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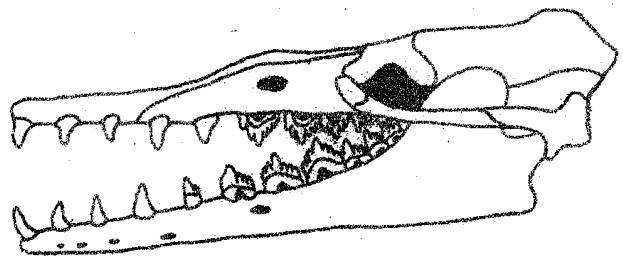

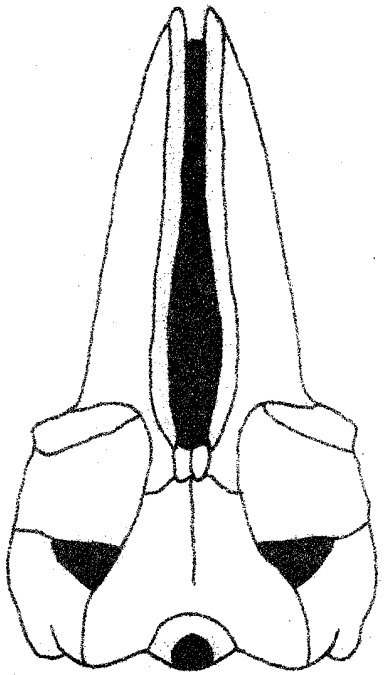

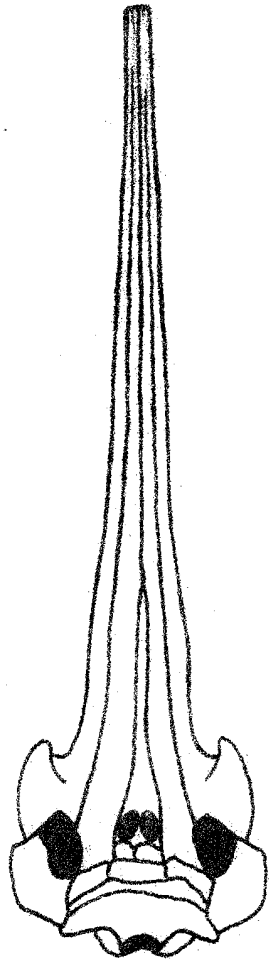

THE FOSSIL WHALES OF FLORIDA

Gary S. Morgan *

This issue of the *Plaster Jacket* provides a general survey of Florida's fossil whales. Descriptions of the different types of extinct whales found in Florida and illustrations of their most commonly fossilized elements are presented to serve, in part, as a guide to the identification of whale fossils found in the state. The present issue fills the last remaining gap in the *Plaster Jacket's* coverage of Florida's fossil marine mammals. Earlier *Plaster Jackets* by Roy Reinhart on fossil sea cows *(Plaster Jacket no. 15)* and Clayton Ray on fossil seals and walruses *(Plaster Jacket no. 27)* concentrated on the other two groups of marine mammals which have left a fossil record in Florida.

INTRODUCTION

The following introduction is provided to familiarize the readers with both modern and fossil whales. For further reading on the subject consult the bibliography on page 19. Whales, dolphins, and porpoises comprise the mammalian order Cetacea. Compared to other mammals, they have many highly specialized features, most of which are related in some way to their aquatic existence. Some of the aquatic specializations found in cetaceans include: development of the forelimb into flippers; loss of the hind limbs; development of horizontal flukes at the posterior

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end of the body for propulsion; migration of the external nares (blowhole) back to the highest point on the skull, resulting in a telescoping or overlapping of certain of the skull bones; a complex modification of the ear region in adaptation to underwater hearing and echolocation; and an overall streamlining of the entire body, including an almost total loss of hair and formation of an insulating layer of blubber. Although some of these modifications are found in other marine mammals (sea cows, seals, sea lions, and walruses), none of these groups is so completely adapted for life in the sea as are the cetaceans. The Order Cetacea can be divided into three major groups or suborders: (1) Archaeoceti, (2) Odontoceti, and (3) Mysticeti (see Cover).

ARCHAEOCETI

The Archaeoceti are an extinct group of primitive toothed whales that lived during the Eocene and Oligocene epochs, although their remains are common only in the late Eocene. The archaeocetes appear to be an ancestral group for all cetaceans, and therefore they retain many primitive features of the land mammals from which they evolved. They can be differentiated from the two groups of modern whales by a number of features, including: (1) the incomplete development of aquatic specializations in the skull--in particular, the incomplete posterior migration of the external nares (the blowhole is located about halfway between the snout and the top of the head), the absence of telescoping skull elements, and the retention of long, well developed nasal bones; (2) a heterodont dentition --in other words, archaeocetes, like most other mammals, have their teeth differentiated into incisors, canines, premolars, and molars; (3) a tooth formula very near that of most primitive land mammals--primitively mammals had 3 incisors, 1 canine, 4 premolars, and 3 molars in each jaw quadrant for a total of 44 teeth, archaeocetes have 42 teeth, having lost only the third upper molar; (4) diagnostic, two-rooted serrated cheek teeth--the shape of these teeth resembles a yoke and hence their common name, the zeuglodont whales. Several of the archaeocetes, such as *Basilosaurus*, had very elongated bodies, much as did the mosasaurs, an extinct group of Mesozoic marine reptiles. This serpent-like appearance is reflected in the great elongation of the centra of the lumbar and caudal vertebrae. Archaeocete whales have been found in Egypt and Nigeria in Africa, in France, England, Russia, New Zealand, Antarctica, and in the southeastern United States from North Carolina to Texas, including Florida.

ODONTOCETI

The Odontoceti or toothed whales are the most common and diverse of the two groups of modern cetaceans. All of the smaller living cetaceans and a few of the larger species are odontoceres. The toothed whales include a wide variety of living forms, such as river dolphins, beaked whales, sperm whales, narwhales, belugas, pilot whales, killer whales, and numerous species of smaller dolphins and porpoises. The odontocetes are characterized by: (1) the presence of teeth, which for living species are homodont; in other words all of the teeth are of the same general shape and function (an extinct group of odontocetes,the squalodonts, had serrated cheek teeth and conical incisors, much as did the archaeocetes). Most modern odontocete species have simple conical teeth, but a few varieties have spatulate (flattened) or leaf-shaped teeth and in one species, the narwhale, the male has a tremendously elongated tusk which protrudes from the snout. Many toothed whales have a large number of teeth in comparison to other mammals; for instance, the La Plata River dolphin of South America may have as many as 240 teeth; (2) a blowhole with a single external opening;

(3) an asymmetrical skull, especially in the region around the blowhole. This asymmetry of the skull appears to be a relatively modern trend in the odontocetes as Oligocene and Miocene toothed whales had symmetrical skulls; (4) rudimentary nasal bones; (5) the extreme posterior migration of the blowhole, with an accompanying telescoping of skull bones. The living odontocetes share this last feature with the Mysticeti, but not with the structurally more primitive archaeocetes. The odontocetes first appeared in the Oligocene and by the Miocene had already become quite diverse. Several extinct families of toothed whales and a large number of extinct genera have been described from middle and late Tertiary marine deposits throughout the world. In addition, fossil representatives of most of the modern families of odontocetes are known from the Miocene to the Pleistocene. Modern genera are known from the Pliocene. The majority of whale fossils found in Florida belong to some type of toothed whale.

MYSTICETI

The third major group of whales are the Mysticeti. The mysticetes, also known as baleen or whalebone whales, include the largest living animals and, for that matter, the largest animals that ever lived. Along with the toothed sperm whale, the baleen whales form the basis for the commercial whaling industry. The modern mysticetes include the right, bowhead, gray, humpback, minke, sei, finback, and blue whales. Baleen whales are characterized by: (1) the complete lack of teeth in the adult animals; instead, they have long, fringed, keratinous plates (composed of a substance similar to that of our fingernails) called baleen or whalebone, hence the two common names used for the group. These baleen plates, attached to the roof of the whale's mouth, are used to filter planktonic crustaceans (krill) and other small invertebrates and fish from sea water; (2) a blowhole with two distinct external openings; (3) a symmetrical skull; (4) broadly curved mandibles that do not meet in a symphysis. Baleen whales first occur in the Oligocene but their remains do not become common until the Miocene. The cetotheres, an extinct group, were the common mysticetes of the Miocene. Cetotheres are known from Florida, but only from isolated ear bones. In the Pliocene they were replaced by the more advanced groups of baleen whales. Fossils of these advanced mysticetes are relatively common in Florida, especially their large vertebrae and distinctive ear bones.

FLORIDA'S FOSSIL WHALES

In 1889 the well known American vertebrate paleontologist, Joseph Leidy, first noted the presence of fossil whales in Florida. These fossils, described by Leidy as "half a dozen vertebrae and several teeth of several Cetacea of the family of the Dolphins," were from the Peace Creek deposits in the southwestern part of the state. Since Leidy's time much has been written about Florida's fossil whales (see bibliography), and a number of genera and species new to science have been described from the state. It is not difficult to understand why whale fossils are so common in Florida. It has been known for many years that up until approximately 25 million years ago, Florida was completely submerged and that since then peninsular Florida has been wholly or partially inundated by the sea several times. Because of this predominant influence of the sea throughout Florida's geologic history, it is not surprising that the majority of rocks and sediments found in the state are marine in origin. These sediments document a fairly complete record of marine life in Florida,

including whales, for the last 45 million years of geologic time. Florida's Miocene and Pliocene marine sediments produce the largest number of whale fossils, although fossil whales are known from the Eocene and Pleistocene as well. In the following section I have, for the purpose of discussion only, divided the Cenozoic history of Florida into three units of time: (1) the Eocene and Oligocene; (2) the Miocene and Pliocene; and (3) the Pleistocene and Recent. The different varieties of whales found in each time unit are discussed and the most common fossils likely to be found are illustrated and described.

Eocene and Oligocene (25-55 million years ago)

All whales so far recovered from Eocene rocks have been representatives of the suborder Archaeoceti. Finds of archaeocetes in the Eocene limestones of northern Florida have been rare thus far, in contrast to their fairly common occurrence in sediments of equivalent age in Alabama and Mississippi. The shoreline of the Eocene sea extended across Alabama and Mississippi, and it has been hypothesized that archaeocetes lived in nearshore waters and therefore seldom ventured far out to sea in the area where Florida is now located. In recent years archaeocete fossils, including several nearly complete skeletons, have been turning up regularly in Eocene limestone deposits in North and South Carolina. It is possible that archaeocete fossils are more common in Florida's Eocene limestone than their meager fossil record would indicate.

Because of the apparent rarity of archaeocete whale fossils in Florida, it would be useful to elaborate on the discovery of several of the best specimens.

C. Wythe Cooke in 1915 was the first to record an archaeocete whale from the state. This fossil consisted of the posterior portion of a skull of a medium-sized archaeocete, *Zygorhiza*, collected by G.C. Fraser from a quarry in the Ocala Limestone, 2 miles southeast of Ocala in Marion County. Over the next 40 years vertebrae of archaeocetes were reported from limestone quarries in the north-central region of Florida on several occasions. C.C. Meffert collected a single veretebra from the same quarry where Cooke's specimen was found. Harbans Puri recovered a series of rib fragments and vertebrae of a large archaeocete from the Ocala Limestone at the Williston Shellrock Mine near Mayo in Lafayette County. Dow Rowland and P.A. Leivonen collected several vertebrae from a quarry near Haile in Alachua County. More recently, Dr. Kelly Brooks of the Geology Department, University of Florida, found the complete incisor of a large archaeocete in a chunk of Ocala Limestone from a quarry near Gainesville in Alachua County. Fred Dixon recovered an archaeocete skull fragment with the periotic in place, from the Sam Wall Quarry in the Ocala Limestone, 8 miles northeast of High Springs in Alachua County. Dave Gillette collected the cheek tooth of an archaeocete in 1975 from the Steinhatchee River in Lafayette County. The most recent discovery was a vertebra found by Pop Taylor in the Withlacoochee River.

The two recent discoveries of archaeocete whale fossils in rivers brings to mind an important point that should be considered by anyone collecting fossils in Florida's rivers. The majority of fossils found in rivers in the state are relatively young in age, usually late Pleistocene. In several instances, however, such as the archaeocete whale tooth from the Steinhatchee River, very old fossils have become mixed with much younger fossils on the bottom of the river. In the northern part of the state many rivers flow through and on top of limestone of Eocene and Oligocene age. When this happens, the possibility

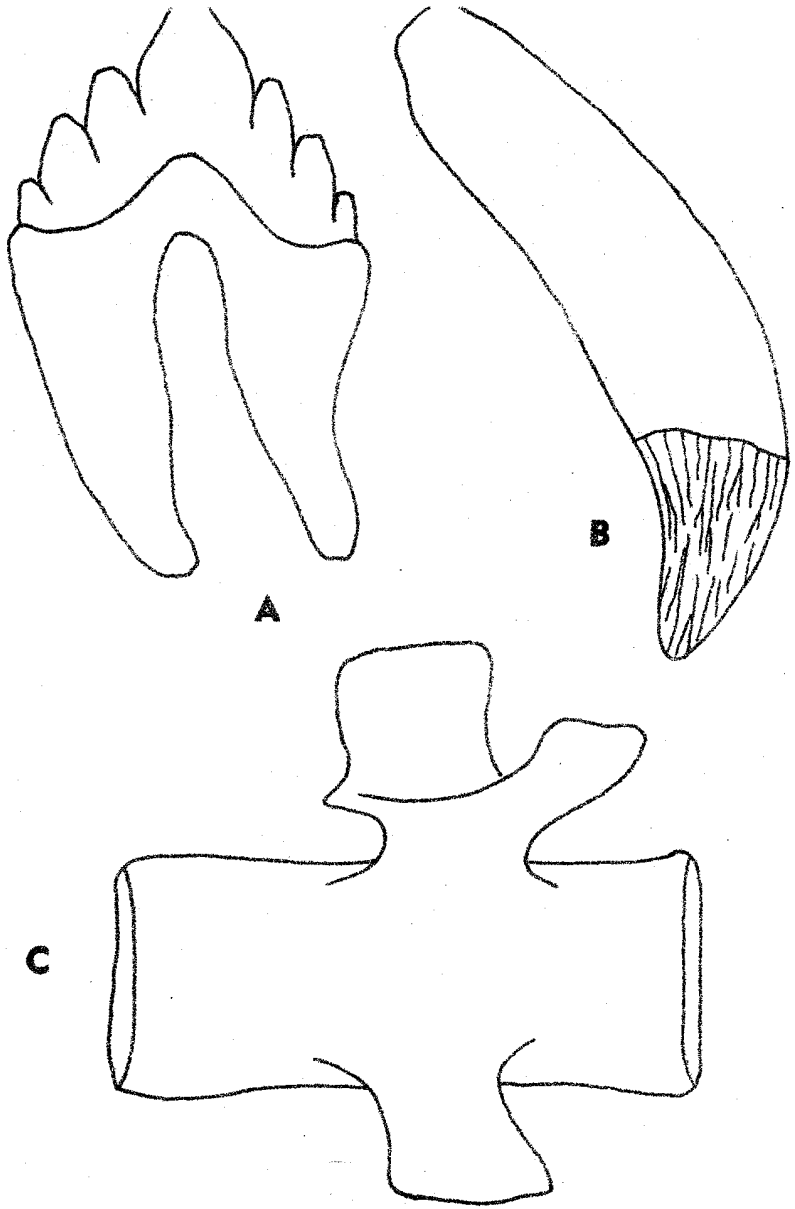

FIGURE 1. Archaeoceti. All figures are natural size unless noted otherwise.

could be considered that older fossils eroded from the limestone beds might be mixed on the river bottom with much younger fossils eroded from unconsolidated sands, clays, and marls, deposited on top of the limestone at a much later date. For this reason, it is important to be able to recognize the most common elements of archaeocete whales so that they can be separated from fossils of Pleistocene terrestrial animals.

The cheek teeth of archaeocete whales are very distinctive. They are two-rooted, coarsely serrated, and laterally compressed so that the serrations are lined up in a row from the front to the back of the tooth (see Figure 1A). There is one serration or cusp in the center of the tooth that is much larger than the others. The remaining cusps decrease in size away from the main cusp. The incisors and canines are similar in appearance, both being somewhat tusk-like (see Figure 1B). They are long and relatively narrow, somewhat curved, laterally compressed, and have a distinct conical enamel crown ornamented with coarse striae (grooves). The enamel crown comprises about one-fourth of the tooth's total length. There are two types of archaeocete whale known from Florida. One of these, *Basilosaurus*, was the giant of the group. It reached a total length of 65 feet, the skull alone being 5 feet long. *Basilosaurus* is characterized by its large size and by the extreme elongation of the centra in the trunk and tail vertebrae (see Figure 1C). Vertebrae of *Basilosaurus* may be as much as 1 1/2 feet in length and 8 inches in diameter. The cheek teeth of this large archaeocete reach a maximum of 3 1/2 inches in diameter from front to back and 5 inches in height. Its incisor and canine tusks are 5-7 inches long and 1 - 1 1/2 inches wide. The second type of archaeocete, *Zygorhiza* (drawing of skull on front cover), is considerably smaller; its maximum length was 20 feet, the skull comprising 3 feet of that. *Zygorhiza* differs from *Basilosaurus* primarily in its smaller size and in the construction of the vertebrae.

The vertebrae of *Zygorhiza* do not have an elongate centrum and bear a close resemblance to the vertebrae of modern whales. The teeth of *Zygorhiza* are similar to those of *Basilosaurus*, although smaller.

No whale fossils have yet been discovered in Florida's Oligocene rocks. In fact, whales were relatively rare throughout the world during the Oligocene epoch. This is indeed unfortunate, as it was during the Oligocene that both the toothed and baleen whales first appeared, presumably evolving from an archaeocete ancestor. The paleontological evidence for this evoluntionary history is, however, far from complete, and therefore any find of an Oligocene cetacean from Florida would be of exceptional importance.

Miocene and Pliocene (2-25 million years ago)

Cetacean fossils are relatively common in Florida's Miocene and Pliocene sediments. Probably the most productive area for fossil whales of this age is the Bone Valley region of central Florida. This area, comprising parts of Polk, Hillsborough, Hardee, Manatee and DeSoto counties, is underlain by the Mio-Pliocene Bone Valley Formation. The Bone Valley Formation is mined extensively in this area for phosphate, used primarily for the production of fertilizer. It is through these mining operations that the majority of whale fossils are unearthed. Fossils are left on spoil piles after mining operations and are picked up sometime later by fossil collectors. The most nearly complete specimens, however, are almost always found in place in undisturbed sediments.

Several types of fossil cetaceans are found in the Bone Valley sediments. The first group is commonly known as the long-beaked dolphins. They are moderate-sized toothed whales with remarkably elongated rostral (snout) regions of the skull and

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correspondingly elongated lower jaws (see skull on front cover). Long-beaked dolphins are a characteristic element of Miocene cetacean faunas in Europe and North America, but become rare by the Pliocene. It is for this reason that the fossil cetacean expert, Remington Kellogg (1924 - 1959), argued that the fossils of long-beaked dolphins in the Bone Valley area actually were derived from clay and phosphate deposits of Miocene age underlying the typical Pliocene portion of the Bone Valley Formation in this region. Unfortunately the majority of fossils pertaining to these dolphins are picked up from spoil piles and therefore cannot be dated using the stratigraphic sequence of sediments.

Three genera of long-beaked dolphins are known from the Bone Valley. Two of these, *Schizodelphis* and *Pomatodelphis*, are very similar and will be discussed together. The narrow, elongated rostrum of these dolphins is extremely fragile and only a few complete specimens are known from Florida. A nearly complete skull of *Pomatodelphis*, collected by Arnie Lewis in 1957 at the Homeland Mine in Homeland, Polk County, measured almost 3 feet in length, of which four-fifths was the rostrum. Broken segments of the rostra and lower jaws of *Schizodelphis* and *Pomatodelphis* are rather common in the Bone Valley. These fragments are noticeably flattened and vary from one to several inches in width (see Figures 2A and B). Most commonly these fragments are found without teeth and on one surface will have two straight parallel rows of shallow, closely spaced pits or depressions known as alveoli. When the dolphin was alive these alveoli held the teeth and some fragments can be found that still contain teeth. The individual teeth are elongate and slightly curved, and have conical enamel crowns (see Figure 2C). The crown of the tooth, usually one-fourth or less of the tooth's total length, is covered by hard, shiny enamel, which is normally darker in color than the rest of the tooth. The

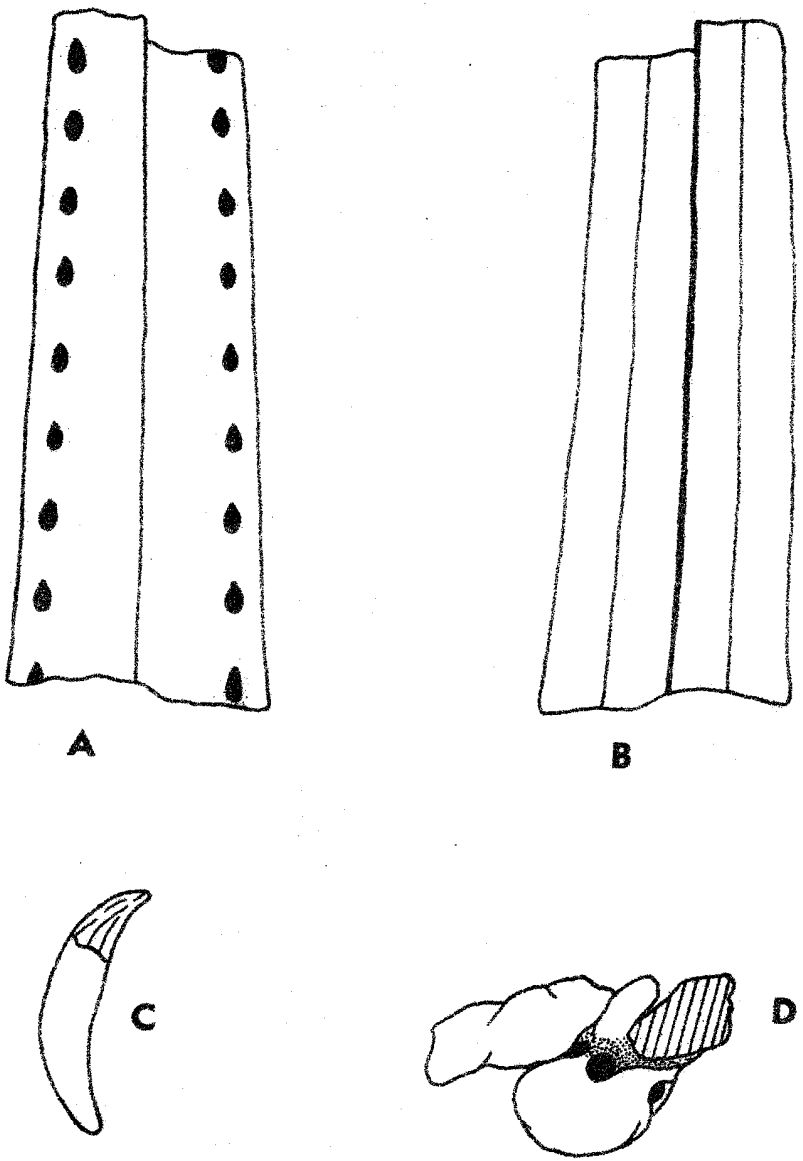

FIGURE 2. Odontoceti. *Schizodelphis*, a long-beaked dolphin. (A) rostrum, ventral view; (B) rostrum, dorsal view; (C) anterior tooth; and (D) periotic.

root of the tooth has a dull finish and is lighter in color than the crown. The tooth in Figure 2C is from the anterior end of the jaw. Farther posterior in the skull and lower jaws, the teeth tend to be smaller and more slender. The distinctive ear bones or periotics of these small long-beaked dolphins are also relatively common fossils, probably because they are composed of very dense bone (see Figure 2D).

The third type of long-beaked dolphin from the Bone Valley area, *Megalodelphis*, is known from only a very few specimens. This dolphin was almost twice as large as *Schizodelphis* or *Pomatodelphis* and, in fact, is the largest known long-beaked dolphin. The alveoli in the skull and jaws of *Megalodelphis* are large, deep and more widely spaced than in the previous two genera. The elongated rostrum of *Megalodelphis* is flattened like those of the smaller forms and like them it is composed of the premaxillary and maxillary bones. Rostral and mandibular fragments of this large dolphin vary from 2 1/2 to 5 inches in width. The teeth are 1 1/2 - 2 inches in length, have conical enamel crowns, are noticeably curved, and have somewhat expanded roots (see Figure 3D). The enamel crowns are curved inward toward the tip and have vertical grooves on the surface. Teeth of *Megalodelphis* might be confused with teeth of the large marine crocodile *Gavialosuchus*, which occur in these same beds. The crocodile teeth can be distinguished by the presence of a distinct carina or ridge on the anterior and posterior edges of the crown, by the presence of an open rather than a closed root, and by their less noticeable curvature.

Another variety of dolphin from the Bone Valley, *Goniodelphis*, is an extinct relative of the modern Amazon River dolphin, *Inia geoffrensis*, which lives in the Orinoco and Amazon rivers in South America. Aside from two fragmentary skulls and a

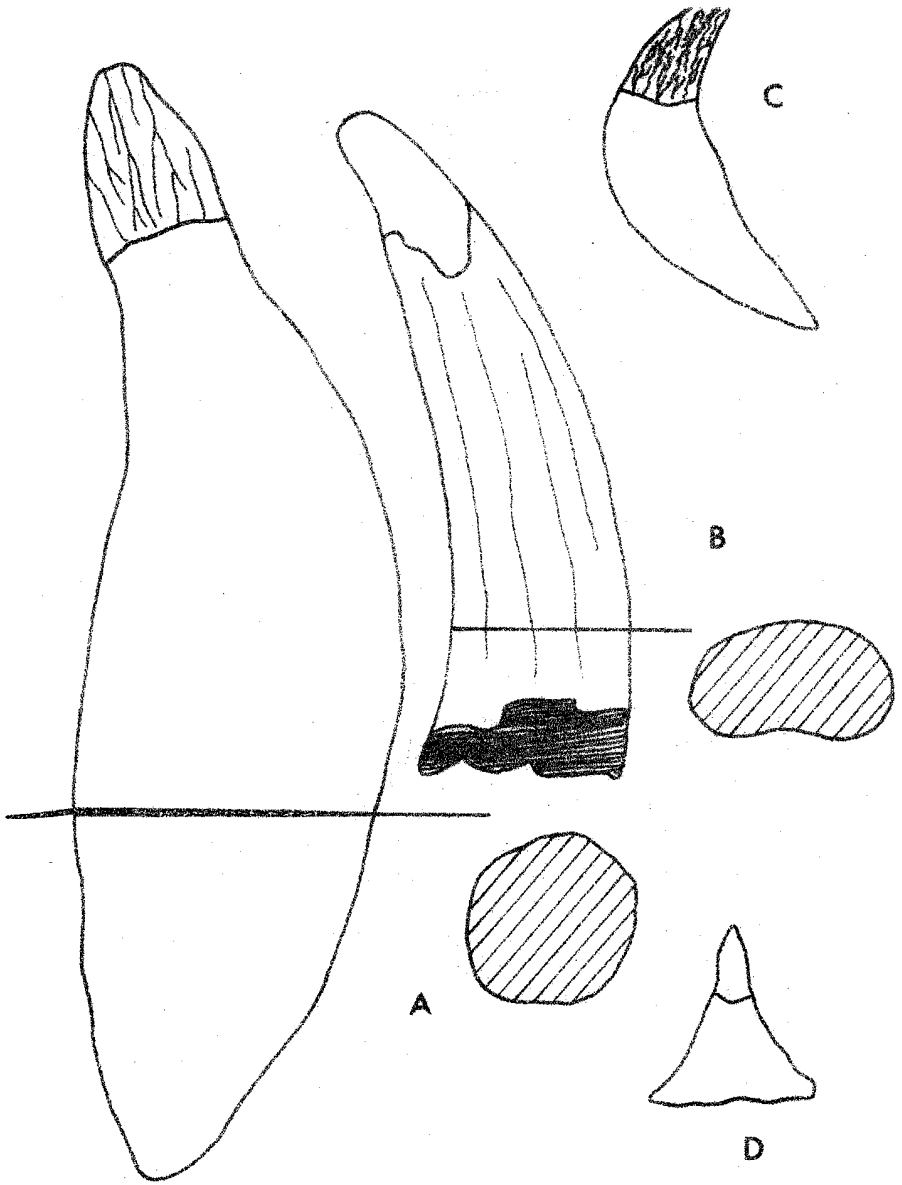

FIGURE 3. Ondontoceti. (A) tooth of *Scaldicetus*, a sperm whale; (B) tooth of *Kogiopsis*, a sperm whale; (C) tooth of *Goniodelphis*; and (D) tooth of *Megalodelphis*.

nearly complete set of lower jaws, the only known fossils of *Goniodelphis* are isolated teeth. Although the enamel crowns of its teeth are similar in size and shape to those of the smaller long-beaked dolphins, the teeth of *Goniodelphis* are readily identified by their greatly expanded roots (see Figure 3C). The expanded roots, which are compressed laterally, give the tooth an almost triangular shape.

Several varieties of sperm whale are known from the Bone Valley. *Kogiopsis* is similar in structure to the modern pygmy sperm whale, *Kogia*, although it is much larger. Isolated teeth referable to *Kogiopsis* are relatively common. They are considerably larger than the teeth of the dolphins discussed above. The teeth of *Kogiopsis* are 3 - 4 inches in length, 1 - 1 1/2 inches in diameter, slightly curved, and lack a distinct enamel crown (see Figure 4A). The outer surface of the tooth is composed of cementum rather than enamel and may bear coarse longitudinal grooves; wear facets are often present. If the cementum is broken away revealing the inner dentine core, numerous very thin, concentric layers of dentine may be seen. A second type of sperm whale, referred to as *Scaldicetus* is represented in the Bone Valley fauna by teeth only. The teeth of *Scaldicetus* are somewhat larger than those of *Kogiopsis* (5-8 inches long and 1 1/2-2 inches wide) and have a distinct enamel crown (see Figure 3B). The crown, which may show wear facets, comprises only one-fifth to one-sixth of the tooth's total length and is separated from the root by a noticeable constriction. The root widens to at least twice the width of the crown about halfway along its length and then tapers toward the end of the root. Although many genera of sperm whales have been named on the basis of teeth, studies of modern sperm whale teeth demonstrate that they are extremely variable and probably are not reliable for identifying species.

Baleen whales from the Bone Valley fauna are represented primarily by vertebrae and by their distinctive globular-shaped ear bones (auditory bullae). The nearly complete mandible, more than 6 feet in length, of a baleen whale is known from a phosphate mine near Pierce in Polk County (see Figure 4C). This fossil, *Balaenoptera floridana*, belongs to the same genus as the modern blue and finback whales. The auditory bullae of baleen whales are distinctive and, because they are composed of dense bone, are often preserved fossils. Ear bones of at least three different types baleen whales are known from the Bone Valley region. The bulla of a fossil member of the genus *Balaenopte* from the Yorktown Formation at the Lee Creek Phosphat Mine, Aurora, North Carolina, is figured for comparis with fossils of closely related species such as *Balae tera floridana* (see Figure 4B). The bullae of two di erent genera of the extinct baleen whales known as cetotheres have been reported from the Bone Valley, *Mesocetus* and *Isocetus*. It can be seen from Figure 3 that the auditory bulla of *Mesocetus* is considerably smaller and of quite different shape and structure than the bulla of *Balaenoptera*. Cetotheres, like the long-beaked dolphins, occur commonly in the Miocene of Europe and North America and then become extinct b the Pliocene. It appears likely, then, that the Florida cetothere specimens are derived from the older sediments underlying the typical Bone Valley phosphatic gravels.

Most of the large vertebrae found in the Bone Valley are from baleen whales. Generally only the centrum of the vertebra remains. The remainder of the vertebra is fragile and is seldom preserved. The centra of fossil baleen whale vertebrae are essentially cylindrical in shape and very large; from 6 - 12 inches in diameter and up to 1 foot in length.

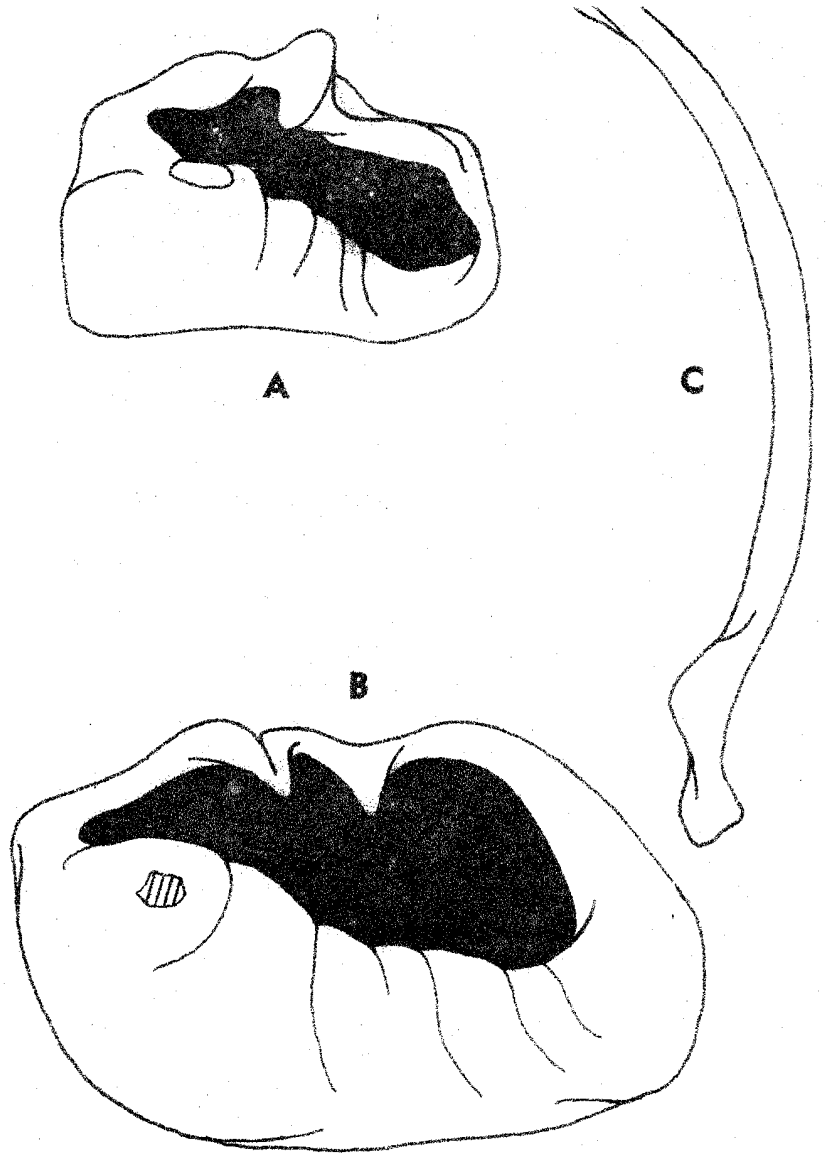

FIGURE 4. Mysticeti. (A) auditory bulla of *Mesocetus*, a cetothere; (B) auditory bulla of *Balaenoptera*; and (C) mandible of *Balaenoptera* (X 1/16).

Pleistocene and Recent (2 million years ago to the present)

By the Pleistocene, Florida's whale fauna was essentially modern. Almost any species of whale or dolphin found in Florida's waters today might be found as a fossil in Pleistocene sediments. Pleistocene whale fossils are found most commonly along Florida's coasts, particularly in beach deposits, shell marl pits, and on spoil piles around dredging operations. The Florida State Museum has the partial skull of a right whale, *Eubalaena glacialis*, from a beach deposit near Jacksonville. Dr. Clifford Jeremiah has collected numerous auditory bullae and other cranial fragments of humpback, *Megaptera novaeangliae*, and finback, *Balaenoptera physalus*, whales from dredging sites near Jacksonville. The Museum also has the complete skull and lower jaw of an unidentified baleen whale from a beach deposit near Sarasota and the complete skull of a goose-beaked whale, *Ziphis cavirostris*, from a beach deposit in West Florida. Fossils of several varieties of toothed and baleen whales are common in the shell marls of the Caloosahatchee Formation in Sarasota, Charlottee, Lee, Glades, and Hendry counties.

Whales from Pleistocene and Recent deposits and archaeological sites are important, because they may document the former occurrence of whale species in Florida that have only recently become extinct. For instance, the gray whale, *Eschrichtius robustus*, is known at the present time only from the northern Pacific Ocean. Historical records, however, indicated that this species may have occurred in the Atlantic at one time. Documentation of these historical records was first provided by the discovery in the late 1860's of an undoubted gray whale mandible from a beach deposit in New Jersey. Several more recent discoveries of gray whale remains further document the former presence of the grey whale in the Atlantic Ocean. It is very probable that the Atlantic gray whale wintered as far south as Florida, and therefore its remains should be looked for in Pleistocene and Recent beach deposits along Florida's Atlantic and Gulf coasts.

I would like to thank Clayton E. Ray and Frank C. Whitmore for many helpful comments on this paper.

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Also include recent National Geographic article.

ANNOUNCEMENT:

The third Annual Florida Paleontological Meeting will have a fossil identification session to be held at the Florida State Museum during the afternoon lab sessions.