Bruner, John Clay. 1997. El Tiburón "Megadiente" *Carcharodon megalodon* "De dientes duros y enormes". *Mundo Marino Revista Internacional de Vida Marina.* Septiembre - Octubre 1997(5):6-11.

The "Megatooth" shark, *Carcharodon megalodon* "Rough toothed, huge toothed"

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It is a warm sunny day off the coast of what will become North Carolina in another 15 million years. A mother right whale, *Mesoteras*, has just calved and nudges her young to the surface to draw in its first breath of air. Suddenly a large dorsal and caudal fin of a *Carcharodon megalodon* breaks the surface of the water and the young calf disappears within seconds in a swirl of red water. Swallowed whole by a 17 meter giant "Megatooth" shark, the *Mesoteras* calf dies in a scene reminiscent today of adult Great White sharks feeding on seals off California and Australia.

The Age of the giant "Megatooth" shark:

Carcharodon megalodon (Agassiz, 1843), the giant "Megatooth" shark, ruled all the warmwater seas during the Neogene Period (Miocene [5-24 mya] and Pliocene[1.67-5 mya]). At the beginning of its reign, *C. megalodon* was unaware of the evolution of the first hominoids on land (*Proconsul*), but would have witnessed the first monsoons and upwellings in the Arabian Sea which connected the Mediterranean Sea with the Indian Ocean.

Vertebrae and teeth and estimating size of "Megatooth":

Today, the only remains of the largest meat-eating fish to ever live, are a few vertebrae and teeth. The teeth of the giant "Megatooth" shark are prized by amateur fossil collectors and are known from Europe, Africa, Australia, India, Japan, North and South America. John Maisey, curator of vertebrate paleontology at the American Museum of Natural History (AMNH), wrote in his 1996 book Discovering Fossil Fishes, (p. 91) "Many other sharks, including some from the Devonian, replaced and discarded their teeth with greater abandon. Shark tooth production must rank as one of the most efficient organic methods of removing phosphate from the biological environment and burying it in sediment. There probably is more phosphate in a single 15-centimeter Miocene fossil white shark tooth than was used during the whole life of a meter-long Devonian shark. Fossil teeth provide dramatic testimony of increasing phosphate consumption during the evolution of sharks." In 1982, Maisey was hired by the Smithsonian Institution to reconstruct a more accurate representation of the "Megatooth". Previous reconstructions had been made of "Megatooth's" jaws but now Maisey was aided by Pete Harmatuk's (an amateur fossil collector) find of a partial set of *C.*

megalodon teeth from a North Carolina phosphate quarry. Prior to this, only individual vertebrae similar to the modern ones seen in Fig. 1 and separate teeth (see Figs. 2-4) were known to science. The closest living analogue, and closest living relative to the giant "Megatooth" shark is the Great White shark *Carcharodon carcharias* (Linnaeus, 1758). The Great White shark has been used as a model to reconstruct the giant "Megatooth." Maisey used the partial set of "Megatooth" teeth to make a more accurate comparison with jaws of the living Great White shark. In 1985, the new reconstruction went on public display. Unhappily for science fiction writers, the "new" "Megatooth" jaws were two-thirds the size of the jaws reconstructed by Bashford Dean before WWI at New York's AMNH. In Dean's day, scientists still believed that the living Great White shark reached up to 35 to 40 feet in length. So it was not unbelievable to estimate "Megatooth" reaching 100 to 120 feet in length when it had teeth three times the size of a Great White shark.

Just as humans have different types of teeth in their jaws (incisors, canines, premolars, molars). "Megatooth" also had different functional teeth in different areas of its upper and lower jaws (see Fig. 3). Applegate and Espinosa-Arrubarrena (1996) aided by the new discovery of a second known associated set of teeth for "Megatooth", described by Uyeno *et al*. (1989), have published an artificial dental forunula for "Megatooth".

A I-II - Int 1 - L 7 - P 4
a i-iii - l 8 - p4

The upper jaw, starting near the symphysial joint where both the right and left sides of the jaw meet at the midline, has two anteriors (A I & II), followed by one intermediate (Int 1), seven laterals (L 7), and four posteriors (P 4). The lower jaw differs in having three anteriors (a i-iii), no intermediate, eight laterals (l 8), and four posteriors (p 4). The first two anteriors (A I & II) and the second lateral (L 2) of the upper jaw were the largest teeth in the mouth of a "Megatooth". Mike Gottfried *et al*. (1996, p. 60) published a formula that can be used to calculate the size of the "Megatooth" specimen on the basis of the A II tooth height and another graph that can be used to predict the weight of the shark. The "Megatooth's" total length in meters = ((0.96) X (total height of tooth in mm)) minus (0.22). Using this formula, the largest "Megatooth" specimen (Fig. 4) in the University of Alberta Paleontology Collections was calculated as coming from a shark 14.7 m (48.4 feet) long and weighing 35,000 kg (77,092 lbs).

"Megatooth" fossils and "Tongue stones"

Nicholas Steno, a mid-17th century physician to the Duke of Florence, published a little book in 1667, The head of a shark dissected. In this book he argued the similarities between the teeth of a modern day shark and the "Tongue stones" dug out for centuries from the soft rocks in the cliffs of the island of Malta. He argued these were the teeth of long dead sharks and published what John Maisey credits as the first published illustration (a *C. megalodon* tooth) of a fossil, and making Steno the world's first paleontologist.

"Megatooth", a taxonomic controversey

Welton and Farish (1993, p. 18) wrote there are at least 65 nominal species for the Miocene "Megatooth" shark because of the failure of earlier paleontologists to understand how much variation exists in tooth shape. Different tooth rowgroup positions, variations, ontogenetic stages and even pathologies were ascribed to new species and even new genera in some cases. Also, fossil and modern sharks can have worldwide distributions but some early shark paleontologists would describe new species based only on geographic separation despite a lack of morphological separation. There is currently disagreement among paleontologists as to which family "Megatooth" belongs. Applegate (1991, personal communication) and Applegate and Espinosa-Arrubarrena (1996) want to place *Carcharodon* in its own family Carcharodontidae. Martin (1996), based on an analysis of the mitochrondial DNA sequences of the Great White Shark and other sharks, places *Carcharodon* in the Family Lamnidae (the more traditional view) along with the genera Isurus and Lamna. There is a raging controversey in the shark circle of scientists as to what genus "Megatooth" belongs [*Carcharodon* versus *Carcharocles*]. Back in the frontier days of the "Dinosaur Wars" between Cope and Marsh in the American West, collectors from the different camps would take potshots at each other with their rifles. Today's scientists battle it out on the internet. For example, see the website of Jim Bourdon, an elasmobranch enthusiast, who is providing a history of the debate at [http://www.lifeweb.com/user/raja2/ss/cvc_intr.html]. In a sense, the internet battles can be just as life-threatening. A too-impassioned response to an electronic bulletin board may influence one of the few judges for the dwindling supply of research money to cut your funds and end your career as a research scientist.

E. Casier (1960) questioned the monophyly of *Carcharodon* and split it into three genera, using the generic name *Carcharocles* for "Megatooth". Henri Cappetta (1987) followed Casier and wrote, *Carcharocles* is thought to be derived from *Otodus serratus*, an early Eocene species, that already shows the beginning of the serration of the cutting edges. *Carcharocles* during its evolution gradually lost its lateral denticles. Gery Case supports the use of "*Carcharocles* ". Case *et al.* wrote (1996, p. 107) "The first occurrence of *Carcharocles sokolowi* appears in the Eocene and it was the earliest representative of the Great White shark. The fossil teeth of the Great White shark have had several names over the past 150 years, starting with the name *Carcharodon*. The name *Carcharodon* is now relegated to the modern White Shark. After *Carcharodon* these fossil teeth were called *Procarcharodon* by Casier. The name *Carcharocles* takes precedence over the name *Procarcharodon* by 37 years."

The following authors support the *Carcharodon* camp: Applegate and Espinosa-Arrubarrena (1996), Gottfried, Compagno, and Bowman (1996), Hubbell (1996), and Purdy (1996). Figure 2 is an abbreviated version of what Applegate and Espinosa-Arrubarrena (1996) envison is the evolution of "Megatooth". The Late Cretaceous shark *Cretolamna appendiculata*, through maybe five or six intermediate species, eventually gave rise to the Early Miocene *Carcharodon subauriculatus*, that may have given rise to "Megatooth". And, there is even disagreement how many species are present in the genus *Carcharodon*. Applegate and Espinosa-Arrubarrena (1996), list nine described and undescribed species, while Purdy (1996) lists eleven.

What did "Megatooth"eat?

Although the Great White does not feed exclusively on seals it has been shown they are an important prey item. When the population of seals increases, so does the numbers of Great Whites (Purdy, 1996). Although it first appeared in the Eocene, it was during the Miocene the mammalian order Cetacea (whales) reached its highest diversity and abundance. Almost every known family of toothed and baleen whale are known from the end of the Miocene. Large whale vertebrae and flipper bones have been found with large bite marks made by serrated teeth that match the teeth of *C. megalodon* (Purdy, 1996). Also, identified "high-use" areas by marine vertebrates during the Miocene and Pliocene often have associated fossils of *C. megalodon* and whales (Purdy, 1996). From such evidence, paleontologists have surmised a predator-prey relationship of *C. megalodon* on large whales.

Death of the "Megatooth"?:

By the end of its reign, *C. megalodon* would have witnessed the Mediterranean becoming a tributary of the Atlantic, the closing of the isthmus of Panama, a new genus of hominids on the African savannah called Homo, the onset of Arctic glaciation and the returning of the Earth to a predominantly glacial mode. The decrease in the oceans' temperature during the mid-Pliocene may have spelled the doom of *C. megalodon*. Casey and Pratt's (1985) report that juvenile Great White sharks have a lower tolerance to cooler waters and an intolerance to higher temperatures that may limit them to nursery areas in the North Atlantic. Fossils of *C. megalodon* are found only in regions that were predominantly warmwater environments. Perhaps the reduction in ocean temperatures in the mid-Pliocene, reduced the number of possible nursery sites on the continental shelf for *C. megalodon*. Another possibility is that their prey, the great whales, escaped to colder waters where "Megatooths" could not follow. Recent discoveries of fossil baleen whales from the Late Pliocene in Antarctica, demonstrate that great whales began living in these areas at that time.

Reports of giant Great White sharks up to 10 m long (Long, 1995, p. 80) in recent times and perhaps the influence of Hollywood (Jaws III) have led some scientists to suggest that "Megatooth" still lives in the oceans somewhere. Gilbert Whitley, the late curator of fishes at the Natural History Museum in Sydney, Australia, wrote (1940, p. 125), "Large teeth belonging to species of White Pointer have been dredged at great depths in the oceans and indicate that enormous sharks are either still living or only became extinct fairly recently. A man could stand upright with ease in the jaws of such a monster which has been calculated to have measured 80 feet in length." However, no well documented "Megatooth" fossils have been found younger than 3 mya, but remember paleontologists once believed that all coelacanths went extinct at the end of the Cretaceous, 65 mya, and it is still alive today!

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Captions for Figures

Fig. 1. Two recent shark vertebrae. Centrum on left has been cut in half. Red arrows are the openings for the dorsal arch base (dab) and the blue arrows are the openings for the ventral arch base (vab).

Fig. 2. "Megatooth" and two of its possible early ancestors. Blue arrows point to lateral denticles. Black & white bars = 1 cm.

Cretolamna appendiculata Cretaceous to Early Eocene =>
Carcharodon subauriculatus Early Miocene =>
Carcharodon megalodon Middle Miocene to Late Pliocene

Fig. 3. Nine "Megatooth" specimens from Florida, Pork County, Mulberry UALVP 454. The 2 largest broken teeth on the bottom right are probably first or second anteriors from the upper jaw. The small complete tooth on the bottom left is possibly a seventh lateral.

Fig. 4. The largest "Megatooth" specimen in the University of Alberta's Vertebrate Paleontology collections (UALVP 15258) was collected from Venice, Florida in 1980 by the late Dennis C. Wighton. The tooth has a total height of 15.6 cm and the shark it came from had a calculated total length of 14.756 m (48.41 ft).

ERRATA

p. 6 Figure caption of life size tooth should be "*C. megalodon*"
p. 7 Figure caption of reconstructed jaw should be "*C. megalodon*"
p. 9 Fig. 1. Abbreviations for dorsal arch base (dab) and ventral arch base (vab) were changed by artist to "dad" & "vad", respectively.
Fig. 2. Color of arrows pointing to lateral denticles are BLUE not RED and *Carcharodon subauriculates* is spelled wrong
p. 11 Maisey, John G. 1996 was dropped from literature cited.
Uyeno *et al*. change to 1989 from "(1989".
Whitley, 1940 capitalize Australia both times