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A contribution to the natural history of the white-tip shark, *Pterolamiops longimanus* (Poey)

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Abstract—Until recently little has been known about the common, pelagic shark, *Pterolamiops longimanus.* Data gathered during recent offshore cruises show it to be abundant and widely distributed in the warm waters of the western North Atlantic. It occurs at a wide range of salinities but withdraws from some waters when the temperature gets as low as about 21°C. It is rarely present in water shallower than about 100 fathoms. In a sample of 110 sharks few were over 250 cm in total length, although the maximum size reported in the literature is much longer. Fish and cephalopods are the most frequent food items in white-tip stomachs. White-tips are cautious, persistent, and sluggish in their behaviour. They are responsible for considerable damage to long line caught tuna in the Gulf of Mexico. Geographical sexual segregation is a feature of white-tip life history. Fragmentary data indicate that the mating and pupping season is in the late spring or early summer and that the gestation period is about one year. Females probably first mate at a length of about 200 cm, and probably bear young in alternate years thereafter. The number of pups per litter varies from 2 to 9 with a mean of about 6. Shark suckers (*Remora remora*), pilotfish (*Naucrates ductor*), dolphin (*Coryphaena hippurus*) and a copepod parasite or parasites are common associates of the white-tip.

INTRODUCTION

RECENTLY, BIGELOW and SCHROEDER (1948), in their monograph " Sharks," wrote of the white-tip, " Astonishingly little is known of the habits of *longimanus*, considering that it is one of the members of its genus that has been recognized the longest."

That this is true is probably explained by the animal's rather strict oceanic habit which makes it largely unavailable to seaside naturalists. However, with an increasing number of offshore surveys it is becoming better known. MATHER and DAY (1954) found it to be widespread, abundant, and the commonest pelagic shark in the warm parts of the North Atlantic. BULLIS (1955) regards this shark as responsible for most of the damage to long line-caught tuna n the Gulf of Mexico, although it was quite unknown from that area prior to an investigation of offshore waters begun in 1950 by the U.S. Fish and Wildlife Service.

Although BIGELOW and SCHROEDER (1948) also assume the white-tip to be common in the Mediterranean on the basis of statements by MÜLLER and HENLE (1841), GÜNTHER (1870), DODERLEIN (1881), and others, TORTONESE (1951) states that its presence there is not now demonstrable by museum specimens or other verifiable records. MAUL (1955) records the species from Madeira.

The authors have been gathering data on the Atlantic white-tip shark independently during the course of other work for the past few years. BACKUS has made observations from the Research Vessels *Atlantis* and *Bear* of the Woods Hole Oceanographic

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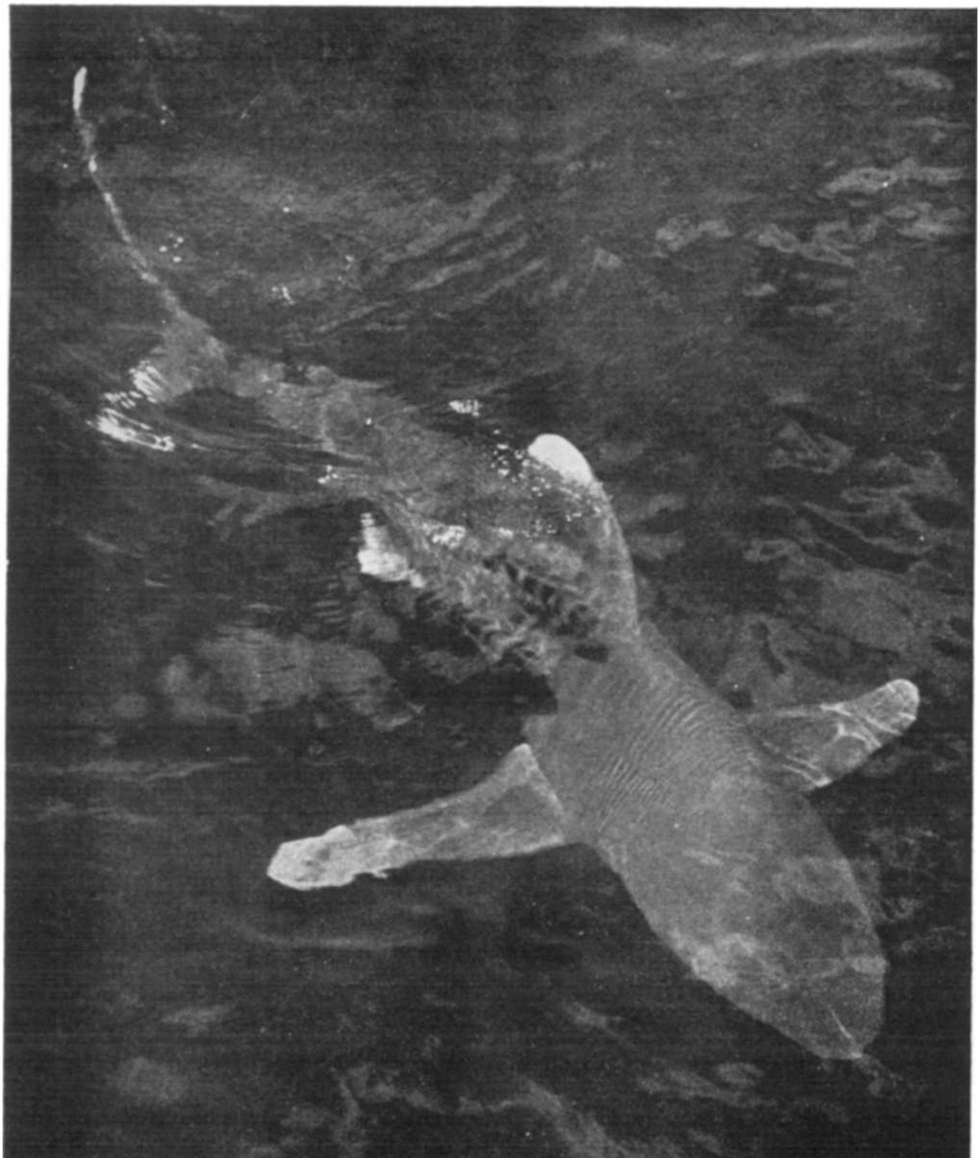

Fig. 1. White-tip shark (*Pterolamiops longimanus*) with two pilotfish, photographed at sea by JAN HAHN, Woods Hole Oceanographic Institution.

Institution, and SPRINGER has made observations from the Exploratory Fishing Vessel *Oregon* of the U.S. Fish and Wildlife Service. ARNOLD has furnished records of captures made from the U.S.F.W.S. Vessel *Alaska* and from recent cruises of the *Oregon*. In many cases, in the absence of the authors, fishing was done and records kept by co-workers or crew members of the above vessels. Furthermore, we have

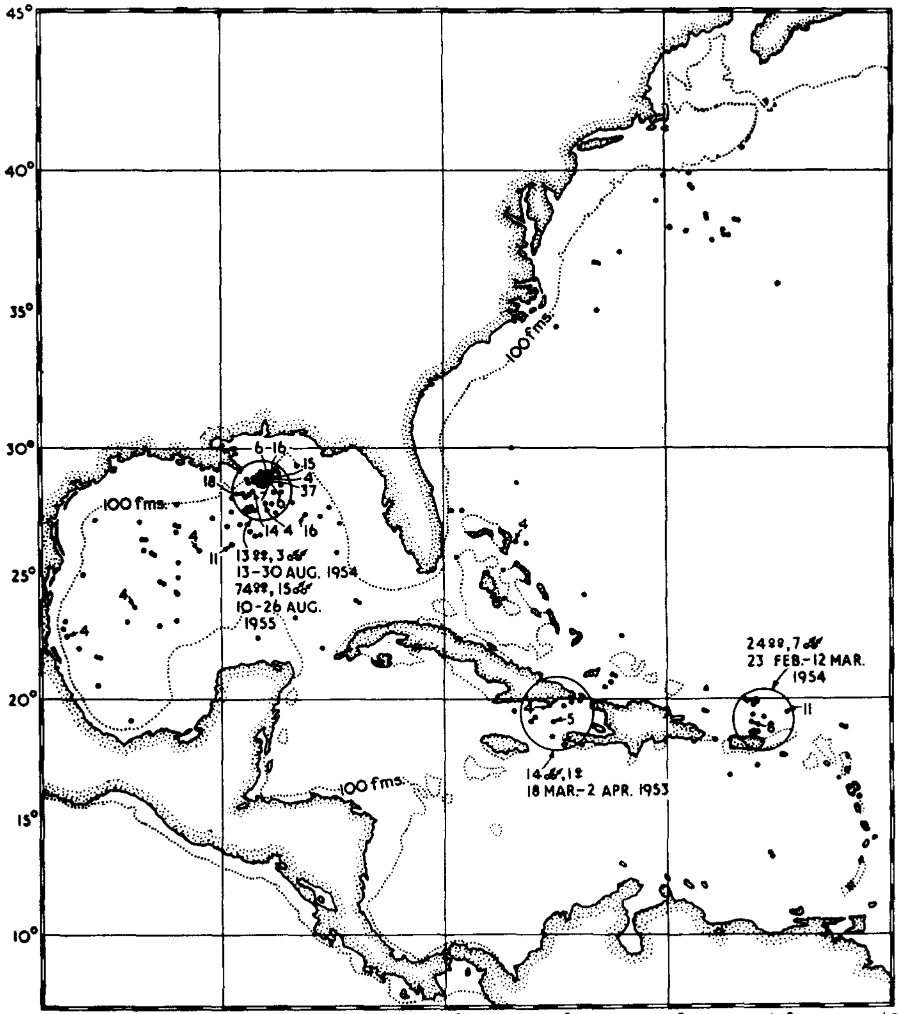

Fig. 2. Distribution of white-tip shark captures. The scanty literature records are omitted. Three areas in which sexual segregation has been noted are encircled. All captures save one are outside the 100-fathom curve.

used records furnished by W. W. ANDERSON of captures made from the U.S.F.W.S. Research Vessel *Theodore N. Gill*, and Mr. WILLIAM C. SCHROEDER of the Woods Hole Oceanographic Institution has given us records of captures from *Caryn* and *Cap'n Bill II*. Because of this diversity of sources, our data vary in their completeness and do not show the geographic distribution of the fishing effort which produced them.

Our records (Fig. 2) are mostly from hand line and long line captures near the surface, but some sight records are included. Statements concerning the absence of white-tips from inshore waters and from parts of the Straits of Florida are largely made on the basis of SPRINGER'S observations during commercial shark fishing operations on the continental shelf off Florida, in the Gulf of Mexico, off the Caribbean coasts near Nicaragua and Trinidad, and off the coasts of the Guianas between 1930 and 1949.

NOMENCLATURE

The species included in *Carcharhinus* as previously understood (see BIGELOW and SCHROEDER, 1948) were divided into three genera in a recent revision of western-Atlantic Carcharhinidae (SPRINGER, 1950a ; 1951). A primary division of these sharks was based on the presence or absence of a median, longitudinal ridge in the skin between the first and second dorsal fins. *Carcharhinus* was retained for the smooth-backed members of the older genus. The ridge-backed members were divided between *Eulamia* (with acuminate first dorsal and pectorals) and *Pterolamiops* (with broadly rounded first dorsal and pectorals). The white-tip belongs to the latter genus in this classification.

In general, though observations have not covered all species, the large ridge-back, carcharhinid sharks in the western North Atlantic are oceanic, although they may at times range into coastal waters. Conversely, western North Atlantic observations from off the shelf are lacking for any smooth-backed carcharhinids excepting two doubtful observations of *Negaprion brevirostris* (Poey). The smooth-backed species of the genus *Carcharhinus* (as restricted by SPRINGER) are shallow water species particularly abundant near mouths of large rivers. *Eulamia* contains sharks of the reefs, the outer parts of the continental shelf, and, to some extent, the high seas. *Pterolamiops* is strictly pelagic.

Field identification of the white-tip shark is easily made because it is the only large carcharhinid having a high first dorsal that is broadly and evenly rounded at its apex. The very large pectorals with broadly rounded tips are also distinctive. The middorsal ridge is readily observed in freshly caught late embryos, young, and adults, but its existence in preserved ones cannot always be demonstrated. Usually the pectorals and the first dorsal are tipped with white, but the amount of white showing is variable and its complete absence is fairly common. Black tips on the pelvics, second dorsal, anal, and lower caudal characterized a young example collected off Tampico, Mexico. This distribution of black spots is shown in MAUL'S figure (1955, Fig. 9). The black spots, if regularly present in young white-tips, tend to disappear in preserved specimens, and become obscure in living white-tips as they approach maturity. The pectorals and first dorsal fin of the Tampico specimen were not white-tipped, although the first dorsal was somewhat lighter near the tip.

DISTRIBUTION

BIGELOW and SCHROEDER (1948) suggested that the physical factor which primarily determines the distribution of this " . . . more strictly pelagic . . . " shark is salinity. Data available to them indicated that this animal was not found at salinities lower than about 35·5‰. They concluded that its offshore habit was at least in part caused by an avoidance of low salinities. Thus they explained the absence of the white-tip along the east coast of the United States in summer where it might be expected on the basis of temperature alone.

Our records show that the white-tip occurs over a wide range of salinities. In 29°N, 88°W, for instance, where we have many records for July and August, the salinity may be lower than 28‰ (Dept. of Oceanography, A & M College of Texas, 1954). Furthermore, on the basis of salinity we cannot explain the absence of the white-tip from the northern and western side of the Gulf Stream in its passage through the Straits of Florida and northward along the Florida coast past the Bahamas (where the salinity is high). The area from Key West to off Palm Beach, Florida, was fished extensively by commercial shark fishermen from 1935 to 1949 using bottom set lines. Although the white-tip is apparently not available to bottom lines, regular trails of offshore fishing using floating lines were carried on. The only record of capture of a white-tip by a commercial boat was from the eastern side of the Gulf Stream near Bimini. We have caught the white-tip from early June to late October north of Cape Hatteras and west of the Gulf Stream. While we have not fished much in this region during the cold season, it seems probable that the white-tip withdraws to the south and east at this time. We have noted a withdrawl from the northern Gulf of Mexico when the waters there were cool. This may begin as early as December. In 1955 the most noticeable change in the shark fauna here occurred about 1 February. Sea surface temperatures at this time in the northern Gulf (over water deeper than 100 fathoms) are in the neighbourhood of 70°F (FUGLISTER, 1947). The withdrawal of the white-tip is accompanied by an offshore movement of some of the larger inshore sharks, notably *Galeocerdo cuvier* (Lesueur) the tiger shark, and several species of *Eulamia.*

Our records show that white-tips are ordinarily present in the surface waters where depths exceed 100 fathoms, but that they occasionally move into the adjacent shallower water. We suggest that the controlling factor is competition for food with other species of sharks which places the relatively slow-moving white-tip at a disadvantage.

The northernmost record for the white-tip in the western Atlantic, so far as we know, is for one taken in 40° 43'N, 66° 39'W on 25 July, 1953 (Fig. 2). SCHUCK and CLARK (1951) report a specimen taken in 40° 40'N, 57° 02'W on 12 June, 1950.

It has been generally supposed that the blue shark (*Prionace glauca*) is the abundant, widely-distributed, warm-water, oceanic shark. While gathering our white-tip records (Fig. 2) only one blue shark (a male, 295 cm, from between Santiago and Cabo Cruz, Cuba, 19° 30'N, 76° 50'W on 25 April, 1955) was seen by us in the area of the chart south of latitude 32°N. Published records within this area as given by BIGELOW and SCHROEDER (1948) include one each for St. Thomas, Cuba, and Miami, although HOWELL-RIVERO reported it as often seen around Cuba (in a personal communication also cited by BIGELOW and SCHROEDER). MATHER and DAY (1954) reported only 2 blue sharks (as compared with about 30 white-tips) in the wide area of the southern North Atlantic for which they had observations. This raises the point as to what the source is in the North Atlantic from which male blue sharks invade the waters off our northeast coast in such abundance in the summer.

SIZE

Very few sharks over about 250 cm or under about 150 cm in total length were caught. Since white-tips are born at a length of about 65-75 cm (BIGELOW and

SCHROEDER, 1948) it is apparent that we have not sampled a large part of the population (75-150 cm in length) (Fig. 3). It might be argued that our hooks are too large to catch the smaller sizes, but we discount this since we have caught small specimens of other species. Furthermore, it is certain that we would see the smaller sizes swimming about the vessel and nosing the baits if they were present. A young white-tip 102 cm in total length was taken near Tampico, Mexico, in late January from a long line set near the surface where the water depth was 1,200 fathoms. No

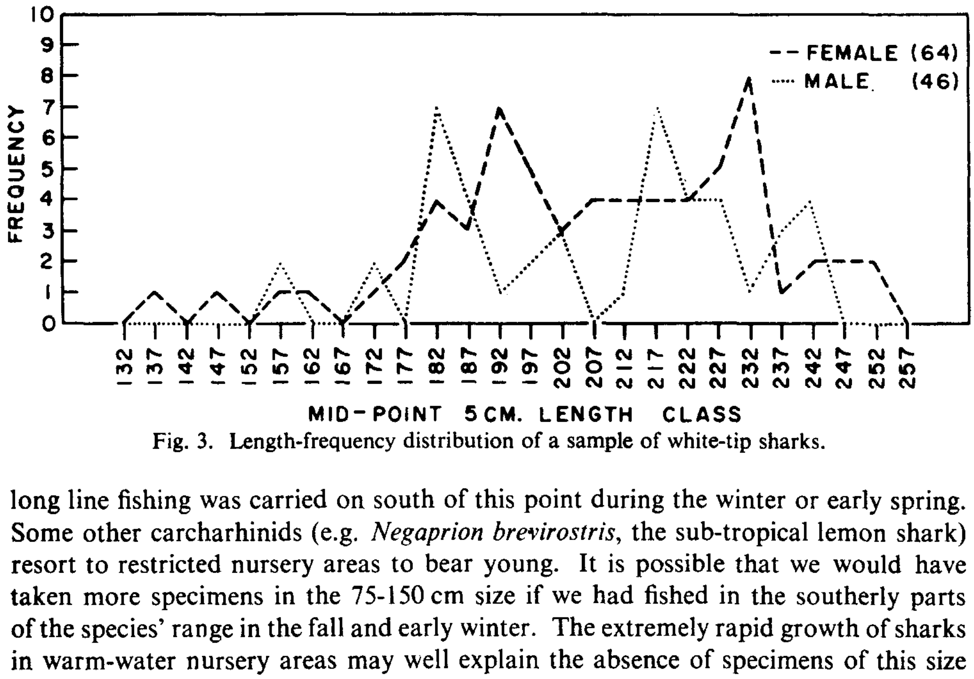

Fig. 3. Length-frequency distribution of a sample of white-tip sharks.

long line fishing was carried on south of this point during the winter or early spring. Some other carcharhinids (e.g. *Negaprion brevirostris*, the sub-tropical lemon shark) resort to restricted nursery areas to bear young. It is possible that we would have taken more specimens in the 75-150 cm size if we had fished in the southerly parts of the species' range in the fall and early winter. The extremely rapid growth of sharks in warm-water nursery areas may well explain the absence of specimens of this size in our collections (made mostly in the spring and summer) as has been noted for *Negaprion*, (SPRINGER, 1950b).

The longest white-tip for which BIGELOW and SCHROEDER (1948) had exact measurements was 350 cm long. This is considerably longer than our longest specimen. BIGELOW and SCHROEDER write that 12 to 13 feet (365–395 cm) is considered the maximum size, but that it is probable that an even larger size may be attained. Our data are insufficient to establish the size range of the species. However, in connection with the extremely large specimens mentioned above, a condition parallel to that found in the great hammerhead shark (*Sphyrna tudes*) is suggested. Unpublished measurements by SPRINGER of a series of adult great hammerheads show that a small percentage of the females are very much larger than the bulk of the adult breeding population. This and other observations support the possibility that some of the extreme size records for sharks persistently referred to in the literature are valid but are based on abnormal individuals, apparently always females. A false idea of the abundance of such sharks becomes established because these individuals, though solitary, eventually wander out of normal ranges into shallow water where they are easily caught. Furthermore, the capture of especially large sharks excites so much interest that they receive a disproportionate amount of attention in the literature.

A male white-tip 204 cm long weighed 60–65 kg (135–145 lb).

FOOD

Eighty-eight white-tip stomachs have been examined. Forty-one of these contain food, although a number contained only a cephalopod beak or two. It is possible that cephalopod beaks resist digestion to a greater degree than anything else that the shark ordinarily eats. This may bias the following data : Cephalopoda – in 19 stomachs ; fish – 20 (including blackfin tuna and another scombrid fish, barracuda, look-down (*Selene*), and a white marlin about 250 cm with no evidence that it had been taken from a long line) ; garbage – 13 ; sargassum and other seaweed (probably accidental) – 4 ; unidentified animal remains – 1 ; unidentified sea bird – 1 ; Crustacea – 1.

Only a few white-tips taken on tuna long lines are included above. In general the latter had empty stomachs or contained only tuna or bait used for the tuna. One stomach contained several pounds of oil.

BEHAVIOUR

White-tips almost always exhibit some suspicion of a baited hook. They generally make several passes at a bait before taking it. Between these passes they may swim away 50 to 100 yards. On 18 March, 1953, between captures (0915-1315) in the Windward Passage, there were about 6 white-tips around the vessel continuously. These were nosing baited hooks and would not take them although they immediately engulfed similar baits not on hooks.

Although white-tips exhibit a cautious approach to objects suspected of being edible they are remarkably persistent. A great deal of effort has been wasted by the crew of the *Oregon* in attempting to drive white-tips away from the vessel while long lines were being hauled. The long line is hauled as the vessel moves slowly forward and the line with the catch is taken over the side. A few white-tips usually gather within ten to fifty feet of the stern but swim forward and downward at the approach of a hooked tuna. The tuna come from ten or more fathoms and are not visible from the vessel when the sharks seem to detect their presence. The sharks meet the tuna more than thirty feet from the vessel and get one or more bites before the tuna can be landed. White-tips are commonly caught on the long lines and may occasionally attack spent or dying tuna on the lines before they are hauled. However, more of the shark damage well below the surface in the Gulf of Mexico results from attacks by silk sharks (*Eulamia floridana*), mako sharks (*Isurus oxyrinchus*), and occasionally by other species of *Eulamia*. All of these sharks are numerous enough to be a serious problem for tuna fishermen. We have not seen the mako sharks at the surface except when they come up on a hook or hanging onto a tuna, but silk sharks in the Gulf of Mexico are often numerous when sets are made near the continental shelf and permit comparative observations. The silk sharks are less bold than the white-tips but are much faster. Consequently, if baits are being thrown overboard in large quantities when both species are present, the white-tips get most of the baits close to the boat but the silk sharks get all of those that sink rapidly or drift some distance from the vessel. Several times we have seen a silk shark and a white-tip of about equal size in competition for the same discarded fish. If the white-tip was close enough, it got the fish by driving the silk shark away.

The white-tip does not leap when hooked and puts up a relatively feeble resistance to capture. In this respect it is comparable to the blue shark. The silk shark shows much more speed and power than a white-tip, but once on deck the latter is more troublesome. On a few occasions white-tips have been observed to be capable of at least short bursts of speed. We have attempted to use a type of firecracker, generally known as a cherry-bomb, to drive sharks away from the vessel. The cherry-bomb was put inside a fish, the fuse lit, and the assembly tossed overboard. Due to the deliberate appraisal of the bait by the white-tip this was not often successful. The premature explosion merely caused the shark to move off a few feet, than to resume its patrol. On one occasion, however, a white-tip picked up a fish with a slow fuse and the bomb exploded in its mouth. Smoke and bits of fish blew out of its gill openings, and the shark exhibited a creditable speed in moving away.

Recently, six or seven white-tips were around the *Oregon* as long line-caught white-tips were being killed and thrown overboard. The dying specimens were never attacked although as they sank they were followed out of sight by other white-tips. Even floating livers were untouched. This reaction to livers is not typical however, as we have often used them as bait on hand lines to catch other white-tips.

When white-tips swallow objects immediately at the surface the top part of the head is lifted well out of water. On one occasion when one of us was dangling a bait in front of a shark hard by the vessel's side it made many attempts to swallow the bait before it succeeded. Such exhibitions of clumsiness make one wonder how this animal can capture live fish and cephalopods and how one (which we identified from portions of its teeth) could strike a plastic encased instrument which was being towed at night at a speed of several knots. We might say in this connection that white-tips appear to be equally active by day and night.

SEXUAL SEGREGATION

Two types of sexual segregation are known in sharks. A " behavioural " type is exemplified by the tendency of individuals of the spiny dogfish (*Squalus acanthias*) to school with others of like size, the species sorting into aggregations of large mature females ; mature males of medium size ; immature females of medium size ; or small fish of both sexes (FORD, 1921). That a given school tends to be of one sex had been noted by earlier authors (MEYER, 1875 ; SMITT, 1895 ; and BORCEA, 1906).

FORD also described what can be called " geographical " segregation in the rough-dog (*Scyliorhinus caniculus*). Several thousand specimens examined at Plymouth showed that males predominated in the winter (a peak predominance of about 65%) while females predominated in the summer (a peak of about 58%).

Geographical segregation was described by RIPLEY (1946) for the soupfin shark (*Galeorhinus zyopterus*). He showed that the sexes were generally unequally represented as a function of area or of depth in four California fishing areas. That this phenomenon exists in the blue shark (*Prionace glauca*) is indicated by BIGELOW and SCHROEDER (1948) who in writing of summering fish off northeastern United States and Canada say, " . . . few, if any, females take part in this yearly incursion . . . "

We have some information showing that geographical sexual segregation is also a feature of the life history of the white-tip. In an area in the northern Gulf of Mexico whose radius is about 75 miles, 13 females and 3 males were caught during 13–30 August, 1954. A similar ratio (74 females to 15 males) was found in the same area during 10–26 August, 1955. In an area between Cuba, Hispaniola, and Jamaica with a radius of about 90 miles, 15 white-tips were caught during 18 March – 2 April,

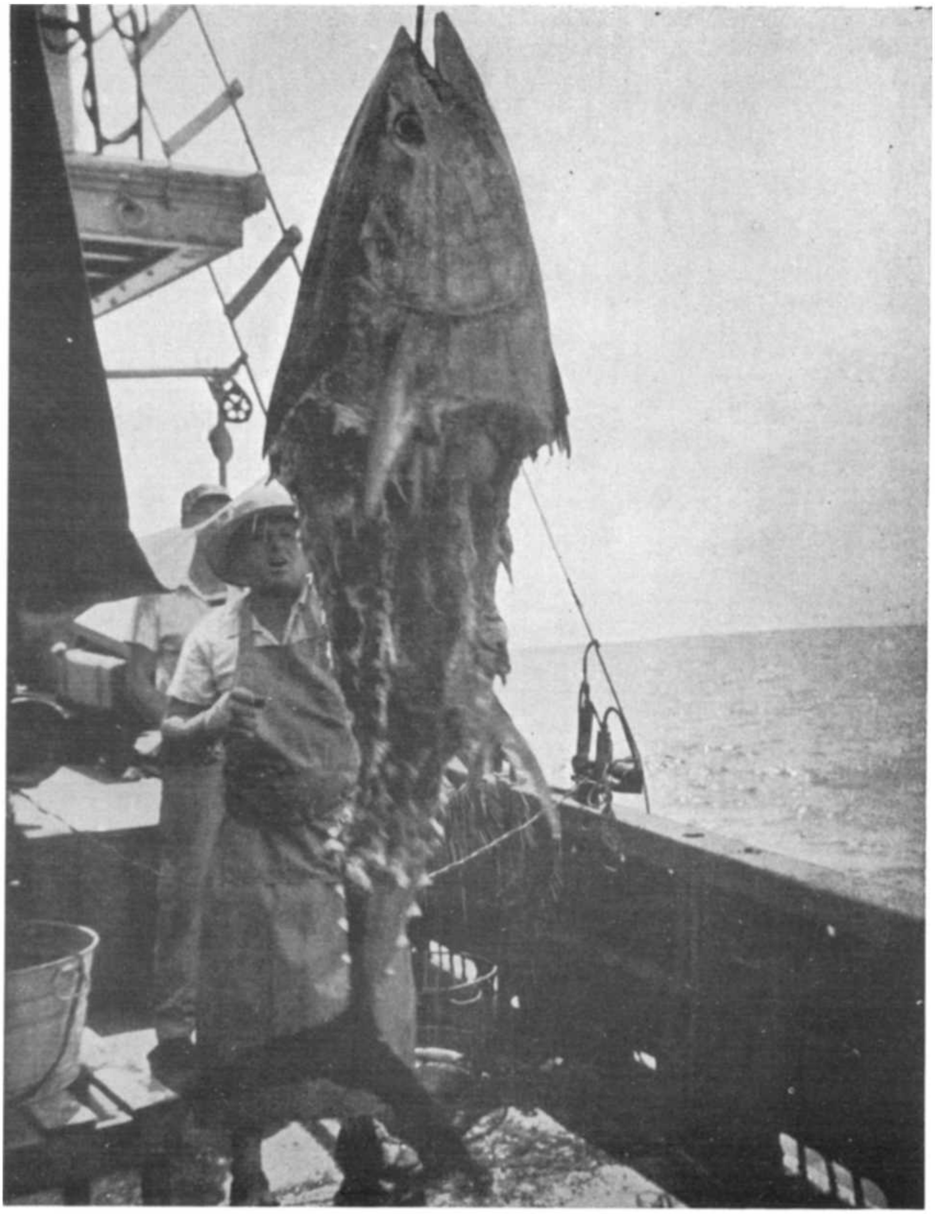

Fig. 4. Long line-caught bluefin tuna showing damage by white-tip sharks. This tuna weighed about 500 pounds before being attacked. Photo by ARNOLD.

1953, 14 being males. In an area of about 80 miles in radius north and east of Puerto Rico 24 females and 7 males were caught during 23 February – 12 March, 1954 (see Fig. 2).

The geographical segregation phenomenon is not understood, but may be related to the existence of favoured pupping areas in which females tend to congregate seasonally.

REPRODUCTION

The fragmentary data available (Table 1, Fig. 5), suggest that both mating and pupping take place in the late spring or early summer and that the gestation period is about one year.

Table 1.

Locality	*Date*	*Number of litters*	*Total number of specimens*	*Approx. mean total length*	*Authority*
Northeastern Gulf of Mexico	13 Aug., 1951	1	7	150	Backus, Springer and Arnold
Northern Gulf of Mexico	14–16 Aug., 1951	2	16	65	,,
Northern Gulf of Mexico	26–28 Aug., 1951	2	14	160	,,
38° 25′N, 68° 07′W	24 Sept., 1955	1	4	240	,,
Central Gulf of Mexico	15 Dec., 1954	1	4	410	,,
Northern Gulf of Mexico	13 Jan., 1955	1	4	465	,,
North of Puerto Rico	23 Feb.–1 Mar., 1954	6	33	440	,,
Trinidad Islet (20°S, 29°W)	8 April, 1913	1	1	670	Nichols and Murphy (1914)
28° 40′N, 78° 46′W	3 May, 1886	1	5	520	U.S. National Museum (courtesy L. P. Schultz)

We have noted two conditions of the oviducts in females without pups. In some females (generally the smaller ones) the oviducts are approximately circular in cross-section and about 10–15 mm in diameter. The oviducts are hard and the lumen is not very evident. The oviduct is held close to the dorsal wall of the body cavity by a narrow mesentery. Females in this category, which we presume are nulliparous, measured 173, 180, 189, 192, 198 and 198 cm ($\bar{x} = 188{\cdot}3$) during 23 February – 23 March, 1954 (the only period during which we have made this type of observation).

In other females (generally the larger ones) the oviducts are flattened and measure about 30–40 mm from edge to edge. They are soft and limp, and the lumen is conspicuous. The oviduct lies loosely in the body cavity suspended by a wide mesentery. We presume these females to have previously borne young. During

23 February – 23 March, 1954, such females measured 192, 209, 215, 216, 221, 230, 232, and 246 cm ($\bar{x} = 221{\cdot}2$).

Females with pups measured during this same period were 189, 205, 207, 212, 225, and 241 cm ($\bar{x} = 213{\cdot}2$).

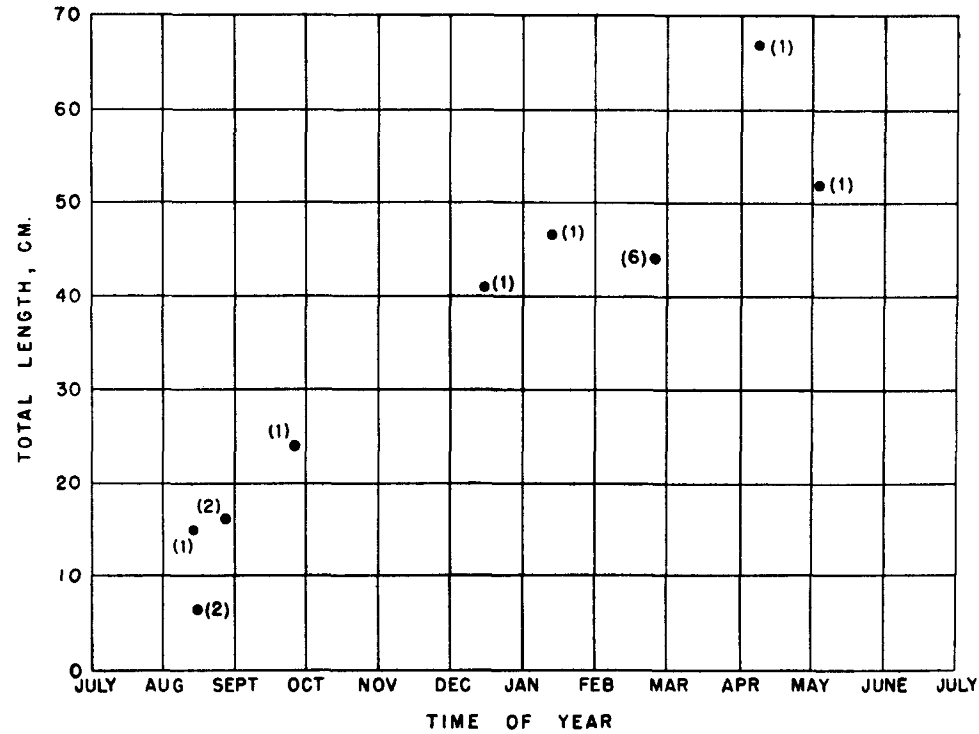

Fig. 5. Relationship between average length of embryos and time of year. The number in parentheses by each point indicates the number of litters used in arriving at the mean length.

Our original interpretation of the stretched oviducts was that females possessing them had recently dropped young. But since pregnant females at the same time were all carrying pups much smaller than the known maximum size, we no longer favour this notion. Moreover, females with stretched oviducts had large ovarian eggs measuring 25–45 mm in diameter (except one with very small eggs), while pup-bearing females had much smaller eggs (the largest being 10–15 mm in diameter). This suggests the possibility that females with stretched oviducts at this season are those that bore young the previous summer and that will mate again in the coming summer. We presume that pregnant females (with small eggs) would not mate during the coming summer.

The nulliparous females were of such a size that they could be expected to mate during the coming summer. Some of them bore ovarian eggs 10–15 mm in diameter, but some had very small eggs. None had eggs comparable in size to those of the larger non-pregnant females.

There is a good correlation (Fig. 6) between the length of the mother and the number of pups she bears ; the greater the length, the greater the number of pups. The number of pups per litter in our series (15 litters) varies from 2 to 9 with an average of about 6.

In one litter of 9, 8 embryos measured from 495 mm to 595 mm, while the ninth measured only 240 mm. It was noted that the pseudoplacental connection was lacking between the small specimen and the mother.

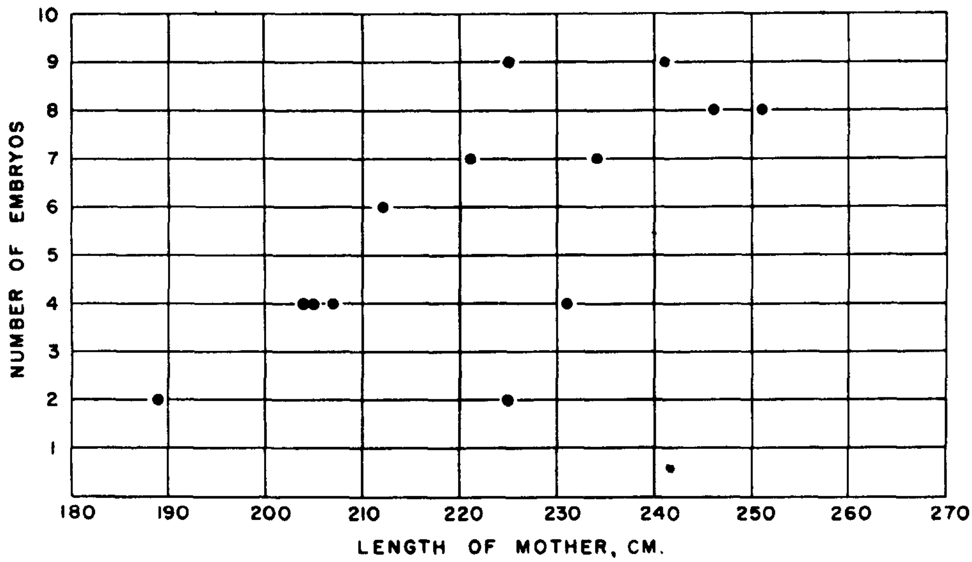

Fig. 6. Relationship between length of mother and the number of young she bears.

ANIMAL ASSOCIATES

One to 3 shark suckers (*Remora remora*) are generally attached to white-tips. They adhere so persistently that they are taken with the shark unless scraped off as the latter is pulled in over the rail. We have frequently seen them adjust their position on the shark with a rapid wriggling motion while the latter was being boated.

Often 1 or 2 pilotfish, *Naucrates ductor*, are in company with the white-tip (see Fig. 1). They generally swim a little above and behind the shark's first dorsal fin. They swim nervously back and forth near the shark after the latter has been hooked.

On several occasions we have seen one or several dolphins (*Coryphaena hippurus*) (8-10 on one occasion) swimming with the shark. They are generally to the rear or one side of the shark and by no means follow his movements as closely as the shark pilot. SCHUCK and CLARK (1951) in reporting their capture of a white-tip wrote that the stomach contained a dolphin, and they speculate as to the condition of the dolphin when captured. They also report the absence of dolphins in the immediate area of the capture of the shark, the implication being that dolphins avoid the latter.

A copepod parasite (or parasites) which is superficially attached to the white-tip's skin is frequent and often numerous.

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