Whale's streaming baleen tangles to trap food

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Many whales filter food from water using racks of baleen plates in their mouths, but no one had ever investigated how baleen behaves in real life. According to Alexander Werth from Hampden-Sydney College, baleen was viewed as a static material, however, he discovered that baleen streams in water just like long hair and fringes from adjacent baleen plates tangle to form the perfect net for trapping food at natural whale swimming speeds.

Diving and plunging through the waves to feed, some whales throw their jaws wide and engulf colossal mouthfuls of fish-laden water while other species simply coast along with their mouths agape (ram or skim feeding), yet both feeding styles rely on a remarkable substance in the whales' mouths to filter nutrition from the ocean: baleen. Alexander Werth from Hampden-Sydney College, USA, explains that no one knew how the hairy substance actually traps morsels of food. 'The standard view was that baleen is just a static material and people had never thought of it moving or that its function would be altered by the flow of water through the mouth', he says. Werth became fascinated with the substance during his postdoc days, when he worked with the Inupiat Eskimos of Barrow, Alaska, and decided to find out more about how the flexible material filters whale-sized mouthfuls of water. He publishes his discovery that baleen is a highly mobile material that tangles in flowing water to form the perfect net for trapping food particles at natural whale swimming speeds in *The Journal of Experimental Biology*.

Explaining that baleen is composed of keratin – the same protein that makes hair and fingernails – Werth also describes how the protein forms large continually growing plates, each with an internal fibrous core sandwiched between smooth outer plates. Whales usually carry 300 of these structures on each side of their mouths – arranged perpendicular to the direction of water flowing into the mouth – and Werth explains that the plates are continually worn away by the tongue to form bristly food-trapping fringes on the tongue-edge of each plate. In addition, the baleen fringes of the skim-feeding bowhead whale's bristles are twice as long as the lunging humpback's. Having obtained baleen samples from the body of a stranded humpback during graduate work at the New England Aquarium and collected samples from ram-feeding bowheads in Alaska, Werth began to compare how well the baleen trapped minute latex beads carried in flowing water.

First, he tested a small section of each type of baleen in a flow tank as he varied the flow speed from 10 to 120 cm s and altered the inclination of the baleen to the water flow from parallel to perpendicular. Monitoring the fringes and recording how many beads became lodged for 2 s or more, Werth saw that the bristles trapped most beads at the lowest speeds, and as the flow increased the bristles began streaming like hair, increasing the fringe's porosity and reducing the number of snagged particles: single baleen plates are less effective filters at higher swimming speeds.

However, Werth says, 'It doesn't make sense to look at flow across a single plate of baleen, it's like looking at feeding with a single tooth; you can't chew anything with just one tooth, you need a whole mouthful.' So, he built a scaled down rack of six, 20 cm long baleen plate fragments and tested how well they trapped the latex beads.

This time, Werth could clearly see the fringes from adjacent baleen plates becoming tangled and more matted as the flow increased, trapping the most particles at speeds ranging from 70 to 80 cm/s, which corresponds exactly with the swimming speed of bowhead whales skimming through shoals of copepods. However, when he compared the porosity of the baleen of both species, he was surprised by the similarity of the performances, despite the whales' different feeding styles.

Having found that baleen filters best at the natural swimming speed of skim-feeding bowheads, Werth is keen to scale up and investigate how full-sized 4 m long baleen plates perform

More information: Werth, A. J. (2013). Flow-dependent porosity and other biomechanical properties of mysticete baleen. J. Exp. Bio. 216, 1152-1159. jeb.biologists.org/content/216/7/1152.abstract

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