Researcher outlines how whales' sensory systems have evolved through imaging technology

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Rachel Racicot with beluga whale Juno at Mystic Aquarium in Connecticut. Credit: Vanderbilt University

If you've ever had an ear infection that made you dizzy or unbalanced, the infection likely was affecting your vestibular complex—part of the intricate system of hard and soft tissues that make up the inner ear. Knowledge of this structure has been made possible through computed tomography scans—imaging technology that continues to shape our understanding of evolution across species.

In a review of a century of research on sensory systems of whales, Rachel Racicot, research assistant professor of biological sciences, describes advances in the field and key questions that remain. The article, "Evolution of whale sensory ecology: Frontiers in nondestructive anatomical investigations" was published on Sept. 21 in the journal *The Anatomical Record*.

"Anatomy and morphology are areas of research where we are making huge discoveries, especially when we can include fossils to help inform our understanding of evolution, function and convergence that we wouldn't otherwise be aware of," said Racicot, also a faculty member of the Evolutionary Studies Initiative. "The evolution of sensory systems in whales (and other groups) can be studied using nondestructive CT scanning and other techniques."

When animals die and become fossils, soft tissues, including those in the ear, break down, and bony areas become scattered with empty pockets where these soft tissues were once housed remain. By recreating these areas digitally, researchers can determine the frequencies animals could hear. One of the questions this technique addresses is whether echolocation evolved independently in different whale groups.

According to Racicot's review, it is thought that the first completely marine whales used low-frequency communication, which could travel long distances. Later on, a group of whales evolved higher frequency communication and developed echolocation. In 2019, she discovered that echolocation may have evolved twice and in separate groups of whales.

Whales aren't the only animals whose ears are being examined with imaging techniques; researchers are also looking at dinosaurs, birds and other mammals. "Another cool study found that cochlear coiling has independently evolved at least twice: once in monotremes (platypus) and another time in therians (live-bearing mammals)—something that we wouldn't have been able to detect without including fossils in the analysis," she explained.

Racicot's review also acknowledges the open questions about how the whale sensory system has evolved, which are critical to our understanding of the overarching evolutionary trends in ocean-dwelling mammals that have proven difficult to access and study.

This work is already informing and directing the research of Racicot and her trainees. Several undergraduates in her lab are reviewing a data-intensive sample of ziphiid (beaked whale) inner ears to understand their hearing sensitivities. "We can't directly measure their hearing ranges easily because they are deep sea diving animals, but there's a lot of interest because they tend to strand when naval sonar is used," Racicot said.

"Many of the big questions we've answered using nondestructive imaging like CT scans in studying sensory evolution in whales have led to more questions—which means there are so many more discoveries to be made!"

More information: Rachel Racicot, Evolution of whale sensory ecology: Frontiers in nondestructive anatomical investigations, *The Anatomical Record* (2021). DOI: 10.1002/ar.24761

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