Cryptozoology Meets Ecology: A Look into the Megalodon

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Meeting the Megalodon

When thinking of fearsome apex predators of the ocean, most people might think of the great white shark (*Carcharodon carcharias*). It is widely perceived by humans as an aggressive hunter which occasionally targets humans when they find themselves in its habitat. Although these attacks are often a case of mistaken identity (International Shark Attack Files, 2021), the reputation remains. However, the great white was not always at the very top of the food chain. During the Miocene epoch of the Cenozoic era, over 20 million years ago, the last of a line of megatooth sharks was gaining traction in the ancient open oceans. The megalodon (*Otodus megalodon*) was likely the largest shark to ever exist, and certainly the largest predatory shark. From the Discovery Channel documentaries to the outlandish movies and viral videos that star the creature, humans seem fascinated with it.

To give a sense of scale, the great white shark is the largest predatory shark living today. As a note, the whale shark (*Rhincodon typus*) is technically the largest of all modern sharks, but it is a filter-feeder that subsists on plankton, not other fish. Megalodon teeth can reach up to almost 18 centimeters, or about 7 inches, while the great white shark has record-breaking teeth at about 6 centimeters, just under 3 inches (Rafferty, 2022; Georgiou, 2022). It is clear to see the size difference between the two just from those measurements, and resulting body length estimates reflect this. Megalodons are estimated to be at a maximum of 18 meters (about 60 feet) while a great white shark's maximum size is around 6 meters (20 feet).

The majority of scientific researchers agree that the megalodon went extinct around 3 million years ago near the end of the Pliocene epoch, but others outside the field seem to think otherwise. Skeptics propose that the megalodon has survived in hiding in the intervening epochs, and their theories garner attention from the larger uninformed public. However, overwhelming evidence points to the extinction of the megalodon, and ecological mechanisms can further illustrate how it could not survive in modern oceans. Although misinformation makes the persistence of the megalodon seem more

believable, the fossil records pointing to its extinction and an analysis of the megalodon's needs to modern ocean ecology clearly illustrate how unlikely that possibility is.

Why Not?

Animals being declared extinct and later reappearing is not an unheard-of phenomenon. In cases where this happens, the species is sometimes referred to as a Lazarus taxon, defined as a record of a species with gaps between specimens and no physical changes between instances (Carlton, 2019). This is most often observed in fossils where paleontologists will find a species in two different time frames and no instances in between. Another definition, however, includes species found in the fossil record and are then discovered alive in the modern era. A good example of this is the Coelacanth (*Latimeria chalumnae*). Coelacanth fossils were already known of and involved in theories about the evolution of animals from aquatic or semi-aquatic to terrestrial living when a museum curator took note of the contents of a recent fishing trawl and found a recently deceased coelacanth within the haul (Thomson, 1992). There are similar accounts of other animals, from fish to birds to even one case of a whale (Fordyce, 2013), which have been identified first in fossils and then in the wild, so what, some may ask, differentiates these cases from that of the megalodon?

This phenomenon is pointed out by the Discovery Channel documentary, *Megalodon: The Monster Shark Lives*, part of their annual Shark Week special, which aims to spread the word of megalodon sightings and a potential attack off the coast of South Africa. The documentary follows a marine biologist named Collin Drake investigating supposed sightings of a megalodon. The initial hook for the documentary features footage of a small recreational vessel being capsized by something off-screen which Collin Drake asserts can only be a megalodon based on its size and supposed temperament. Throughout the episode, Collin Drake's team use a variety of methods to attempt to find the megalodon. Two expert paleontologists, Dr. Stephen Godfrey and Dr. Bretton Kent are also featured in the documentary to give more detail on the megalodon and the beliefs of its physiology, behavior,

and habitat in prehistoric times. The finale shows the attempt of Collin Drake and his team to lure the megalodon out of hiding and attach a tracker to it. There are a few moments of chaos as the shark supposedly shows up and attacks their ship, and as they finally observe the signal of the tracker, it shows something quickly diving deep into the ocean (McLaughlin, 2013).

Assessing the Disinformation

The documentary would make for convincing evidence if it was not intensely clear that the majority of it was fabricated. To start, the self-reported marine biologist Collin Drake heading the search is not a real person. He is a fictional character played by actor Darron Meyer as seen in the credits and on the episode's IMDb page (IMDb, 2014). Simply finding information on Drake, the witnesses interviewed, or even records of the attack itself was incredibly difficult, which casts further doubt on the credibility of the whole affair. In addition, the scientists that they do interview for the production have published peer-reviewed research on the subject, but their work clearly corroborates with current assumptions of the megalodon's extinction. Dr. Stephen Godfrey, a published researcher and curator of paleontology, has several research papers documenting fossils from other marine life found with megalodon teeth embedded in them, and each paper introduces the shark (and others within the same family) as "extinct megatooth sharks" (2018; 2021). Dr. Bretton Kent, another paleobiologist who is a professor at the University of Maryland, has a paper that goes into detail about the evolution and classification of various cartilaginous fish, and when discussing the megalodon, his writing clearly differentiates it from its extant (i.e. still living) relatives like the great white (2018).

Furthermore, the documentary has a sequel that fails to add any valuable contribution to the original claim. *Megalodon: The New Evidence* takes the form of a pseudo-documentary where Collin Drake argues for the megalodon's continued existence against guests and invites more scientists to support his stance (2014). Unlike the first entry, it is nearly impossible to find any trace of the researchers featured in this entry, both in terms of research articles and a general search online,

implying they might also be actors. Those who argue against his point too are yet to be found, most notably a man named Gavin Curring who is introduced as a government official from South Africa. Curring, like the others, cannot be found with a general search along with being entirely absent from the official website of the South African government.

Both documentaries present the question of the megalodon's survival in a manner that reflects the hunt for a mysterious cryptid rather than a search for an actual creature. From emotional language in calling the megalodon a "natural-born killer" to claiming that there is only one creature that has survived the past 3 million years instead of a stable breeding population, the framing of the series is more leaned toward spectacle than information. This is highlighted by the second episode where Drake states that the South African government put a stop to his investigation and encourages the audience to question their authority. Planting seeds of doubt into credible sources in what essentially amounts to a mockumentary works against the objectives of actual researchers who put a great amount of effort into studying, experimenting, and explaining their ideas to others in their field and the broader public.

Introducing the Scientific Approach

In the realm of paleobiology, a combination of the two neighboring sciences, an incredible amount of work is done to examine the remains of an extinct creature and hypothesize what it may have looked like and how it may have behaved in its environment. For instance, based on the shape of teeth, scientists can hypothesize if an animal was an herbivore or a carnivore since herbivores typically have blunt square-shaped teeth for grinding plants while carnivores have sharp triangular teeth for attacking and tearing flesh. Similarly, the size and body shape of an animal can determine how it might have navigated its environment by the different adaptations it developed over time, like a decrease in size contributing to better mobility in dense forests. In some cases when there are many instances of fossilization within one species, scientists can follow changes in the structure over time and infer what physical changes may have occurred based on how certain bones may have changed and what muscles

they may have attached to. From these inferences, scientists can get a clearer picture of an organism's niche (i.e. what role it plays in its ecosystem) and what its environment may have looked like for it to take the form and structure that we see.

There are many road bumps involved in studying shark history specifically. Most notably, sharks have cartilaginous skeletons, made of flexible cartilage and not bone, which does not fossilize as easily. It is already very rare for a creature to be preserved in a way that leads to a fossil that researchers can recover and study today, so having an unorthodox skeleton like a shark's leads into more unknowns. Its existence is largely known by fossils of its teeth which, as mentioned before, are remarkably large. Through examining the teeth and inferring their position in a megalodon's mouth, researchers can use modern analogs, like great white sharks, to infer their total body size (Perez et al., 2021). This process does introduce some potential errors since there's no certainty on how closely modern sharks resemble the megalodon. There are some hypotheses that the family of lamnid sharks (which includes the great white) are the closest living relatives based on adaptions like partial endothermy (Greenfield, 2022), but the family is also used in comparison since they occupy similar ecological roles as apex pelagic predators, meaning they likely have similar adaptations (Cooper et al., 2020).

Examining the Evidence

One of the most prominent claims in the Discovery Channel's documentaries seeks to explain why there are no confirmed sightings of a megalodon. According to the narration of the episode, megalodon sharks moved deeper into the ocean where humans could not explore for millions of years and have only recently come out of hiding because of human effects on the global climate (McLaughlin, 2013). Claiming that megalodons might be lurking deeper in the ocean is a common explanation given by those who believe it still lives, and it is possible that this documentary gave some credence to that idea. At the surface, the assertion does not seem too outlandish. The ocean is incredibly large, and it is true that researchers have only thoroughly studied fractions of it. It is also true that previously unheard-

of creatures are occasionally discovered in those hard-to-reach depths. The problem with this assertion lies in the plethora of data regarding its extinction along with considering the ecological needs of a predator as big as the megalodon.

Extinction Predictions

When establishing a species as extinct, researchers use a variety of methods to determine the age of fossils, like radiometric dating. They then take the youngest (as in most recently deceased) fossils and use mathematical modeling to determine the most likely date of their extinction (J. Cooper, personal communication, February 24, 2023). A study by Dr. Robert Boessenecker, a vertebrate paleontologist with a focus on the Cenozoic cetaceans the megalodon might have preyed on, looked into some samples of megalodon tooth fossils and reassessed the dates of some since they were reported to be from later than the estimated extinction time of 3.6 million years ago (2019). Upon reinspection, it was found that many of the samples were mis-dated, and when a mathematical model is made with these re-dated samples, the estimated extinction date was around 3.5 million years.

Although many sources agree on the date of the megalodon's extinction, there is no certainty as to why the species went extinct. Jack Cooper, a PhD student working for the Pimiento Research Group, suggests that rapid changes and eventual decrease of sea levels happening around the same time led to an upheaval to many important aspects of the species' survival (personal communication, February 24, 2023). It is possible that changes in ocean upwelling (i.e. cooler, nutrient rich water rising from deeper in the ocean) could have impacted the entire ecosystem, including the baleen whales that depend on microorganisms for food. Additionally, lowering sea levels could have impacted megalodon nurseries. Modern sharks use areas of shallow waters as places to lay their eggs or occasionally give live birth depending on the species. A study by Professor Jose Luis Herraiz et al. examined five different coastal areas with a large concentration of smaller megalodon teeth, likely representing juveniles of the species (2021). These areas were likely megalodon nurseries that provided a safe haven for the young sharks as

they matured. Lowering sea levels likely impacted the viability of these nurseries and made it more difficult for young sharks to grow to maturity. At the same time, great white sharks cohabitated with megalodons for a period of time. As the larger sharks had difficulty maintaining the fragile niche they create with their size, it is possible that smaller great whites were able to sustain themselves on a variety of smaller fish and marine mammals like dolphins (R. Boessenecker, personal communication, March 3, 2023). The most likely conclusion, as with most extinctions, is that many factors happening in a short period of time left the megalodon unable to adapt quickly enough and caused the species to die out.

Ocean Ecology Compatibility

A vital consideration when assessing a creature's ability to survive in a certain habitat is their ability to find food. For a creature as large as the megalodon, they would need to have access to a vast amount of calories in order to function. A study by Jack Cooper et al. (2022) attempted to use 3D models of the shark based on recent size estimates to approximate how many calories it would need to consume regularly. The team concluded that the shark would need over 90,000 kilocalories per day, which is 20 times the daily calorie intake of a great white. By comparing the caloric content of various possible prey of the megalodon (e.g. fish, marine mammals, and other sharks) and placing the options in a mathematical model, they concluded that it was most likely that megalodons would have consumed a baleen whale every few months rather than eating an array of smaller fish every day. This corroborates with other studies that hypothesize the megalodon reached its considerable size because it began preying on these larger mammals that were otherwise unthreatened, creating its own niche to take advantage of (Pimiento, 2015).

Most sharks, and most likely the megalodon during its time, live in the epipelagic zone of the ocean where enough light shines through to enable photosynthesis (Smithsonian Ocean, 2018). Because of the high availability of algae, many different types of creatures can sustain themselves, especially

apex predators like sharks, dolphins, and whales who rely on a stable food web underneath them. For a megalodon relying on something that would be considered the apex of modern oceans for food, they would need to undergo a relatively quick adaptation in behavior and physique to be at home in deeper ocean zones, especially at the abyssal level that some claim it resides in. This also ignores other changes a megalodon would need to adapt to deeper ocean environments, like resistance to the high pressure or being able to see in darker waters. All of these changes would take an extremely long time to develop and would be especially difficult for a creature already struggling from habitat loss and food insecurity as described by the estimates of its extinction.

When asked, Cooper also described a few different threats that the megalodon might face if it were still hunting today (personal communication, February 24, 2023). For one, orcas are known to harass and occasionally attack great white sharks since they often compete for the same prey (Towner, 2022). Although a single orca (*Orcinus orca*) might serve as a quick meal for a megalodon, a large pod of orcas might serve as a regular nuisance. Another consideration for potential threats to the megalodon is human activity. While the documentary claims that climate change related to human activity is the cause for a megalodon in hiding to make itself known, in reality, human activity is the cause of strife for many sharks. As mentioned before, ecosystems are deeply interconnected, and small changes in any level of a food web causes unrest in the rest of the community. It is undeniable that many aspects of human behavior have placed stress on ocean ecosystems, from ocean acidification impacting the coral that many fish use for shelter to overfishing reducing populations and accidentally catching larger predators like sharks and dolphins. While the different species it would encounter could make life difficult for a modern megalodon, it is undeniable that humans and the consequences of their actions would have the greatest and most devastating impact on the species.

Appreciating the Research

With proper explanation, understanding the reality of the megalodon is remarkably easy. The mechanisms behind paleontology, evolution, and ecology can be simplified and made accessible to others. In cases like that of the Discovery Channel's documentaries, convincing the audience relies on a lack of important contextual information and a lack of curiosity to question the information given. However, the goals of researchers and the broader scientific community are diametrically opposed to this. Science relies on making hypotheses, testing them, sharing findings, and encouraging others to add their input.

The harm of false information cannot be understated. Along with occasionally allowing harmful ideas to spread, it inhibits proper informed communication. When asked if rumors about the megalodon impacted his research, Dr. Robert Boessenecker stated that while his research is unaffected, communication between non-scientists, like fossil hobbyists and the press, can become more complicated (personal communication, March 3, 2023). To have productive, informative, and impactful conversations, the broader public needs to have access to articles like the ones featured in this paper along with an understanding of or willingness to learn the theories at play.

This paper, along with being an engaging passion project, represents an effort to implement this practice and provide both primary sources and the surrounding information to interpret them while tackling a relatively harmless issue. For researchers like Jack Cooper and the rest of the Pimiento Research Team, who relate their studies with the megalodon to work with conservation efforts for modern sharks, being able to effectively describe their findings and conclusions to others is essential to taking action. In larger concerns in ecology, like those involving conservation and endangered species, it is vital for everyone involved, researchers and laymen alike, to understand the importance of scientific research, discuss it, and contribute.

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