successful when young were used (Aronson and Aronson, MS) rather than adults. Large nurse sharks (over 120 cm) were caught on set lines, except for two specimens taken on hand lines. Small specimens were caught in stop nets, or were taken by hand from under rocky ledges by skindivers.

Gudger (1942) stated that in this species a continuous process of fertilization, shell formation, and early development goes on in a single female during "a limited period of time." William Gray of the Miami Seaquarium informed us that he catches newborn, spotted specimens, about 12 inches long (30 cm) throughout the year. Henri Pauchey of Marathon, Florida, who has collected specimens for this Laboratory and has fished for many years in the Florida Keys has caught many young nurse sharks of 12-14 inches when they are common in that area in late spring and early summer. Bigelow & Schroeder (1948) reported free-swimming young of 27-29 cm (10-11″) but did not mention the time of year. The smallest free-swimming specimen examined locally was about 40 cm, in October, and specimens about 70 to 90 cm have been collected from May through November.

Bigelow & Schroeder (1948) stated that a 5-ft female has been found with embryos but this size reference (Beebe, 1941) is uncertain. Bell & Nichols (1921) reported an 8′6″ female caught 22 July off North Carolina with 14 eggs on each side. Presumably these were fertilized and in the uterus, as it is noted they had delicate, horny shells. According to Springer (1938), the nurse shark matures at about 230 cm (7′6″). We examined a female of exactly that size which was mature, had large ovarian eggs 45 mm in diameter, and which was apparently a virgin considering the

small vaginal opening. This specimen was caught 18 April 1964, and is not mentioned elsewhere in this paper.

Of the eight females in our records, three were over 230 cm but none had embryos. Five mature males (238 to 257 cm) were caught in May, June, and July, 1963. All appeared to have mated shortly before. Their claspers were hemorrhaging subdermally and externally. Smears showed motile sperm in quantity in the seminal vesicles and sperm fluid was oozing from the urogenital pore. In one male, motile sperm were numerous in viscous white mucus in the clasper groove. The other males also had quantities

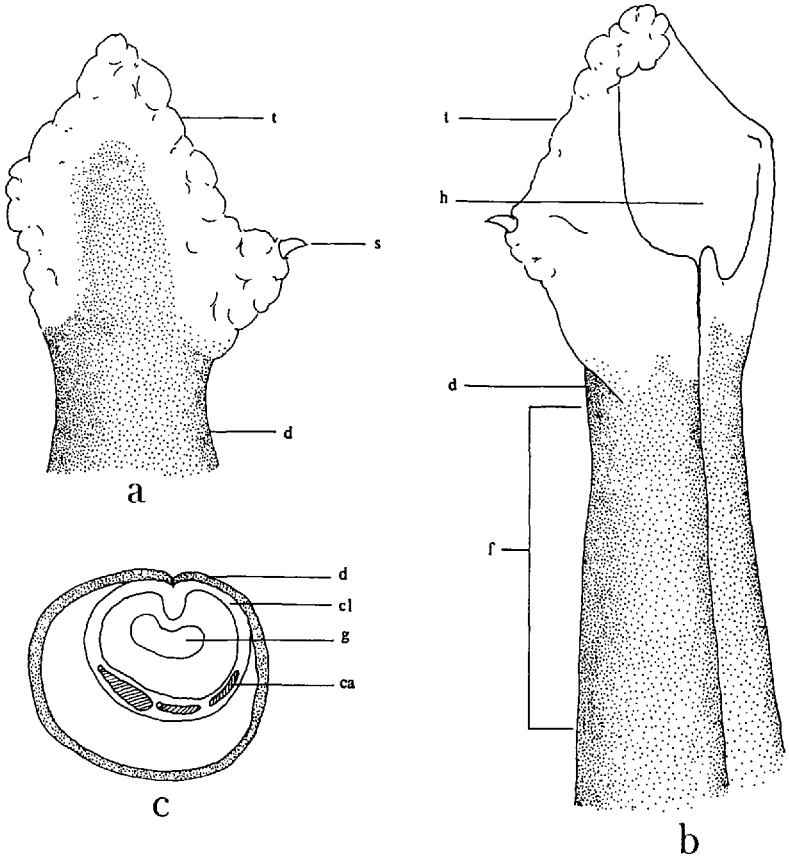

FIGURE 8. Right clasper of male *Ginglymostoma cirratum* 257 cm total length. *a.* clasper head in partly open position, ventral view; *b.* distal ¾ of clasper, dorsal view; *c.* cross section of clasper through area of fusion; *d.* dermal denticles (stippled); *t.* swollen, vascular tissue; *h.* hypopyle; *s.* spur; *f.* longitudinal extent of fusion (57 mm); *cl.* clasper cartilage; *g.* clasper "groove"; *ca.* calcified area of cartilage.

of this mucus in the clasper grooves but no sperm could be found. This secretion of the claspers is similar to that found in claspers of batoids where it is thought to be a nutritive and/or protective medium for sperm transport (Lamarca & Gilbert, 1961).

In two males, 239 and 249 cm, the claspers were fused over the grooves for a distance of 25 and 57 mm, or about 12 and 23 per cent respectively of the groove (Fig. 8). Clasper lengths are given in Table 21.

Weight-length relationships are summarized in Table 19.

As most nurse sharks caught are kept alive for some period, stomach contents of few freshly caught sharks have been examined. Those which were examined contained mostly mollusks and some small specimens of *Mugil* sp.

Family RHINCODONTIDAE
Whale Sharks

Rhincodon typus Smith — Whale shark

A single specimen, about 28 feet long, was sighted by several sport-fishermen less than 1 mile offshore just south of Gasparilla Pass, on 6 December 1958. The shark was basking at the surface and the caudal fin was protruding about 6 feet above the water. They were able to get very close and reported seeing the white spots and narrow stripes on the dark body. Gudger (1939) mentioned sightings of three whale sharks, 18 to 20 feet, reported by a ship's officer in the Gulf of Mexico at 26°15′N, 86°58′W, in May 1938, the only other record close to our area.

Family CARCHARHINIDAE
Requiem Sharks

Aprionodon isodon (Valenciennes) — Finetooth shark

One female, 76 cm, in Lemon Bay, Placida, 27 May 1955, was obtained from a stop net. Springer (1938) reported several specimens from Englewood but considered this species uncommon in our waters.

Carcharhinus acronotus (Poey) — Blacknose shark

Difficulties were experienced in obtaining whole specimens of this small shark as it is eaten quickly by other sharks when caught on the set lines. Of 54 specimens caught in this manner, almost half (24) were mutilated, and in many cases only the head remained. Of the specimens which could be measured and the sex identified, 15 were females 45 cm (1′5″) to 126 cm (4′1″) and 20 were males 98 cm (3′2″) to 117 cm (3′10″). Total lengths of some of the mutilated sharks were estimated from head measurements, but none exceeded the size range of those mentioned above. In addition six small specimens were caught close to shore in the Gulf by other fishermen. This species has been caught locally from March through November, with the greatest catches during May.

Springer (1938) reports that females with nearly full-term embryos, three to six in a litter, are caught January through April. We have examined two gravid females. A 118-cm (3′10″) female captured 22 March carried four embryos 35 to 38 cm. A 118-cm (3′11″) female captured 23 May carried three embryos 37 to 39 cm. Embryos are attached to the uterine wall by a yolk-sac placenta.

A specimen 45 cm still bearing an umbilical scar was captured 6 June, and a specimen 60 cm was caught 22 August. Bigelow & Schroeder (1948) reported an embryo or newborn of 49 cm with an umbilical scar.

C. acronotus in this area is mature at 103 cm, agreeing with Springer's (1938) records. Maturity probably is reached in about two years with yearlings measuring about 81-84 cm. Two mature males examined 11 October and 22 November had testes considerably reduced in size and no sperm was found in smears taken from the Wolffian ducts. A comparison of clasper length with total length of males is summarized in Table 21.

Evidence for a spring mating period is shown by the capture on 1 June of a mature male with seminal vesicles full of sperm fluid and a female with large ovarian eggs.

Weights of adults are 22 to 24 pounds.

In most cases, the stomachs of these sharks were empty. In some, *Chilomycterus schoepfi* and *Lagodon rhomboides* have been identified among the partly digested fish remains.

Carcharhinus leucas (Valenciennes) **Bull shark**

This is the most common shark caught on the set line, accounting for 18 per cent of the catch. A total of 129 bull sharks is recorded: 62 males 88 cm (2′11″) to 249 cm (8′1″); 63 females 155 cm (5′1″) to 264 cm (8′8″); and four of undeterminable sex. Adult males and females are represented almost equally in the seasonal distribution of this species. In March, about a month before the young are born, the catch increases. This increase continues through the mating season and into August, then declines during the winter months (Figure 4).

Four gravid females were examined (Table 3). The near full-term embryos removed from female CHML No. 84 lived, ate well, and were

TABLE 3

DATA ON GRAVID FEMALES AND EMBRYOS OF *Carcharhinus leucas*

CHML No.	T. L. of ♀ feet	cm	No. in litter ♂ ♂	♀ ♀	Totals	T. L. of embryos cm	Date
44	8′2″	249	1	4	5	36.4-39.3	27 Oct.
122	7′7″	233	3	3	6	66.0-68.5	12 May
38	8′4″	254	2+	1+	3+	67.6-74.0	20 May
84	8′6″	257	2+	1+	10	73.5-75.0	30 April

used in instrumental conditioning experiments (Wright & Jackson, 1964) and other physiological studies.

In three females the condition of the dissected uteri showed signs of parturition; fairly recently in a female examined 19 July, and some time before (based on older attachment scars) in females examined 10 August and 9 October. The above data indicate that young of approximately 74-75 cm and possibly somewhat larger are born in April, May, and June in this area (Figure 9).

Seemingly this conclusion disagrees with Bigelow & Schroeder (1948), who recorded females with embryos which they considered nearly ready for birth. These were taken in Florida in October, January, and February, and they suggested that young are born in Florida in late winter and early spring. However, they apparently underestimated the size at birth, which they gave as 65 to 70 cm, and if they had seen later embryos they would have approximated our findings.

We obtained an 88-cm specimen on 27 May. Springer & Woodburn (1960) recorded a 92-cm specimen caught in Tampa Bay in November. Bigelow & Schroeder (1948) recorded a 92-cm specimen taken in Florida

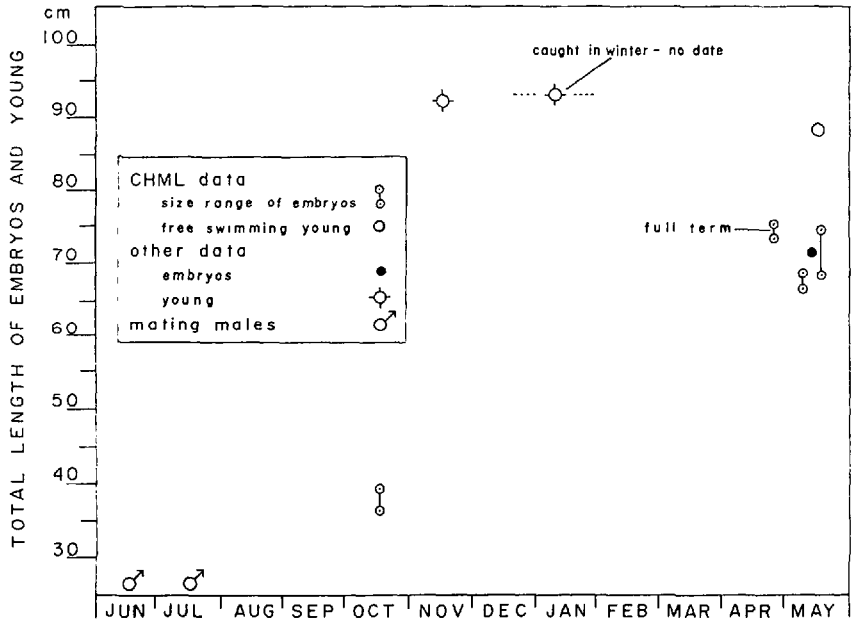

FIGURE 9. Monthly sizes of embryos and young of *Carcharhinus leucas*. Other data Included: Springer 1940a, Bigelow and Schroeder 1948, Springer and Woodburn 1960.

in winter and estimated this as a yearling. All of the above are probably under a year old and the 88-cm specimen only a few months old.

The mating season is June and July. During these months eight of the males examined had bleeding claspers. Schwartz (1960a) reported an adult male of 7′2″ captured from Chesapeake Bay in July as having "gonads . . . . about an inch wide and full of milt." In May we recorded females with ovarian eggs 25-32 mm in diameter. Dr. Thomas B. Thorson (personal communication) noted larger eggs (estimated as nearly 50 mm) in a freshwater specimen of *C. leucas* caught in summer about 300 yards from the mouth of Rio San Juan at San Juan del Norte, Nicaragua. The available information suggests a gestation period of 10 to 11 months.

Adult females are usually larger than males. Our records show 14 females 244 cm (8′0″) and over whereas only 2 males reached this size. The smallest female carrying embryos or with large ovarian eggs was 233 cm (7′7″); the smallest breeding male was 225 cm (7′4″). The male had claspers 7.5 per cent of the total length.

Weight-length relationship of bull sharks.—Accurate weights were taken on 104 bull sharks: 49 males, 49 non-gravid females, 4 gravid females, and two in which sex was not recorded. Average weights in various size groups are compared with those of seven other species of sharks (Table 19). Table 4 compares the male bull shark weights with those of the female in various size groups.

Non-gravid female bull sharks were 16.4 to 20.5 per cent heavier than males in size groups measured to the nearest 15 cm in the 180- to 240-cm total length range. Gravid females affect the average weight of females in each size group by a relatively insignificant amount (less than 3.3 per cent). However, only one or two gravid females are in each of three size groups (225, 240, 255 cm). A larger number of gravid females, especially a weighted average versus non-gravid females, might make a more significant difference. The only female (CHML No. 84 in Table 3) that contained full-term embryos was below average in weight (325 pounds) for that size group (average weight 382 pounds).

We considered the possibility that the variation in weights within a size group was due to seasonal changes. For example, sharks might feed more at one time of year than another, or might store reserve in form of lipids in the liver, as has been shown by Denton (1961) in the basking shark. However, our data show no correlation.

Most of the stomachs examined were empty but *Archosargus probatocephalus, Caranx* sp., *Centropomus undecimalis, Euthynnus alletteratus, Galeichthys felis, Lactophrys tricornis, Megalops atlanticus, Mugil* sp., *Prionotus* sp., and parts of other sharks, crustaceans, and mollusks were found.

Proportional dimensions for this species are summarized in Table 20.

TABLE 4

A COMPARISON OF THE WEIGHTS OF MALE AND FEMALE *Carcharhinus leucas*[1]

Total Length Groups in cm[2]	Males			Females				
	No. of Specimens	Weight Range	Average Weight	No. of Specimens	Weight Range[3]		Average Weight[4]	
60	1	5	5	—	—		—	—
135	1	37	37	—	—		—	—
150	0	—	—	2	66-84		75	—
165	0	—	—	3	56-112		81	—
180	9	96-137	112	4	96-146		115	—
195	11	74-145	117	14	100-181		130	—
210	11	123-225	164	3	184-198		170	—
225	11	174-253	209	7+(1)	197-339	(284)	223	(226)
240	5	176-281	244	11+(1)	207-350	(390)	284	(293)
255	0	—	—	5+(2)	323-490	(325,463)	382	(385)
Total	49			49+(4)				

[1]Weights are given to the nearest pound.
[2]Total length groups are to the nearest 15 cm.
[3]Weights for gravid females are in parentheses.
[4]Figures in parentheses include weights for gravid as well as nongravid females.

Carcharhinus limbatus (Valenciennes) Blacktip shark

This species was not caught in the winter months (December through February) but was fairly common the rest of the year. We examined 64 specimens: 38 females, 78 cm (2′6″) to 191 cm (6′3″); 19 males, 86 cm (2′10″) to 175 cm (5′9″), and 7 damaged specimens of undetermined sex.

Data on gravid females are summarized in Table 5.

TABLE 5
DATA ON GRAVID FEMALES AND EMBRYOS OF *Carcharhinus limbatus*

CHML No.	T. L. of ♀ feet	T. L. of ♀ cm	No. in litter ♂♂	♀♀	Totals	T. L. of embryos cm	Date
31	5′4″	164	—	—	3	ca. 7.5	23 Aug.
34	5′9″	175	2	4	6	not noted	5 Sept.
35	5′1″	156	1	2	3	not noted	6 Sept.
16	6′0″	182	—	1+	8	24.2	1 Oct.
59	5′3″	161	3	1	4	25.9-26.8	4 Oct.
18	5′10″	178	1	5	6	29.2-30.5	8 Oct.
36	5′11″	179	4	2	6	27.0	10 Oct.
37	6′0″	182	3	0	3	43.0-47.0	15 Nov.
32	5′10″	178	6	1	7	36.9-40.3	17 Nov.
6	5′7″	169	4	4	8	47.8-51.6	19 Mar.
10	5′7″	169	5	2	7	51.7-60.0[1]	8 Apr.
11	5′10″	178	3	3	8[2]	49.2-53.0	10 May
14	6′2″	187	—	—	—	—[3]	23 May

[1]Full term. Young dissected from female lived over one month.
[2]Sex of two embryos not determined.
[3]Had recently given birth to young.

The monthly size records of embryos agree with Springer (1938, 1940a) and Bigelow & Schroeder (1948) and suggest that young are born in April, May, and probably early June (Figure 10).

Several males examined 27 May, 8 June, and 18 July had enlarged testes and quantities of sperm-filled fluid in the seminal vesicles indicating the mating season. A female caught 17 May had very large ovarian eggs. From these data the gestation period is apparently 10 to 11 months. Free-swimming young of 76-89 cm found in March and April probably are yearlings.

The smallest mature female in our records is 155 cm (5′1″). The smallest mature male is 135 cm (4′5″). In this male and four larger specimens (143 to 163 cm) the clasper length varied from 6.5 to 7.6 per cent of the total length and the siphon sacs reached to or nearly to the mid-pectoral region (23-33 per cent of total length). A slightly smaller male (134 cm) had full-length siphon sacs (26 per cent), but undeveloped claspers of only 4.1 per cent of total length. A male 126 cm (4′2″), with undeveloped siphon sacs (less than 5 per cent of T.L.) and claspers (4.3 per cent of T.L.), barely extending beyond the distal margin of the pelvic fins, had fully developed testes and from 3 to 5 cc of sperm-filled

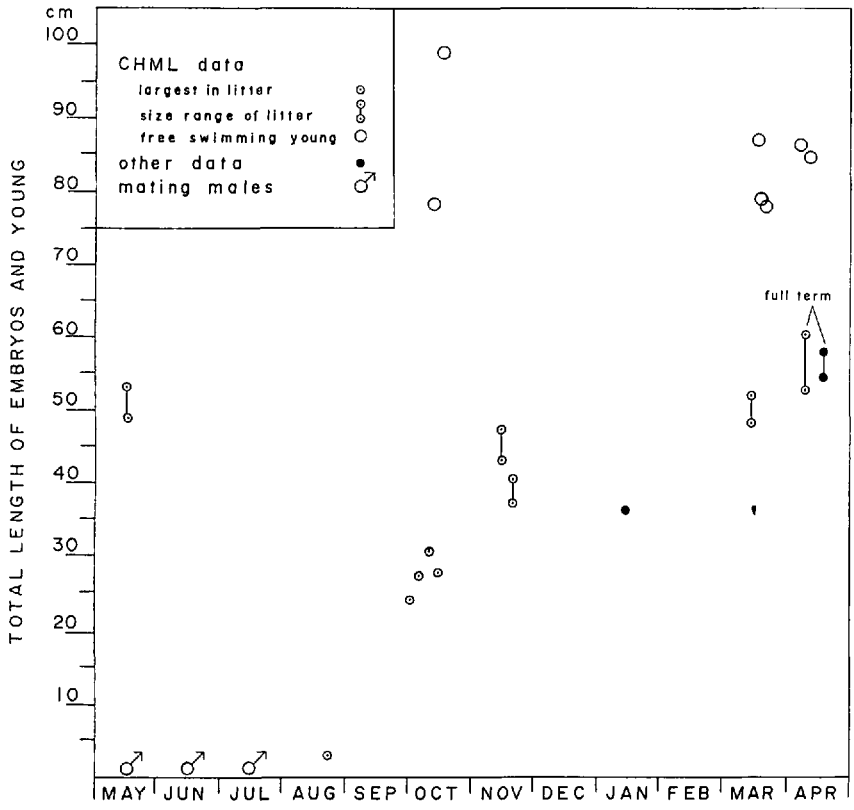

FIGURE 10. Monthly sizes of embryos and young of *Carcharhinus limbatus*. Other data included: Springer 1938, 1940a.

fluid in each seminal vesicle. This male was caught 18 July 1963. The condition of the testes in males smaller than this was not noted as it had been assumed they were immature by the lack of development of the secondary sex characters. A similar condition of mature testes and immature claspers and siphon sacs has been noted by us in *C. leucas*. Clasper lengths compared with total length and maturity are summarized in Table 21. Proportional dimensions are summarized in Table 20 and weights in Table 6.

Contents of stomachs included *Caranx* sp., *Centropomus undecimalis, Chilomycterus schoepfi, Galeichthys felis, Lactophrys tricornis, Lagodon rhomboides,* and remains of crabs.

Carcharhinus maculipinnis (Poey) Spinner shark

Springer (1938, 1940a) reported only adult males of this species from

TABLE 6

A COMPARISON OF THE WEIGHTS OF MALE AND FEMALE *Carcharhinus limbatus*[1]

Total Length Groups in cm[2]	Males			Females					
	No. of Specimens	Weight Range	Average Weight	No. of Specimens	Weight Range[3]		Average Weight[4]	
75	—	—	—	1	7		7	
120	2	21-24	23	3	23-37		28	
135	3	33-49	39	—	—		—	
150	3	40-50	44	1+(1)	56	(66)	56	(61)
165	1	64	64	6+(1)	60-92	(85)	74	(75)
180	1	80	80	4+(2)	79-111	(95-100)	97	(97)
Total	10			15+(4)				

[1]Weights are given to the nearest pound without gravid females.
[2]Total length groups are to the nearest 15 cm.
[3]Weights for gravid females are in parentheses.
[4]Figures in parentheses include weights for gravid as well as nongravid females.

the Englewood area but no embryos or young. Our records include young of both sexes, sub-adult, and adult males. This species is caught infrequently. Only 20 specimens were examined: 17 caught on set lines, two on rod and reel, and one found dead on the beach. Of these, four were non-gravid females of 89 cm (2′11″) to 118 cm (3′11″), 10 were males of 88 cm (2′11″) to 203 cm (6′7″), and six were mutilated specimens of approximately 90 to 200 cm from the shark lines.

Clasper lengths of males are summarized in Table 21. The smallest mature male was 188 cm (6′2″). Bigelow & Schroeder (1948) reported a 6′3″ female carrying 10 young.

Separation of this species from *C. limbatus* using existing key characters given in the literature presented problems. The tooth serrations in young and position of the first dorsal fin in relation to the pectorals did not show the clear-cut differences indicated in the keys. Dr. J. A. F. Garrick advised us that the difference in the prenarial distance is the most reliable character. It is longer (1.2 to 1.5×) than the distance from front of nostrils to front of mouth in *C. maculipinnis,* while in *C. limbatus* it is shorter (0.7 to 1.1×).

Proportional dimensions and data on weights are summarized in Table 20.

Carcharhinus milberti (Valenciennes) Sandbar shark

This species was the second most frequently captured shark on the setlines. A total of 110 adult or sub-adult specimens were collected: 91 females 167 cm (5′6″) to 230 cm (7′6″), 15 males 192 cm (6′3″) to 204 cm (6′8″), and three damaged specimens of undetermined sex. These were caught from 6 November through 2 April (Fig. 4).

Reproduction.—Springer (1960) made an extensive study of this species, analyzing data from populations in both the Atlantic and the Gulf of Mexico. He suggested that in the Gulf of Mexico the northwestern area apparently is a nursery range for this species. He pointed out, however, that this is indicated only by the capture of a few females with near full-term embryos, and one 30-inch free-swimming specimen. According to Springer, his overall data indicate the size at birth is 17 to 25 inches, and the time of birth from March through early August. He estimated the length at birth as about 24 inches (61 cm) "in northern Florida waters."

There are no records of young from our area. We examined 26 litters of embryos from 39 cm in November to 58 cm in March (Table 7). On 1 March 1962 a 206-cm (6′9″) female captured in January gave birth to several young in the pen, but these were eaten by other sharks before we could examine them. Gravid females have been captured in this area as late as 2 April. Embryos about 540 mm, removed prematurely, have lived for several days but did not appear full term.

Helm (1961), in a popular account, wrote of seeing a female dusky

TABLE 7
DATA ON GRAVID FEMALES AND EMBRYOS OF *Carcharhinus milberti*

CHML No.	T. L. of ♀ feet	cm	No. in litter ♂♂	♀♀	Totals	T. L. of embryos cm	Date
34	6′6″	190	1	10	11	39.0-40.6	17 Nov.
94	6′10″	209	6	3	9	28.8[1],41.4-44.0	10 Dec.
95	7′1″	217	7	4	11	38.0-42.0[2]	11 Dec.
96	6′8″	202	8	3	11	36.0-39.5[2]	11 Dec.
63	7′0″	214	6	4	10	43.0-46.0	22 Dec.
42	6′11″	210	5	4	9	45.0-47.5	25 Dec.
45	6′11″	213	4	5	9	42.0-46.0	26 Dec.
64	7′4″	223	—	—	10	45.2	27 Dec.
45a	7′0″	215	4	6	10	47.0-49.0	31 Dec.
83	6′10″	209	4	4	8	37.8[3],40.0[3],46.5-49.8	10 Jan.
85	6′8″	203	3	5	8	ca. 46.0	15 Jan.
87	7′0″	215	5	4	9	46.8-51.0	16 Jan.
48	7′0″	213	4	8	12	44.4-47.8	29 Jan.
31	6′8″	204	7	3	10	not measured	3 Feb.
49	7′0″	213	3	6	9	52.1-59.2	28 Feb.
67	6′9″	206	—	—	2+[4]	not measured	1 Mar.
7	6′9″	205	—	—	10	not measured	2 Mar.
8	6′9″	205	—	—	5	not measured	2 Mar.
21	6′7″	203	—	—	8	not measured	22 Mar.
23	6′10″	209	1	8	9	not measured	23 Mar.
24	6′6″	201	3	4	7	not measured	23 Mar.
54	6′10″	209	1	3	4	not measured	25 Mar.
25	6′7″	203	4	4	8	not measured	26 Mar.
59	6′9″	206	6	3	9	55.0-58.0[5]	27 Mar.
26	6′10″	210	4	5	9	not measured	1 Apr.
27	6′8″	203	4	6	10	not measured	2 Apr.

[1]A runt, not mummified.
[2]All yolk gone except about 5 cc in smallest embryo.
[3]Mummified embryos.
[4]Born alive in pen, eaten by other sharks.
[5]Born alive in pen.

shark give birth to young on the northwest coast of Florida in March. He described the young as about a foot in length. Considering the size of the young and the time of birth, it seems possible that this was a sandbar shark.

Springer (1960) presented evidence that the maximum mating activity of this species is in June on the southeastern coast of Florida. He estimated the gestation period at nine months, with a range of eight to twelve months. We have no evidence on time of mating except for extrapolation of data on ovarian egg size. Measurements of largest egg sizes show a gradual increase in diameter from 10 mm in November to 30 mm in July. However, the female carrying 30-mm eggs in July was caught 26 January and lived in the laboratory pen isolated from males. Eggs of 30 mm are full size according to Springer. A gravid female caught by us on 11 December had a single large egg in the ovary which measured 35 mm. This appeared to be a resorbing egg.

Springer (1960) noted mummified embryos 25-38 cm long, about the size when the yolk of the egg is completely absorbed. One litter examined by us (CHML No. 83, Table 7) contained mummified embryos 38 and 40 cm, considerably smaller than their litter mates. Another litter of embryos (CHML No. 94) contained one live runt embryo.

Springer mentioned occasionally finding white ovarian eggs in *C. milberti* and other species, and suggested that this is due to some pathological condition. He found them in exceptionally large specimens of *C. obscurus* and *Sphyrna* sp. The largest female specimen of *C. milberti* we examined, 230 cm (7′6″), had white ovarian eggs of 10 mm. Females of this species and others have been noted to have both the large, normal yellow eggs as well as some smaller, white ones, but no relation to size or any abnormal condition has been noticed except as noted under *Sphyrna mokarran* (p. 58).

Maturity and growth.—The smallest mature male measured by Springer was 5′11″, and the smallest mature female was 6′0″. None of the males we examined was less than 6′3″. Some males were not examined for maturity but of eight that were, all were mature (Table 21) and it might easily be assumed that the others were mature or nearly so, considering their size. The smallest mature female was 185 cm (6′1″). The state of maturity in all females was not observed, but of those that were, all were mature or nearly so, although some, including a 203-cm (6′8″) specimen, apparently had never carried young. The smallest female of 167 cm (5′6″) was probably immature. All other females were 6 feet or more. A female specimen, No. 101, 197 cm (6′5″), was a mature virgin; the hymen

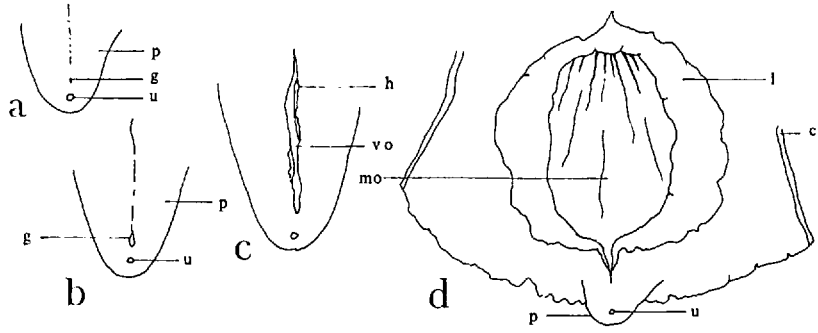

FIGURE 11. Diagramatic sketches of the changes in the vaginal opening of a typical carcharhinid female based on sketches and studies of *Carcharias taurus, Carcharhinus leucas, C. milberti, Galeocerdo cuvieri,* and *Negaprion brevirostris. a.* juvenile; *b.* sub-adult; *c.* mature virgin; *d.* mature, mating; *p.* urinary papilla; *u.* urinary pore; *g.* genital pore; *l.* labium; *e.* cut edge of cloaca; *v.o.* vaginal opening of mature virgin; *h.* remains of hymen; *m.o.* vaginal opening of mating female.

which virtually seals the vaginal opening in immature sharks had ruptured but was still in place (Fig. 11c).

Springer noted that the male/female ratio is about equal in embryos, 1:1.2 in young off North Carolina, and 1:5 in adults from Salerno, Florida. He also recorded that only 17-18 per cent of the mature females from Englewood were gravid, all of which points to a decrease in the presence of males, leading up to an apparent "shortage of males in the breeding population."

Our records show a comparable male/female ratio, 1:1.1, or 53 per cent females in the 21 litters where sex is recorded, and a predominance of males in the adult population of about 6:1. Of 89 mature or nearly mature females 27 per cent were gravid. In *Negaprion brevirostris* and in *Galeocerdo cuvieri* the percentage of mature females found gravid was 43 and 33 respectively.

A comparison of the weights of males and females (Table 8) shows that non-gravid females are 15 to 20 per cent heavier than males in the same size group and gravid females are only slightly heavier than non-gravid females. Proportional dimensions are summarized in Table 20.

Stomach contents.—A list of stomach contents includes *Archosargus probatocephalus, Bagre marinus, Brevoortia* sp., *Caranx crysos, Chilomycterus schoepfi, Cynoscion* sp., *Dasyatis* sp., *Dorosoma* sp., *Galeichthys felis, Haemulon* sp., *Lagodon rhomboides, Menticirrhus* sp., *Mugil* sp., *Opsanus* sp., *Paralichthys* sp., *Scomberomorus cavalla, Sphyraena barracuda, Sphyrna tiburo, Syngnathus* sp., octopods, and remains of other mollusks.

Carcharhinus obscurus (Lesueur) Dusky shark

We examined 49 specimens of this species: 47 females from 287 cm (9′4″) to 342 cm (11′3″) and 2 males 299 cm (9′10″) and 316 cm (10′4″). The males were caught 13 April and 20 May. Springer (1938) reported no adult males taken from Englewood and none taken after February. The females were caught 19 November through 30 March within 3 miles of shore, with one exception, a 319-cm (10′4″) gravid female captured by a sportfisherman 30 August, 50 to 60 miles offshore, on the bottom in 35 meters of water. This exceeds the range of this paper but is included here because this species is rarely, if ever, caught locally in the summer and because this female was gravid and adds to our data on embryonic development.

The gravid females fall into two distinct groups (see Fig. 12 and Table 9) based on the sizes of their embryos. The appearance and morphometric data on these females show no differences. For the purpose of this discussion we refer to the main group as A and the second group as B. Group A consists of 14 gravid females caught during the winter months, with embryos 43 to 70 cm, and the one exception caught in August. Group B

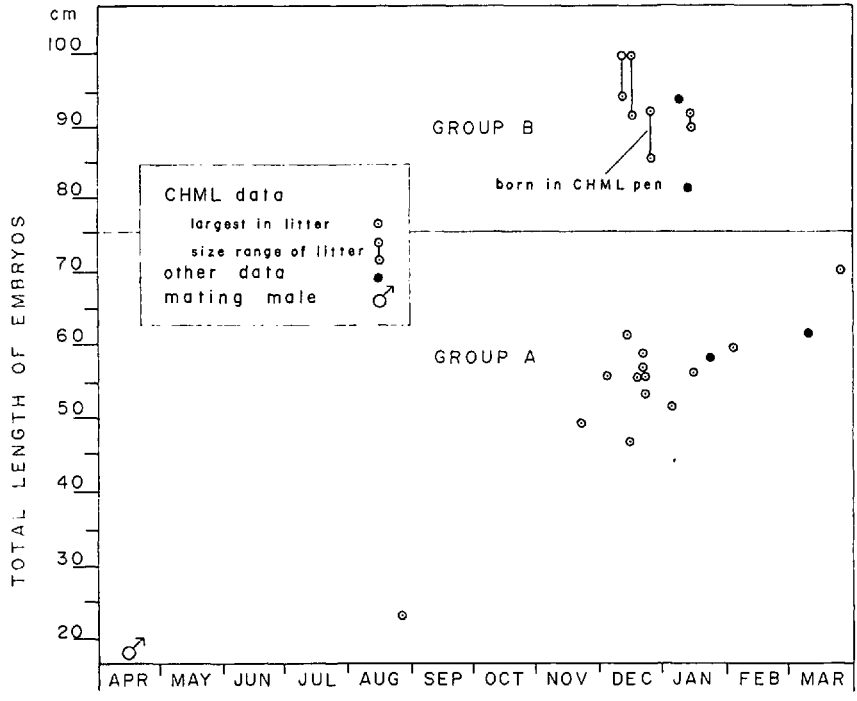

FIGURE 12. Monthly sizes of embryos of *Carcharhinus obscurus*. Other data included: Springer 1938, 1940a.

consists of four females carrying near or full-term young 85 to 100 cm at the same time of year.[1]

Springer's (1938, 1940 a) records of lengths of embryos taken in winter also show the two size groups corresponding to our records.

Bigelow & Schroeder (1948) suggested the size at birth for this species as about 85 to 97 cm. Their study material includes two free-swimming specimens taken in August; an 85-cm specimen from the Gulf off Louisiana; and a 10-cm female from the vicinity of Woods Hole, Massachusetts. They further mention new-born specimens taken off southeastern Florida in late winter. Probably the smaller embryos of 43 to 70 cm (group A) we examined would reach full size (Fig. 12) by summer. The females carrying the larger near-term embryos (group B) possibly give birth in the Sarasota area. No free-swimming specimens were captured locally, but a female (CHML 27) caught 14 December lived until 31 December, and gave birth to seven young 84 to 94 cm on 25 December in the CHML pen. Although these young were slightly smaller than the largest embryos we

[1]On the basis of precaudal vertebral counts (87-91) of both groups A & B, we have ruled out the possibility of any of these being *C. galapagensis* (see Garrick & Schultz, 1963).

TABLE 8

A COMPARISON OF THE WEIGHTS OF MALE AND FEMALE *Carcharhinus milberti*[1]

Total Length Groups in cm[2]	Males			Females				
	No. of Specimens	Weight Range	Average Weight	No. of Specimens	Weight Range[3]		Average Weight[4]	
45.0	3	1-2	1	3	1-2		1	
165.0	0	—	—	1	82		82	
180.0	—	—	—	2	103-125		114	
187.5	1	107	107	3	123-137		130	
195.0	4	98-145	124	13+(5)	101-195	(145-195)	146	(151)
202.5	2	125-134	130	11+(6)	109-196	(140-216)	150	(168)
210.0	1	133	133	10+(5)	131-255	(151-184)	160	(162)
217.5	0	—	—	2	192-224		208	
225.0	0	—	—	2	163-187		175	
232.5	0	—	—	1	209		209	
Total	11			48+(16)				

[1]Weights are given to the nearest pound.
[2]Total length groups are to the nearest 7.5 cm.
[3]Weights for gravid females are in parentheses.
[4]Figures in parentheses include weights for gravid as well as nongravid females.

TABLE 9
DATA ON GRAVID FEMALES AND EMBRYOS OF *Carcharhinus obscurus*

CHML No.	T. L. of ♀ feet	cm	No. in litter ♂♂	♀♀	Totals	T. L. of embryos cm	Date
Group A							
10	10′6″	319	—	—	(2+)	21.6-22.8	30 Aug.
54	10′3″	312	5	2	7	46.8-49.7	22 Nov.
57	ca. 10′7″	323	1	7	8	43.0-47.0	13 Dec.
32	10′7″	322	3	3	6	51.6-52.7	22 Dec.
51	10′8″	326	3	7	10	52.0-56.0	4 Dec.
1	11′0″	336	4	2	6	52.0-56.0	19 Dec.
30	10′4″	316	5	1	6	(37.6)[1] 53.1-56.4	22 Dec.
31	11′0″	335	5	4	9	50.5-56.2	22 Dec.
28	9′6″	289	3	5	8	57.2-59.0	21 Dec.
5	10′6″	318	5	4	9	57.2-60.8	19 Dec.
29	10′6″	319	5	3	8	48.5-51.0	5 Jan.
12	9′7″	292	4	3	7	all ca. 56.0	15 Jan.
40	9′11″	301	5	3	8	56.0-59.0	2 Feb.
9	11′10″	338	2	1	(3[2])	68.0-69.9	30 Mar.
Group B							
27	10′0″	305	—	—	(7[3])	85.5-92.4	25 Dec.
45	10′9″	329	4	4	8	91.5-100.0	16 Dec.
46	10′8″	324	4	4	8	94.5-100.0	16 Dec.
18	10′1″	306	4	4	8	90.0-96.5	15 Jan.

[1]Mummy embryo.
[2]Only one uterus functional.
[3]Gave birth in pen; some embryos probably eaten.

examined, they appeared full term and in excellent condition. They lived about one week when sudden, freezing weather killed all sharks in the pens, including the mother of these young, also still in good condition.

Measurements of the largest ovarian eggs in nine females showed a range of 14 to 20 mm in November, 20 mm in December, and one of 25 mm in January. These would possibly be full size in the spring.

During dissection of the male captured in April much semen spilled from the right seminal vesicle before it could be collected but the remainder measured over 300 cc. If this sperm-laden male is an indication of a spring mating season the gestation period for this species could be about eight or nine months (population B) or about 16 months (population A). The evidence for 16-months gestation is stronger when one considers the information in Figure 12 on development of embryos in Group A and the free-swimming young reported by Bigelow & Schroeder (1948). This is longer than known gestation periods of other large carcharhinid sharks (Backus, Springer, & Arnold, 1956; Ripley, 1946; Springer, 1950b and 1960).

In the 18 litters studied, 129 embryos were recorded. In the 16 litters counted the number of embryos per litter varied from six to nine with an

average of eight. Not included in the above is a litter of three embryos found in a female with only the right side of the uterus developed, and two embryos taken out of a female collected in August, but the uterus was not examined completely. The male:female ratio in embryos is about equal (1:1.1). Our data show no correlation between the size of the female and the number of embryos being carried.

Victor Springer (1961) recorded two female specimens (10′2″ and 10′10″) from Boca Ciega Bay, Tampa, in December 1960 as *Eulamia floridana.* The teeth from these specimens were subsequently checked by Stewart Springer (personal communication) who has identified the specimens as *C. obscurus. Eulamia floridana* (=*Carcharhinus falciformis,* according to Garrick & Schultz, 1963) is unlikely to occur in the shallow coastal area of the central Gulf coast of Florida.

Weight-length relationships of *C. obscurus* are summarized in Tables 10 and 19 and proportional dimensions are given in Table 20.

Fishes found in *C. obscurus* during this study included *Brevoortia* sp., *Caranx hippos, Chaetodipterus faber, Haemulon* sp., *Mugil* sp., *Menticirrhus saxtilis, Paralichthys* sp., *Raja* sp., *Scomberomorus maculatus, Sphyraena* sp., *Strongylura* sp., *Trachinotus* sp., and some eels. Invertebrates included squid, octopods, starfish, barnacles, and the bryozoan *Zoobotryon.*

Galeocerdo cuvieri (Peron and Lesueur) Tiger shark

This species is found throughout the year with females outnumbering the males in our catches, 2.5:1. This is the only species in which as many juveniles and sub-adults are caught on the shark lines as are adults. This shark was caught in all months but September but this may be due to the fewer times lines are set in that month because of weather conditions. We examined 59 tiger sharks: 41 females 133 cm (4′4″) to 373 cm (12′3″); 16 males 102 cm (3′4″) to 352 cm (11′7″); and two mutilated specimens of undetermined sex. These were caught on the set lines with the exception of a 102-cm male specimen caught on rod and reel 28 miles offshore in 30 meters of water.

We examined four gravid females, 335 cm (11′0″) to 356 cm (11′8″), carrying from 37 to 50 embryos (Table 11). All the embryos (except one mummy) from the female caught 21 May were alive and active when the female was dissected. The umbilical cords dropped off easily and there was no bleeding. These young were placed in pens. Some were eaten by adult sandbar sharks *(C. milberti)* also kept in one of the pens but many tiger sharks survived and fed in captivity. One lived 12 weeks and grew from 69 to 89 cm and from 2½ to 4¾ lbs., when it was killed accidentally while still in excellent condition. A 69-cm embryo was examined at the University of Miami which was taken from a female captured at Government Cut, Miami, on 17 May. A female examined in Sarasota on 11 July

TABLE 10

A COMPARISON OF THE WEIGHTS OF MALES AND FEMALES OF *Carcharhinus obscurus*[1]

Total Length Groups in cm[2]	Males			Females				
	No. of Specimens	Weight Range	Average Weight	No. of Specimens	Weight Range[3]		Average Weight[4]	
82.5	1	11	11	3	9-10		9	
90.0	2	11-13	12	3	10-12		11	
97.5	—	—	—	1	10		10	
277.5	—	—	—	1	517		517	
285.0	—	—	—	(1)	—	(535)	—	(535)
292.5	1	368	368	3	463-551	—	498	—
300.0	—	—	—	7+(2)	339-571	(444-580)	454	(467)
307.5	1	345	345	2+(3)	437-461	(487-546)	449	(488)
315.0	—	—	—	2+(1)	480-532	(532)	506	(515)
322.5	—	—	—	(3)	—	(437-603)	—	(532)
330.0	—	—	—	(1)	—	(506)	—	(506)
352.5	—	—	—	(1)	—	(645)	—	(645)
Total	5			22+(12)				

[1]Weights are given to the nearest pound.
[2]Total length groups are to the nearest 7.5 cm.
[3]Weights for gravid females are in parentheses.
[4]Figures in parentheses include weights for gravid as well as nongravid females.

TABLE 11
DATA ON GRAVID FEMALES AND EMBRYOS OF *Galeocerdo cuvieri*

CHML No.	T. L. of ♀ feet	cm	No. in litter ♂ ♂	♀ ♀	Totals	T. L. of embryos cm	Date
54	11′8″	356	—	—	56	0.6 - 0.26	12 June
25	11′0″	335	—	—	37	0.44 - 0.72	28 June
26	ca. 11′0″	—	—	—	37	ca. 68.0[1]	21 May
27	11′5″	345	22	28	50	51.0[2],71.0[3], 74.5-77.0	6 June

[1]Full-term embryos, lived and fed in pens; one lived over three months.
[2]Mummified embryo.
[3]A noticeable runt.

appeared to have given birth recently. Although Springer (1938) thought possibly there is no special period for release of young, he found early and late embryos in April and very early embryos in June at Englewood. On the basis of the above data it seems that the young are born in the spring. Baughman & Springer (1950) gave information pointing toward a spring breeding period. We examined a mature male on 25 May with engorged and bleeding claspers. The gestation period could be slightly over a year explaining the presence of both early and late embryos in spring (Fig. 13).

It was noted in both females carrying the very early embryos that there were a number of extra shells in the uterus which did not contain embryos or yolk. The two females with large, near-term embryos 68 to 77 cm (Table 11) each carried also an exceptionally small, mummified embryo.

Free-swimming young of 18 to 20 inches (45 to 50 cm) reported by Bigelow & Schroeder (1948) and Baughman & Springer (1950) seem premature. On several occasions young removed prematurely survived several days. In two cases a dusky shark and a lemon shark living in captivity each released one premature embryo which lived over a day.

Springer (1949) stated that the tiger shark matures at about 9′6″. The smallest mature female in our records is 297 cm (9′9″); however, a larger female, 332 cm, had small uteri and apparently had never carried embryos. Only six mature or nearly mature males were captured, all over 290 cm (9′6″).

The testes produce mature sperm before external secondary sex characters are fully developed. A 213-cm male had sperm-filled fluid in the seminal vesicles although the claspers did not extend beyond the distal margin of the pelvic fin and the siphon sacs were also undeveloped.

This species does not ordinarily live well in captivity, although in the last few years some have survived over half a year at marine laboratories and aquariums in various parts of the world. Three specimens lived well

in pens for many months and ate regularly. One of these, a male 321 cm (10′6″), actually beached its head on the sloping shallow end of its pen when the feeder approached. It was hand-fed easily in this position which rendered it relatively harmless. The shark then had to struggle to return to the water. Another, a 246-cm female, was trained to press a target which rang a bell to obtain its food.

This large species, which appears sluggish and docile in captivity, is commonly considered one of the most dangerous of sharks. A small shark of this species is thought to have attacked a swimmer in this area (Clark, 1960).

Weights and proportional dimensions are given in Tables 12, 19, and 20.

The feeding habits and stomach contents of the tiger shark have occasioned several papers on this subject alone (Gudger 1948, 1949; Saunders & Clark, 1962). Stomach contents of this species in our area include: *Bagre marinus, Dasyatis* sp., *Elops saurus, Galeichthys felis, Lactophrys tricornis, Mugil* sp., *Ogcocephalus* sp., *Symphurus* sp., parts of sharks, birds, turtles, tunicates, octopuses, crabs, horseshoe crabs, mollusks, jellyfish, and assorted trash such as rubber bands and cigarette packages.

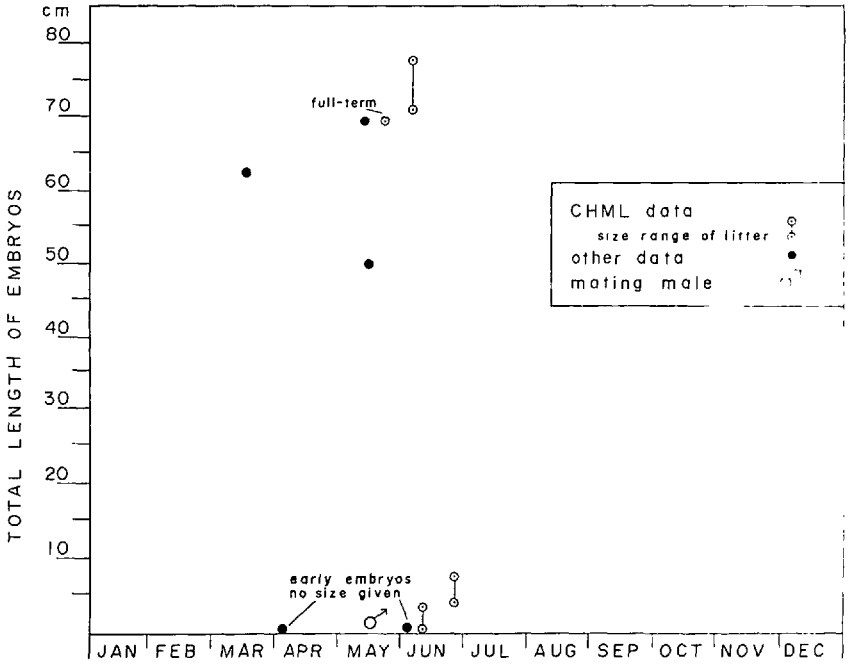

FIGURE 13. Monthly sizes of embryos of *Galeocerdo cuvieri*. Other data included: Springer 1938, 1940a; one specimen from Miami.

TABLE 12

A COMPARISON OF THE WEIGHTS OF MALES AND FEMALES OF *Galeocerdo cuvieri*[1]

Total Length Groups in cm[2]	Males			Females		
	No. of Specimens	Weight Range	Average Weight	No. of Specimens	Weight Range[3]	Average Weight[4]
105	1	7	7	0	—	—
150	0	—	—	1	70	70
165	0	—	—	2	48-63	56
180	0	—	—	1	75	75
195	0	—	—	1	83	83
210	2	92-123	108	1	85	85
225	1	111	111	2	114-119	117
240	0	—	—	1	127	127
255	1	158	158	3	157-242	194
270	1	295	295	0	—	—
300	0	—	—	1	357	357
315	2	337-462	399	0	—	—
330	0	—	—	4	425-725	541
345	1	442	442	2+(1)	530-602+(725)	566 (618)
360	0	—	—	2	729-733	731
Total	9			21+(1)		

[1]Weights are given to the nearest pound.
[2]Total length groups are to the nearest 15 cm.
[3]Figure in parentheses is weight of a gravid female.
[4]Figure in parentheses includes weight of gravid female.

Mustelus norrisi (Springer) Florida smoothhound

We examined 17 specimens from this area: 12 males 50 to 85 cm (20 to 34 inches) and five females 66 to 96 cm (26 to 39 inches) including two gravid females 91 and 96 cm. With the exception of one specimen found dead on the beach all were caught from December 1963 to April 1964, by rod and reel or in commercial nets set on the bottom close to shore in water less than 7 meters. Their prior absence is not presently explicable. Springer (1939b) reported mature males caught in gill nets off Englewood during winter but no females. Victor Springer (1961) reported several specimens, including a gravid female (see below) from St. John's Pass, Madeira Beach, 40 miles north of Sarasota, in late January.

The two gravid females examined by us each carried litters of ten embryos. The embryos from the female caught 27 December measured 23 to 24 cm, and from the female caught 22 January 25 to 28 cm. Each embryo was contained within a thin, transparent membrane and attached by a vascular pseudoplacenta. There was no yolk material except in one mummified embryo which had a dried-up yolk. All the heads were directed anteriorly. The embryos were not full term. They were lively in both cases when removed from the mother and were put into an outdoor tank in which some survived for several days. The mummified embryo, about 40 mm, had external gills and the caudal section was tightly curled and imbedded in the dried yolk.

A gravid female, taken by the M/V SILVER BAY on 25 March 1958, on the bottom in 90 meters about 26 miles east of the Mississippi delta, was given to us by Harvey Bullis. It contained eight embryos 34 to 37 cm. Three males and one female were in the left side of the uterus and two males and two females in the right. The ovary of this female had eggs of various sizes, the largest being 15 mm in diameter. This female, although out of the geographic range considered in this report, is mentioned because few gravid females of this species have been examined.

Victor Springer (1961) reported a gravid female taken in January in

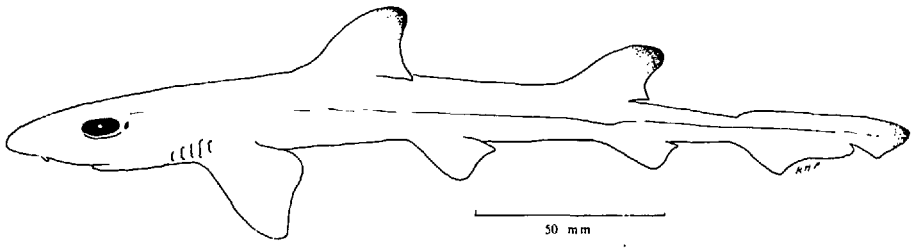

FIGURE 14. Embryo of *Mustelus norrisi* 236 mm T.L.

TABLE 13

DATA ON SIX FEMALES AND EMBRYOS OF FIVE LITTERS OF *Mustelus norrisi*

T. L. of ♀ cm	No. in litter ♂♂	♀♀	Totals	T. L. of embryos Range in cm	Date	Locality	Source
68	—	—	0	—	25 Jan. 1964	Sarasota, Florida	CHML No. 4
83		ca.	12	18.2-19.4	14 Dec. 1906	Key West, Florida	Springer, S. (1939b)
91	2	8	10	22.6-23.6	27 Dec. 1963	Sarasota, Florida	CHML No. 2
96	8	1	10[1]	(0.4)[1] 24.8-27.5	22 Jan. 1964	Sarasota, Florida	CHML No. 3
96	8	6	14	(18.5)[2] 23.8-26.8	28 Jan. 1961	Tampa, Florida	Springer, V. (1961)
118	5	3	8	34.2-36.5	25 Mar. 1958	North central Gulf of Mexico	CHML No. 1 from M. V. Silver Bay

[1]One mummy, sex undeterminable.
[2]Apparently a runt.

the Tampa Bay area. He noted that these embryos were different from the mother in having the lower lobe of the caudal fin poorly developed and rounded rather than strongly developed and pointed. Also, both dorsal fins and the dorsal lobe of the caudal fin of the embryos had "large black blotches." The embryos of the two litters from Sarasota likewise had embryos with the lower caudal lobe rounded and the black posterior edges fading to dusky on the dorsal and caudal fin (Fig. 14). A 68-cm female specimen we examined had the second dorsal fin tipped with black and the tip of the upper caudal lobe slightly dusky. The only other record of a gravid female which we could find in the literature was the allotype, from Key West, Florida, described by Springer (1939b).

A summary of the data on gravid females, two from the literature and three examined by us (Table 13), shows a gradual increase in the size of the embryos from 18 cm in December to 37 cm in March.

Most specimens between 60 and 70 cm were mature, the females apparently maturing at a slightly larger size. The 680-cm non-gravid female was a mature or nearly mature virgin with an intact hymen. The maximum size of the ovarian eggs was 3 mm.

Morphometric data on four embryos, four adult females, and one male are presented in Table 14. Differences between proportional measurements of embryos and adults show a decrease in eye diameter with age, a decrease in the snout-to-mouth measurement, and an increase in the height of the first and second dorsal fins.

The stomach contents of Sarasota specimens included a small amount of well-digested teleost fishes, but consisted mainly of crabs and shrimps. The northern Gulf specimen had an empty stomach.

Negaprion brevirostris (Poey) Lemon shark

We examined 75 lemon sharks from this area: 48 females 69 cm (2′3″) to 291 cm (9′6″); 24 males 95 cm (3′1″) to 296 cm (9′8″), and three damaged specimens of undetermined sex. The smaller specimens (less than 166 cm) were taken with stop nets in bays and the larger sharks were taken on setlines in the Gulf. These were caught in most months of the year but in May the catches of both sexes increased greatly. This increase may be due to three factors: the gathering of males and non-gravid females for mating; the arrival of near-term gravid females ready to release their young in shallow waters; and increased fishing in 1962 and 1963 at this time of year for this species and the tiger shark, *Galeocerdo cuvieri* (Fig. 2), which are fished for more intensively for biochemical samples. A lipid from the liver has been found to increase mammalian resistance to disease (Heller *et al.*, 1963).

This species lives well in captivity and has been kept in the CHML pens for behavioral studies (Clark, 1960, *et seq.*). We examined nine

gravid females (Table 15); young were netted in various months and young were born in the laboratory pens. These records combined with other reports on this species (Bigelow & Schroeder, 1948; Springer, 1938, 1940a) and Springer's (1950b) monograph on the natural history of this species give further information on the stages of embryonic development and indications of growth in the young.

Mating season.—Bigelow & Schroeder (1948) stated that the lemon shark breeds in southwestern Florida in spring and summer. Our records confirm

TABLE 14

DIMENSIONS OF *Mustelus norrisi* AS PER CENT OF TOTAL LENGTH

	Embryos				Adults				
CHML[1] No.	2a	3a	2b	3b	4	2[2]	3[2]	1[2,3]	14
Sex	♀	♀	♂	♂	♀	♀	♀	♀	♂
Total length (cm)	22.6	24.9	23.6	25.2	68.0	90.6	95.5	118.0	57.1
Standard length	79.6	79.1	80.9	79.4	81.5	82.6	82.7	77.9	80.6
Snout to mouth	8.0	8.8	8.1	7.6	5.7	5.4	5.1	5.1	5.6
Mouth breadth	6.2	5.0	5.9	5.4	5.3	5.3	4.9	5.2	5.1
Eye diameter	4.4	4.2	4.2	4.0	2.5	2.1	2.3	2.0	2.3
Dorsal 1, height	7.5	7.0	8.5	7.2	9.0	9.3	8.3	10.1	8.7
Dorsal 1, base	10.6	10.2	11.0	10.7	10.1	11.9	10.2	11.4	11.2
Dorsal 2, height	6.2	6.2	6.4	5.9	6.0	6.8	6.8	7.0	5.8
Dorsal 2, base	10.6	9.3	9.7	8.3	10.3	8.3	8.8	7.4	8.6
Caudal, upper margin	21.2	20.4	19.4	20.8	18.7	19.8	16.9	20.2	19.1
Caudal, lower margin	7.5	8.0	8.1	8.4	8.0	8.3	8.6	8.1	7.5
Pectoral, anterior margin	12.4	12.0	12.3	11.9	14.0	14.1	12.8	14.4	12.6
Pectoral, inner margin	7.1	7.6	5.9	7.5	6.3	5.8	5.8	6.1	5.8
Pectoral, distal margin	9.3	7.2	8.9	7.1	10.4	10.7	9.7	11.4	9.9
Pectoral, base margin	4.9	3.3	5.5	3.8	4.7	—	—	—	4.2
Pelvic, anterior margin	7.1	7.6	7.2	6.7	5.8	7.2	7.4	7.4	7.2
Pelvic, inner margin	4.4	3.3	4.7	3.4	4.7	3.8	4.4	4.8	3.3
Pelvic, distal margin	5.3	4.4	5.5	5.2	5.3	5.8	6.0	7.0	5.2
Clasper, length	—	--	2.5	2.8	—	—	—	—	8.4
Anal, height	3.5	2.8	3.0	3.0	3.2	3.8	3.6	3.4	2.8
Anal, base	6.0	6.0	6.4	5.3	7.5	5.8	6.5	4.7	5.9
Snout to Dorsal 1	32.2	30.0	30.8	29.8	33.4	29.3	28.1	28.8	28.2
Snout to Dorsal 2	60.0	61.0	60.0	61.5	62.6	64.5	62.0	65.0	60.7
Snout to Pectoral	21.8	21.3	20.3	18.6	17.5	17.6	16.9	18.2	18.0
Snout to Pelvic	45.3	45.5	44.5	46.0	44.0	44.6	44.1	43.2	42.2
Snout to Anal	66.0	66.5	65.0	67.5	65.0	67.8	65.8	66.5	65.5
Interspace between:									
Dorsal 1 and 2	17.7	21.6	17.8	20.6	22.8	22.9	25.0	22.9	21.9
Dorsal 2 and caudal	11.0	12.0	11.4	12.3	10.6	11.3	—	9.3	12.8
Anal and caudal	8.4	10.8	8.5	9.5	8.8	7.8	8.8	5.9	9.8

[1]Embryo number corresponds to that of gravid female from which embryo was removed.
[2]Gravid.
[3]Specimen obtained from the M/V SILVER BAY in the northern Gulf of Mexico.

this and indicate a peak of mating activity in spring. Mating behavior of this species was observed in the pens in May and June, and sharks in copula were seen on 1 May (Clark, 1963c). The bleeding claspers of a male captured in May indicated recent mating activity in the non-captive shark. A female captured on 2 June was kept in a pen with a male and some apparent courtship activity of this pair was noted. The female died 11 August and had quantities of sperm in the uteri.

State of testis after mating season.—Springer (1950b) stated that the size of the testes was not recorded to determine if there is any reduction in size following the breeding season. We examined only one mature lemon shark after the breeding season, on 16 October. The testes in this shark were decidedly reduced in size, consisting of little more than the longitudinal canal and epigonal organ. The seminal vesicles were not distended and no sperm could be found in smears from the testes or Wolffian ducts. A similar condition was noted in a mature specimen of *Carcharhinus acronotus* in October and November and in a specimen of *C. leucas* in November.

Egg size.—According to Springer (1950b) the ovarian eggs in this species reach a diameter of 25 mm or more. Our records of 21 mature or nearly mature females examined 25 April through 9 August show nine females with ovarian eggs measuring 35 to 40 mm. These large eggs number from 15 to 24 in the right ovary (the underdeveloped left ovary has never been found with eggs over 9 mm) with many smaller eggs (under 11 mm) also present. Except for two, females 250 cm and larger all had large eggs. Of these two one carried full-term embryos and the other showed signs of recent parturition. Females from 241 to 248 cm are probably just reaching maturity (see below).

One female captured 8 May and observed in courtship activity in the pen died on 9 August. She had full-size (40 mm) ovarian eggs as well as eggs in the uterus. Although the embryos had not attained a macroscopically visible size the uterine eggs appeared to be normal, each in an individual, teardrop-shaped sac measuring 35×90 mm. The shell or sac covering is a golden brown, cellophane-like material twisted at either end of the sac to form long, crimped cords which are bunched up and are deeply embedded in the uterine wall. The cord from the apical and anteriorly directed end of each sac measured about 90 cm when stretched out and is the more deeply embedded. The posterior cord is about 16 cm long.

Parturition.—Springer (1950b) stated that the climax of the parturition period is April through June. Our records support this on the basis of young born in our pens, the size of the embryos, and the condition of the uteri in females examined during these months.

Two litters of healthy, full-term young were born in the pens. On 11 or 12 May 1958, a female about 250 cm captured a few days before gave birth to five young which lived and fed for weeks until they were eaten by another newly captured mature male shark of the same species. On 5 May 1962, we removed six young from a 256-cm female. These lived in the pen until 22 September when they escaped during a flood.

In April and May, all embryos from newly captured females examined were near or full term. Between 29 April and 18 May, four gravid females had 53 embryos about 55 to 61 cm. After 18 May we found no females carrying sizeable embryos. Fertilized eggs with embryos too small to see macroscopically were found in the uteri in August. Small embryos 13-15 mm were found in December (Table 15).

In females not carrying embryos in May the uteri may be narrow, indicating that the females are immature or just maturing, or the uteri may be large, elastic, or flabby. Sometimes these large uteri have birth scars and gelatinous material indicating recent parturition. Three such females were noted in May.

Gestation period.—Springer (1950b) estimated that the gestation period of the lemon shark is 10 months. F. G. Wood, Jr. has informed us (personal communication) that a female lemon shark kept in captivity at Marineland, Florida, for slightly over a year without contact with a male gave birth to a litter of young.

We have a particularly interesting case of a female observed for one and a half years. She was captured on 8 May 1958 and gave birth to five healthy young on 11 or 12 May. Many behavioral tests were made on this shark and a male captured 16 May 1958 (Clark 1960, 1962, 1963a & c). This pair was observed copulating on 1 May 1959. On 10 December 1959 when the female died she contained six embryos 34-39 cm long. This indicates a gestation period of close to 12 months.

Litter and embryo sizes and growth rate.—In our records of nine litters the numbers of embryos per litter ranged from five to 17 with an average of 11 (Table 15).

From records of embryos, new-born, and young, an estimate of the growth rate of young was attempted. Springer (1950b) suggested that young born in late May and early June reach a length of 65 inches (165 cm) in 6 months. We found only two cases where growth rate of young was noted. Springer (1939b) observed a growth of roughly 10 cm in the first 40 days of young which were observed living under a dock at Placida. We kept a female of about 170 cm from 24 April to 12 September and noted a growth of about 35 cm during this time. Growth of a captive shark may not reflect the growth rate in nature but suggests a growth rate of about 8 cm per month at this size. If we consider the

TABLE 15

DATA ON GRAVID FEMALES, EMBRYOS, AND YOUNG OF *Negaprion brevirostris*

CHML No.	T.L. of ♀		No. in litter			T.L. of embryos	Date
	feet	cm	♂ ♂	♀ ♀	Totals	Range in cm	
72	8′6″	260	—	—	10[1]	minute	9 Aug.
14	8′5″	256	3	3	6	33.8-38.6	10 Dec.
13	8′9″	266	7	10	17	All ca. 58.0	29 Apr.
36	8′8″	263	—	—	16	full term ca. 60.0	1 May
42	9′2″	280	—	—	12	near term	5 May
43	8′5″	256			6	full term ca. 60.0	5 May
44	9′6″	291	5	8	13	60.0-62.0	7 May
75	8′10″	270	5	6	11	55.0-60.0	8 May
14	(8′5″)	(256)[2]	—	—	5	full term ca. 60.0[3]	12 May
23	9′2″	279	—	—	12	full term ca. 60.0	18 May

[1]Also nine large eggs in ovary.
[2]Size at death, 19 months after this parturition.
[3]Born naturally in shark pen.

parturition season and our records of lengths of young caught in February, March, and April (81 to 122 cm), and November (94 cm), a young specimen of 165 cm seems more likely to be a yearling (Fig. 15).

Maturity.—Springer (1950b) stated that the lemon shark rarely grows to more than 9′4″ and that the largest male he examined was 9′2″ and the largest female 9′4″. We examined two specimens over this size, a male 296 cm (9′8″) and a female 291 cm (9′6″).

Springer (1950b) noted that maturity is reached at 7′5″ or more. We examined one female 236 cm (7′8″) with sizeable elastic uteri. However, we have examined four females 239 cm (7′10″) to 242 cm (8′0″) which were immature, one 240 cm (7′11″) female was noted to be definitely a virgin as the vaginal opening was minute. The other three had small, tight uteri not capable of permitting entry of a full-size ovarian egg. The smallest female examined with full-size ovarian eggs was 252 cm (8′3″) and the smallest female with young was 256 cm (8′4″). We have little evidence of male size at maturity. Most males captured were 251 cm (8′2″) and larger, and obviously mature. Clasper lengths are given in Table 21.

Length-weight proportions are summarized in Table 16 and 19 and proportional dimensions in Table 20.

Stomach contents.—The stomach contents of the specimens examined included *Bagre marinus, Chilomycterus schoepfi, Galeichthys felis, Mugil* sp., *Rhinobatos lentiginosus,* and octopods.

Scoliodon terraenovae (Richardson) Atlantic sharpnose shark

Although Springer (1938) reported that specimens were taken in all

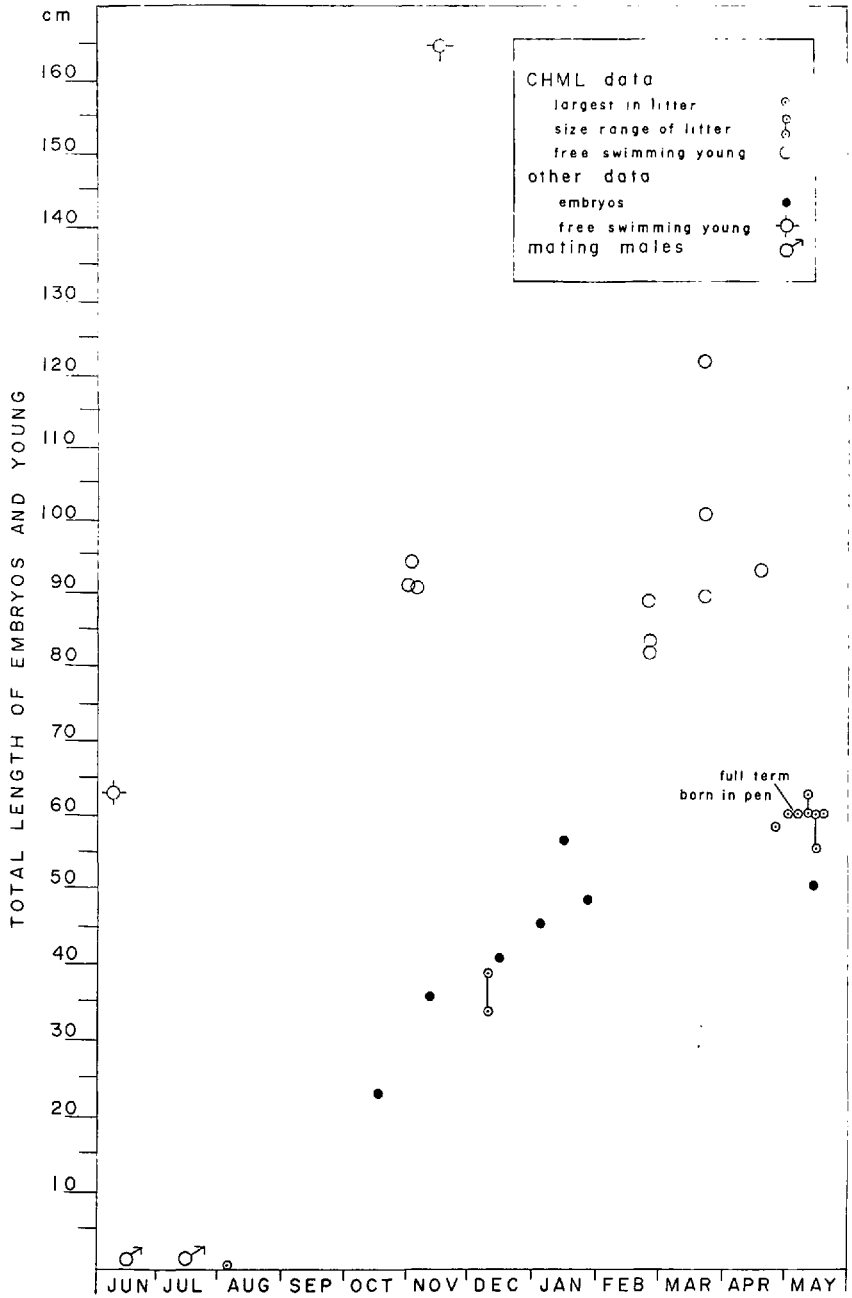

FIGURE 15. Monthly sizes of embryos and young of *Negaprion brevirostris*. Other data included: Springer 1938, 1950b.

months at Englewood, we did not obtain any with our shark lines or from local fishermen in the years included in this study. While this paper was in preparation, commercial fishermen suddenly began bringing specimens of this shark to us. From 17 March 1964 to 2 April 1964, 22 were brought in; 16 were males 61 cm (2′0″) to 99 cm (3′3″), and six were females 60 cm (2′0″) to 83 cm (2′9″).

Five of the females were immature. One female of 83 cm (2′9″) carried five uterine eggs, three on the left and two on the right. The females had the ovary developed on the left side, contrary to other local species examined. The smallest mature male was 83 cm (2′9″).

Weights of adults are 5 to 10 pounds.

All the specimens examined had full stomachs. Many contained fish of considerable length (23-26 per cent) as compared to the total length of the shark. Contents included: *Eucinostomus gula,* monacanthids, *Menticirrhus* sp., clupeids, *Brevoortia* sp., an ophichthid eel, and shrimps.

Family Sphyrnidae
Hammerhead Sharks

The taxonomy of hammerhead sharks was revised by Tortonese (1950) and Fraser-Brunner (1950), resulting in major changes in scientific names long accepted and used in the older literature. The hammerheads discussed here have been affected as follows:

Sphyrna tudes auctorum	=	*S. mokarran* (Rüppell)
S. bigelowi Springer	=	*S. tudes* (Valenciennes)
S. diplana Springer	=	*S. lewini* (Griffith)

Measurements on large specimens of hammerheads are scant. In Table 20 the proportional dimensions of *S. mokarran* and *S. lewini* are summarized. In sub-adults and adults, dimensions such as the height of the first and second dorsal fins and the anterior margin of the pectoral and pelvic fins show no overlap and may be used as distinguishing characters.

Key to Species of Hammerhead Sharks which do or may occur on the central west coast of Florida[2]

A. No median indentation on the anterior margin of the head.
  B. Head shovel shaped with a smoothly curved anterior margin; teeth smooth; maximum size under 5 feet ..... *S. tiburo*

[2]After this key was made, we had the opportunity to examine the key to species of *Sphyrna* in a manuscript by Carter Gilbert who has completed a detailed study of this genus. Our simplified local key shows no disagreement except that Dr. Gilbert lists large individuals of *S. lewini* with weakly serrated teeth which we have not found.

TABLE 16
A COMPARISON OF THE WEIGHTS OF MALES AND FEMALES OF *Negaprion brevirostris*[1]

Total Length Groups in cm[2]	Males			Females		
	No. of Specimens	Weight Range	Average Weight	No. of Specimens	Weight Range[3]	Average Weight[4]
60	1	2	2	1	2	2
105	1	10	10	0	—	—
210	1	151	151	0	—	—
225	0	—	—	3	139-197	167
240	2	190-207	199	8	123-214	185
255	8	187-270	239	2 + (2)	232-286 (287-331)	259 (284)
270	2	210-230	220	5 + (2)	247-297 (278-295)	268 (273)
285	0	—	—	1	300	300
Total	15			20 + (4)		

[1]Weights are given to the nearest pound.
[2]Total length groups are to the nearest 15 cm.
[3]Weights for gravid females are in parentheses.
[4]Figures in parentheses include weights for gravid as well as nongravid females.

BB. Head hammer-shaped with a three-lobed anterior margin; teeth slightly serrate; reaches about 12 to 13 feet; (not yet found in this area) ..... *S. zygaena*

AA. A median indentation in the four-lobed anterior margin of the hammer-shaped head.

C. Height of 1st dorsal fin 14.5 to 18.0 per cent of total length in specimens 3 feet and over (embryos and new born have lower fins which are bent backwards).

D. Teeth of upper jaw serrate; anal fin base 1.1 to 1.4 times longer than base of 2nd dorsal fin; adult size 10 to 15 feet ..... *S. mokarran*

DD. Teeth of upper jaw smooth; anal fin base 1.8 to 2.1 times longer than base of 2nd dorsal fin; adult size over 5 feet (not yet found in this area) ..... *S. tudes*

CC. Height of 1st dorsal fin 12.1 to 13.5 per cent (embryo to adult); teeth in both jaws smooth; adult size about 6 to 8½ feet ..... *S. lewini*

Sphyrna mokarran (Rüppell) Great hammerhead

Twenty-one specimens were examined from March through July with the exception of an immature female caught in November: one immature male 219 cm (7′2″); 15 females, one 81 cm (2′8″) and 14 ranging in size from 199 cm (6′6″) to 414 cm (13′7″); and five damaged specimens of undetermined sex. These sharks were hooked on setlines with two exceptions: the smallest female was caught on rod and reel in the Gulf, and an incomplete specimen (head only) estimated to be 150 cm, which was taken from the stomach of a large bull shark.

Table 17 and Fig. 16 correlate our data on three gravid females with those of Springer (1940a) showing an increase in size of embryos from 44 cm in March to 68 cm in June. Embryos have a pseudo-placental attachment of heavy vascular tissue firmly embedded in the uterine wall. Bigelow & Schroeder (1948) estimated size at birth at slightly less than 70 cm. The smallest free-swimming young examined by us, caught 29 July, measured 81 cm. This evidence indicates the time of birth as late spring and early summer, and the 81-cm specimen may have been two or three months old.

Small eggs, less than 3 mm in diameter, were noted in a 35-cm non-gravid female in June, and approximately 60 eggs of 25 mm diameter in another non-gravid 414-cm female in April. Bigelow & Schroeder estimated size at maturity as not less than 10 feet. Our smallest gravid female was that size.

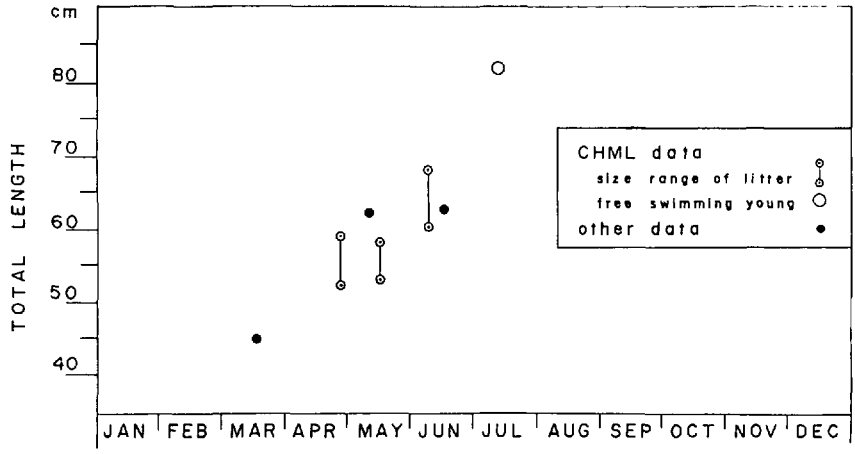

FIGURE 16. Monthly sizes of embryos and young of *Sphyrna mokarran*. Other data included: Springer 1940a.

Springer (1960) noted that in this species there can be a great increase beyond the usual adult size of 10 to 12 feet. Ten per cent of his sample lot measured approximately 15 feet and one was 18 feet. Although we have not seen any specimens of *Sphyrna* larger than 414 cm (13′7″) from this area, 15- to 20-foot hammerheads are frequently reported by local tarpon fishermen and a 14½-ft specimen was measured and photographed by William M. Stephens.

In a 357-cm (11′10″) female there were apparent signs of senility. Although the fish was caught during the mating season the ovary was small and degenerate in appearance, containing only small white eggs. The muscle tissue was strongly fibrous and soft. In the course of removing the pituitary it was noted that the chondrocranium had an exceptionally thick layer of calcification compared with chondrocrania of other large hammerheads.

Stomach contents of this species included parts of sharks and rays, *Bagre marinus, Caranx* sp., *Chilomycterus schoepfi, Lactophrys trigonus, Megalops atlantica, Opsanus* sp., serranids, squid, and crabs. One specimen had about 50 caudal spines from sting rays in its throat, tongue and mouth. The stomach of a small specimen (81 cm) contained a piece of a carangid fish measuring about 11 cm.

Sphyrna tiburo (Linnaeus) Bonnethead

This small shark is not caught on our set lines, although it is common in this area (Clark, 1963b). We obtain specimens from local anglers and commercial netters who fish in the bays, passes, and shallow coastal waters of the Gulf.

TABLE 17
DATA ON GRAVID FEMALES, EMBRYOS, AND YOUNG OF *Sphyrna mokarran*

Length of ♀ feet	cm	No. in litter ♂♂	♀♀	Totals	T.L. of embryos cm	Date	Source
—	—	—	—	—	44.0	March	Springer (1940)
10′0″	304	9	12	21	52.0-58.0	30 April	CHML No. 17
—	—	—	—	—	56.0	May	Springer (1940)
12′0″	367	18	23	41	53.0-57.0	18 May	CHML No. 4
10′2″	308	5	8	13	60.0-67.5	6 June	CHML No. 6
—	—	—	—	—	60.0	June	Springer (1940)
—	—	—	—	—	67.3[1]	—	Bigelow and Schroeder (1948)
—	—	—	—	—	81.0[2]	9 July	CHML No. 21

[1]Newborn.
[2]Free-swimming young.

Bigelow & Schroeder (1948) noted that this species is probably a year-round resident of Florida. Springer (1938) reported no midsummer catches. Our records show only one summer catch (in July) and the majority of the remaining specimens were caught in the spring and fall.

We examined 63 specimens from this area: 43 males 36 cm (1′2″) to 91 cm (3′0″); 18 females 41 cm (1′4″) to 103 cm (3′4″); and two specimens within this size range of undetermined sex. Only two gravid females were examined. A 92-cm specimen captured 21 March had two uterine eggs on each side. The eggs (about 18 mm diameter) were presumably fertilized but the embryos were not visible. A 103-cm (3′4″) specimen captured 24 April had 12 small embryos 3 to 4 cm, seven in the left uterus and five in the right. A non-gravid female captured 17 March had 14 ovarian eggs of 21 mm. These were probably full-size eggs ready for fertilization.

A male with enlarged testes and sperm oozing from the urogenital pore was examined 8 October. Massive schooling was observed in November (Clark, 1963b) and may be related to the mating season. Since the females appear to have mated in the spring and there is some evidence of fall mating, it is likely that mating goes on year round, or that there is a spring and fall mating season.

Because early records often did not include data on maturity other than a clasper-length measurement, an attempt was made to estimate maturity by the length of the clasper expressed as a per cent of the total length. A large male of 97 cm captured in the north central Gulf in 90 meters by the R/V SILVER BAY was given to us by Harvey Bullis. This specimen had a clasper length of only 5.8 per cent of total length which falls in the range of our immature specimens. Further data on clasper lengths of this species from Stewart Springer (personal communication) were compared

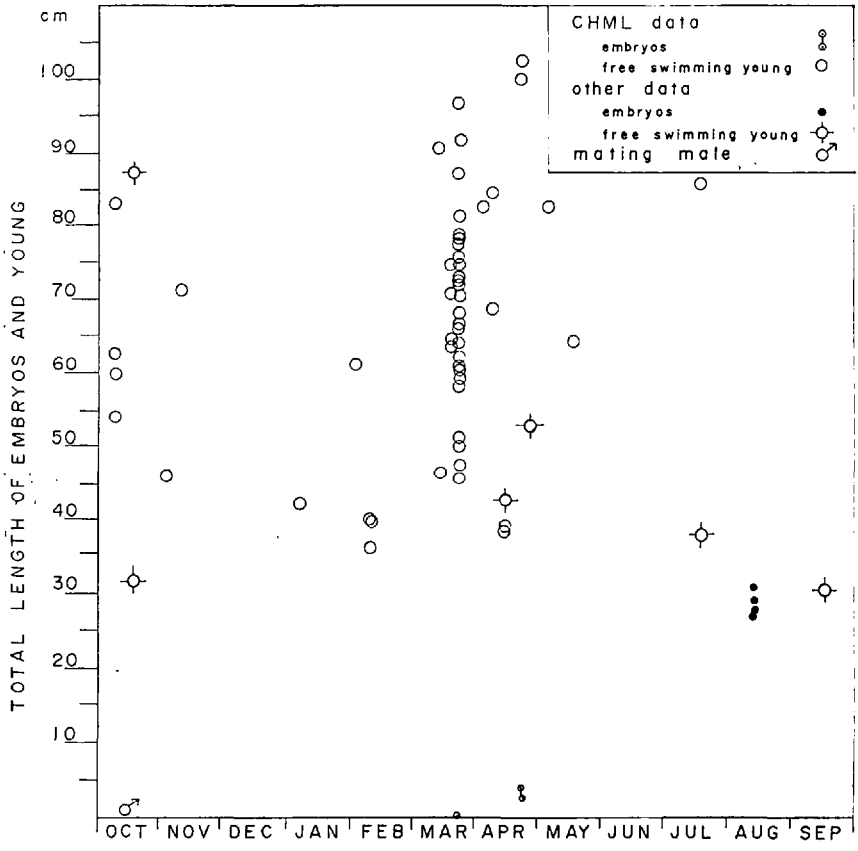

FIGURE 17. Monthly sizes of *Sphyrna tiburo*. Other data included: Gunter 1945 (Texas), and a specimen from St. Petersburg.

with our data (Table 18). This table shows the size range at which the males mature and the claspers lengthen. It also shows that after maturity the length of the clasper does not increase proportionally with the total length of the shark. Thus, an exceptionally large adult (*e.g.*, the SILVER BAY specimen) can have a clasper length falling into the "immature" category when expressed as per cent of total length.

The actual length in mm of the clasper was also somewhat smaller in the SILVER BAY specimen than other mature specimens. Springer (personal communication) suggests that if a specimen moves from a normally fluctuating and sometimes warm environment in shallow water to the more stable and generally cooler environment in deep water its sexual maturation might be delayed.

The smallest mature female was 87 cm and a larger female of 91 cm

was still immature. The males were mature at 76 cm and longer except for one specimen which was mature at 68 cm.

Callinectes sapidus was found in the stomachs of several specimens. Local fishermen catch this shark on lines baited with shrimp.

TABLE 18
A COMPARISON OF TOTAL LENGTH AND CLASPER LENGTH WITH RESPECT TO MATURITY IN *Sphyrna tiburo*

♂ T.L.	Clasper length		Locality	Source	Date	Stage of maturity
cm	mm	% T.L.				
29.2	5	2.4	Brazil	Springer	—	immature
35.5	9	2.5	local	CHML No. 6	9 Feb.	immature
40.0	5	1.2	local	CHML No. 5	9 Feb.	immature
40.7	12	2.9	Texas	Springer	July	immature
41.7	8	1.9	local	CHML No. 22	4 Jan.	immature
54.6	14	2.7	Texas	Springer	July	immature
56.4	16	2.8	Texas	Springer	July	immature
58.4	33	5.7	local	CHML No. 29	18 March	immature
59.2	20	3.4	local	CHML No. 46	18 March	immature
59.8	33	5.5	local	CHML No. 23	16 Jan.	immature
60.0	32	5.3	local	CHML No. 38	18 March	immature
60.4	35	5.8	local	CHML No. 45	18 March	immature
60.7	33	5.4	local	CHML No. 48	18 March	immature
63.2	35	5.5	local	CHML No. 44	18 March	immature
65.9	35	5.3	local	CHML No. 37	18 March	immature
66.8	32	4.8	local	CHML No. 43	18 March	immature
67.5	48	7.1	local	CHML No. 42	18 March	mature
70.3	35	5.0	local	CHML No. 61	24 March	immature
70.9	45	6.3	local	CHML No. 21	9 Nov.	immature
72.0	42	5.8	local	CHML No. 41	18 March	immature
72.5	36	5.0	local	CHML No. 40	18 March	immature
74.4	50	6.7	Englewood, Fla.	Springer	Jan.	adult
74.5	64	8.6	local	CHML No. 52	24 March	immature[1]
74.8	62	8.3	local	CHML No. 30	18 March	no notes
75.5	57	7.5	local	CHML No. 63	11 April	adult
76.5	45	5.9	Englewood, Fla.	Springer	—	no notes
77.2	63	8.2	local	CHML No. 58	18 March	adult
77.8	62	8.0	local	CHML No. 51	24 March	adult
78.9	66	8.4	local	CHML No. 53	24 March	adult
80.0	54	6.7	Englewood, Fla.	Springer	March	adult
80.0	61	7.6	Englewood, Fla.	Springer	March	adult
82.2	60	7.3	local	CHML No. 16	8 May	adult
83.2	62	7.5	local	CHML No. 18	8 Oct.	adult
86.0	61	7.1	Englewood, Fla.	Springer	March	adult
86.2	56	6.5	Surinam	Springer	Jan.	adult
87.5	59	6.7	Englewood, Fla.	Springer	March	adult
89.0	66	7.4	Englewood, Fla.	Springer	March	adult
97.0	56	5.8	Gulf of Mexico 50 fathoms	M/V SILVER BAY	Sept.	no notes

[1]This specimen was mature in all respects except claspers were flexible.

Sphyrna tudes (Valenciennes) Hammerhead

Gilbert (1961) reported eight large, juvenile specimens collected by the U.S. Fish and Wildlife Service's motor vessel OREGON in the northern Gulf of Mexico off the coast of Mississippi at a depth of 40 feet. There are no records of this species from Florida waters but its range suggests it may occur on the west coast of Florida.

Sphyrna zygaena (Linnaeus) Smooth hammerhead

This species may occur in this area, as Bigelow & Schroeder (1948) listed both coasts of southern Florida in the range for this species. They and Springer (1940b) also pointed out the earlier confusion of this species with *S. diplana,* which subsequently was shown to be *S. lewini* by Fraser-Brunner (1950). Therefore, Springer's earlier references (1938 and 1940a) to *S. zygaena* in the Englewood area actually refer to *S. lewini.* Springer (1963) believed it possible that all records of *S. zygaena* from the Gulf of Mexico are based on misidentifications.

Sphyrna lewini (Griffith) Scalloped hammerhead

We have relatively few records of this species. Springer (1938, 1940b, 1940c) studied specimens from Englewood under the names *S. zygaena* and *S. diplana* and reported that young and immature specimens are common in spring and fall, and adult and sub-adult males are common in winter.

Five specimens were taken on the set lines: an immature male 152 cm (5′0″), three apparently mature males 177 cm (5′9″) to 209 cm (6′10″), and the head of a larger specimen, about 230 cm (7½ ft.).

The stomach of one specimen contained four small squid and two others contained well-digested fish.

DISCUSSION AND CONCLUSIONS

Catch per Unit Effort

In set-line fishing between 1955 and 1963, December and March produced the greatest number of sharks per unit effort (Table 1). However, the highest catch per unit effort for any single month was in May 1962. The only months we expended more than one unit of effort and caught no sharks were November 1957, March 1963, August 1963, and September 1963. These were all during periods of local severe "red tide" outbreaks, which were found to involve *Gymnodinium breve.* The bait on the set-lines during "red tide" is often untouched whereas ordinarily it is eaten by crabs and small fishes. We have noted that when *G. breve* exceeds a concentration of 80,000 per liter in shark pens, the captive sharks stop feeding before any teleost fishes are found dead. After high concentrations of *G. breve* (over one million per liter) all captive sharks died. Local observers have reported seeing sharks swimming through areas of "red tide"

TABLE 19

A COMPARISON OF THE LENGTH-WEIGHT RELATIONSHIP IN EIGHT SPECIES OF SHARKS[1]

Total Length in cm[2]	*Sphyrna mokarran*		*Galeocerdo cuvieri*		*Carcharhinus obscurus*		*Negaprion brevirostris*		*Carcharhinus leucas*		*Ginglymostoma cirratum*		*Carcharhinus milberti*		*Carcharhinus limbatus*	
Groups	2 ♂ ♂	8 ♀ ♀	9 ♂ ♂	21 ♀ ♀	5 ♂ ♂	22 ♀ ♀	15 ♂ ♂	20 ♀ ♀	49 ♂ ♂	49 ♀ ♀	14 ♂ ♂	3 ♀ ♀	9 ♂ ♂	46 ♀ ♀	10 ♂ ♂	15 ♀ ♀
60	—	—	—	—	—	—	2	**2**	**5**	—	—	**7**	—	—	—	7
75	—	—	—	—	—	9	—	—	—	—	—	—	—	—	—	—
90	—	—	—	—	12	11	—	—	—	—	12	—	—	—	—	—
105	—	—	7	—	—	10	10	—	—	—	20	—	—	—	—	—
120	—	—	—	—	—	—	—	—	—	—	—	—	—	4	23	28
135	—	—	—	—	—	—	—	—	37	—	—	—	—	—	39	—
150	—	—	—	70	—	—	—	—	—	75	—	—	—	—	44	56
165	106	—	—	56	—	—	—	—	—	81	—	—	—	82	64	74
180	—	—	—	75	—	—	—	—	112	115	—	—	—	124	80	97
195	82	76	—	83	—	—	—	—	117	130	—	—	123	144	—	—
210	—	—	108	85	—	—	151	—	164	170	—	—	133	166	—	—
225	—	124	111	117	—	—	—	167	209	223	175	152	—	196	—	—
240	—	137	—	127	—	—	199	185	244	284	181	180	—	—	—	—
255	—	—	158	194	—	517	239	259	—	382	222	—	—	—	—	—
270	—	202	295	—	—	498	220	269	—	—	—	—	—	—	—	—
285	—	—	—	—	368	455	—	300	—	—	—	—	—	—	—	—
300	—	—	—	357	345	483	—	—	—	—	—	—	—	—	—	—
315	—	—	399	—	—	—	—	—	—	—	—	—	—	—	—	—
330	—	—	—	541	—	—	—	—	—	—	—	—	—	—	—	—
345	—	425	442	566	—	—	—	—	—	—	—	—	—	—	—	—
360	—	—	—	731	—	—	—	—	—	—	—	—	—	—	—	—
375	—	541	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[1]Based only on an average of specimens examined at the Cape Haze Marine Laboratory 1955-1963; gravid females excluded; weight to the nearest pound, corrected for stomach contents.

[2]Total length groups to the nearest 15 cm.

and feeding on the dead fish. It seems probable that the dead or dying fish have drifted out of the area of high concentration of *G. breve* or that sharks can go into "red tide" areas for short periods of time to feed. A few non-captive sharks died during "red tide" and washed ashore.

In Table 1, the annual totals of catch per unit effort give a slight indication that our shark fishing may be reducing the local shark population. The general reduction in catch from 1955 to 1963, with the exceptional high catch in 1957 after a lack of fishing in 1956, may be due in part to our fishing but other factors should also be noted. In 1957 the data are meager, and include December, the best overall month for catching sharks even during the 1957 red tide which seemed to have no effect on the usual large catches of the dusky and sandbar sharks in December. The drop in water temperature in December may be unfavorable to *G. breve* which disappeared for the rest of that winter but reappeared again in May and intermittently appeared through 1958, disappearing again in December. In December 1958, set-lines were not operated, resulting in the low figure that year compared with other years in Placida.

In general, the years 1955-1960 in the Placida area show a higher catch per unit effort compared with 1961-1963 in the Sarasota area. The deeper nearby waters and other local conditions near Placida (Gasparilla Sound, Boca Grande Pass) may attract more sharks. Our composite data agree closely with Springer's data (1951) on the catch per unit effort in the Salerno area.

The low catch per unit figure for 1961 (0.76) again is partly explained by the lack of fishing in December and/or overfishing in the Placida area. The low figure (0.63) for 1963 may be blamed in large part on the red tide. Certainly the seasons when set-lines are operated and the occurrence of red tide outbreaks can influence the catch per unit effort. There is also an indication in our fishing records for Sarasota that set-lines operated 3 miles offshore obtained more sharks during spring months than lines set 1 mile offshore.

Reproduction

Mating season and gestation.—Although all sharks have internal fertilization, copulation has been reported for only a few small species (*Heterodontus franscisci,* Dempster & Herald, 1961; *Scyliorhinus canicula,* Ford, 1921), and in one case for the lemon shark (see p. 51). "Courtship" behavior has been described for many species, from known precopulatory actions such as the male biting and gripping the pectoral fins of the female in *Heterodontus* and *Scyliorhinus* to vague actions such as unusual close following of pairs and nonspecific body contacts thought to be part of courtship in species as large as the basking shark (Matthews, 1950).

A number of morphological signs give evidence of mating season. In

the male, a combination of the following is a good indication: semen oozing from the urogenital opening from slight manipulations in the cloacal region, or when the shark is lifted for weighing; sperm recovered in smears taken from the clasper groove; white viscous mucous in the clasper grooves; vascular, swollen tissue on the clasper; subdermal and external bleeding in the distal portion of the clasper as well as swollen tissue with fresh stretch marks at the base of the clasper (Springer, 1960); seminal vesicles filled with semen; and enlarged testes. Mature males of three species were captured out of mating season. These had small testes which appeared regressed. The claspers of males during the mating season may bleed readily when the shark is lifted by the head for weighing. In large male sharks over 300 pounds, however, this is not a good criterion as they may bleed from the claspers due to pressure from this weight. These heavy sharks also bleed from the skin of the caudal peduncle and tail. Hence the vascular condition of the clasper area alone cannot be considered evidence of mating after a large shark has been lifted by the head.

Large testes and large quantities of semen in the seminal vesicles may be present in immature males (see pp. 32 and 44) with underdeveloped, short claspers and siphon sacs, contrary to the conclusions of Templeman (1944) who used "the presence of sperm in the sperm sacs and stage of development of the vas deferens" as the criterion for determining maturity in *Squalus acanthias*. Quantities of semen in an immature male is possibly a sign of an approaching mating season before which the claspers and siphon sacs will develop rapidly.

In females we consider evidence of the mating season to be full-size ovarian eggs and sperm in smears from the uterus and vagina. Strong evidence that reproduction is biennial is shown in the lemon shark by the presence in spring of roughly half of the mature females with full-size ovarian eggs and half with near-term young. In mature females of the sandbar, tiger, and bull sharks the percentage of mature females which are gravid is much less. This may be due to a shortage of males in the case of the sandbar shark (Springer, 1960) and the tiger shark, or it could indicate that reproduction occurs normally only about every three years in species such as the bull shark where males and females are represented almost equally in the adult population.

All the local shark species from which we were able to obtain evidence seem to mate in the late spring and early summer and have a gestation period of nine to 13 months (Fig. 18) with the exception of *Carcharhinus obscurus* and the common small species, *Mustelus norrisi* and *Scoliodon terraenovae,* which may mate and bear their young in the late winter and early spring, and *Sphyrna tiburo* which may have two mating seasons (spring and fall). We did not find evidence that any of the common sharks in this area mate and bear young throughout the year as do some small

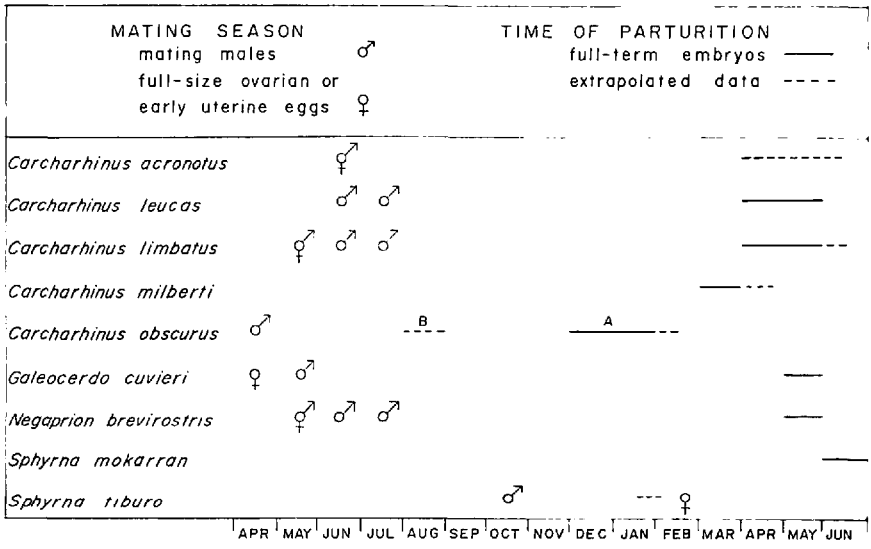

FIGURE 18. Comparative summary of reproductive cycles in 9 species of sharks showing time of mating, parturition period and suggested gestation period.

species (Olsen, 1954), as well as several large pelagic sharks at least in certain geographical localities (Strasburg, 1958), and at least one deep-sea shark (Gudger, 1940). The temperature changes in the shallow littoral zone covered in this report undoubtedly control a definite mating season and gestation period for resident sharks. Regular migrants also seem to have a defined stage of gestation when they appear locally, although the gestation period may vary according to the migratory patterns of different populations which would expose them to different temperatures. Dean (*in* Smith, 1942) suggested that the gestation period of *Heterodontus japonicus* might vary from one to two years depending on temperature.

With the possible exception of the bonnethead, we have no data to indicate an indefinite mating season for any local shark species or even of an accessory population such as Springer (1963) has suggested for species such as the widely distributed tiger shark. In the tropics (as in deep water) where seasonal temperature and light changes are not as trenchant as in higher latitudes, gestation periods may be of a definite length but mating and parturition take place throughout the year.

A pseudo-, or yolk-sac placenta has been reported for *Negaprion brevirostris* (Springer, 1950b), *Carcharhinus milberti* (Springer, 1960), *C. leucas* (Hess, 1961), and *Sphyrna tiburo* (Bigelow & Schroeder, 1948). Hess (1961) discussed the aplacental embryonic development of *Galeocerdo cuvieri*. Near-term young of *G. cuvieri* examined by us had dried up yolk

sacs about the size of a shriveled pea and no evidence of uterine "milk." Local species in which we noted pseudo-placental attachments are *Carcharhinus acronotus, C. limbatus, C. obscurus, Mustelus norrisi,* and *Sphyrna mokarran.*

Maturity.—A male is considered mature when (1) the clasper head or rhipidion (Leigh-Sharpe, 1920) is fully formed and can be spread open on a fresh specimen, (2) the clasper proximal to the head is rigid due to calcification of the supporting cartilage[3], (3) the base of the clasper rotates easily and the clasper can be directed anteriorly, (4) and the siphon sacs are fully elongated. In all local mature males examined, with the exception of the nurse shark, the siphon sacs extend to about the mid-pectoral region. In the nurse shark the siphon sacs are much shorter and may function differently from those of the more streamlined sharks, which are filled, prior to copulation, while swimming with the clasper held in a forward position (Springer, 1960).

As noted above immature sharks may have quantities of semen in the seminal vesicles and enlarged testes (p. 32 and 44).

In a near-adult female which has not yet carried young, maturity is not readily apparent outside the mating season when the ova are still small. We have found that the easiest way to determine maturity is to examine the vaginal opening and hymen (Fig. 11). In a young female the urinary papilla seems to have only one opening, but on examination the orifice of the vagina is visible as a pinpoint opening a few millimeters anterior to the urinary pore. From the genital opening a faint line may extend anteriorly for a distance varying with the age and size of the female and the species. In the very young females there appears to be no slit in the relatively tough membrane. As maturity approaches the membrane becomes more delicate and that in the mature virgin is easily ruptured with a probe.

Weight-Length Relationships

Unfortunately, accurate weights could not be taken of many specimens. Some specimens were mutilated, and some were kept alive in captivity and when they died weeks, months, or years later they were emaciated to some extent and weights, although taken, were not considered normal. In some cases of sharks over 600 pounds, mechanical problems in lifting them precluded obtaining an accurate weight.

Usually sharks are brought back to the Laboratory in a tow boat with well-space capable of handling several sharks 7 to 10 feet long. Occasionally the tow boat was not used and a shark was towed back by the hook in its mouth causing the stomach to fill with water. Corrections in weight

[3]Springer (1950) considers calcification of the clasper a sure sign of sexual maturity. We have noted, however, in the case of one tiger shark and one bonnethead that males with calcified claspers had siphon sacs less than 50 per cent as long as when fully developed.

were made for water in the stomach and other heavy stomach contents such as quantities of food.

In eight species of sharks, a sufficient number of individuals were weighed to show that mature females are significantly heavier than males in the same size group (Table 18). In general the larger the size group, the greater the sexual difference which is to be expected as the weight increases by the cube of the linear measurement. It is somewhat surprising that the gravid state of the female has only a small effect on the weight of the female. Although gravid females in general are somewhat heavier (Tables 3, 5, 7, 9, 11, 15, 18) than non-gravid females, a few near-term gravid females (*e.g., Carcharhinus leucas*) were lighter than the average non-gravid female. As many near-term females are caught with bait, we know they feed at this time.

Proportional Dimensions

In general, data on proportional dimensions of large sharks are scarce for they are seldom preserved and accurate measurements in the field are rarely taken. In Table 20, proportional dimensions are listed for nine species of large local sharks on which accurate measurements were taken. The data for each are separated, whenever possible, for purposes of comparing males and females (for possible sexual differences) and embryos, young, and immature for growth changes.

Complete sets of measurements were not always taken, especially when a number of sharks were brought in at one time. Of the specimens included in Table 20, obvious errors in measurements were omitted. Checking for gross errors can be done for a number of measurements. Standard length can be checked by several sets of measurements such as the sum of distances (1) from snout to the origin of the anal fin, (2) the base of the anal fin, (3) from the anal fin to the origin of the caudal fin—the only discrepancy being the angle of the base of the anal fin to the horizontal axis of the shark, this hypotenuse-base discrepancy being almost negligible. Measurements of deformed fins were not included and in a few cases measurements were missing as a part of the specimen was mutilated.

Garrick (1964) reviewed observed changes in proportional dimensions in sharks and pointed out that although the pattern of growth change is not identical in all sharks, there are some general features various species have in common such as: (1) accelerated growth in the trunk region compared to the head and tail; (2) a broadening of the head region; (3) a tendency for the pectoral fin to increase its relative length; (4) a noticeable decrease in eye diameter; and (5) a tendency for relative heightening of the dorsal fin in galeoid sharks. Table 22 summarizes noticeable patterns of growth changes (or lack of such changes) in the nine species for which we give such data in Tables 14 and 20.

TABLE 20

MORPHOMETRIC DATA ON NINE SPECIES OF SHARKS

(Values expressed as per cent of total length unless otherwise indicated.)

	Carchartinus leucas									
No. and Type	2 Embryos Average[1]	10 Immature ♂♂ (Range)	Average	6 Immature ♀♀ (Range)	Average	10 Mature ♂♂ (Range)	Average	7 Mature ♀♀ (Range)	Average
Total length (cm)	(36-38)37	(166-210)	193	(164-200)	189	(219-240)	228	(221-249)	242
Weight (lbs.)[2]									
Standard length	62.0	(72.1-75.5)	73.6	(72.5-74.5)	73.7	(71.5-78.7)	74.9	(72.0-78.0)	76.0
Snout to mouth	6.5	(5.2-6.2)	5.5	(5.7-6.4)	6.1	(5.0-6.2)	5.8	(5.5-6.3)	6.1
Mouth breadth	10.4	(9.6-12.7)	10.6	(9.3-11.3)	10.4	(10.2-13.1)	11.2	(8.8-12.0)	10.9
Eye diameter	1.9	(0.7-1.8)	1.1	(0.9-1.2)	1.1	(0.7-1.1)	0.9	(0.7-1.1)	0.9
Nostrils: dist. between	6.8	(6.1-6.9)	6.5	(6.1-6.4)	6.2	(6.2-7.5)	6.7	(6.1-6.7)	6.5
Dorsal 1, height	7.7	(10.6-12.6)	11.6	(10.8-11.8)	11.4	(8.9-11.8)	11.0	(10.4-12.4)	11.4
Dorsal 1, base	11.0	(10.8-12.5)	11.7	(10.4-12.3)	11.5	(11.0-12.3)	11.7	(11.5-12.8)	12.0
Dorsal 2, height	3.9	(3.6-4.7)	4.4	(3.8-4.3)	4.1	(3.6-4.6)	3.9	(3.8-4.6)	4.0
Dorsal 2, base	5.0	(4.3-5.3)	4.9	(4.5-5.4)	4.9	(4.2-5.8)	4.7	(4.3-5.0)	4.5
Anal, height	4.2	(3.6-5.3)	4.5	(3.6-5.1)	4.5	(3.8-4.8)	4.3	(4.0-4.9)	4.4
Anal, base	4.5	(4.1-4.9)	4.5	(4.3-4.9)	4.5	(3.5-4.9)	4.4	(4.2-5.0)	4.5
Caudal, upper margin	29.0	(27.1-30.3)	28.0	(26.6-27.5)	27.1	(24.0-27.8)	26.2	(25.5-28.0)	26.4
Caudal, lower margin	11.4	(11.9-14.9)	12.8	(12.0-13.2)	12.7	(10.7-13.7)	12.3	(11.9-13.9)	12.8
Pectoral, anterior margin	15.0	(20.0-23.6)	21.5	(20.6-21.9)	21.2	(18.8-22.2)	20.2	(21.0-22.6)	21.5
Pectoral, inner margin	5.7	(5.1-6.3)	5.6	(5.1-7.0)	5.9	(5.1-6.3)	5.5	(4.8-6.3)	5.6
Pectoral, distal margin	10.7	(17.5-21.4)	19.4	(18.2-20.2)	19.4	(16.3-19.5)	18.2	(17.9-21.4)	20.0
Pelvic, anterior margin	6.3	(6.5-7.3)	7.1	(7.2-8.0)	7.6	(6.3-8.0)	6.9	(6.8-7.8)	7.2
Pelvic, distal margin	5.6	(6.3-7.7)	7.4	(5.3-8.0)	7.0	(6.1-7.5)	6.7	(7.2-8.6)	7.6
Clasper, length		(2.8-3.7)	3.5			(5.7-10.4)	7.7		
Snout to Dorsal 1	32.8	(26.8-32.9)	29.2	(27.8-29.8)	29.0	(27.4-30.6)	28.8	(28.6-32.0)	30.7
Snout to Dorsal 2	60.0	(59.0-65.4)	62.2	(61.0-63.0)	62.0	(61.5-64.4)	62.8	(61.7-67.3)	65.1
Snout to Pectoral	22.0	(18.2-23.8)	21.0	(19.7-21.9)	20.9	(19.2-23.6)	21.5	(19.5-23.6)	21.0
Snout to Pelvic	49.9	(48.6-50.5)	49.7	(49.9-53.9)	51.6	(48.3-58.0)	52.3	(52.0-58.0)	54.3
Snout to Anal	62.4	(63.7-68.4)	63.0	(62.7-67.1)	64.5	(61.8-72.4)	66.5	(66.5-70.0)	67.9
Interspace between:									
Dorsals 1 & 2	20.8	(20.2-23.2)	21.7	(18.2-23.1)	21.1	(20.8-23.2)	22.4	(21.0-24.4)	22.5
Dorsal 2 and caudal 1	8.0	(6.7-8.4)	7.3	(4.0-7.7)	6.9	(6.5-8.6)	7.4	(6.5-7.5)	7.2
Anal and caudal	6.6	(4.8-6.2)	5.7	(2.4-6.0)	4.8	(4.5-8.0)	5.7	(5.5-5.9)	5.8
Greatest depth	16.4	(17.4-21.6)	16.0	(16.0-18.9)	17.1	(11.7-17.4)	14.6	(13.6-20.9)	17.4

[1]Range omitted as very close in all cases.

[2]See tables 4, 6, 8, 10, 12, 16 & 19 for data on weights not presented here.

TABLE 20, Continued—MORPHOMETRIC DATA ON NINE SPECIES OF SHARKS
(Values expressed as per cent of total length unless otherwise indicated.)

	Garcharhinus maculipinnis				*Carcharhinus limbatus*					
No. and Type	1 ♂ +2 ♀ ♀ Immature		6 Mature ♂ ♂		1 ♂ +1 ♀ Immature		8 Mature ♀ ♀		8 Mature ♂ ♂	
	(Range)	Average	(Range)	Average	(Range)	Average	(Range)	Average	(Range)	Average
Total length (cm)	(88-110)	96	(188-203)	196	(78-85)	82	(120-161)	136	(123-191)	167
Weight (lbs.)[1]	(7-17)	10	(113-133)	123						
Standard length		73.6	(76.2-77.0)	76.8	(71.9-71.0)	71.5	(70.5-76.0)	74.2	(72.3-78.3)	74.6
Snout to mouth	(8.5-8.5)	8.5	(6.8-7.8)	7.3	(7.4-7.4)	7.4	(6.7-7.5)	7.2	(6.3-7.4)	6.8
Mouth breadth	(7.8-8.0)	7.9	(8.4-9.9)	9.0	(8.2-8.5)	8.4	(8.0-9.7)	8.8	(8.5-9.8)	9.1
Eye diameter	(1.0-1.7)	1.3	(1.0-1.3)	1.2	(1.2-1.5)	1.4	(1.1-1.4)	1.3	(1.0-1.5)	1.2
Nostrils: dist. between	(5.2-5.6)	5.4	(4.9-5.7)	5.1	(4.9-5.3)	5.1	(4.8-5.3)	5.1	(4.8-5.5)	5.1
Dorsal 1, height	(6.3-9.2)	7.8	(8.5-9.8)	9.0	(10.2-10.7)	10.5	(10.6-12.1)	11.0	(10.6-12.4)	11.6
Dorsal 1, base	(8.4-9.7)	8.9	(9.4-10.6)	9.7	(9.6-9.8)	9.7	(9.6-10.9)	10.4	(10.0-11.7)	10.7
Dorsal 2, height	(1.8-2.5)	2.2	(2.1-2.8)	2.4	(2.4-2.8)	2.6	(2.5-3.4)	3.1	(2.8-3.7)	3.4
Dorsal 2, base	(2.9-3.4)	3.2	(3.1-3.9)	3.6	(4.1-4.4)	4.3	(3.3-4.4)	3.9	(4.1-4.8)	4.4
Anal, height	(2.4-3.1)	2.8	(3.3-3.7)	3.6	(3.4-3.8)	3.6	(3.1-4.0)	3.5	(3.2-4.3)	3.7
Anal, base	(3.8-4.1)	4.0	(3.9-4.9)	4.3	(4.1-5.4)	4.8	(4.1-4.8)	4.4	(3.9-4.8)	4.3
Caudal, upper margin	(25.4-27.0)	26.3	(24.0-26.4)	25.4	(26.6-27.1)	26.9	(26.6-28.4)	27.6	(26.2-28.0)	27.0
Caudal, lower margin	(11.2-11.7)	11.4	(11.1-12.0)	11.5	(12.0-12.2)	12.1	(11.6-14.0)	12.9	(12.9-14.3)	13.5
Pectoral, anterior margin	(13.5-14.4)	14.0	(15.5-17.5)	16.3	(16.1-17.1)	16.6	(16.7-18.9)	17.5	(17.3-20.0)	18.5
Pectoral, inner margin	(2.6-4.1)	3.4	(3.4-5.7)	4.0	(4.3-4.7)	4.5	(4.4-5.0)	4.6	(4.3-5.4)	4.7
Pectoral, distal margin	(11.1-13.2)	12.1	(14.3-16.5)	14.9	(13.6-14.5)	14.1	(14.2-16.6)	15.2	(13.8-17.6)	16.3
Pelvic, anterior margin	(4.5-5.1)	4.6	(5.2-6.6)	5.6	(5.3-6.1)	5.7	(5.2-6.3)	5.8	(6.1-6.9)	6.5
Pelvic, distal margin	(4.5-5.4)	5.0	(5.5-6.2)	5.8	(6.1-6.6)	6.4	(5.6-7.2)	6.4	(6.1-7.9)	7.1
Clasper, length	2.3		(7.2-7.7)	7.4	2.5					
Snout to Dorsal 1	(32.2-34.7)	33.1	(32.6-35.5)	34.0	(28.2-32.2)	30.2	(29.8-35.0)	31.7	(30.0-35.7)	32.0
Snout to Dorsal 2	(58.5-64.8)	62.7	(66.1-68.7)	67.0	(54.9-63.3)	59.1	(62.7-66.1)	63.9	(61.1-65.9)	63.5
Snout to Pectoral	(22.2-23.1)	22.7	(22.5-29.6)	25.1	(20.8-23.6)	22.2	(21.2-25.3)	23.2	(22.6-24.0)	23.1
Snout to Pelvic	(50.7-51.5)	51.1	(51.7-54.7)	53.2	44.1		(46.7-54.2)	50.8	(49.8-53.5)	51.6
Snout to Anal	(62.9-63.1)	63.0	(62.4-68.3)	66.2	(54.9-62.2)	58.6	(62.7-69.6)	64.4	(62.0-70.9)	65.3
Interspace between:										
Dorsals 1 & 2	(22.5-23.1)	22.8	(23.0-24.2)	23.5	(18.7-21.8)	20.3	(21.9-22.9)	22.4	(20.4-24.6)	22.1
Dorsal 2 and caudal	(7.2-7.6)	7.4	(6.1-7.2)	6.4	(5.5-6.5)	6.0	(6.3-7.1)	6.8	(5.7-7.8)	6.8
Anal and caudal	(6.4-6.6)	6.5	(5.8-6.7)	6.2	(5.1-6.4)	5.8	(5.8-6.5)	6.2	(5.1-6.3)	5.7
Greatest depth	(11.7-13.6)	12.7	(15.5-18.1)	16.8	(12.9-14.3)	13.6	(13.3-17.6)	15.4	(14.1-18.5)	15.9

[1]See tables 4, 6, 8, 10, 12, 16 & 19 for data on weights not presented here.

TABLE 20, Continued—MORPHOMETRIC DATA ON NINE SPECIES OF SHARKS
(Values expressed as per cent of total length unless otherwise indicated.)

No. and Type	*Carcharhinus obscurus*						*Carcharhinus milberti*					
	2 ♂ + 3 ♀ Embryos		Mature ♂	Mature ♂	6 Mature ♀ ♀		4 Embryos		6 Mature ♂ ♂		11 Mature ♀ ♀	
	(Range)	Average			(Range)	Average	(Range)	Average	(Range)	Average	(Range)	Average
Total length (cm)	(86-92)	90	299	316	(296-322)	318	(479-506)	495	(194-203)	199	(194-212)	206
Weight (lbs.)[1]	(9-12)	10	368	345	(376-546)	458	(2-2)	2				
Standard length	(71.2-73.8)	72.1	75.9	74.8	(73.2-76.3)	74.2	(71.6-73.6)	72.3	(72.7-77.2)	75.5	(71.4-77.6)	75.0
Snout to mouth	(7.9-8.3)	8.1	6.0	6.0	(5.6-6.2)	5.9	(8.5-8.8)	8.7	(6.2-6.9)	6.5	(4.1-7.2)	6.2
Mouth breadth	(8.0-10.3)	8.7	9.0	8.7	(8.9-10.8)	10.0	(7.8-8.6)	8.2	(8.8-9.9)	9.3	(9.5-10.2)	9.7
Eye diameter	(1.3-2.0)	1.5	1.1	1.1	(0.9-1.1)	1.0	(2.4-2.9)	2.6	(1.0-1.4)	1.3	(1.2-1.9)	1.6
Nostrils: dist. between	(5.9-6.6)	6.2	6.5	5.7	(5.6-6.6)	6.0	(5.9-6.5)	6.2	(5.4-5.9)	5.7	(5.4-6.3)	5.9
Dorsal 1, height	(7.7-8.6)	8.0	8.4	9.4	(8.0-9.8)	8.9	(8.9-9.9)	9.3	(12.7-14.3)	13.7	(12.4-14.4)	13.4
Dorsal 1, base	(8.7-11.4)	9.5	9.2	8.9	(8.9-9.5)	9.2	(10.8-12.4)	11.9	(11.0-13.4)	11.8	(11.0-13.8)	12.1
Dorsal 2, height	(1.3-2.5)	2.1	2.1	2.4	(2.0-2.7)	2.4	(3.0-3.7)	3.4	(2.9-4.4)	3.6	(2.4-4.0)	3.2
Dorsal 2, base	(2.7-3.7)	3.1	2.4	2.9	(2.6-3.8)	3.2	(3.6-5.2)	4.5	(3.9-5.2)	4.3	(2.9-4.8)	4.2
Anal, height	(2.9-3.5)	3.1		3.5	(2.5-4.1)	3.4	(3.7-4.6)	4.0	(3.8-4.8)	4.5	(3.8-4.9)	4.4
Anal, base	(3.8-4.7)	4.1	3.5	3.5	(3.6-3.9)	3.8	(4.4-4.8)	4.7	(4.0-6.3)	4.8	(4.0-5.6)	4.6
Caudal, upper margin	(26.8-28.0)	26.5	26.2	26.6	(25.0-28.2)	26.7	(22.8-27.4)	25.0	(26.7-28.1)	27.3	(24.8-28.2)	26.1
Caudal, lower margin	(10.9-12.7)	11.4	12.2	11.7	(7.9-13.3)	12.0	(10.6-11.2)	10.9	(11.3-12.6)	11.9	(11.3-12.5)	11.9
Pectoral, anterior margin	(17.0-20.1)	18.1	18.9	19.8	(19.5-21.0)	20.4	(16.0-17.1)	16.4	(20.5-23.2)	21.8	(19.9-23.8)	20.6
Pectoral, inner margin	(5.0-5.4)	5.1	5.1	4.9	(4.4-5.3)	4.9	(5.3-6.0)	5.7	(5.7-6.2)	6.0	(5.2-7.5)	6.2
Pectoral, distal margin	(12.3-15.2)	11.5	16.6	18.5	(17.0-19.1)	18.3	(10.4-12.0)	11.4	(18.2-22.0)	20.1	(17.5-23.2)	20.1
Pelvic, anterior margin	(4.9-5.6)	5.2	5.0	5.9	(5.1-6.2)	5.8	(6.1-6.3)	6.2	(5.2-7.5)	6.3	(5.7-6.9)	6.2
Pelvic, distal margin	(5.1-5.8)	5.6	5.5		(5.6-6.4)	6.1	(5.9-6.4)	6.1	(6.2-7.2)	6.8	(7.0-8.0)	7.5
Clasper, length	(2.5-2.7)	2.6	8.1	8.9			(1.8-1.8)	1.8	(7.5-9.5)	8.9		
Snout to Dorsal 1	(32.0-32.8)	32.3	32.1	32.7	(29.5-32.8)	31.4	(26.5-29.3)	28.0	(27.2-29.9)	28.5	(27.4-32.7)	28.8
Snout to Dorsal 2	(62.4-65.5)	64.0	66.6	65.7	(63.0-67.1)	64.7	(60.4-61.6)	60.9	(61.2-64.8)	63.1	(57.9-66.5)	64.7
Snout to Pectoral	(20.9-23.9)	22.5	21.7	22.2	(19.6-22.7)	21.0	(20.8-23.6)	22.4	(19.3-23.6)	21.4	(20.6-25.9)	24.0
Snout to Pelvic	(49.5-52.9)	50.9	52.9	51.5	(50.5-55.5)	53.6	(47.6-49.7)	48.7	(47.7-51.5)	49.3	(50.4-57.0)	52.8
Snout to Anal	(61.7-64.0)	63.0	66.2	62.5	(63.6-67.7)	65.4	(59.5-60.8)	60.2	(61.6-65.5)	63.5	(62.4-70.7)	65.7
Interspace between:												
Dorsals 1 & 2	(22.2-25.4)	23.3	26.1	24.1	(23.2-25.2)	24.1	(20.9-22.4)	21.6	(23.2-24.8)	24.0	(22.5-26.0)	24.5
Dorsal 2 and caudal 1	(6.5-7.9)	7.2	6.9	7.1	(5.8-6.8)	6.2	(7.3-7.9)	7.5	(6.1-7.3)	7.0	(6.3-7.8)	6.9
Anal and caudal	(6.3-7.4)	6.7	5.7	5.9	(4.3-5.9)	5.1	(6.2-6.8)	6.4	(5.8-6.5)	6.1	(5.7-7.1)	6.3
Greatest depth	(12.0-16.7)	14.0	15.4		12.8		(14.3-16.7)	15.5	(12.5-18.4)	15.4	(14.5-21.0)	18.2

[1]See tables 4, 6, 8, 10, 12, 16 & 19 for data on weights not presented here.

TABLE 20, Continued—MORPHOMETRIC DATA ON NINE SPECIES OF SHARKS
(Values expressed as per cent of total length unless otherwise indicated.)

No. and Type	*Galeocerdo cuvieri*								*Negaprion brevirostris*					
	Immature ♂	Immature ♀	Immature ♀	9 Sub-adults (6♂♂ & 3♀♀)		2 Mature ♂♂		4 Mature ♀♀		Immature ♂	2 Mature ♂♂		7 Mature ♀♀	
				(Range)	Average			(Range)	Average				(Range)	Average
Total length (cm)	102	113	133	(187-269)	233	321	352	(331-362)	343	93	251	256	(222-279)	253.7
Weight (lbs.)[1]	7	8	29	(70-295)	161	337	442	(425-775)	555	10	190	166		
Standard length	70.0	65.6	72.8	(70.5-75.0)	72.4	80.9		(74.4-79.8)	77.9	71.5	75.5	78.8	(75.0-77.5)	76.2
Snout to mouth	4.4	5.3	4.8	(3.7-4.5)	4.1	3.1	3.7	(4.0-4.8)	4.3	5.2	3.8	4.3	(3.6-5.0)	4.3
Mouth breadth	8.3	9.3	9.8	(7.9-10.7)	9.3	8.9	9.2	(9.7-12.3)	10.1	9.0	9.8	9.2	(8.8-10.6)	9.8
Eye diameter		2.2	2.3	(0.9-1.9)	1.4	1.2	1.0	(1.1-1.3)	1.2	1.6	1.0	0.8	(0.8-1.1)	1.0
Nostrils: dist. between	4.9	4.9	4.8	(4.1-5.9)	4.9	4.8	4.4	(4.5-5.1)	4.9	5.0	4.9	4.7	(4.5-5.6)	4.9
Dorsal 1, height	7.4	8.2	8.7	(6.4-9.1)	8.1	7.5	8.8	(7.2-8.5)	8.0	7.5		8.6	(7.9-8.9)	8.2
Dorsal 1, base	8.1	8.4	9.1	(7.5-9.4)	8.7	9.3	9.1			9.7	9.2	9.8	(9.0-10.8)	9.9
Dorsal 2, height	2.5	2.7	3.8	(2.0-3.8)	3.0	3.1	3.4	(2.6-3.5)	3.2	6.5	7.2	8.0	(6.8-7.9)	7.5
Dorsal 2, base	3.9	3.6	3.2	(3.6-4.7)	4.1	2.1	3.8	(4.0-4.7)	4.4	7.2	7.9	7.0	(6.8-8.1)	7.4
Anal, height	2.6	2.7	2.7	(2.3-4.3)	3.4	3.2	3.7	(4.6-4.8)	4.7	4.3	6.2	6.4	(5.0-5.9)	5.5
Anal, base	3.6	3.6	3.8	(3.3-4.5)	3.7	3.5	4.1	(3.5-4.1)	3.9	5.4	6.0	5.9	(5.4-6.5)	5.9
Caudal, upper margin	31.4	33.0	30.8	(27.6-29.3)	28.4	24.7	24.9	(24.1-26.3)	25.0	23.8	25.0	24.7	(22.8-25.7)	24.6
Caudal, lower margin	12.2	11.6	12.0	(10.6-13.9)	12.2	11.0	12.2	(12.7-13.3)	12.9	11.9	11.3	12.0	(10.0-13.0)	11.5
Pectoral, anterior margin	14.1	14.2	12.8	(13.4-17.3)	14.8	15.0	14.8	(14.9-16.2)	15.5	16.4	17.8	19.3	(17.4-20.8)	19.5
Pectoral, inner margin	4.1	4.1	4.5	(4.2-5.4)	4.8	4.7	5.1	(4.3-5.3)	4.9	6.5	6.4	6.8	(6.5-7.4)	6.9
Pectoral, distal margin	11.8	11.1	12.2	(10.8-14.9)	12.8	11.8	12.7	(12.9-13.6)	13.2	12.4	17.5	18.2	(18.1-22.0)	19.5
Pelvic, anterior margin	5.1	5.3	4.9	(4.4-7.1)	5.5	7.0	7.4	(5.8-7.2)	6.3	7.9	8.7	9.2	(8.6-10.3)	9.1
Pelvic, distal margin	3.4	4.4	5.3	(1.8-4.3)	3.3	4.8	5.3	(5.9-6.8)	6.4	7.1	7.8	8.1	(7.0-9.0)	8.5
Clasper, length	2.3			(2.3-4.8)	3.4	7.7	6.2			2.2	7.4	7.5		
Snout to Dorsal 1	27.0	27.6	27.9	(25.7-30.5)	27.1	29.1	27.6	(28.1-30.4)	29.5	35.7	33.6	34.4	(34.4-36.6)	35.6
Snout to Dorsal 2	51.0	55.5	61.8	(58.7-61.9)	60.0	61.9		(63.3-64.6)	64.0	63.8	61.9	62.4	(61.0-70.6)	64.0
Snout to Pectoral	20.0	21.4	21.1	(17.5-21.6)	19.2	20.1	19.0	(18.1-22.2)	19.9	19.5	18.5	21.6	(20.0-24.3)	21.6
Snout to Pelvic	44.2	46.2	53.5	(46.7-53.5)	49.3	48.0	52.5	(52.6-54.6)	53.7	50.8	46.4	49.6	(50.1-54.0)	51.4
Snout to Anal	57.9	58.6	65.3	(57.4-66.3)	62.0	61.4		(64.6-68.3)	66.1	63.8	61.0	64.0	(63.4-72.0)	66.1
Interspace between:														
Dorsals 1 and 2	22.7	22.2	23.3	(22.6-25.8)	24.7	23.2	25.3	(25.4-25.8)	25.6	19.5	18.3	19.3	(18.0-18.8)	18.4
Dorsal 2 and caudal	9.8	8.7	7.5	(7.5-10.6)	9.3	8.4	8.2	(7.9-8.6)	8.3	6.5	6.6	6.8	(6.3-6.5)	6.4
Anal and caudal	7.1	7.1	6.4	(6.6-7.8)	7.1	6.8	6.7	(6.1-6.9)	6.5	6.7	6.6	11.9	(5.9-6.5)	6.2
Greatest depth	7.4	8.4	15.7	(10.7-18.8)	13.6	15.7	10.1	(9.4-18.8)	13.9	12.4	10.5		(9.2-18.8)	12.7

[1]See tables 4, 6, 8, 10, 12, 16 & 19 for data on weights not presented here.

TABLE 20, Continued— MORPHOMETRIC DATA ON NINE SPECIES OF SHARKS
(Values expressed as per cent of total length unless otherwise indicated.)

	Sphyrna mokarran				*Sphyrna lewini*		
No. and Type	1 Young ♀	4 Immature (1 ♂ & 3 ♀ ♀)		1 Mature ♂[2]	4 Mature ♀ ♀	1 Immature ♂	3 Mature ♂ ♂
		(Range)	Average		(Range) Average		(Range) Average
Total length (cm)	81	(219-270)	244	316	(311-372) 351	152	(177-209) 193
Weight (lbs.)[1]		(106-181)	141		(425-541) 483	30	
Standard length	67.0	(66.5-69.5)	68.4	71.0	(70.0-77.0) 73.0	71.0	(70.0-72.0) 71.0
Snout to mouth	6.8	(5.1-5.3)	5.2	4.7	(4.9-5.1) 5.0	5.2	(4.9-4.9) 4.9
Mouth breadth	6.2	(6.8-7.4)	7.1	7.6	(8.1-10.5) 8.9	6.2	(6.1-6.8) 6.5
Eye diameter	1.5	(1.0-1.9)	1.4	1.0	(0.7-1.0) 0.9	1.4	(1.3-1.6) 1.5
Nostrils: dist. between	16.2	(16.3-17.3)	16.8	19.5	(17.1-19.5) 18.6	17.7	(17.4-18.4) 18.1
Dorsal 1, height	14.5	(15.3-18.0)	16.4	15.7	(15.5-17.2) 16.3	12.1	(12.4-13.5) 12.5
Dorsal 1, base	8.6	(9.3-9.8)	9.5	10.5	(9.2-10.5) 9.9	9.8	(9.9-10.6) 10.3
Dorsal 2, height	4.7	(5.0-5.7)	5.4	5.5	(5.5-5.9 5.7	1.9	(2.3-2.8) 2.6
Dorsal 2, base	4.1	(4.6-5.2)	4.9	4.6	(4.4-4.9) 4.7	3.3	(2.8-3.1) 3.0
Anal, height	3.2	(3.7-4.8)	4.3	4.4	(3.7-4.9) 4.2	3.1	(2.8-3.0) 2.9
Anal, base	5.9	(6.2-6.6)	6.4	5.5	(5.2-6.7) 5.9	4.7	(4.9-5.1) 5.0
Caudal, upper margin	31.0	(30.9-33.5)	32.0	28.6	(28.2-29.0) 28.6	31.0	(30.5-31.2) 30.9
Caudal, lower margin	10.5	(11.7-13.3)	12.8	12.2	(11.1-12.0) 11.5	11.8	(12.2-12.4) 12.3
Pectoral, anterior margin	12.3	(13.7-15.4)	14.6	15.0	(14.7-16.1) 15.3	11.8	(13.0-13.0) 13.0
Pectoral, inner margin	3.6	(3.4-3.4)	3.4	4.6	(3.6-3.9) 3.8	4.2	(2.9-4.3) 3.4
Pectoral, distal margin	10.4	(13.0-15.1)	13.5	13.3	(13.4-15.3) 14.0	11.3	(10.8-11.8) 11.2
Pelvic, anterior margin	6.9	(8.0-9.4)	8.9	8.5	(7.9-10.0) 9.2	5.0	(5.1-6.0) 5.4
Pelvic, distal margin	6.8	(3.1-3.6)	3.4		(4.0-6.3) 4.7	5.5	(6.6-7.8) 7.2
Clasper, length	—	(3.8)	3.8			4.1	(6.5-7.6) 6.8
Snout to Dorsal 1	26.0	(24.1-26.8)	25.5	29.0	(26.9-34.2) 29.9	25.6	(24.9-27.2) 26.0
Snout to Dorsal 2	55.5	(54.8-56.5)	55.7	59.8	(58.0-64.4) 61.0	59.5	(60.0-62.0) 61.0
Snout to Pectoral	20.5	(17.0-19.3)	18.5	19.6	(17.4-20.2) 18.8	18.4	(19.2-20.5) 20.0
Snout to Pelvic	—	(41.0-44.9)	43.1		(45.8-52.0) 48.9	42.0	(44.2-46.0) 45.1
Snout to Anal	52.6	(54.0-56.6)	55.0	60.8	(56.3-58.0) 57.2	56.5	(56.5-60.5) 58.5
Interspace between:							
Dorsals 1 and 2	21.5	(18.6-21.7)	20.6	22.8	(21.2-22.8) 22.1	25.6	(24.5-26.4) 25.8
Dorsal 2 and caudal	7.7	(7.6-7.9)	7.7	7.5	(7.4-7.7) 7.6	9.9	(6.4-7.7) 7.1
Anal and caudal	6.9	(6.2-6.9)	6.5	6.2	(6.2-6.7) 6.4	6.9	(6.1-6.7) 6.5
Greatest depth	—	(12.6-13.7)	13.1	14.3	(11.4-14.7) 13.5	12.4	(15.5-15.5) 15.5

[1]See tables 4, 6, 8, 10, 12, 16 & 19 for data on weights not presented here.
[2]Pelvic fins and viscera mutilated.

TABLE 21

A COMPARISON OF CLASPER LENGTH WITH RESPECT TO MATURITY IN EIGHT SPECIES OF SHARKS[1]

Total Length Groups[2]	*Carcharhinus acronotus* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Carcharhinus limbatus* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Carcharhinus maculipinnus* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Carcharhinus milberti* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Carcharhinus leucas* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Ginglymostoma cirratum* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Negaprion brevirostris* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.	*Galeocerdo cuvieri* No. of ♂♂	Clasper L. mm	Clasper L. %T.L.
90	1	33	3.4	2	21	2.5	1	20	2.3				1	19	2.2				1	20	2.2			
105	4	93	8.2	1	50	4.8	2	17	1.6													1	23	2.2
120	4	93	8.1	1	55	4.4	1	20	1.8							1	17	1.4	1	23	2.0			
135				3*	86	6.2																		
150				2	113	7.5																		
165				3	113	7.1							1	35	2.1									
180													7	55	3.0	1	50	2.9						
195							6	145	7.3	7	174	8.8	1	63	3.2									
210										1	157	7.4	6*	100	5.1							2	55	2.6
225													10*	176	7.8							1	65	2.9
240													3	195[3]	8.1[3]									
255																3	188	7.4	3	189	7.4	2	93	3.6
270																1	160	6.0	1	160	6.0			
285																						1	102	3.7
300																						1	247	7.7
345																						1	218	6.2

[1]Based only on an average of male specimens examined at Cape Haze Marine Laboratory 1955-1963. Immature sharks are listed above dotted line, mature sharks below except in groups indicated by * which includes both immature and mature individuals.

[2]Total length of each male rounded to the nearest 15 cm.

[3]These data (225, 190, 170 mm; 9.5, 7.9, 6.9%, respectively) show the trend in proportional decrease and possible shrinkage of the claspers in larger (older?) males. See also under *Sphyrna tiburo* and Table 18.

TABLE 22

SUMMARY OF PATTERNS OF GROWTH CHANGES IN NINE SPECIES OF SHARKS BASED ON DIMENSIONS, EXPRESSED AS PER CENT OF TOTAL LENGTH, GIVEN IN TABLES 14 AND 20

(O = no perceptible change; √ = some indication; √√ = definite indication.)

	Relative increase in:				Relative decrease in:		
	Trunk length	Head width	Pectoral length	Dorsal height	Head length	Tail length	Eye diameter
Mustelus norrisi	√√	√	√√	√√	√√	√	√√
Carcharhinus leucas	√√	√	√√	√	√	√√	√√
Carcharhinus milberti	√	√√	√	√√	√	O	√√
Carcharhinus obscurus	O	√	√√	√	O	O	√√
Carcharinus maculipinnis	√	√√	√√	√	√	√	O
Carcharhinus limbatus	√	√	√√	√	√	O	√
Galeocerdo cuvieri	√	√	√	√	O	√√	√√
Negaprion brevirostris	O	√	√√	√	√	O	√√
Sphyrna mokarran	√	√√	√√	√√	√	√	√√

Breder (1934) noted a difference in the general body shape of male and female nurse sharks and the larger pectoral fin of the male compared with a female of the same size. We have insufficient data on large female nurse sharks to supplement Breder's observations. The limited comparative data in Table 20 on mature males and females do not show any noticeable difference in pectoral fin measurements. Our measurements, unfortunately, would not show up any difference in the general body shape (width) between sexes as noted by Breder.

Summary

This report is based on over nine years of shark collecting on the central west coast of Florida between Placida and Sarasota, by the Cape Haze Marine Laboratory. Most specimens were caught on the Laboratory's set lines in the Gulf of Mexico, 1 to 5 miles from shore. Others were obtained from local fishermen operating nets and lines in the Gulf, bays, and passes.

The specimens totaled 762 plus 842 embryos of 16 species: *Carcharhinus leucas* (135), *C. milberti* (109), *Negaprion brevirostris* (76), *Carcharhinus limbatus* (64), *Sphyrna tiburo* (63), *Carcharhinus acronotus* (61), *Galeocerdo cuvieri* (60), *Ginglymostoma cirratum* (58), *Carcharhinus obscurus* (49), *Scoliodon terraenovae* (22), *Sphyrna mokarran* (21), *Carcharhinus maculipinnis* (20), *Mustelus norrisi* (17), *Sphyrna lewini* (5), *Aprionodon isodon* (1), and *Carcharias taurus* (1).

Records were kept on weights, measurements, stomach contents, condition of gonads, embryos, and any unusual conditions.

The highest catch per unit of effort was in December, February, and March, 1.72, 1.22, and 1.42, respectively. The lowest, in September, was 0.28. Outbreaks of "red tide" (involving *Gymnodinium breve*) and weather conditions influenced the catch per unit effort.

Galeocerdo cuvieri and *Carcharhinus leucas* were caught throughout the year. *C. milberti* and *C. obscurus* were caught November through April. The majority of other sharks were caught from early spring to late fall, with an increase during May, June, and July.

Gestation periods for seven species were estimated from morphological and behavioral evidence. Full-size ovarian eggs, enlarged testes, full seminal vesicles, and swollen, bleeding claspers were taken to indicate the mating season.

Time of parturition was approximated by extrapolation of data on the monthly increase in sizes of embryos, capture of young with fresh umbilical scars, and the post-parturition condition of the uteri. In some cases captive sharks gave birth and courtship and copulation were observed in the Laboratory pens. Pseudo-placental attachments have been found in *Mustelus norrisi, Sphyrna mokarran,* and in every species of *Carcharhinus* (except *C. maculipinnis* as no gravid females were examined).

Data on weights in eight species show that mature females are heavier than the males for the same size. Females appear to mature at a larger size and maximum lengths are greater than males.

Stomach contents included a variety of invertebrates, at least 33 genera of teleost fishes, rays, sharks, skates, turtles, and birds.

Ginglymostoma cirratum. Males in mating condition were captured in May, June, and July. Maturity is reached at 320 cm.

Carcharhinus acronotus. Young are born in the late spring. Maturity is reached at 103 cm probably in two years with the yearlings measuring about 80 cm.

Carcharhinus leucas. Males and females were represented almost equally. Young of about 75 cm are born in spring. Mating season is June and July. Mature size is about 230 cm.

C. limbatus. Embryos showed a size increase from 7.5 cm in August to full-term size of 60 cm in April. Parturition may extend into early June. Mating occurs in May through July. Young, about 80 cm, probably yearlings, were captured in March and April. The smallest mature female was 155 cm and the smallest mature male 135 cm.

C. maculipinnis. Young of both sexes, sub-adult, and adult males were captured infrequently.

C. milberti. All specimens captured were mature or very nearly so. Over 80 per cent were females. Gravid females carried embryos of 39 cm in November to 58 cm in March. A captive female gave birth in March. The smallest mature female was 185 cm.

C. obscurus. Gravid females fell into two groups: those carrying embryos of 43 to 70 cm and those carrying full-term young of 85 to 100 cm at the same time of year. A captive female gave birth 25 December to young of 84 to 94 cm. Ovarian eggs are 14 to 20 mm in November to 25 mm in January. Only two males were caught. A male captured in April was full of sperm. Gestation period may be 16 months.

Galeocerdo cuvieri. Juveniles and sub-adults were caught as frequently as adults. Gravid females carried either very early embryos, 72 mm and smaller, or near-term embryos 68 to 77 cm in May and June. We examined a male 25 May in post-mating condition. The gestation period may be slightly over a year. Maturity is reached at 290 cm.

Mustelus norrisi. Most specimens between 60 and 70 cm were mature. Embryos 24 to 28 cm occurred in late December and January.

Negaprion brevirostris. Many adults were caught in May when about half of the mature females carry nearly full-term young of 60 cm, and

half have full-size ovarian eggs 35 to 40 mm. Mating takes place in May through July. Maturity is reached at about 250 cm.

Scoliodon terraenovae. One female, 83 cm, had uterine eggs in March. The ovary in this species is developed on the left side, contrary to all other local species examined.

Sphyrna mokarran. Gravid females carrying embryos of 53-60 cm were captured in May and June. A free-swimming specimen, 81 cm, was caught in July.

S. tiburo. A 92-cm female had uterine eggs in March and a 103-cm female had embryos 3 to 4 cm in April. Females are mature at 90 cm and males at about 76 cm.

SUMARIO

TIBURONES DEL CENTRO DE LA COSTA DEL GOLFO DE LA FLORIDA

Este reporte está basado en más de 9 años de recolección de tiburones en la parte central de la costa de la Florida, entre Placida y Sarasota, por el Laboratorio Marino de Cabo Haze. La mayoría de los ejemplares fueron cogidos en los cordeles puestos por el Laboratorio en el Golfo de México, de 1 a 5 millas de la costa. Otros fueron obtenidos de pescadores locales que operan con redes y cordeles en el Golfo, bahías y pasos.

Los ejemplares hicieron un total de 762 más 842 embriones de 16 especies: 135 *Carcharhinus leucas,* 109 *C. milberti,* 76 *Negaprion brevirostris,* 64 *Carcharhinus limbatus,* 63 *Sphyrna tiburo,* 61 *Carcharhinus acronotus,* 60 *Galeocerdo cuvieri,* 58 *Ginglymostoma cirratum,* 49 *Carcharhinus obscurus,* 22 *Scoliodon terraenovae,* 21 *Sphyrna mokarran,* 20 *Carcharhinus maculipinnis,* 17 *Mustelus norrisi,* 5 *Sphyrna lewini,* 1 *Aprionodon isodon* y 1 *Carcharias taurus.*

Se anotaron los pesos, medidas, contenidos estomacales, estado de las gónadas y cualquier condición no corriente.

La captura más alta por unidad de esfuerzo fué en Dicimbre, Febrero y Marzo, 1.72, 1.22 y 1.42 respectivamente. La más baja fué en Septiembre, 0.28. Erupciones de "Marea roja" (en la que estaba envuelto *Gymnodinium breve*), y condiciones climatológicas influenciaron en la captura/unidad de esfuerzo.

Galeocerdo cuvieri y Carcharhinus leucas fueron cogidos durante todo el año. *C. milberti* y *C. obscurus* fueron cogidos de Noviembre a Abril. La mayoría de los otros tiburones fueron cogidos desde principios de primavera hasta finales de otoño, con un aumento en Mayo, Junio y Julio.

Los períodos de gestación de 7 especies fueron estimados por evidencias morfológicas y de comportamiento. Huevos ováricos de tamaño completo, testis aumentados, vesículas seminales llenas y claspers hinchados, sangrando, fueron tomados como indicadores para establecer la época de apareamiento.

La época del parto se calculó aproximadamente por la extrapolación de los datos de aumento mensual en los tamaños de los embriones, captura de jóvenes con cicatriz umbilical reciente y las condiciones post-partum del útero. En algunos casos, tiburones en cautividad parieron y se observó el galanteo y la copulación en los tanques del Laboratorio. Se han encontrado aditamentos pseudoplacentarios en todas las especies de *Carcharhinus* (excepto *C. maculipinnis,* en que no se examinó ninguna hembra grávida), *Mustelus* y *Sphyrna mokarran.*

Datos con respecto a los pesos de ocho especies muestra que: las hembras maduras son más pesadas que los machos del mismo tamaño. Las hembras parece que maduran cuando son más grandes y sus longitudes máximas son mayores que en los machos.

Los contenidos estomacales incluyeron una variedad de invertebrados, por lo menos 33 géneros de peces teleósteos, rayas, tiburones, lijas, tortugas y pájaros.

Ginglymostoma cirratum. Se capturaron machos en condiciones de aparearse an Mayo, Junio y Julio. Alcanza la madurez a los 320 cm de longitud.

Carcharhinus acronotus. Los jóvenes nacen a finales de la primavera. Alcanzan la madurez a los 103 cm, probablemente en dos años, ya que los de un año miden alrededor de 80 cm.

Carcharhinus leucas. Los machos y las hembras estuvieron igualmente representados. Los jóvenes nacen en la primavera midiendo alrededor de 75 cm. La época de apareamiento es Junio y Julio. La madurez es alrededor de los 230 cm.

C. limbatus. Los embriones mostraron un crecimiento desde 7.5 cm en Agosto hasta el tamaño completo correspondiente de 60 cm en Abril. El parto puede extenderse hasta principios de Junio. El apareamiento es desde Mayo hasta Julio. Jóvenes de alrededor de 80 cm, probablemente de un año, fueron capturados en Marzo y Abril. La hembra madura más pequeña midió 155 cm y el macho maduro más pequeño, 135 cm.

C. maculipinnis. Jóvenes de ambos sexos, sub-adultos y machos adultos fueron capturados con frecuencia.

C. milberti. Todos los ejemplares capturados ya eran maduros o estaban próximos a serlos. Más del 80 por ciento eran hembras. Las hembras grávidas llevaban embriones desde 39 cm en Noviembre hasta 58 cm en Marzo. Una hembra cautiva parió en Marzo. La hembra madura más pequeña midió 185 cm.

C. obscurus. Las hembras grávidas comprendieron dos grupos: las que llevaban embriones de 43 a 70 cm y las que llevaban jóvenes de 85 a 100 cm, en la misma época del año. Una hembra cautiva parió el 25 de

Diciembre jóvenes de 84 a 94 cm. Los huevos ováricos miden de 14 a 20 mm en Noviembre hasta 25 mm en Enero. Sólo dos machos fueron cogidos. Un macho capturado en Abril estaba lleno de esperma. El período de gestación puede que sea 16 meses.

Galeocerdo cuvieri. Los jóvenes y los sub-adultos fueron cogidos con la misma frecuencia que los adultos. Las hembras grávidas llevaban o embriones muy tempranos, de 72 mm y más pequeños, o embriones a término de 68 a 77 cm en Mayo y Junio. Examinamos un macho el 25 de Mayo en condiciones post-apareamiento. El período de gestación puede ser poco más de un año. Alcanzan la madurez a los 290 cm.

Mustelus norrisi. La mayoría de los ejemplares entre 60 y 70 cm estaban maduros. Los embriones de 24 a 28 cm fueron a fines de Diciembre y en Enero.

Negaprion brevirostris. Se cogieron muchos adultos en Mayo, cuando alrededor de la mitad de las hembras maduras llevan jóvenes de tamaño de 60 cm, y la otra mitad tienen huevos ováricos de tamaño completo, 35 a 40 cm. El apareamiento tiene lugar desde Mayo hasta Julio. La madurez la alcanzan alrededor de los 250 cm.

Scoliodon terraenovae. Una hembra, de 83 cm, tenía huevos uterinos en Marzo. El ovario en esta especie se desarrolla en el lado izquierdo, contrario a todas las otras especies examinadas en el área.

Sphyrna mokarran. Se capturaron hembras grávidas llevando embriones de 53-60 cm en Mayo y Junio. Un ejemplar de 81 cm nadando libremente fué capturado en Julio.

S. tiburo. Una hembra de 92 cm tenía huevos uterinos en Marzo y una hembra de 103 cm tenía embriones de 3 a 4 cm en Abril. Las hembras están maduras a los 90 cm y los machos alrededor de los 76 cm.

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