# Learning from the heaviest ancient whale

**Peijun Zhang[1,*] and Simon J. Goodman[2,*]**

[1]Marine Mammal and Marine Bioacoustics Laboratory, Institute of Deep-sea Science and Engineering, Chinese Academy of Sciences, 28 Luhuitou Road, Sanya 572000, China

[2]School of Biology, Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT, UK

*Correspondence: pjzhang@idsse.ac.cn (P.Z.); s.j.goodman@leeds.ac.uk (S.J.G.)

Received: August 4, 2023; Accepted: August 13, 2023; Published Online: August 17, 2023; https://doi.org/10.1016/j.xinn.2023.100501



Citation: Zhang P. and Goodman S.J. (2023). Learning from the heaviest ancient whale. The Innovation **4(5)**, 100501.

## A NEW RECORD FOR THE LARGEST KNOWN ANCIENT WHALE FOSSIL

A groundbreaking study published in *Nature* by Bianucci et al. has reported the discovery of a new basilosaurid species, *Perucetus colossus* (Figure 1). The incomplete fossil skeleton found in Peru is around 39 million years old. This ancient whale challenges the long-held belief that the blue whale represents the largest known animal to have ever lived on Earth. *P. colossus* is estimated to have had a body mass between 85 and 340 tons, with an average of 180 tons.[1] In comparison, extant blue whales have an estimated body mass of 100–150 tons. The new study proposes that *P. colossus* was adapted to a fully aquatic lifestyle in shallow water with slow swimming speeds, similar to extant manatees. Elevated bone mass would have aided buoyancy control while diving to shallow depths, as seen in modern-day sirenians. This new discovery not only challenges our understanding of mammalian maximum body mass evolution, but it also expands our knowledge of the lifestyle of ancient cetaceans.

## HOW CETACEANS EVOLVED

Cetaceans are a group of species that originated from terrestrial artiodactyls around 55.5 million years ago and adapted to a fully aquatic lifestyle.[4] The earliest whales, known as archaeocetes, form a paraphyletic stem group of all cetaceans and can be traced back to early and middle Eocene (52–42 Ma) deposits in Africa, North America, Pakistan, and India. Archaeocetes were divided into about five families: Pakicetidae, Ambulocetidae, Remingtonocetidae, Protocetidae, and Basilosauridae, which emerged progressively over the course of around 10 million years. In 2008, Uhen identified numerous synapomorphies and diagnosed a new clade called Pelagiceti, comprising Basilosauridae and Neoceti (odontocetes and mysticetes).[3]

Basilosauridae, the largest of the archaeocetes, were apex predators, preying on smaller archaeocetes and large fish in the ocean. They had a body length of over 15 m. Basilosaurids eventually gave rise to all modern toothed and baleen whales (odontocetes and mysticetes) during or near the Eocene-Oligocene transition. Over time, archaeocetes evolved from semi-aquatic to fully aquatic animals, developing distinct and directionally asymmetrical skulls.

Cranial asymmetry evolved in basilosaurids as part of a complex of traits associated with directional hearing, enabling them to discern higher sonic frequencies emitted by their prey, such as sound-producing fish.[5] Ultrasonic echolocation emerged in Neoceti odontocetes, allowing them to detect silent prey. Asymmetry and much of the sonic-frequency range of directional hearing were eventually lost in Neoceti mysticetes as they shifted to low-frequency hearing and bulk filter feeding. Throughout these evolutionary changes, cetaceans have developed an array of adaptations and modifications to their skull structure, contributing to the diversity and specialization seen in modern cetaceans.

## EVOLVING BIGGER BODIES

Pakicetids, with body lengths of about 1.4 m, were some of the earliest archaeocete cetaceans in the evolutionary lineage of whales. Eventually, they evolved into basilosaurids, a group of ancient whales that grew much larger, with some species like the *Perucetus* reaching around 20 m in body length.

Traditionally, the blue whale has been viewed as the heaviest animal to ever exist, with lengths of up to 33 m and weights of up to 200 tons. However, the find by Bianucci et al. involving the 20-m-long basilosaurid whale *P. colossus* has challenged this position. *P. colossus* has a significantly greater bone mass

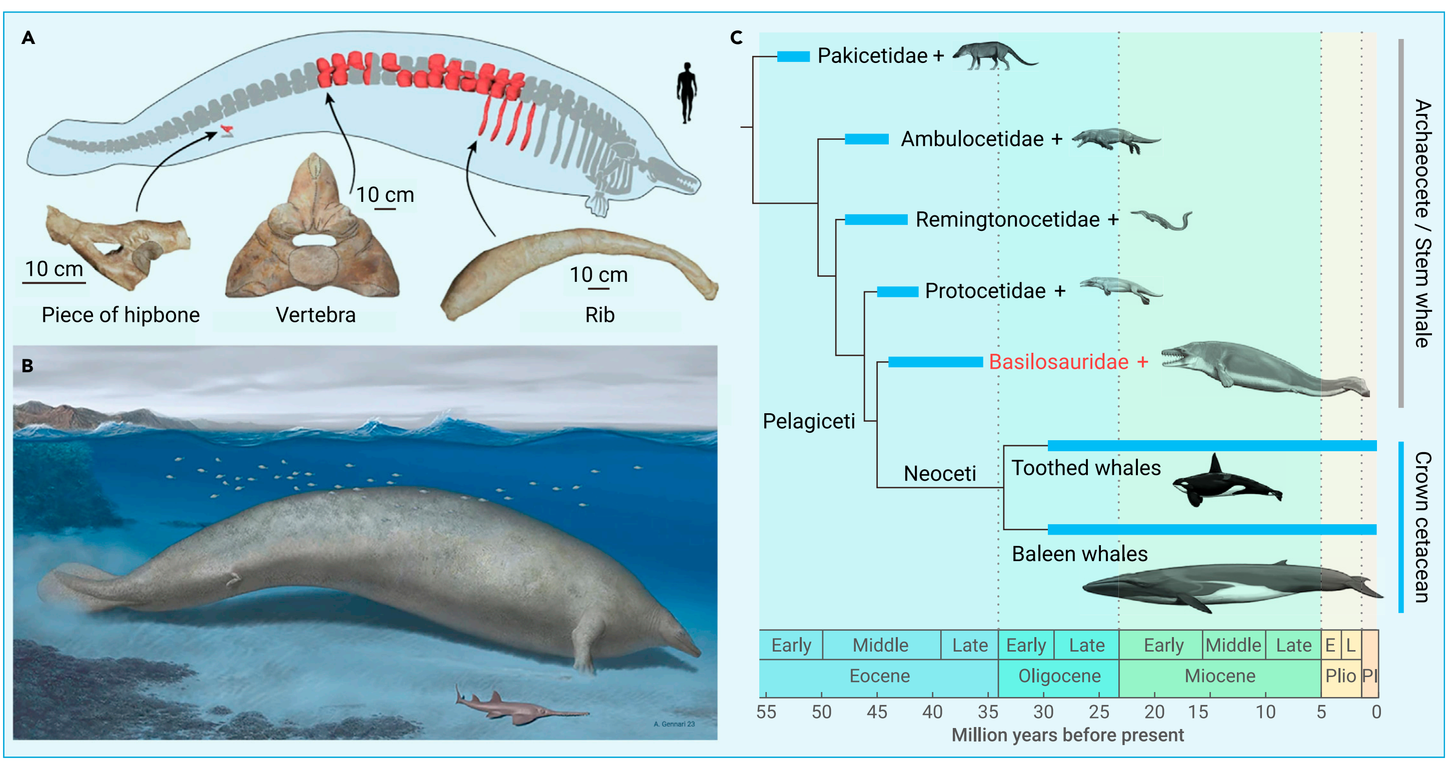


**Figure 1. A representation of the recovered fossils (A, source: ref. [1,2]) and morphological reconstruction of *Perucetus colossus* (B, credit: Alberto Gennari) and the inferred position of Basilosaurids (red text) in the cetacean phylogeny (C, source: ref. [3])** (A) and (B) are reproduced with permission from SNCSC with a license number of 5613700521258.

increase than any other known basilosaurid and sirenian, providing it with static buoyancy control. Its skeletal structure is estimated to weigh 2.0–2.9 times more than that of a 25-m-length blue whale.

With these calculations in mind, *P. colossus* might have weighed between 85 and 340 tons, with an average weight of around 180 tons. This would indeed mean that it might have been heavier than the modern blue whale, potentially claiming the title of the heaviest animal ever to have existed.

However, it is important to note that determining the precise weight of an extinct species is a difficult task, particularly when the available fossils are incomplete. In the case of *P. colossus*, only a small portion of the bones were found. This means that scientists can't be completely certain about the exact weight of *P. colossus*. So while it might be possible that *P. colossus* was the heaviest animal to ever live, this conclusion is still not fully established.[2]

## LIFESTYLE

The extreme pachyosteosclerosis (thickening of bones) of *P. colossus* suggests a shallow-water lifestyle similar to that of extant sirenians, as well as sharing their slow swimming speeds and benthic feeding habits. However, confirming the lifestyle, diet, and overall ecology of *P. colossus* remains challenging due to the incomplete fossil record with unknown skull and teeth structures.

Comparing *P. colossus* to extant species with similar ecological or bone characteristics like gray whales or manatees may provide some insights, but it is essential to remember that *P. colossus* might have had unique adaptations and behaviors that are yet to be discovered. Basilosaurids, like *Basilosaurus*, were apex predators, so it would not be completely implausible for *P. colossus* to have had a predatory lifestyle as well.

The scavenging hypothesis for *P. colossus* does make sense, as feeding on carcasses of sunken vertebrates would provide a low-cost, high-energy food source. This behavior can be observed in some large-bodied demersal sharks and is somewhat aligned with the feeding habits of modern gray whales. However, this hypothesis remains speculative and requires further evidence.

In conclusion, while there are several possibilities about the diet and feeding strategy of *P. colossus*, our understanding is limited by the available fossil evidence. Additional research and better-preserved fossils will be crucial in shedding more light on the ecology and behavior of this ancient cetacean.

## WHAT CAN WE LEARN FROM THE FOSSIL

The flourishing of basilosaurids and their enlarged body size indicates adaptation to fully aquatic life during a warm greenhouse stage (late Eocene) with high seafloor productivity. The hyperspecialization of basilosaurids, such as *P. colossus*, to coastal habitats during the end of the Eocene could have left them vulnerable to major declines in the productivity of these environments, eventually leading to their extinction.

This possible ecological shift could have paved the way for the ancestors of modern cetaceans, which began exploiting more offshore habitats, to eventually diversifying into the array of species we know today. The shift to offshore habitats opened up novel ecologic niches and food resources, allowing new species to evolve specialized feeding strategies, social behaviors, and morphological adaptations that enabled them to thrive in these diverse environments.

In particular, the shift to more pelagic habitats allowed mysticetes (baleen whales) and odontocetes (toothed whales) to adapt to different niches, maximizing their ability to find food and avoid competition. Baleen whales typically feed on large concentrations of zooplankton, while toothed whales are known to eat a wide variety of prey, including fish and marine mammals. Together, these different strategies enabled whales and dolphins to become the dominant marine mammals they are today.

## REFERENCES


1. Bianucci, G., Lambert, O., Urbina, M., et al. (2023). A heavyweight early whale pushes the boundaries of vertebrate morphology. Nature ***620***, 824–829.
2. Marris, E. (2023). Could this ancient whale be the heaviest animal ever? Nature.
3. Berta, A., Sumich, J., and Kovacs, K. (2015). Marine Mammals: Evolutionary Biology (Academic Press).
4. Yuan, Y., Zhang, Y., Zhang, P., et al. (2021). Comparative genomics provides insights into the aquatic adaptations of mammals. Proc. Natl. Acad. Sci. USA ***118***, e2106080118.
5. Fahlke, J.M., Gingerich, P.D., Welsh, R.C., and Wood, A.R. (2011). Cranial asymmetry in Eocene archaeocete whales and the evolution of directional hearing in water. Proc. Natl. Acad. Sci. USA ***108***, 14545–14548.


## ACKNOWLEDGMENTS

This work is supported by Youth Innovation Promotion Association CAS (2020363) and Hainan Provincial Natural Science Foundation of China (422RC744).

## DECLARATION OF INTERESTS

The authors declare no competing interests.