A 'pivotal' moment for understanding whale evolution

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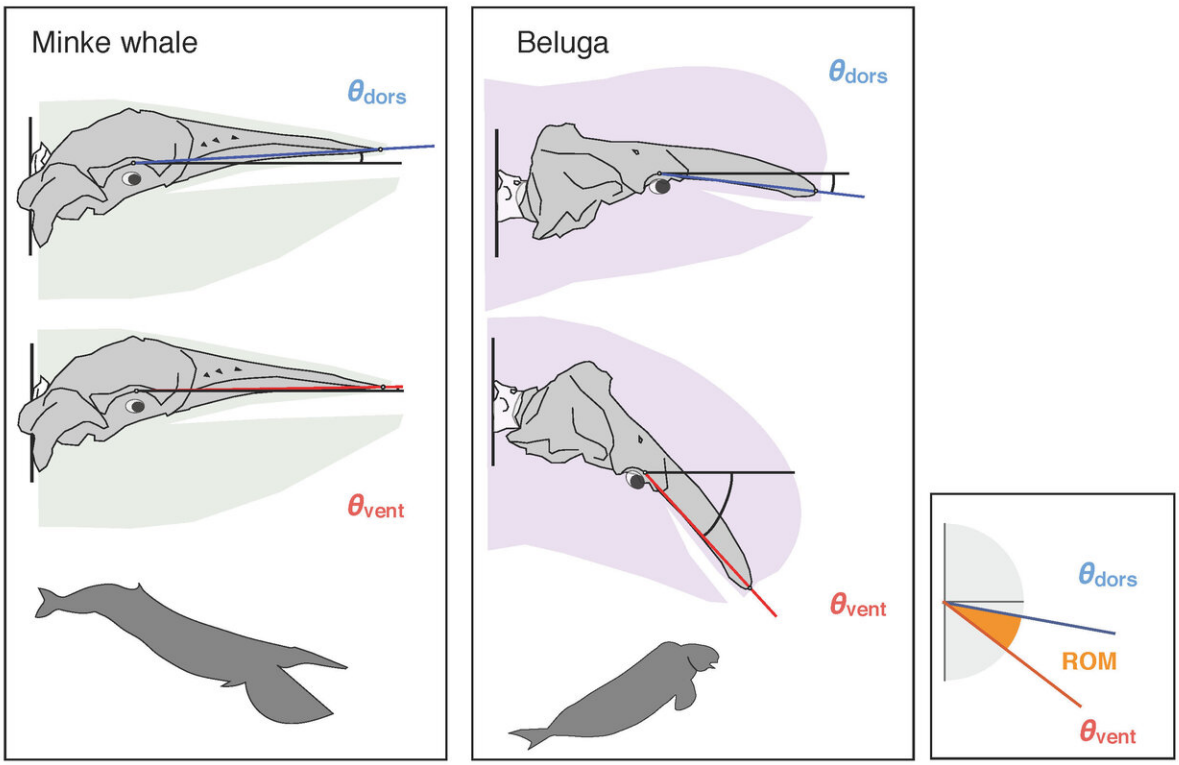

Figure 1: The most dorsi-flexed [θdors(°)] and ventro-flexed [θvent(°)] atlanto-occipital joint angles of minke whale (Balaenoptera acutorostrata) and beluga (Delphinapterus leucas). The range of atlanto-occipital joint angle (ROM) varies by taxa. Credit: Nagoya University

Scientists could soon better investigate the feeding behaviors of extinct dolphin and whale species. A third year student at Japan's Nagoya University has found that the range of motion offered by the joint between the head and neck in modern-day cetaceans, a group of marine mammals that also includes porpoises, accurately reflects how they feed. The authors of the study, published in the Journal of Anatomy, suggest this method could help overcome current limitations in extrapolating the feeding behaviors of extinct cetaceans.

Taro Okamura of Nagoya University and Shin-ichi Fujiwara of the Nagoya University Museum examined the skulls and cervical skeletons of 56 cetaceans that are still in existence, representing 30 different species. They assessed the range of motion of the 'atlanto-occipital joint' in each skeleton, a joint that forms between the base of the skull and the first cervical vertebra. They then categorized each cetacean according to their well-studied feeding behaviors, including how they approach their prey, move it within their oral cavities, and swallow it.

"We found that the range of neck-head flexibility strongly reflects the difference of feeding strategies among whales and dolphins," says Okamura. "This index can be easily applied to reconstruct the feeding strategies of extinct whales and dolphins," he adds.

Cetaceans are known for their diverse behaviors, physiologies, ecologies and diets. Some cetaceans feed on organisms in the open water, while others feed on those found near the ocean floor. Some whales are ram feeders, widely opening their mouths to gather zooplankton and other actively swimming organisms into their mouths while moving forward. Other whales, like the sperm whale, suction their prey into their oral cavities. The orca whale and some dolphins bite the fish they catch into smaller segments, a process that may require head movement. Other dolphins swallow their prey whole.

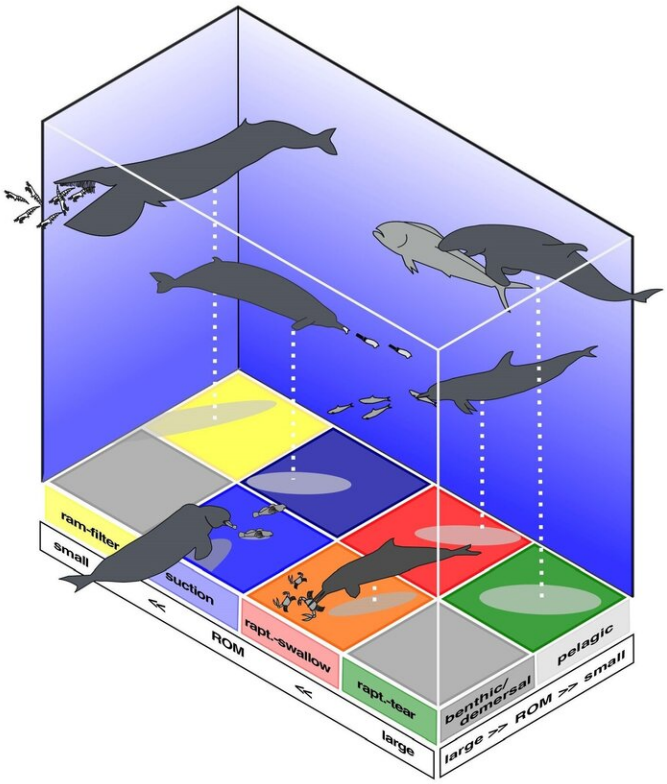

Figure 2: The range of atlanto-occipital joint angle (ROM) depends on the prey habitat, and the way cetaceans use to capture prey. The cetaceans that prefer benthic/demersal prey had a relatively large ROM compared with the ones that prefer pelagic prey. The ROM was relatively large in raptorial feeders, followed by suction- and ram-filter feeders, in ascending order. Among raptorial feeders, the ROM was larger in taxa that facultatively tear off the fresh of prey than the ROM in taxa that swallow the prey without processing. Credit: Nagoya University

Until now, scientists have used the structures of teeth, throat bones and lower jaws in cetacean fossils to develop an idea of what their feeding behaviors might have looked like. But these individual features can't accurately predict the behaviors of extinct cetaceans. For example, the

teeth of some suction feeders, like those of the sperm whale, aren't suggestive of this kind of feeding. Okamura and Fujiwara propose that using a combination of features, which include the range of motion of the atlanto-occipital joint, could help to develop more accurate descriptions of extinct cetacean feeding behaviors.

In prehistoric times, many different types of cetaceans existed, including ones with walrus-like tusks, extremely long snouts, and an ancient sperm whale with huge predatory teeth. The ancient baleen whale had teeth, whereas modern-day baleen whales have 'baleen,' or fringed plates, in their place. This has created much interest in how baleen whale feeding, for example, has evolved from catching prey with teeth to filtering it with baleen.

The two researchers next plan to determine the atlanto-occipital joint range of motion in some of these cetacean fossils to attempt to develop reconstructions of how they used to feed. Answering these questions could help reveal the evolutionary process of the diverse feeding behaviors among cetaceans.

The article, "The range of atlanto-occipital joint motion in cetaceans reflects their feeding behavior," was published online in the *Journal of Anatomy*.

More information: Taro Okamura et al. The range of atlanto-occipital joint motion in cetaceans reflects their feeding behavior, *Journal of Anatomy* (2019). DOI: 10.1111/joa.13111

Provided by Nagoya University