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Human Remains Recovered from a Shark's Stomach in South Carolina

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ABSTRACT: When a local fisherman landed a 243-cm (8-ft), 59-kg (130-lb) tiger shark off the coast of South Carolina, the stomach contents included human remains. The distal femur articulations, complete patella, and proximal fourth of the tibia and fibula with connective tissue and a few hairs were present. The forensic science analysis of this material raised some unique questions not usually confronted by a physical anthropologist. Estimations of time since death necessitated research into the feeding and movement habits of tiger sharks, the digestive mechanics and chemistry of the species, and possible alteration of the skeletal material. The fragmentation of the remains spurred extension of usual identification techniques and raised questions of level of confidence of the methods. The current techniques for diagnosis of sex, race, age, stature, and individualized features, and their utility in this case, are reviewed. Areas for further research are proposed.

KEYWORDS: physical anthropology, pathology and biology, human identification, sharks, skeletal remains, tiger sharks, shark attack

The involvement of physical anthropologists in forensic science identification has increased in recent years; documentation of the range of circumstances and types of cases has merited inclusion in the professional literature [*1–3*]. Individual case reports frequently appear in the media and are of special interest at the annual academy meetings. Besides their intrinsic interest and importance, each case usually has a unique aspect and serves as a continuing test of the theories, methods, and data available for accurate analysis. Since many of the quantitative methods available for human identification depend on complete bones for analysis, fragmentary human remains provide a particular challenge to interpretation.

Background

In May 1982, a fisherman in Port Royal, SC caught an 243-cm (8-ft) tiger shark off Daws Island in the Broad River, an estuary near Beaufort, SC. While the fisherman was waiting for the purchaser of the 59-kg (130-lb) shark to arrive, the stomach contents were examined and bone was noticed. He called the county coroner, who confirmed that the remains were human. Little hope was given for personal identification. The coroner speculated that the remains could be from recent plane crashes in the area, from which not all bodies were

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recovered. Since I had identified other remains for the coroner, he called to see if I would be interested in the material as a curiosity or for teaching purposes, since it was not considered a forensic science problem.

Material

The remains arrived at my laboratory late in June 1982. In a plastic bag were the proximal fourth of the left tibia and fibula, the complete patella, and two distal fragments of the femur. Connective tissue and bits of flesh and skin surrounded the bone. Initial inspection suggested a petite adult individual. The material was photographed, adherent hairs embedded in the bone and sticking to the tissues were removed, and the skin shreds were preserved. Some connective tissue was removed manually and the remaining material was soaked in enzyme detergent and later in a dilute solution of sodium hypochloride. Even though the case was not a pressing legal one, the specimens were processed as completely and systematically as possible.

Tiger Sharks

As forensic scientists we are continually aware of the importance of staying within our own areas of expertise. Since I am not a marine biologist, I contacted a renowned shark authority, Dr. Perry Gilbert of the Mote Marine Laboratories in Sarasota, FL. He provided information on shark attacks, reports of human remains recovered from shark stomachs, and suggestions for a literature search of topics relevant to this case.[3]

The tiger shark, *Galeocerdo cuvieri*, is a member of the largest of all the shark families, the *Carcharhinidae*, sometimes called the typical sharks. It is named not for its ferocious reputation, but for the vertical brown stripes on the backs of the younger specimens [*4,5*]. It ranges the world over, primarily in warm coastal waters, and is often found close to the shore in very shallow water [*6*]. It is known and feared for its ferocity from Australia to the West Indies. The tiger shark is common in South Carolina waters; attacks have been reported fairly frequently. The average size of the adult fish is 300 cm (10 ft) and 180 to 225 kg (400 to 500 lb). It is believed to grow as long as 550 cm (18 ft) and to surpass 900 kg (2000 lb). The all-tackle record tiger shark was taken at Cherry Grove, SC in 1964. It was 438 cm (13 ft 10½ in.) long and weighed 801 kg (1780 lb) [*4*].

Although the distinguishing stripes fade with maturity, the tiger's appearance makes it quite easy to identify. It has a very broad head with a short snout and an upper tail lobe that is long and pointed. The teeth are unique and quite recognizable. They are broad with an outward bending tip. The inner edge is convex and the outer is deeply notched. The serrations are coarse at the base, becoming progressively finer at the tip. The serrations may themselves be serrated [*4,7*].

This shark is known to eat virtually anything. It is one of the very few species that has given the sharks the reputation of scavengers. This reputation may be because many of the stomachs examined were from sharks caught in harbors or shipping lanes, where there is a variety of garbage [*8*]. The shark catcher in this case reported that he has found rocks, sea gulls, turtles, shell fish, and rats in sharks he caught locally. Among the items found in the stomachs of tiger sharks in other areas are large conches, horseshoe crabs, pieces of large sea turtles, porpoise, sea birds, large fish, garbage, and various items such as copper wire, clothing, nuts and bolts [*4*], and an unopened can of salmon [*5*]. There are also several accounts of human remains found in the stomachs of tiger sharks [*9,10*].

Numerous instances of tiger shark attacks on humans have been reported worldwide. In some cases the sharks have later been caught and killed and the stomach contents examined.

[3] P. W. Gilbert, Mote Marine Laboratories, Sarasota, FL, personal communication, 15 Sept. 1982.

Body parts could sometimes be identified as coming from persons known to have been attacked. Means of identification have been scars, fingerprints, and in at least one famous case, a tattoo [5]. In some cases, the remains seem to be identified simply by the knowledge that a certain person had a leg bitten off by a shark in the vicinity of the capture.

Sharks swallow their food whole and digestion does not begin until the food enters the stomach [*11*]. At that point, they can apparently store food undigested for long periods of time. Since it is impossible to know when the shark swallows the food in the wild, it is also impossible to determine the exact length of time that the food remains in the stomach. However, sharks captured and held in captivity until their death have provided some information on this point. Sir Edward Hallstrom reported an episode of a tiger shark held in the zoo in Sydney, Australia. The only food given to it was horsemeat, which it repeatedly regurgitated. It died after 21 days and was autopsied. The stomach contents included two perfectly preserved dolphins. Not only had it failed to begin digestion of the dolphins in three weeks time, it had also vomited the horsemeat while somehow retaining the dolphins [*10*]. According to Coppleson, human remains also appear to remain undigested in shark stomachs for days or even weeks. He has recorded several examples of body parts found in various stages of decomposition. In some cases they were the victims of known shark attacks on swimmers or divers. In other cases, they were the result of sharks mutilating already dead bodies [*10*].

The famous Shark Arm mystery of 1935 in Australia is a good example of a tiger shark retaining human remains for a long period of time. This shark was being held in an aquarium for public viewing when it regurgitated an entire human arm, complete with tattoo. The investigation showed that the arm had not been bitten off by the shark and a case was eventually made that the victim had been murdered and his body dismembered and thrown into the water [*10*]. The tattoo and fingerprints were used to identify the victim. Although a thorough search was made, the rest of the body was never found. The Australian Supreme Court ruled that a single limb could not be a murder victim, so the case was never prosecuted [5]. But it was clear that the shark had swallowed the arm sometime between the last sighting of the victim and when it was captured. The shark was in captivity for eight days before it regurgitated the arm, which was held in its stomach undigested for at least 8 days and possibly for as long as 18 days [*10*].

Circumstances and Time Since Death

Judgments of time since death from wholly or partially skeletalized material have been shown to be highly variable and dependent on local circumstances and environments [*3,12*]. As mentioned above, human remains have been documented to remain undigested from 8 to 21 days in sharks' stomachs. The sketchily known digestive process of tiger sharks precludes accurate estimates of time since death. No shark attacks had been reported in the preceeding month along the South Carolina coast, but a plane crashed in May 1982 near Savannah, GA, which is within the range of movement of the species (up to 48 km [30 miles] a day). To date, only miscellaneous portions of the crash victims, including one foot and three hands, have been recovered.

The location and nature of the bite is inconclusive concerning the circumstances of ingestion. The wounds of a tiger shark bite are usually crescent-shaped and a deep bite produces scratches and occasionally tooth fragments lodged along the edge of the wound. The most common areas bitten are the legs and buttocks [9]. The angle of the bite mark in the bone suggests that the leg was bent when attacked. However, somewhat similar wounds were sustained by a South Carolina native sitting in shallow water [*13*]. At any rate, the knee area was severed from the rest of the body with a bite to the vertical axis of the leg. The wound showed very little tearing but the bite force has been determined to be approximately 294 MPa (30 kgf/mm^2) for each tooth [*14*].

Race

The bone portions themselves were not diagnostic of racial ancestry. The shreds of skin adhering to the bone were the best evidence. Putrefaction had darkened some of the soft tissue, but sufficient dermal and epidermal material was present for evaluation. Some consideration was given to bleaching from hydrochloric acid in the gastric juices and prolonged exposure to seawater, but the most probable diagnosis of race was white.

Sex

All of the bones appeared small and the morphology suggested that they came from a female. Such subjective evaluations can be important, but quantitative methods add credence to evaluation. A number of morphological and quantitative techniques have been developed for the diagnosis of sex from the postcranial skeleton. Multivariate analysis of multiple long bones [*15*] and femora of different samples [*16,17*] produce accurate results with complete bones. The specimens in this case were too fragmentary to even apply the circumference measurements for univariate analysis of the femur [*18,19*]. Even Olivier's [*20*] femur distal epiphyseal breadth could not be used, since a segment of the intertrochanteric area was missing.

The tibia was also too incomplete for multivariate analysis. Only the proximal tibial breadth could be established with reasonable certainty (see Table 1). Olivier [*20*] indirectly provided quantitative information on this dimension by equating the tibial breadth to be redundant to the distal femoral breadth in French samples. Data on the American white and black samples of the Terry collection were available from a discriminant function analysis [*21*]; protohistoric Arikara [*22*] values also had a very good discriminating efficiency. All of these studies support a diagnosis of female for the specimen in question. Another study of the Terry collection of white tibiae [*23*] places it well within the female range.

Although the size and shape of the patella informally have been considered as supportive information for sex determination, a search of the osteological as well as forensic science literature revealed little substantiated data. Volumes of over 15 cm^3 for males and less than 11 cm^3 for females with a percentage error of 3% have been suggested [*24*]. A volume of 9 cm^3 was established for the patella from the shark by using a water displacement method. Because of the scant quantitative data available, measurements on living white males and females (ten each) were collected [*25*]. Maximum heights and widths and tissue thicknesses at each location were determined and then probable bone dimensions tabulated. As can be seen in Table 2, the size of the unknown specimen falls well below the female mean. This information is supportive, but further work with dried specimens of known sex is needed.

Age

The unknown specimen was an adult, as indicated by epiphyseal union. Although the articular surfaces were porous beneath the cartilage, the epiphyses were fully united, as in-

TABLE 1—*Sex determination from proximal width of tibia.*

Source	Male Mean, mm	Standard Deviation, mm	Sectioning Point, mm	Female Mean, mm	Standard Deviation, mm
Iscan and Shaivitz [*21*]	77.33	3.59	73.5	69.72	3.39
Symes [*22*]	79.15	3.06	74.56	69.97	3.19
Olivier [*20*]	76.00[a]	...	...	74.00[a]	...
Present case	...	...	62	...	...

[a] Olivier's data are not given as male and female means, but as minimum male and maximum female widths.

TABLE 2—*Sex determination from patella measurements.*

Parameter	Male Mean, mm	Standard Deviation, mm	Present Case, mm	Female Mean, mm	Standard Deviation, mm
Maximum height	50.7	3.59	35.0	46.17	2.58
Maximum width	50.3	2.58	36.0	45.12	2.16

dicated by gross observation and radiography. No indications of degenerative joint disease were noted. Macroscopic evaluation of age in this instance was very imprecise.

The fibula was submitted to Dr. Ellis Kerley of the University of Maryland for microscopic evaluation. His analysis, based on microscopic structures used in age determination [*26*], suggested an age of 33 years with a range of 28 to 38 and an accuracy of 87% in comparison with samples of known age fibulas.

Stature

Estimations of stature from complete long bones is a well-established and accurate procedure [*27*]. Regression formulas and estimation of maximum bone length from segments [*28*] developed from the Terry collection are somewhat less accepted, because of difficulties in locating some of the landmarks. Estimates of bone length from the distal femur fragment and the superior two segments of the tibia were congruent enough to indicate probable accuracy in this case (see Table 3). Steele's formulas for estimating total living stature could not be applied, since the right combinations of segments were not present. The long bone length estimates were applied initially to both sexes and whites and blacks. Considerable harmony of results was attained. After the age estimate and the sex and race diagnoses were complete, the Trotter and Gleser [*27*] formulas for white females were applied, with the resultant range of 157.5 to 165 cm (5 ft 2 in. to 5 ft 5 in.) for individual bones as well as combinations (see Table 4 and Fig. 1).

TABLE 3—*Maximum lengths of long bones from bone segments.*

Bone	Maximum Length, cm	Range, cm
	TIBIA	
Segment 1 (2.6 cm)	34.45 ± 2.15	32.3-36.6
Segment 2 (5.6 cm)	34.65 ± 1.75	32.9-36.4
Segments 1 and 2	34.05 ± 1.74	32.3-35.8
	FEMUR	
Segment 4 (3.7 cm)	43.28 ± 2.49	40.79-45.77

TABLE 4—*Estimate of stature from long bones.*

Long Bone	Stature Estimate, cm	Range, cm (ft)
Femur and tibia	160.69 ± 3.55	157.14-164.24 (5 ft, 2 in.-5 ft, 5 in.)
Tibia	160.275 ± 3.66	156.6-163.93 (5 ft, 2 in.-5 ft, 4½ in.)
Femur	161.0 ± 3.72	157.3-164.7 (5 ft, 2 in.-5 ft, 5 in.)

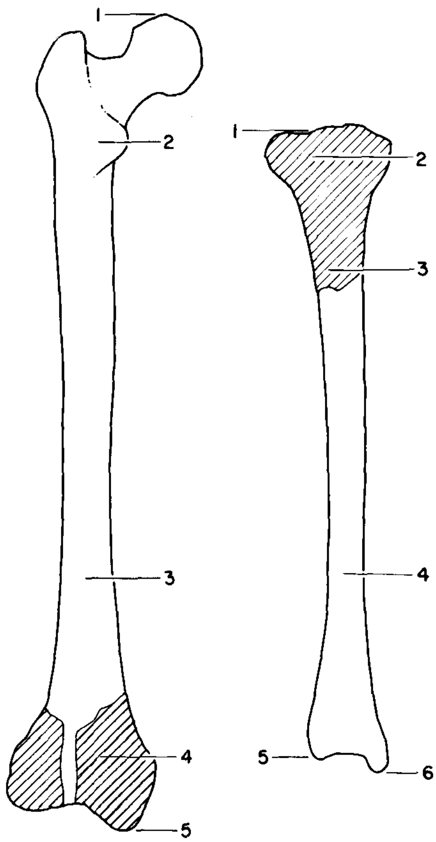

FIG. 1—*Shaded portions indicate femur and tibia elements from shark stomach for estimation of long bone length. Adapted from Steele [28], p. 87.*

Hairs

It initially was hoped that the hair imbedded in the bone and adhering to some of the soft tissue could contribute to the diagnosis of sex and race. Examination of the hair by Dr. Walter Birkby of the University of Arizona indicated that the specimens were not from a human. The individual hairs were tapered and had not been cut. The heavy pigment and the medullary form were outside the human range. Exact origin was not determined. In a subsequent interview with the fisherman, it was found that the remains had been deposited in the back of his pickup truck and hence contamination could have occurred there. Although he could not remember what, if anything else, was in the shark's stomach, he reported that he had caught other sharks with rats as part of the stomach contents.

Summary

The final evaluation of all the data indicated that the human remains retrieved from the shark's stomach were those of a white female, age 28 to 38 with a most likely age of 33, whose stature was between 157.5 and 165 cm (5 ft 2 in. and 5 ft 5 in.). The circumstances of death could not be determined, but the shark bite was along the vertical axis of the leg. The literature review indicated that sharks can retain human remains undigested for up to 21 days, so time since death could not be accurately determined. Positive identification has not yet been established.

Besides the unusual circumstances of discovery of the human remains, this case was illustrative of the utility of many of the techniques that have been developed through the years in physical anthropology. Although many of the methods were developed without a definite forensic science orientation, the range of data allowed application in a forensic science setting. The areas of uncertainty centered around the fragmentary nature of the remains and the inapplicability of some of the quantitative multivariate statistical analyses. As is so often the case, the analysis in this instance highlighted gaps in our repertoire and indicated areas for further research. Racial determination would have been impossible without the shreds of skin. The other identifying characters were reasonably accurate, given the fragmentary nature of the remains.

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