

**Article IX.—THE FOURTH FLORIDA WHALE SHARK,  
RHINEODON TYPUS, AND THE AMERICAN MUSEUM  
MODEL BASED ON IT**

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PLATES XXIII TO XXXII

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INTRODUCTION

Mr. L. L. Mowbray, Director of the Bermuda Aquarium, and the present writer have recently published an article giving an account of the capture of this specimen of *Rhineodon typus*, and of how it was towed to Key West. It was secured near Marathon, in the Florida Keys, by Mr. Claude Nolan of Jacksonville and Capt. Newton Knowles of Miami, Florida, on June 9, 1923. It was harpooned, shot in the spinal region with a high-powered rifle and repeatedly lanced in the gills. Weakened by these onslaughts and especially by the loss of blood from the lance thrusts in the gill region, the whale shark suffered itself to be towed to Marathon and to be tied to the dock there. Here it died some fifty-four hours after the attack began.

Mowbray, who was at Miami at the time, reached Marathon the day after the capture, and to him, as representative of the American Museum, Mr. Nolan presented the great fish. Mowbray wished to save the skin, in order that this might be properly mounted in the Museum. However, there were neither men nor appliances at hand to beach the

fish at Marathon; so after various unavoidable delays it was finally decided to tow it to Key West and there haul it out on the shipways in order to make plaster casts of the fish by sections, to remove and preserve the skin, and to dissect and preserve parts of the viscera and of the skeleton. How, as the result of delays in the towing, the attacks of sharks, and a rapid and entirely unprecedented rise in the temperature of the sea water, bringing about an extraordinarily rapid decomposition of the viscera and flesh, everything possible went wrong despite Mowbray's best efforts—all this may be read in the article above referred to.

Certain of the hard parts of this specimen, the jaws, parts of the tooth bands, parts of the skull, sections of the spinal column, and various branchial cartilages, were preserved and brought to the Museum. In 1930, these were worked up by Dr. E. Grace White, professor of biology at Wilson College, Chambersburg, Pennsylvania, and her paper has but recently been published.

#### MAKING THE MODEL OF THE WHALE SHARK

While the fish was tied to the dock at Marathon, Mowbray made a sketch and a series of measurements of it which have been invaluable. These formed the basal data for the building of a model of the fish, which was constructed on the basis of two inches to the foot, under the personal supervision of Mr. James L. Clark, Chief of the Department of Preparation in the Museum. This work was constantly criticized and checked up by Mowbray, on the basis of his observations of the living or just-dead fish, and by Gudger on the basis of all the known descriptions and of all the then-known figures. Mowbray procured for the Museum a large number of photographs and also a motion-picture film made of the live fish alongside the dock at Marathon. These were of great help in preparing the model. The film was placed in a projector capable of being stopped at any individual "frame" and each picture was thrown on a screen a few feet from the preparators and held there as long as it was wanted. Thus, foot by foot the model was built, and spot by spot it was painted.

However, when the model was done, none of us were satisfied with it; so instead of being put on exhibition it was set aside for further study and criticism. It was clear to me, from a study of all the known photographs of the fish and of figures of mounted skins, that both head and tail were defective. Presently other figures of other specimens, and especially a sketch of the stuffed skin (that of the first discovered fish) in the Paris Museum, came in, as did also a figure of one on exhibit in the British

Museum (Natural History) and also photographs of fresh specimens taken in the Philippine Islands and in Java. These gave a correct idea of the structure of the tail. Then my attention was called to a motion-picture film of a swimming *Rhineodon* taken by Mr. Mack Sennett, the motion picture producer, with a submerged camera, near the extremity of Lower California. A letter to Mr. Sennett, stating our needs and wishes, brought from him the generous gift of a copy of this film.

This film fortunately gave a fair view—certainly better than any had before—of the head region. These various sources of data enabled Mr. Clark and his men to make a new tail for our model and materially to modify the head-parts. This model, which now may be taken as scientifically accurate, has been on exhibition for some time. It is now installed in the new Hall of Fishes and attracts the attention of many visitors, especially when they note its marked coloration and gather that this 5 ft. 4 in. model is but one-sixth the size of the fish itself!

In the meantime, many other things were pressing on my time and calling for working up, and it has been only of late that I could come back to this fish, prepare the manuscript and see it through the press. Plates XXIII, and XXIV, and Plate XXV, figure 1 are made from photographs of this model. However, I am not entirely satisfied with this, but am hoping for more detailed data, and above all for photographs from which to construct a life-size model to be hung in the great Hall of Ocean Life.

#### DESCRIPTION OF THE FOURTH FLORIDA *RHINEODON* AND OF THE MODEL BASED ON IT

The description now to be given is based partly on data recorded from the shark in Mowbray's notes and the photographs of the living fish, and partly on that embodied in the model itself, in the making of which all known accounts and figures have been studied. This section will be illustrated with photographs of the model and of the fish at Marathon.

#### SIZE

This huge shark was 25 ft. 9 in. long from tip of snout to base of caudal, and 6 ft. 8 in. from there to a line dropped from the tip of the upper lobe of the caudal, or 32 ft. 3 in. over all: in round numbers, 32 ft. in extreme length. The circumference behind the eyes was 14 ft., over the first gill-slit 17 ft. 4 in., behind the pectorals 23 ft., in front of dorsal II 6 ft. 4 in. The girth of the caudal peduncle was unfortunately not taken. The vertical depth (spread) of the caudal fin was 12 ft., twice the

height of a tall man. The reader will get some idea of the size of this fish and its tail fin by studying figure 2 of plate XXV. Here the dorsal lobe of the caudal is longer than the man holding it is tall.

That the reader may realize how large our fish was, and that its thirty-two feet are but the measurement of a specimen about the average in size, it will be necessary to state that the range of measured size is from a young fish of fourteen feet to an old "bull" of forty-five feet. Furthermore, in a region where this huge shark abounds, its length has been estimated at seventy to seventy-five feet by whale fishermen accustomed to reckon the size of sperm whales. It does not seem well to go into details of sizes here. These data had perhaps better be reserved for a special article dealing with the recorded measured sizes of this greatest of sharks. However, the sizes of other Florida specimens may be noted here for comparison with that of this particular fish. The first specimen, a young one only 18 ft. long, came ashore at Ormond Beach in 1902; the second, taken at Long Key, in 1912, was 38 ft. long; the third (31 ft. long) was taken in the Bay of Florida in 1919; and the present 32-foot specimen is the fourth. In addition, from adjacent waters, two specimens have been taken from near Havana Harbor: a 32-foot fish in 1928, and another of 34 feet in 1910 (Gudger and Hoffmann, 1928, 1930).

From these brief statements it cannot be doubted that *Rhineodon typus* grows to an enormous size; so large that it may well be said of it that "beside him ordinary sharks look like pilot fish." Personally I am inclined to think that the whale shark is the largest shark that swims the seas. Its only possible rival in magnitude is the basking shark, *Cetorhinus maximus*, for which, unfortunately, no compilation of data as to size has ever been made.

Fairly complete comparative measurements for four specimens of *Rhineodon* are at hand and are set forth in the accompanying table. Along with them are listed the same measurements for our fish.

#### EXTERNAL FEATURES

GENERAL DESCRIPTION.—As may be seen in plates XXIII and XXIV, and plate XXV, figure 1, this great shark is square anteriorly and wedge- or chisel-shaped in its forward parts, rapidly increasing in girth until it reaches its greatest circumference and bulk in what might be called the shoulder region—that of the sector between the anterior gill-slits and the first dorsal. From the region of dorsal I the body rapidly falls away in graceful lines to the caudal peduncle. Anteriorly the body is flattened somewhat, but in the region of the first dorsal fin it becomes

COMPARATIVE MEASUREMENTS OF THE WHALE SHARK <i>Rhineodon typus</i>	SMITH TABLE BAY 1829-1849	BEAN FLORIDA 1902	THURSTON MADRAS 1894	HALY CEYLON 1883	MOWBRAY FLORIDA 1923
Length over all	ft. in. 16 6	ft. in. 18 0	ft. in. 22 0	ft. in. 23 9	ft. in. 32 0
Girth of body behind pectorals	9 3			13 0	23 0
Distance, mouth to base first dorsal	8 6		9 10	10 0	14 6
Distance, front edge D.I to same point D.II	2 0		2 3	2 8	6 4
Distance along anterior edge D.I			1 10	1 10	
Distance along base D.I		1 5	2 0	1 10	2 4
Distance along anterior edge D.II	0 11		0 11	0 11.5	
Distance along base D.II	0 11		0 7	0 11.5	
Length of pectoral fin	3 2	3 1	3 2	3 6	5 8
Breadth of pectoral fin along base	2 0	1 6.5	1 8		
Length (anterior) of up- per lobe of caudal fin	4 0	3 6	5 0	5 0	7 0
Length (anterior) of lower lobe of caudal	2 10		2 6	2 7	5 7
Width of mouth, angle to angle	2 8		2 6	3 0	3 8
Diameter of eye			0 1.5	0 1.5	
Distance, eye to spiracle	0 4.5		0 4		0 3.75
Diameter of spiracle		0 1.5	0 1.4	0 1.5	

COMPARATIVE MEASUREMENTS OF THE WHALE SHARK <i>Rhineodon typus</i>	SMITH TABLE BAY 1829-1849		BEAN FLORIDA 1902		THURSTON MADRAS 1894		HALY CEYLON 1883		MOWBRAY FLORIDA 1923	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Distance, tip of snout to edge first gill-slit	2	10			3	4				
Length, first gill-slit			1	6	1	11				
Length, second gill-slit			1	8	1	11.5	2	7		
Length, third gill-slit			1	7	1	9				
Length, fourth gill-slit			1	4	1	8				
Length, fifth gill-slit			1	1	1	7				

arched and rounded. The whale shark in general form and outline is somewhat tadpole-shaped.

**KEELS.**—One of the most marked external features of the whale shark is the presence of seven longitudinal keels, ridges or chamferings on the dorsal and lateral surfaces. The central one arises on the back of the head about in a line joining the anterior gill-slits and runs backward in the mid-dorsal region clear to the caudal pit. Out of it the dorsal fins arise. On each side an upper lateral ridge arises about in a transverse line joining the middle region of the pectoral fins, runs backward roughly parallel with the central one, and fades away just in front of the second dorsal. Lower lateral chamferings or flutings arise about in the level of the last gill-slit and in turn run backward roughly parallel to the preceding, dying out under the second dorsal. The third and lowermost or mid-lateral keel arises nearly half the width of the pectoral behind its hinder edge and runs backward in about the mid-lateral line of the body, forming a broad keel on each side of the caudal peduncle and ending in the base of the caudal fin rather more than half-way back through the central part of the fin. (See Pls. XXIII, XXIV, XXVII and XXVIII.)

**HEAD.**—The broad, blunt, square head is very thin in the anterior or mouth region but rapidly becomes thicker backward and attains its greatest bulk in the region of the gill-slits where it joins the body. This is clear from plates XXIII and XXIV, and plate XXV, figure 1. As seen in dorsal view it does not seem very greatly wider and bulkier in the hinder region, but when the tape is applied along the curve joining the

front edge of the pectorals it is found to have gained about one-third more in bulk than it had at the mouth. The head, from the central anterior point of the jaws to the anterior edge of the pectoral or to the opening of the fourth gill-slit, measured along the curve, was 5 feet 9 inches long. If we understand the head to reach to the last gill-slit, rather than to the front edge of the pectoral, this length will be increased somewhat. Relatively, the whale shark has a larger head than any other shark. Among sharks its head, looked at from above, has the same relative form as that of the sperm whale among cetaceans. The shark's, however, is thin, the whale's thick in vertical dimension.

The structure of the wide terminal mouth, together with the jaws and curious tooth bands, will be considered later, preparatory to taking up the food and feeding habits.

**EYES.**—The small eyes, of which the diameter was unfortunately not noted, were silvery gray with black pupils. They were situated eleven inches behind the corners of the mouth and slightly above their level. They may be seen in plates XXIII and XXV, figure 1. In our specimen the distance straight over and across the head from eye to eye (following the curve) was 5 feet 3 inches.

**SPIRACLES.**—The spiracles, of which there are two on each side, were 14.75 and 15.75 inches each behind the corner of the mouth, and hence were one inch apart. Both were very small, the anterior being slightly the larger.

**GILL-SLITS.**—These are five in number, the third being in line with the anterior edge of the pectoral. The first gill-strap is widest, the second slightly narrower, the third and fourth together about equal to the width of the first. The gill-slits arise somewhat under the level of the anterior end of the mid-lateral keel and have their lower edges about on the level of a line connecting the eye and the anterior edge of the base of the pectoral. The details of the anterior three are beautifully shown in figure 1 of plate XXVI. The two posterior ones are hardly visible in Mr. Sennett's under-water photograph. The gill-openings are relatively large, in correlation with the manner of feeding of the whale shark, wherein large volumes of water are passed over and through the gill-arches.

**DORSAL FINS.**—The first dorsal is situated about midway of the total length of the body, the anterior edge being almost equidistant from the tip of the snout and the center in the hinder edge of the caudal. In our specimen the distance from tip of snout to front edge of dorsal I was 14 ft. 6 in., to posterior edge 17 ft. 4 in. The fin then was 2 ft. 10 in. long on the base. The height of the fin was about two-thirds of its length. Its

tip was rounded and the hinder edge nearly vertical, making the fin about square behind. The hinder part of the base was free. For these details see Pl. XXIII, and figure 2 of plate XXV. This fin, as well as the second dorsal, arises out of the dorsal keel or fluting.

The front edge of dorsal II in our specimen was situated 4 ft. 1 in. behind the posterior edge of dorsal I, about midway between the anterior edge of dorsal I and the end of the lateral keel in the median part of the caudal fin. The second dorsal was about half the size of dorsal I, rounded in front and like it on top, but had the posterior margin somewhat concave, and hinder part of base free. For this see Pl. XXIII. On this fin, spots are entirely lacking.

**CAUDAL FIN.**—This fin arises just behind the triangular pits on the dorsal and ventral surfaces of the caudal peduncle. These pits allow some slight degree of motion of the fin in a vertical plane. This fin in our specimen was enormously large and markedly lunate. The lobes were unequal in size: the upper being seven feet long, the lower five feet, seven inches. The anterior edges of both lobes were nearly straight. The upper lobe was sharply pointed, lower slightly rounded at the tip. The lateral keel of the caudal peduncle was continued backward on side of fin, half-way to its hinder edge. The distance from pits on caudal peduncle to hinder edge of fin was 2 ft. 8 in., from pits to a perpendicular dropped from tip of dorsal lobe, 6 ft. 8 in. Vertical depth or spread of caudal was 12 ft. The only other fish for which we have a similar measurement is a 20-foot specimen from the Gulf of California, of which it is said: "flukes, six feet between tips."

**PECTORAL FINS.**—These are inserted under the lower end of the third gill-slit, somewhat below the median level of the side of the body. They are of considerable size as may be seen from plates XXIII and XXIV and plate XXV, figure 1. In our specimen the distance from the angle of the mouth to the anterior edge of the base of the pectoral was 5 ft. 9 in., to posterior base of pectoral, 8 ft. 4 in. About half the base of the pectoral (the hinder half) was free from the body. The base of the pectoral was therefore 2 ft. 7 in. wide. The length of the pectoral, measured from the anterior edge of the base around the curve to the tip, was 5 ft. 8 in. The fin is long, falcate, and gracefully turned down at the tip, as shown in the figures above referred to.

**PELVIC FINS.**—These paired fins are inserted about under the middle of the first dorsal. In our specimen the distance from the posterior edge of the pectoral to the anterior edge of the pelvic was 7 ft. and the distance from the corner of mouth was 15 ft. 4 in. measured along curves. The



pelvic fins were small, square behind, and were supported by three cartilaginous rays. Our fish is a male and the claspers were about three feet long. In our specimen there was a hollowed-out recess on the underside of the body to receive the pelvic fins and claspers. The preserved cartilaginous parts of the claspers have been studied by Dr. White in her 1930 article and have proved of particular value in determining the relationships of *Rhineodon*. Those interested in the minutiae of the structure of these cartilages are referred to Dr. White's paper.

**ANAL FIN.**—This fin is only about half the size of the second dorsal and is inserted slightly forward of a perpendicular line dropped from the middle of this fin. The anterior edge of the base of the anal was distant 5 ft. 3 in. from the insertion of the pelvics. The base of the anal was 1 ft. 3 in. long.

#### COLORATION

Because of their color, rectangular arrangement, and large size, the markings of the whale shark are the most conspicuous of any of the shark group. For the entire coloration of our specimen, there are at hand, fortunately, Mowbray's notes made on the live specimen and the photographs and motion picture film made at Marathon, also that made near Cape San Lucas. As the spots and bars occur on the dorsal part of the body only, the cameras got them all.

**GENERAL ACCOUNT.**—The upper parts of our specimen of the whale shark are dark slate inclined to brown, under parts white except the chin region which is light gray. The dark and light parts are roughly separated by a line beginning at the angle of the mouth and extending backward along the lower edge of the gill-slits, running along the upper margin of the base of the pectoral and behind, backward at the same level until it reaches the third vertical bar, thence it inclines upward and backward to about the sixth vertical bar (at the level of the middle of the first dorsal where it strikes the lowest keel) and extends backward with this to the caudal.

**SPOTS AND BARS.**—The head, gill-slit region and upper sides of pectorals are profusely covered with grayish-white or yellowish spots showing no order of arrangement. Behind the pectoral region the spots are arranged in vertical rows, the spots being about six inches apart. The spots also form longitudinal rows, these being about eight inches apart. Separating the vertical rows of spots are vertical bars which have in them lighter places or spots, leading to the conjecture that these bars may be made of confluent spots. The anterior bar on each side

begins about half-way up the body from the upper edge of the pectoral to the mid-dorsal line and in a line joining the mid-regions of the pectorals, thence meanders downward and backward to end in the white part of the lower body just behind the pectorals. The next vertical line slants slightly in an antero-posterior fashion, the third and following ones being practically vertical.

There are fourteen bars on our specimen. They are longest and most distinct forward, becoming shorter and more indistinct as the caudal fin is approached. The first two vertical rows of spots contain five spots. The third, fourth and fifth contain four spots each (the bottom spot in row five being rather indistinct). This fifth row of spots is under the origin of the first dorsal. Back of this to the beginning of the second dorsal, there are three spots in each row, back of this to the caudal, two spots in each vertical row. As may be seen from plate XXIII, all the spots above the lowest fluting are enclosed in rectangular spaces formed by the vertical bars and the longitudinal ridges. These spaces are largest and are nearly square forward, but decrease in height and increase in length from before backward, as the circumference of the body decreases and the keels come closer together. For a general view of this checker-board arrangement of spots and bars see plate XXIV, a dorsal view of the model. For a close-up photograph showing these in more detail, see Pl. XXVI, figure 2, made from a photograph of the fish at Marathon. This spot and square effect is so noticeable that the Cubans call the whale shark, "pez dama," a checker-board fish.

The pelvic and anal fins, located on the under surface of the body, partake of its white color. So does the under side of each pectoral; the upper surface, however, is a dark slate, thickly covered with white spots having no orderly arrangement. On the first dorsal the spots show a tendency to line up with those below. This is plain in the anterior part, less so behind, where the arrangement becomes somewhat confused, the indistinct rows being slightly tilted forward. The second dorsal has no spots. On the base of the upper lobe of the caudal there are two longitudinal rows of spots continuing backward the rows of spots on the caudal peduncle. Above these on the upper lobe are found several longitudinal rows of two spots slightly tilted upward, but toward the tip this arrangement is lost. On the lower lobe there is one longitudinal row of three spots and several of two spots. Looking from the caudal keel upward and downward, each lobe has two lengthwise rows having each three spots at the base, but only two for most of the way. For these points see plate XXIII.

If, now, comparison be made between our illustrations (Pls. XXIII and XXIV) and the first representation ever published (Pl. XXVII), that appearing in Andrew Smith's book (1849), it will be seen that the agreement as to markings is only a general one. The irregular spotting on the head of Smith's specimen agrees with that on ours. Back of the head there are, compared to our specimen, entirely too many vertical bars and enclosed rows of spots. While it is possible that his specimen had more of these, still the more probable explanation is that his figure was presumably not made or at least not finished until some time after the capture of the Table Bay specimen, and it certainly was not published until twenty-one years after. However, it is fair to state that the figure (Pl. XXVI, fig. 3) of the second Florida specimen (Gudger, 1915) apparently shows narrower bands and a greater number than does ours. Lastly, Bean's figure (1905), reproduced as plate XXVIII, shows no vertical bars and has a smaller number of spots on the body proper, these without orderly arrangement. Other figures showing the fish in lateral view are so defective as to bars and spots that it hardly seems worth while to refer to them for comparison.

COMPARATIVE COLORATION.—As to the coloration and markings of various specimens the data may be epitomized as follows: Smith's specimen (1849) was greenish gray above, varying with dull lavender-purple and shaded with brown; below reddish white, becoming redder on edges of fins and under head. The spots and bars have already been referred to and may be seen in plate XXIII.

A specimen from the Gulf of California (1865) was brown above with reddish spots. That from Panama Bay (1884) was brown above with yellow spots so small and closely set over the head as to give it a mottled appearance. A Japanese form (1901) was dark grayish-brown above with round white spots and vertical bars, agreeing in general with the other fish.

The first Florida specimen was dark grayish-brown with large spots, the keels were a light chocolate, and no bars were visible (see Pl. XXVIII). They had probably faded out as they did on the second Florida specimen after a few days' exposure. This latter fish was mouse-colored above with yellow spots two or three inches in diameter separated by vertical bars of the same color. Underneath the color was yellow.

In the matter of coloration and markings of these various specimens we have general similarity in the larger outlines and a considerable variation in details. The explanation is probably as follows: there

is undoubtedly some variation in both color and markings in specimens found in various waters, and there is certainly great variation in these matters due to exposure of the fish to sun and weather. I found in my work on the spotted sting ray, *Aëtobatus narinari*, that exposure of one hour to sun and air would totally change the color of the spots and skin, and this undoubtedly is the case with the whale shark. Furthermore, back of the whole matter is the personal equation of each observer.

#### SKIN

THICKNESS.—The skin of this greatest of sharks is enormously thick, about four inches in the fresh specimen. As in other sharks it is thickest on the back—in the region around the dorsal fin—and thinnest on the flanks and ventral region. How this thickness of hide would compare with that in other large sharks cannot be said as we have no measurements or data of any kind at hand. Undoubtedly, the thickness of skin varies with the kind of shark. The skin of a 12-foot tiger shark (*Galeocerdo tigrinus*) is considerably thinner than that of an 8-foot nurse shark (*Ginglymostoma cirratum*). My harpooners, on various occasions at Key West, had no trouble in harpooning the former; but at Boca Grande Key, some twenty miles west of Key West, where nurse sharks abound, time after time I have seen the same harpoon rebound from the back of a nurse shark, though thrown by a strong man. Sharks, lacking ribs, have the muscles attached directly to the skin which acts in a sense as a supporting exoskeleton, hence in such huge sharks as ours the skin must be very thick and strong to give form and substance to the body. This great thickness, however, makes such a skin very hard to handle; so Captain Thompson found when skinning the second Florida specimen in 1912. When I saw this hide suspended over a long timber under a shed at Miami in July, 1912, I took hold of it and tried to bend it, only to find that bending it was like trying to bend a heavy board. In preparing this skin for mounting, over half a ton of shavings is said to have been removed from the flesh side.

In the literature, but one reference is found concerning the thickness of the skin. Chierchia (1884), in speaking of the dissection of his 29-foot specimen from Panama Bay, says that: "Cutting the animal on one side of the backbone, we met a compact layer of white fat 20 centimeters [7.9 in.] deep. . . ." This "white fat" is the white thick skin now to be described and figured.

Among the materials salvaged by Mowbray from the remains of the whale shark when it was finally hauled out on the shipways at Key

West, four days after its death, was a portion of the skin. From what part of the body it was taken cannot be said; probably, however, from the flank whence it could be cut most easily. This piece of skin was preserved in formalin where it has remained for the seven and one half years since it was cut from the fish. It has of course shrunk considerably from long immersion in the preservative. Plate XXIX, figure 1, is made from a photograph of a freshly cut slice of this material.

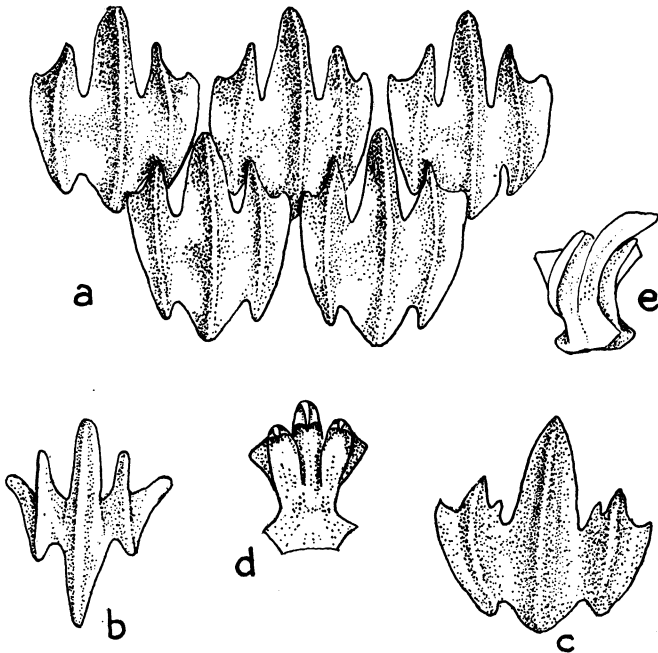


Fig. 1. Shagreen or dermal denticles of *Rhineodon typus*  $\times 40$ .

a—a group of slightly overlapping denticles; b—c—two types of denticles; d—a denticle in face view; e—a denticle in side view.

After White, 1930.

Being in doubt as to its structure, I asked Dr. B. G. Smith to examine it and advise me as to its make-up. However, before cutting sections of the outer portion, it was necessary to decalcify the shagreen with a weak acid for several days. Dr. Smith kindly reports as follows:

The epidermis is practically all missing save only as it is represented by the close-set dermal denticles. This absence of epidermis is undoubtedly due to putrefactive post mortem changes resulting from the long interval between the capture of the fish and the fixing of this specimen of skin, and from the unprecedented high temperature of the sea water as noted above. The exceedingly thick dermis, measur-

ing 45 mm., is of essentially the same structure throughout, consisting of a dense feltwork of fibrous connective tissue. In a superficial zone about two millimeters thick, the fibers are predominantly finer than those of the deeper stratum. These fibers resemble the white fibers of mammalian connective tissue in that each fiber consists of a bundle of very delicate fibrils. The subcutaneous layer is about 28 mm. in thickness and consists of a very loose meshwork of fibrous connective tissue, in which bands of coarse fibers alternate with bands of exceedingly fine fibers.

The structures may be seen in plate XXIX, figure 1. The curled-over epidermal layer with the shagreen is on the outer (top) surface. Next comes the thick dense rubbery white layer of connective tissue. It was cut with a very sharp thin-bladed knife, but, as it was impossible to hold the piece of skin steady enough to get a smooth slice, the changing plane of the cut makes this section look as if it were layered. It is perfectly homogeneous. The third zone comprises the loose meshwork of connective tissue. This figure is natural size.

SHAGREEN.—The skin of this shark is covered with a layer of dermal denticles (Fig. 1) with backwardly directed points which make the skin feel rough to the hand when stroked in reverse—i.e., from tail to head. The dermal denticles, which compose the shagreen of this shark, have for the first time been studied by Dr. White and for this reason it may be permissible to quote her description and reproduce her figure (Fig. 1, herein).

The denticles are minute, less than a millimeter in width [0.5 mm. wide and 0.75 mm. high]. The pedicel is relatively high and the basal plate trilobed.

The denticles vary slightly in shape and width (Fig. 1*a, b, c*). They are arranged in diagonal rows and are slightly overlapping. In some parts the rows are closer together than in others.

The denticles are trikeeled but the apical margin is five-lobed. The median keel is thicker through so that the lateral keels appear to be slightly forward in position (Fig. 1, *d*). The grooves are deep. The margins of the lateral keels curve forward, giving the five-lobed appearance to the margin.

The denticle does not make a sharp angle with its base, being only slightly tilted upwards.

#### MOUTH-PARTS

At first I had planned to go into this subject in an extensive comparative fashion, but it seems best to reserve such for a special article and to confine my observations here to these structures in the specimen under consideration.

MOUTH AND JAWS.—As already noted, the mouth is terminal,—a most unusual position in a shark,—wide, nearly straight across the head, slightly rounded at the corners, and has jaws and lips very thin in comparison with the huge size of the fish. The mouth cavity is

enormous, easily capable of taking in a grown man. All these parts may be made out from plate XXIX, figure 2. The nasal grooves, which are continuous with the labial folds at the outer angles of the jaws, are contained about 5.5 times in the width of the closed mouth. This width in our 32-foot specimen, with the jaws slightly opened, is 3 ft. 8 in. measured straight across. Plate XXV, figure 1, shows the shark in an oblique head-on view. In this the nasal grooves and labial folds can easily be made out. The jaw cartilages of the Marathon specimen are

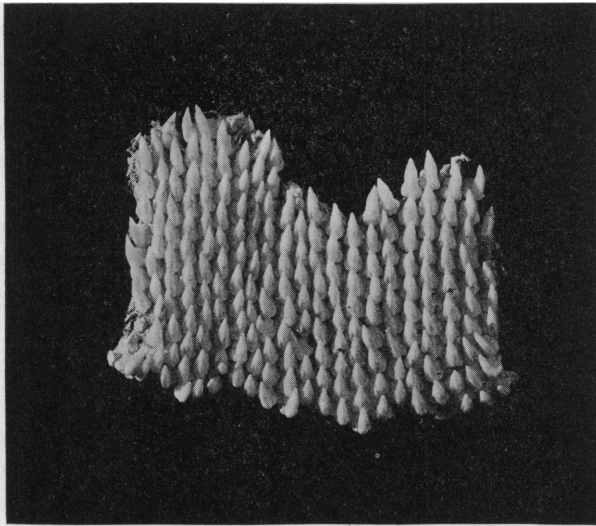


Fig. 2. A fragment of the dental band of the Marathon whale shark, natural size. The teeth point from front to back.  
After White, 1930.

preserved and have been studied by Dr. White, and those interested in the technical aspects of these structures are referred to her paper.

**TOOTH BANDS AND TEETH.**—The lips and the upper tooth band may be fairly clearly made out in plate XXIX, figure 2. Unfortunately, the tooth bands of this specimen were so loosened by putrefaction and so broken up by tiger sharks tearing at the mouth, as the *Rhineodon* was being towed to Key West, that they could not be saved. However, after the shark reached Key West and work on it began there, Mowbray found parts of the tooth band detached and hanging from the mouth. These he salvaged, and figure 2 is a reproduced photograph of one of

these fragments. This consists of twenty-one rows of backwardly pointing teeth. The longest rows of this fragment of the band contain twelve teeth, counting from front to back, but I am sure that this does not represent the full width of the tooth band. It is interesting to note that all these teeth are equally developed from front to back. This is very unlike what is found in other sharks, where only the first two or three longitudinal rows of teeth are fully developed and covered with enamel, the others less and less so until at the very rear they are quite devoid of enamel—so much so as to be cut with a knife as easily as a piece of soft wood.

These teeth are very small (2 mm. high) and backwardly recurved. The drawings which I had made of the individual teeth were turned over to Dr. White for her study of the hard parts of the whale shark, and for them the reader is referred to her paper. Later I plan to describe and discuss tooth bands and individual teeth in detail.

From the figures and data it is clear that the teeth of *Rhineodon* do not serve for biting and chopping as do the teeth of other large sharks; they are merely used for holding whatever is taken into the mouth, as is inferred from the backwardly projecting points.

#### FOOD AND FEEDING HABITS OF *RHINEODON*

It is greatly to be regretted that on reaching Key West the condition of our shark was such as to prevent any dissection of the alimentary canal; and even the dissection and preservation of the branchial apparatus (gill-rakers, etc.) were not undertaken because these were too far gone in putrefaction.

However, it may be said that our fish is a "whale" not merely in size but in feeding also. It is a surface feeder. Lacking the biting teeth found in most other sharks, it is provided with a very efficient branchial sieve apparatus composed of finely divided and close-set gill-rakers. Swimming at or near the surface with its huge mouth open, great quantities of water pass back over the gill-rakers and out through the extensive gill-slits. In this process large quantities of small animal and vegetal matter are strained out: small fish, pelagic crabs and molluscs, jelly fish, diatoms, algæ, etc. It is probably omnivorous with the greater part of its food composed of the animals above named. There is evidence that at the Seychelles in the western Indian Ocean, and also around Havana, *Rhineodon* comes in shore when the sardines and other small fish are schooling. The fishermen declare that it feeds on them. That its



food must be small is attested to by Smith's discovery (1849) that its oesophagus is very small and has an almost right-angled turn which prevents the ingestion of any but small food, fishes, etc. The one direct observation of its food is that by Van Kampen (1907) who dissected in the fish market of Batavia, Java, a 5.75 meter (12.8 feet) specimen harpooned in Batavia Bay. Its stomach contained small *Sepia* shells and some small fishes (gobiids and saurids).

#### OFFENSIVE AND DEFENSIVE HABITS OF THE WHALE SHARK

This specimen is the fourth taken on the Florida coast. Of these four, one came ashore dead on Ormond Beach, but the other three were captured in the waters immediately surrounding the southern point of Florida. The resistance offered by each of the three was infinitesimally out of all proportion to the size and strength of so huge a fish, and to the ferocity reputed to be characteristic of all animals of the shark kind. With regard to this latter point it may be said that the whale shark, though the largest of the sharks, is the least dangerous. To the public, that which makes a shark a shark is its huge widely-distensible mouth filled with many rows of sharp teeth. Our fish is certainly a shark: its mouth is enormous—big enough for a man to crouch in—but this mouth is provided with many rows of small teeth, whereas the ordinary dangerous shark has only six or seven rows of large cutting teeth. The only weapon of offence and defence possessed by the whale shark is its huge caudal fin. A blow from this might easily crush a boat or reduce a man's body to a pulpy mass of flesh. But it has never yet been known to do damage. In the Seychelles Islands. “. . . it now and then rubs itself against a large pirogue, as a consequence upsetting it, but, under such circumstances, it never attacks or molests the men, and while it reigns as a monster among sharks, it is not, in spite of its size, as formidable as the common dog-fish.” The above action is presumably taken to rid itself of barnacles or other marine growths. Two of the Florida specimens were taken in shallow water, another in fairly deep-water—certainly deep enough for the fish to manoeuvre freely—yet none of them put up any fight. This has led to the belief that these fish were either sick or enfeebled by disease, but, since no autopsies were made, this idea, while possibly true, cannot be substantiated. We must then fall back on the comparative evidence. Smith, who discovered the fish in 1828, says (1829) that: “When approached it manifested no great degree of fear, and it was not before a harpoon was lodged in its body that it altered its course and quickened its pace.” Other captors

testify that all it did for them was to swim away, dragging the boat or boats after it.

The second Florida specimen swam in circles (this point is noted by nearly all observers) after being harpooned (Gudger, 1915), and despite harpoonings and shootings he "seemed to fail to recognize that anything in particular was happening to him." The third Florida specimen was taken in shallow water, but made no effort to defend itself or get away. The two Havana fish, whose captures Gudger and Hoffmann (1928, 1930) have described, were also taken in water deep enough for them to have put up a fight, yet neither of them did so.

In short, the whale shark makes no defence when attacked, but merely seeks to get away by swimming. The only zoölogist who writes of anything to the contrary is Wright (1876), who says of specimens harpooned in Seychelles waters: "Men engaged in the sperm whale fishery off St. Denis often told me that they dreaded to harpoon by mistake a *Rhineodon*. A whale must come up to breathe or choke itself. But there were stories told me of how a harpooned *Rhineodon*, having by a lightning-like dive exhausted the supply of rope which had been accidentally fastened to the boat, dived deeper still, and so pulled the pirogue and crew to the bottom." And Dr. H. M. Smith in a popular paper has given a spirited figure of such a dive. This is due to three things: a rope attached to the boat, deep water, and the fact that the whale shark is a fish breathing by gills and not by lungs. Taking all the evidence into consideration, my statement of 1915 is still correct: "Undoubtedly *Rhineodon typus* is the mildest mannered shark that swims the seas."

#### OCCURRENCE IN THE ATLANTIC OCEAN OF *RHINEODON TYPUS*

Whence come these specimens to the Straits of Florida? This is a question for which an answer must be attempted, and while the discussion of the whale shark in the waters of the globe may well be reserved for a later paper, it is pertinent to show its distribution in the Atlantic and its subsidiaries. It has been shown that four specimens (including the one under consideration, that of 1923) have been taken in southern Florida waters. Recently the capture of two others off Havana harbor has been recorded, and information at hand indicates that others have been seen there. Mowbray, whose acquaintance with southern Florida and adjacent waters is very extensive both in space and time, has for a number of years been seeking a solution of this problem. Some years

ago he learned from Pensacola fishermen, who frequent the snapper banks in the Yucatan country, that they have not infrequently seen huge spotted sharks, so large that they could be no other sharks than ours.

In 1923, Mr. F. W. Wallace, in the course of a study on the red-snapper fisheries prosecuted in the Gulf of Mexico, makes the following statement which, while more or less hearsay and exaggerated, is certainly corroboratory:

. . . the men tell of a famous whale shark known among the snapper fleet as "Big Ben," which is longer than our vessel. As the 'Hays' was some 76 feet in length, he must be 'some' shark. Many of our crowd have seen him, and they say that he has come alongside of a vessel and men have jumped over the rail and stood on his barnacle-covered back. . . . Fishermen becalmed off Contoi Islands in the Yucatan Channel have seen them basking around them in great numbers.

Furthermore, Mr. J. Hume Macdonald of this city has sent me a copy of a letter from a kinsman resident at Belize in which it is stated that for fifty years it has been known that a similar, huge, spotted shark, sixty or seventy feet long, is found in the same region and bears the colloquial name of "Sapodilla Tom."

And finally, Van Campen Heilner, the well-known sportsman and angling writer, wrote me from Europe some years ago as follows: "I recently met a man in England who knows of a reef in the Caribbean where the whale sharks are as 'thick as porpoises' as he put it. This man broached the subject himself and did not know that I was even aware that there was such an animal."

Dr. H. M. Smith, formerly U. S. Commissioner of Fisheries, tells me that he is firmly convinced of this Yucatan habitat, since reports have been coming in to him at intervals for many years that specimens had been seen at various times in that general region.

These various accounts of the occurrence of *Rhineodon* in this region, coming at different times from different men who know nothing of each other, certainly bear an air of probability, to put it no stronger.

Furthermore, I have (unconfirmed) newspaper reports of the occurrence of gigantic spotted sharks, called whale sharks by the reporters and correspondents, found around Trinidad and throughout the Caribbean generally.

All these accumulated data, brief and fragmentary as they are, indicate that the whale shark abounds and may have a breeding ground in Caribbean-Gulf waters.

Furthermore, there are two records of *Rhineodon* in the central Atlantic, between South America and Africa, attested by photographic

evidence. In May, 1922, the steamer 'American Legion' impaled a whale shark on her bow while about northeast of the Abrolhos Light, coast of Brazil (Gudger, 1922, 1923). In 1924, the motor ship 'Alba' similarly rammed one on the Ivory Coast of the Gulf of Guinea near the mouth of the Sassandra River (Gudger, 1927).

But the insistent question is: Are these great sharks indigenous to Caribbean-Gulf waters? Consideration of the evidence set out above leads me to think so; but before going farther into this matter, and before setting forth a theory to explain how whale sharks may have gotten into the Atlantic and its adjacent waters, it will be necessary to recount a few points in the history of this remarkable fish.

As previously noted, the whale shark was first discovered in Table Bay, Cape of Good Hope, in 1828. In 1829, and more fully in 1849, it was described and (1849) figured by Dr. Andrew Smith, surgeon to the troops at Cape Town. Nearby (comparatively speaking) is one of the regions in which *Rhineodon* is most abundant, namely, in the waters around the Seychelles Islands in the western Indian Ocean between the equator and Madagascar. Here they were found in 1870 and 1876 by Perceval Wright, and here they are reported today by Mr. P. R. Dupont, the government botanist in the Seychelles. Mr. Dupont writes that sometimes two or three may be seen at one time when they come inshore, apparently to feed on a *Caranx* which schools at this time of year.

The way is now cleared for a presentation of a theory of the occurrence of our fish in the Atlantic, and particularly in Caribbean-Gulf waters, by my colleague, Mr. J. T. Nichols. He argues that these fish breed in the region between the Seychelles and Mauritius, thence drift down with the Mozambique Current to the Cape of Good Hope. Some of them round the Cape and are carried northward in the current flowing along the west coast of Africa, thence are carried westward in the equatorial drift, through the Caribbean and Gulf of Mexico, to be stranded on Florida shoals. He thinks the Abrolhos Light specimen was carried south by that branch of the equatorial current which is split off at Cape San Roque and flows southwest along the coast of Brazil.

Whether one agrees with Mr. Nichols or not, it will be granted that his ingenious suggestion certainly fits the facts in extraordinary fashion and offers a clear explanation as to how *Rhineodon* may have first got into the Atlantic and into the Caribbean Sea and the Gulf of Mexico. However, the question of the distribution of *Rhineodon* in the Atlantic is but one section of the greater question of its world-wide distribution, which needs fuller study.

#### OTHER MOUNTED SPECIMENS AND PRESERVED SKINS AND MODELS OF THE WHALE SHARK

Since there is reason to believe that our model is not merely the latest but the best representation of *Rhineodon typus*, it will be of interest to make some brief historical study of skins and of other mounted specimens for comparison. It may be premised at once that these are few and far between, being limited to one preserved skin, two models, and eight mounted skins of the largest and the rarest shark.

In addition to its relative scarcity and its being found generally in out-of-the-way places, its huge size and the great thickness of its skin make the handling, preservation, and mounting of it a matter of the greatest difficulty. In fact, when it is realized that the whale shark

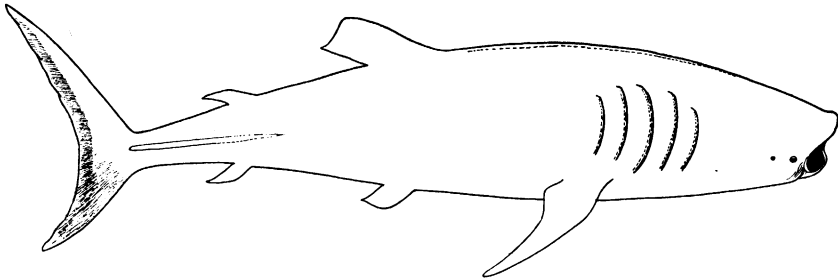


Fig. 3. An outline drawing of the mounted specimen in the Museum d'Histoire Naturelle, Paris.

Courtesy of M. Angel.

has the thickest skin (about four inches) of any animal in the world, that this skin cannot be easily removed like that of a mammal but has to be cut loose from the body of the fish, and that the fish's measured length varies from fourteen to forty-five feet, the magnitude of the task can be better realized. Fish skins, if mounted untanned, always crack. Before being tanned a *Rhineodon* skin would have to be reduced by over four-fifths by paring, and these things are only possible where men and appliances in abundance are available.

The oldest mounted skin is that of Smith's (1829) fish—the first ever recorded. Smith says that it "was caught by fishermen in Table Bay during the month of April, 1828, and the skin was purchased for £6 sterling and forwarded to the Paris Museum." This was done, according to a letter from Dr. J. Pellegrin of the Museum d'Histoire Naturelle, by J. Verreaux. Through the courtesy of Monsieur F. Angel

of the Museum, I am able, in figure 3, to reproduce an outline sketch of this mounted skin. The date for this cannot be definitely established, but it was prior to 1865. It is about fourteen feet long.

The next oldest mounted specimen (about twenty-two feet long) is that in the Colombo Museum, Ceylon, prepared in 1883 under the supervision of A. Haly, the director. This specimen may be seen in plate XXX made from a photograph kindly sent to me by Dr. Joseph Pearson, the present director. Haly got a second specimen of *Rhineodon* in Ceylonese waters, and in 1889 sent its skin to the British Museum (Natural History) where it was mounted by Gerrard in 1890. Through the kindness of Mr. J. R. Norman of the department of fishes, I am able to reproduce a photograph of this specimen as plate XXXI.



Fig. 4. The mounted whale shark in the establishment of a curio dealer in Tokyo, Japan.

After Kishinouye, 1901.

The next mounted specimen from the point of age is that in the Madras Government Museum. This 22-foot specimen is recorded by Thurston as having come ashore at Madras. It was presumably put on display in 1894, the year from which the figure (Pl. XXXII, fig. 1, herein) dates, and was also presumably mounted under the direction of R. H. Thurston.

Mounted fish No. 3 is that described by Kishinouye as being in the hands of a Japanese curio dealer in Tokyo, in 1901. Figure 4 is a representation of this crudely mounted fish. The fish when fresh measured about 1000 cm. (33.4 ft.).

The next skin is not mounted but is that of the 18-foot specimen which came ashore at Ormond Beach, Florida, in 1902. This is among the treasures of the United States National Museum, where, through the kindness of Mr. B. A. Bean, acting curator of fishes, I have been per-

mitted to study it. Mr. Bean has had a figure of it drawn and this is reproduced herein in plate XXVIII.

The second Florida specimen (1912) mounted by J. S. Warmbath for its owner, Capt. Charles Thompson of Miami, is shown in figure 2 of plate XXXII. This mount has been exhibited all over the United States. It has probably gone to pieces by this time. It was in bad shape when seen by me in 1914.

In 1919, a 31-foot whale shark was stranded and killed near Cape Sable, Florida. The skin was removed, and an effort was made to purchase it for the American Museum by Mr. Arthur D. Lord of this city, a member of the Museum. However, as an exorbitant price was asked, the negotiations fell through. I understand that this skin has since gone to pieces.

Next to be listed is the first specimen taken near Havana in 1927. It was mounted and displayed in 1928, throughout Cuba, by its captors. For a record of it see Gudger and Hoffman (1928). We understand that this specimen has been destroyed by fire. It is shown herein as figure 3 of plate XXXII.

According to Pillay (1929), there is a painted plaster cast of a specimen 13 feet, 7 inches long, in the fish gallery of the Trevandrum Museum, Travancore, India. No details are given.

In June, 1930, Gudger and Hoffman put on record the capture of a second specimen of this great shark (34 feet long) near Havana. This fish was mounted for display, but the exhibition of it was a financial failure, because the first fish had been mounted and exhibited in Havana and throughout the island shortly before it. Consequently, no care was given this second mount and it has been allowed to go completely to pieces. No photograph of this mount has been obtainable.

Finally Herre writes me that:

There is a stuffed specimen, about 4.2 m. long, in the Museum of Santo Tomas University [Philippine Islands]. According to the Philippino Curator, it was taken in Manilla Bay, about 1840, by fishermen from Navotas. It has evidently suffered hard usage, and in places painted canvas has been used to repair injured portions, but it has all the typical characters except the white spots.

If we accept the date of capture as fairly accurate, there is no record of even the approximate date of mounting. Hence it seems best to put it last so that it may be counted among the mounted specimens.

Last of all comes our model of the 1923 Florida (Marathon) specimen made under the direct supervision of, and in part by the hands of, Mr. James L. Clark, head of the department of preparation in the Ameri-

can Museum. As to its excellence, nothing need be said other than to compare the figures of it with those of the other mounted specimens reproduced herein. However, we are not content and still hope for a mounted skin, or for a life-size model based on more complete data, to be hung in our great Hall of Ocean Life. When this time comes we will then have an eminently satisfactory specimen of the greatest of all sharks since the days of *Carcharodon megalodon*, millions of years ago.

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1923. 'An Extraordinary Capture of the Giant Shark, *Rhineodon typus*.' *Natural History*, XXIII, pp. 62-63, 2 figs.  
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<sup>1</sup>For a nearly complete bibliography of *Rhineodon* (one containing the authors not specifically set out above but referred to in this paper), see Gudger, 1915.



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**PLATE XXIII**

**Lateral view of the model of the whale shark in the American Museum. Note the wedge-shaped head and the widespread lobes of the tail fin.**





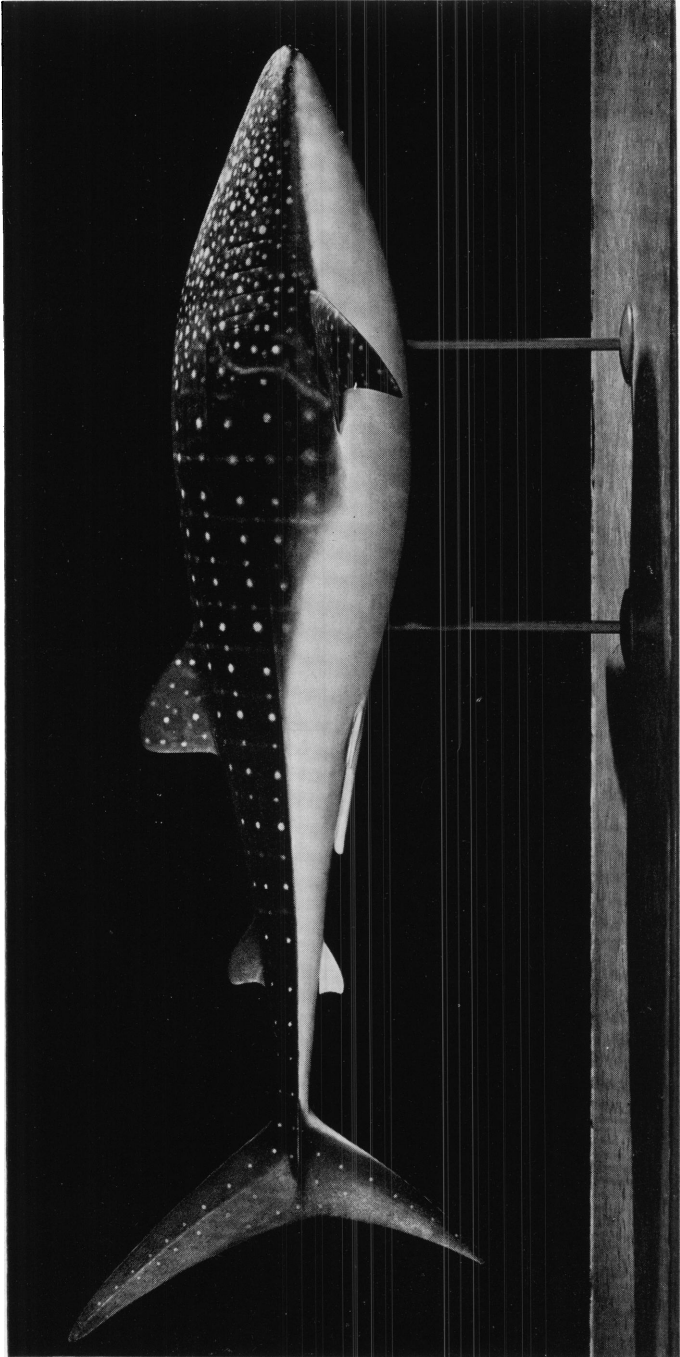


PLATE XXIV

The model of the whale shark seen in dorsal view. Note how square the snout is and how large the fish is anteriorly.

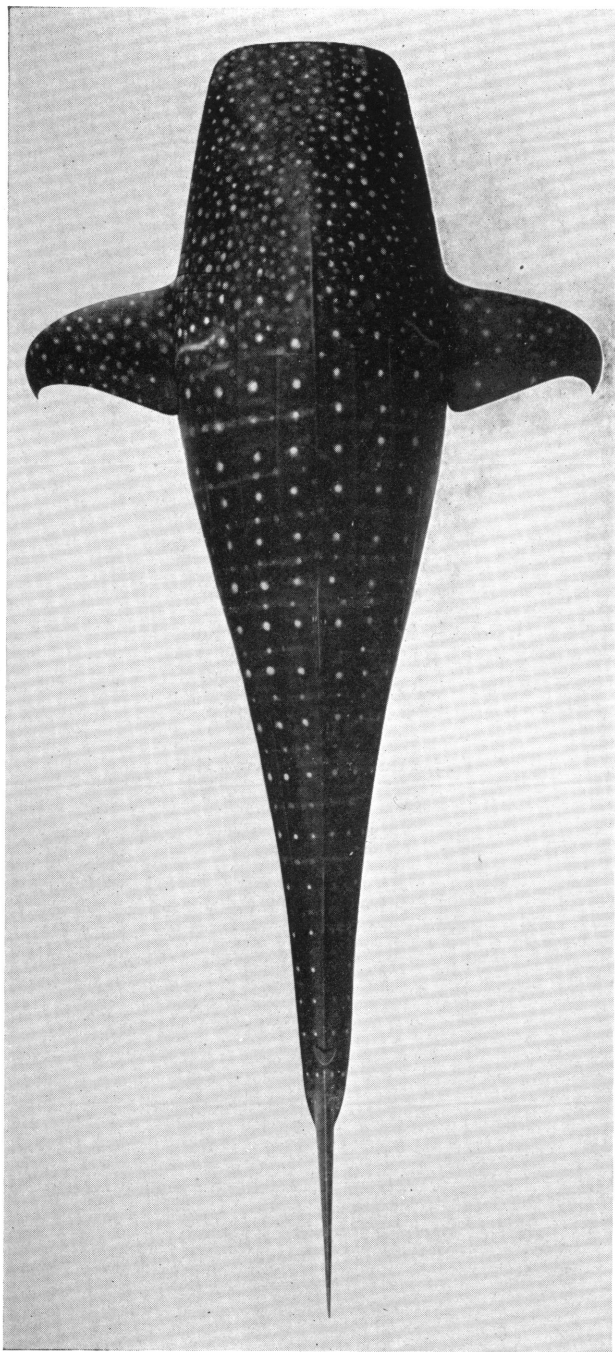


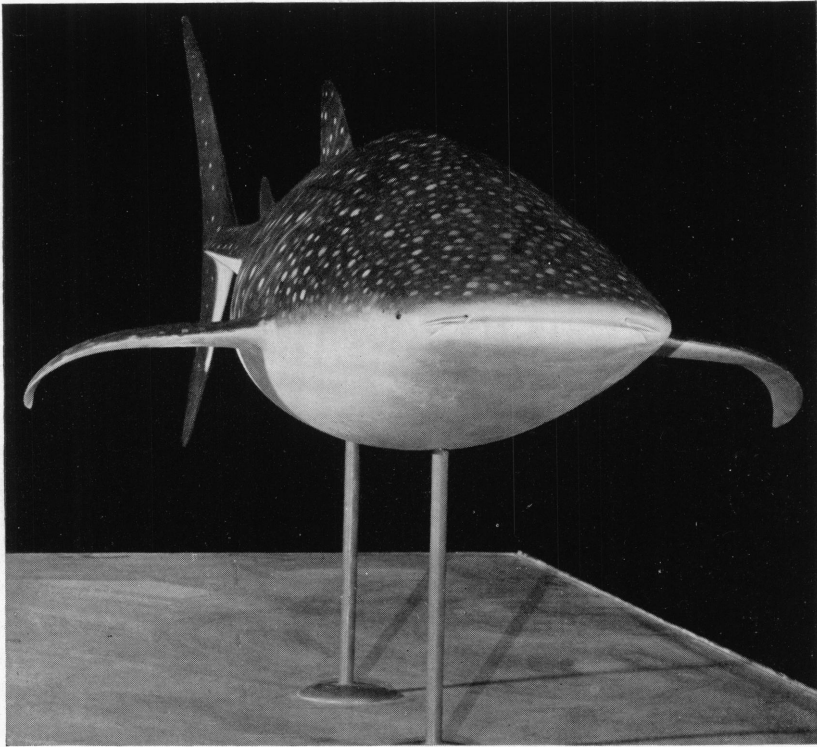
PLATE XXV

Fig. 1. The head of the American Museum model of the whale shark, seen in left oblique view. Note the thin lips, the labial folds, and the eye.

Fig. 2. The whale shark tied to the wharf at Long Key, Florida, on June 10, 1923. Note first and second dorsal fins, and the upper lobe of the caudal—as long as the man holding it is tall.

After Gudger and Mowbray, 1930.





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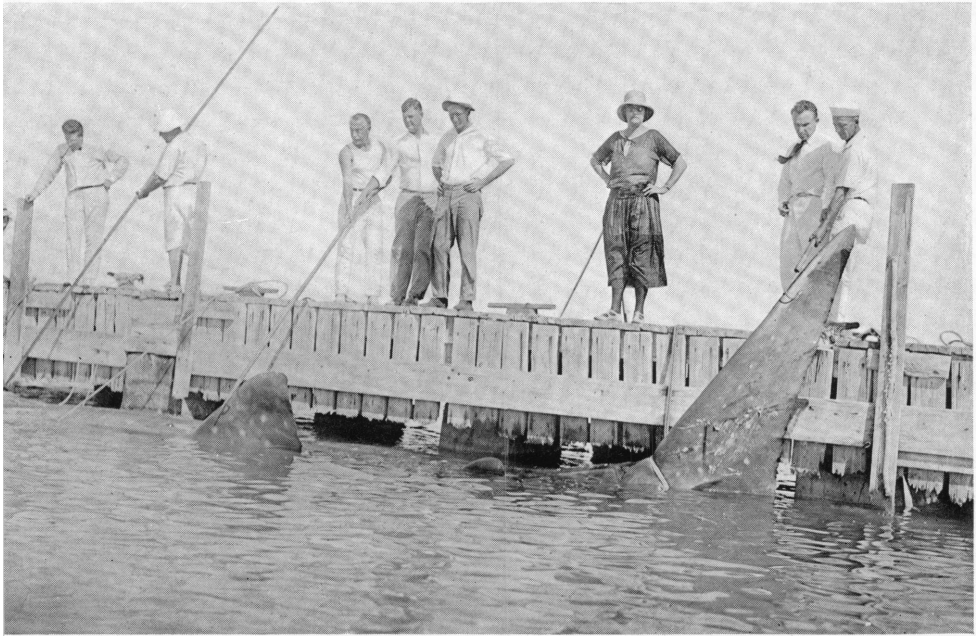


PLATE XXVI

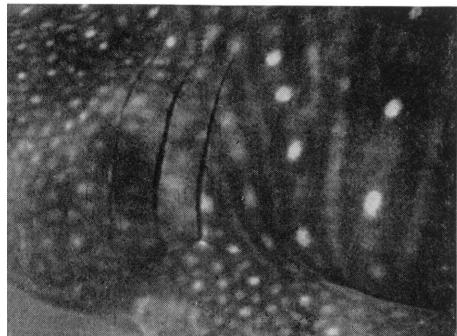
Fig. 1. The left gill-slit and pectoral fin region of the whale shark. From a submarine motion-picture film, by courtesy of Mr. Mack Sennett.

Fig. 2. A close-up view of the body of the whale shark to show the checker-board arrangement of spots, bars, and keels.

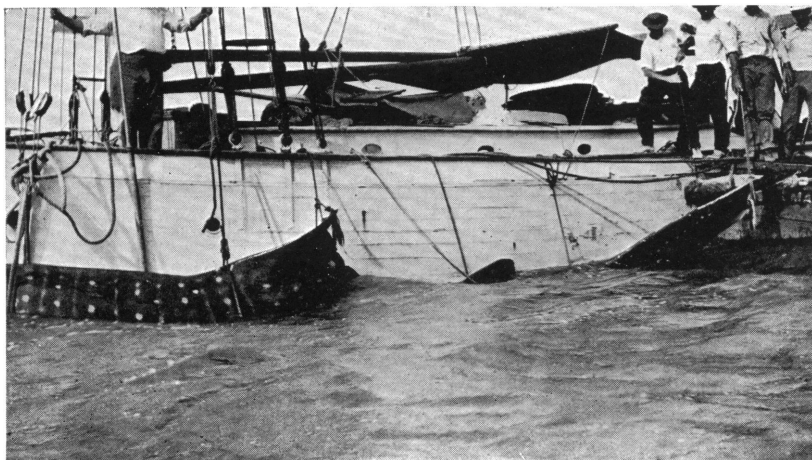
After Gudger and Mowbray, 1930.

Fig. 3. The 1912 Florida *Rhineodon* alongside a schooner. Note size of fish, position of fins, and order of spots and bars.

After Gudger, 1915.



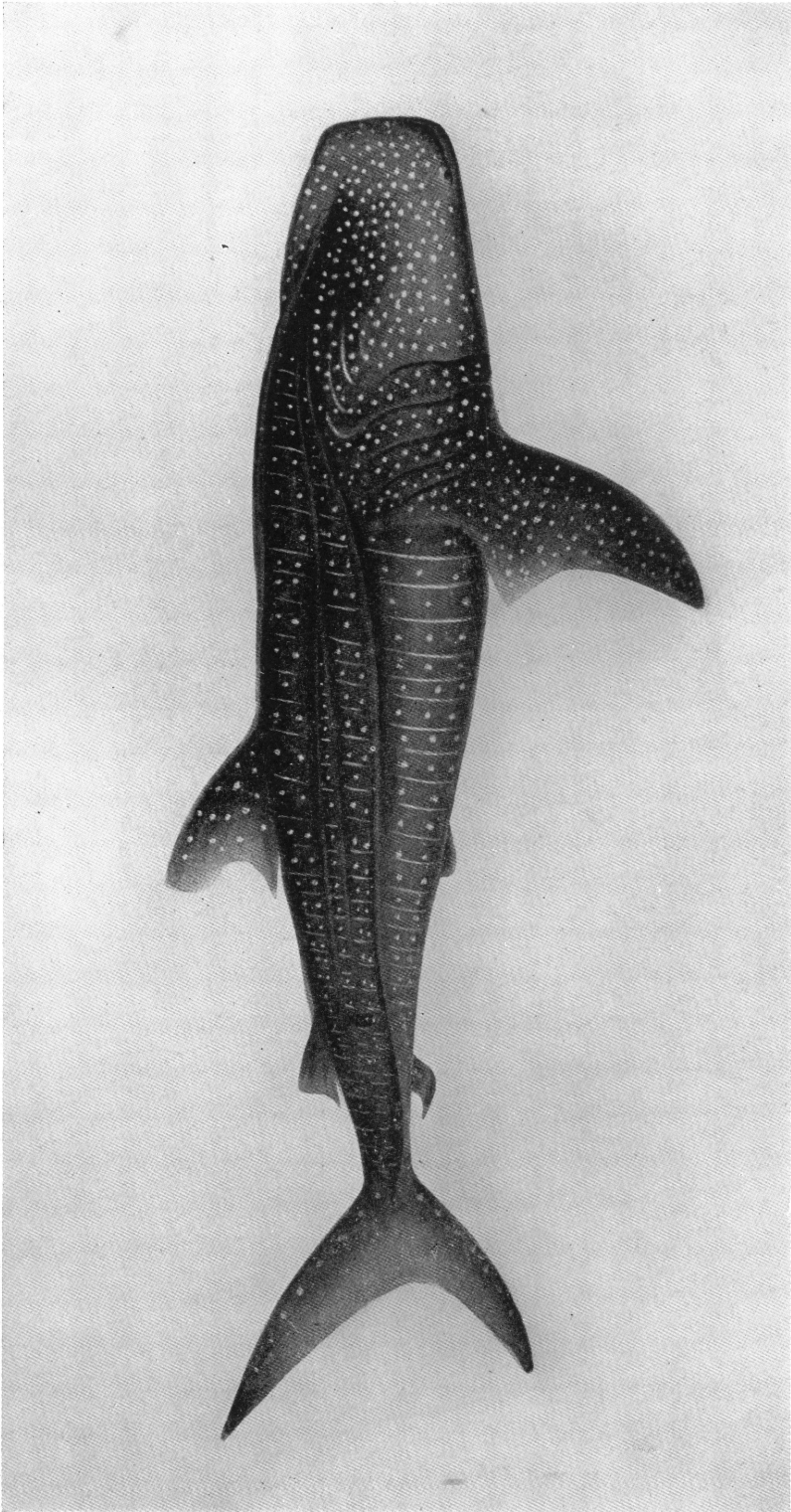
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3

PLATE XXVII

A reproduction of the first drawing ever made of *Rhineodon typus*.  
After Smith, 1849.



**PLATE XXVIII**

**Figure of the skin of the *Rhineodon* stranded on the coast of Florida in 1902.  
After Bean, 1905.**

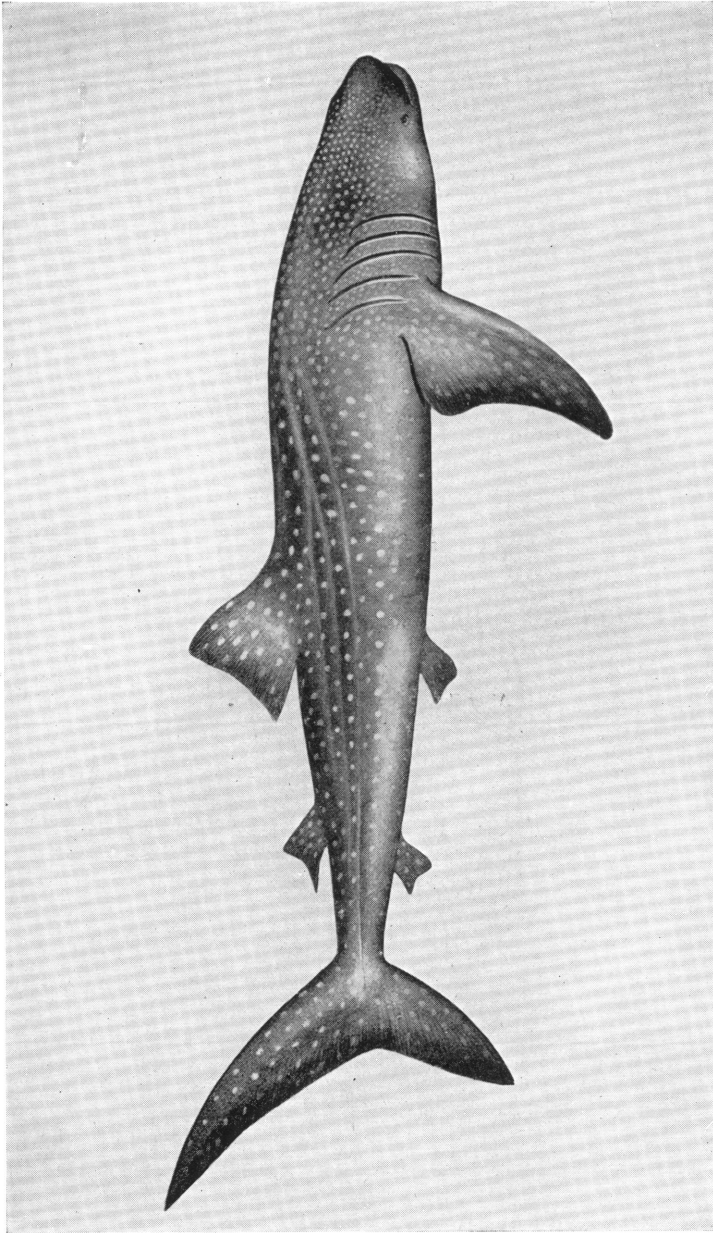


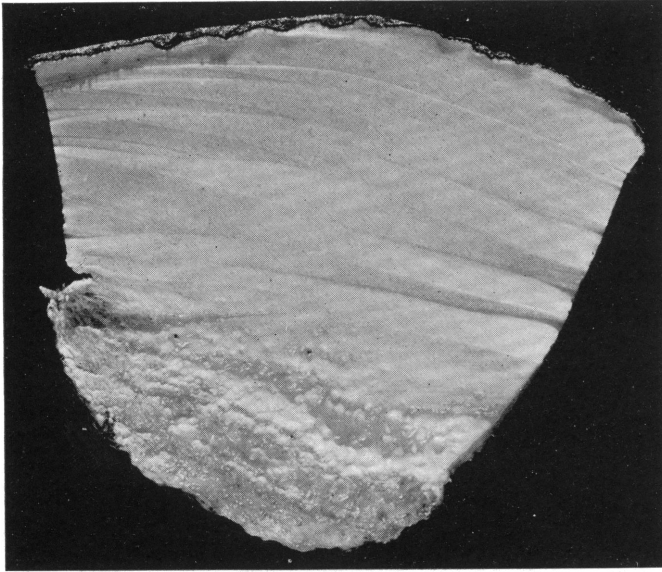
PLATE XXIX

Fig. 1. Section of skin of *Rhineodon* in formalin for seven years. Note the epidermis above (curled over at the edge), next the thick layer of connective tissue, at the bottom (inside of the skin) the loose layer of connective tissue.

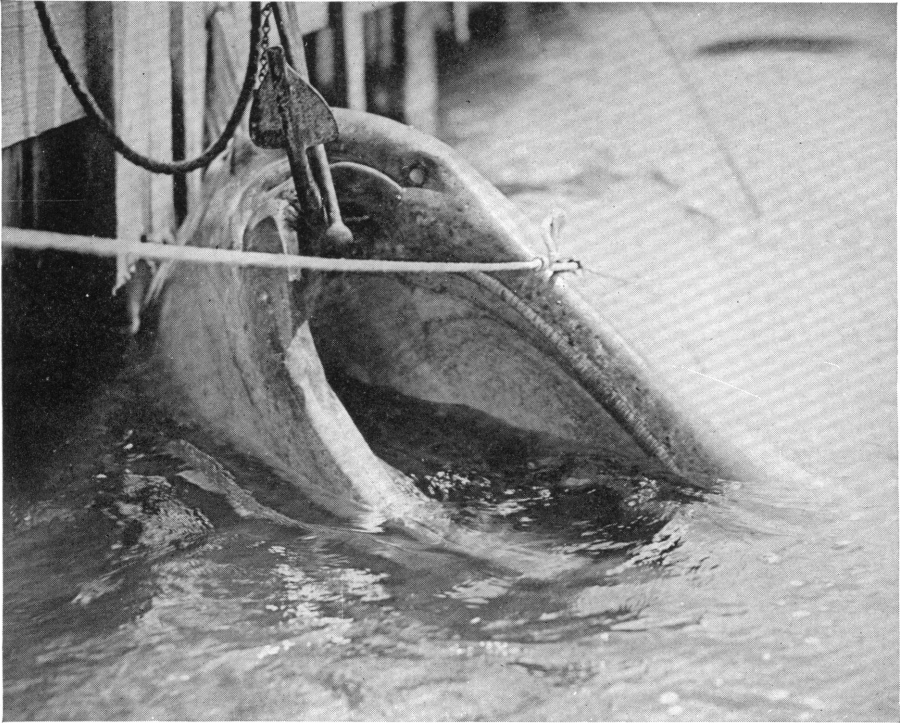
Fig. 2. The cavernous mouth of the Marathon whale shark. In the upper jaw may be seen the dental band with the teeth in card-like rows. To the left is the eye.

After Gudger and Mowbray, 1930.





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**PLATE XXX**

**The mounted whale shark in the Colombo Museum, Ceylon.**  
Courtesy of Dr. Joseph Pearson, Director.

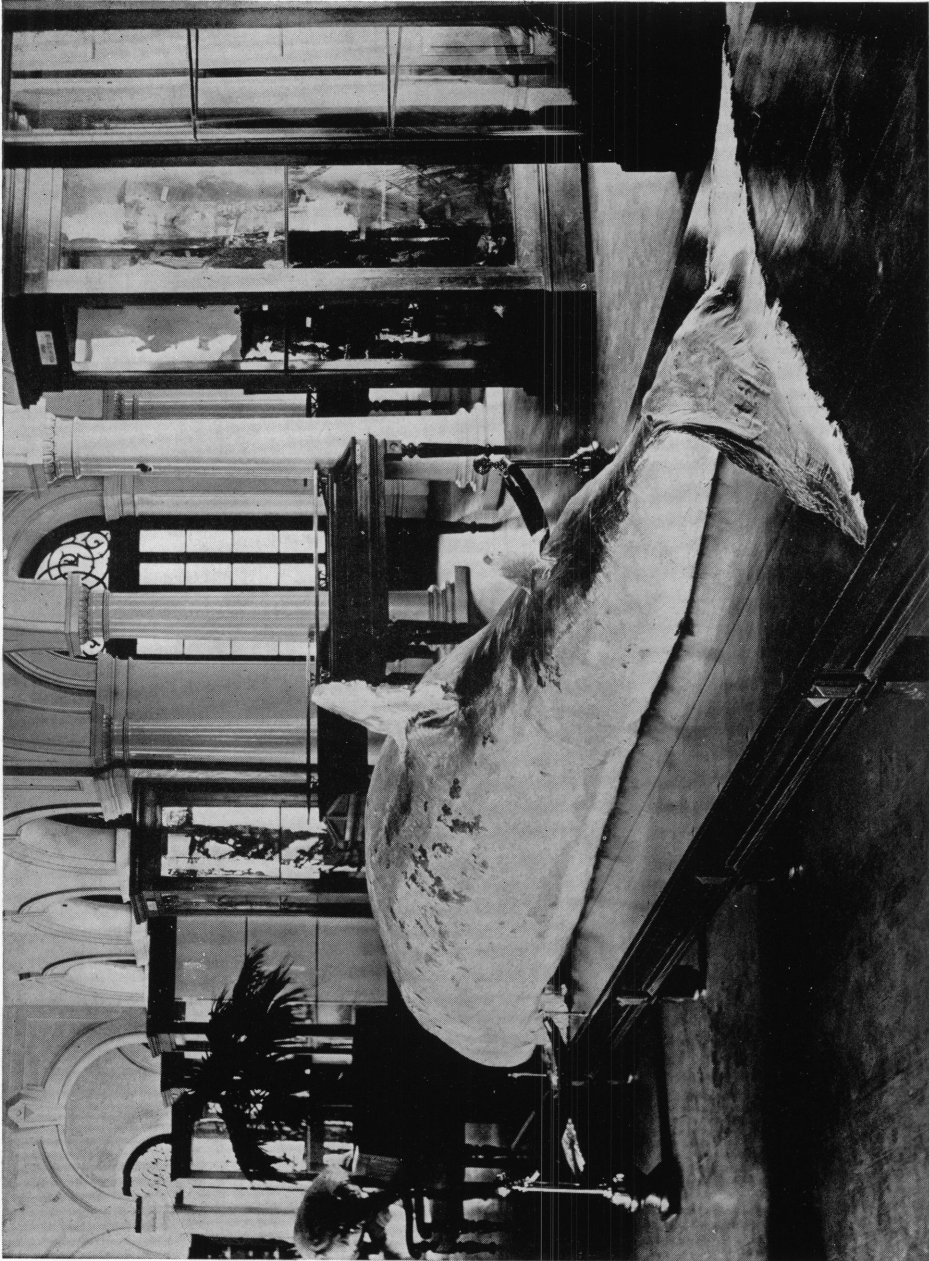


PLATE XXXI

The mounted specimen of the whale shark in the British Museum.  
Courtesy of Mr. J. R. Norman.

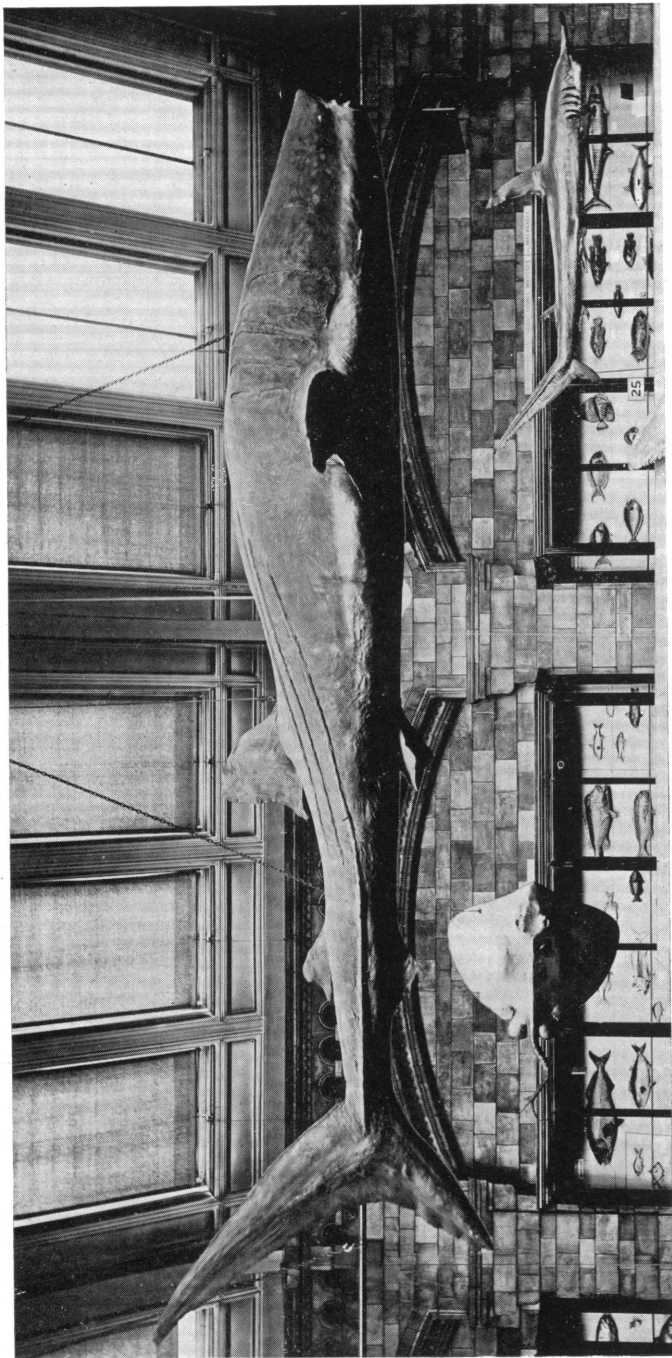
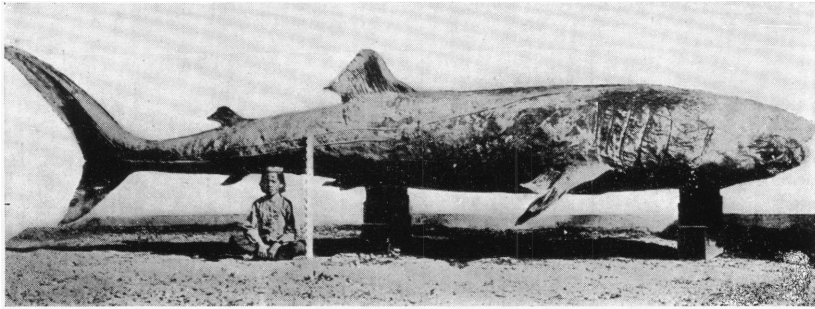


PLATE XXXII

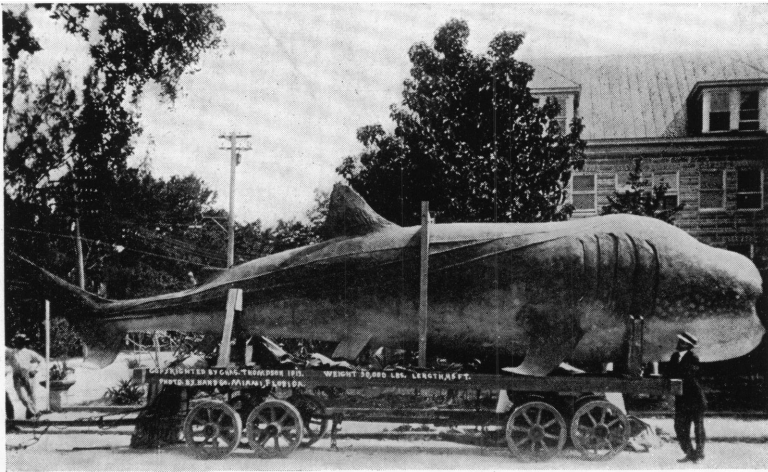
**Fig. 1.** The mounted whale shark in the Madras Museum.  
After Thurston.

**Fig. 2.** The mounted skin of the 1912 Florida whale shark.  
After Gudger, 1915.

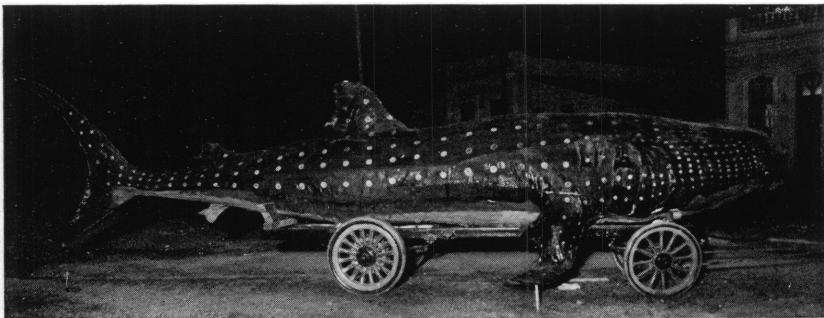
**Fig. 3.** The mounted skin of the first Havana fish.  
After Gudger and Hoffmann, 1928.



1



2



3





## INDEX TO VOLUME LXI

New taxonomic names are printed in **heavy-faced** type, also the main reference in a series of references.

- Acanthidium aciculatum*, 145.  
*Acantholera*, 84.  
*Achaetella varipes*, 84.  
*Actæa acantha*, 117, 119, 120, 123.  
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