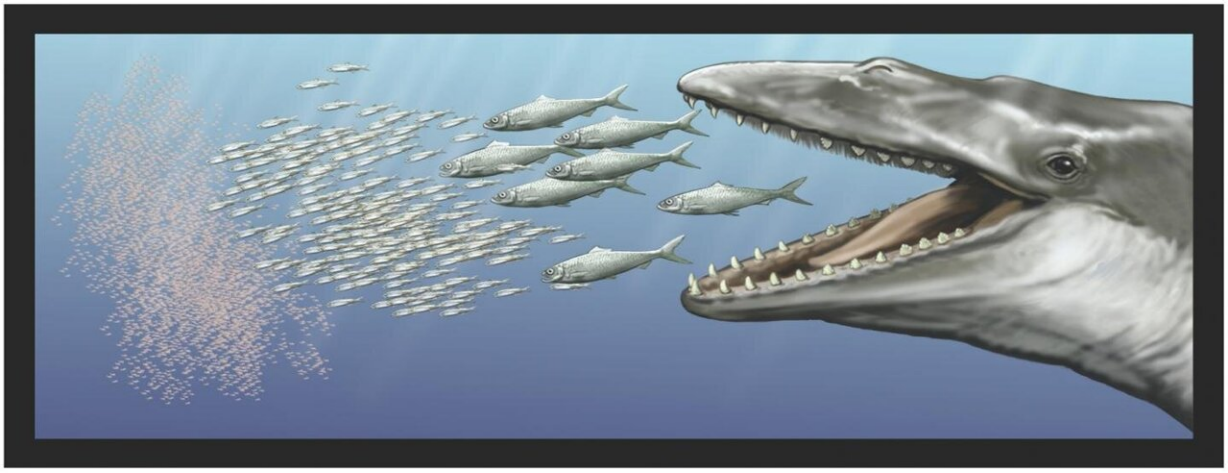
Dental crowding: Ancient baleen whales had a mouth full

May 24 2021



Artist's reconstruction of *Aetiocetus weltoni*, a 25 million year old baleen whale, with teeth and baleen. Co-occurrence of teeth and baleen side-by-side allow the animal to eat single prey, such as small fish, with their teeth, as well as large accumulations of small crustaceans with their baleen. Credit: Art by C. Buell, used with permission from J. Gatesy.

A strange phenomenon happens with modern blue whales, humpback whales and gray whales: they have teeth in the womb but are born toothless. Replacing the teeth is baleen, a series of plates composed of thin, hair- and fingernail-like structures growing from the roof of their mouths that act as a sieve for filter feeding small fish and tiny shrimp-like krill.

The disappearing embryonic teeth are testament to an evolutionary history from ancient whales that had teeth and consumed larger prey. Modern baleen whales on the other hand use their fringed baleen to strain their miniscule prey from water, hence the term filter feeding.

A new study that utilized high-resolution computed tomography (CT) to scan a 25 million year-old fossil whale skull found neurovascular evidence that *Aetiocetus weltoni*, an evolutionary "cousin" of today's baleen whales (Mysticeti), had both teeth and baleen simultaneously in adulthood, making for a very crowded mouth.

The Oligocene age mysticete fossil was discovered along the coast of Oregon by graduate students with the Museum of Paleontology at the University of California, Berkeley, and loaned to biologist and lead author Eric Ekdale with San Diego State University and paleontologist Thomas Deméré with the San Diego Natural History Museum for the study.

Since baleen decomposes and is rarely preserved intact in fossils, the scientists relied on digital reconstructions with CT imaging to search for evidence of baleen in *Aetiocetus*. The study revealed grooves and holes on the roof of the mouth that connect internally with a vascular canal in a fashion consistent with the pattern of blood vessels that lead to baleen in modern mysticetes.

What that demonstrates is that the blood supply for the teeth was co-opted for a new function, to support the growth of baleen in living baleen whales, the authors said.

The study also revealed separate connections between the major internal canal and smaller canals that would have delivered blood to the upper teeth, which is consistent with the pattern of blood supply to teeth in living toothed whales such as sperm whales and killer whales, porpoises,

dolphins, and terrestrial mammals.

"We have found evidence that supports a co-occurrence of teeth and baleen, indicating the tooth-to-baleen transition occurred in a stepwise manner from just teeth, to teeth and baleen, to only baleen," Ekdale said.

Shift in food habits

"Our study provides tangible fossil evidence of a major shift in feeding behavior from a raptorial carnivorous feeding mode to a bulk filter-feeding mode for obtaining food, among the largest animals that have ever lived in earth's oceans," Ekdale said. "Krill are around 1/600th the size of blue whales. That's like us humans eating nothing larger than sesame seeds floating in a pool."

The four main living groups of baleen whales each pursue different diets and use their baleen filter in different ways, so they divide up ocean resources rather than compete with each other for the same prey.

The study will be published with open access May 24 in the *Zoological Journal of the Linnean Society*, part of the Oxford University Press family of journals.

Anatomical distinction

In the case of *Aetiocetus*, which was less than half the size of a living gray whale, what puzzles some researchers in the field is how the whale managed to process its food, if it had both baleen and teeth, since the baleen might get in the way of teeth in the mastication process. However, the position of the holes observed in *Aetiocetus* suggests that the baleen was not in the "line of fire" and unlikely to result in interference between the teeth and baleen.

The study establishes that "while the tiny holes on the palate of *Aetiocetus* may look similar at a superficial level to other mammals, we can clearly demonstrate that this anatomy is related to baleen in baleen whales," Deméré said.

Ancestors of whales evolved for hundreds of millions of years, first on land as terrestrial mammals, and began their invasion of the sea around 53 million years ago. It's this transition and the subsequent diversification of fully aquatic whales that fascinates Ekdale and Deméré, and discoveries such as theirs indicate how remarkable is the history of life on our planet.

More information: *Zoological Journal of the Linnean Society* (2021). DOI: 10.1093/zoolinnean/zlab017

Provided by San Diego State University

Citation: Dental crowding: Ancient baleen whales had a mouth full (2021, May 24) retrieved 26 April 2024 from https://phys.org/news/2021-05-dental-crowding-ancient-baleen-whales.html

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