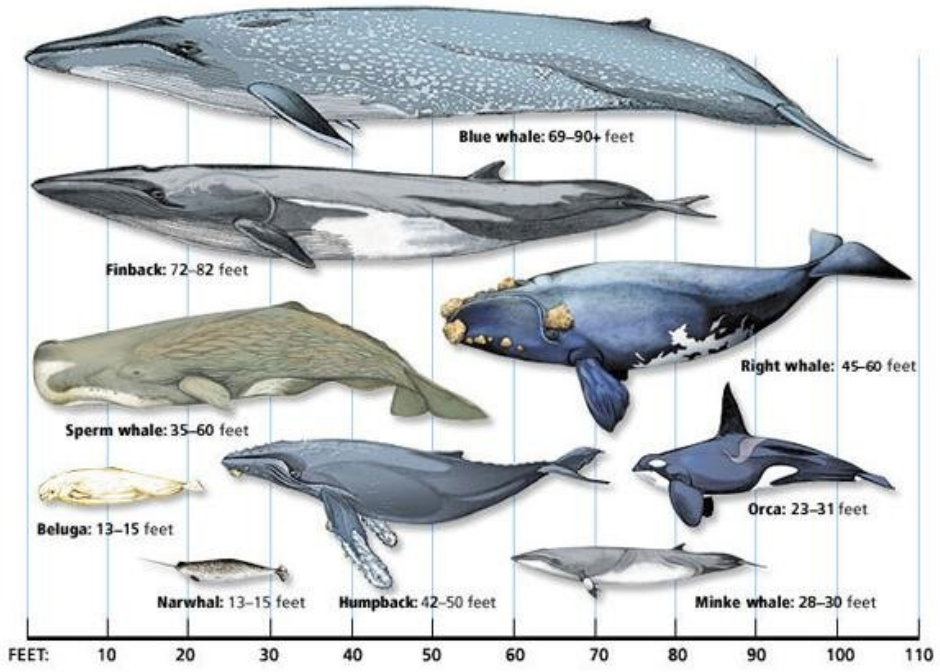
Whale cams track swimming efficiency of ocean giants

February 19 2020, by Liza Lester



Credit: Smithsonian Institution

The relatively squat and gangly humpback whale moves more efficiently through the water than its sleeker, larger cousin, the blue whale, according to new research that used devices attached to the animals to collect information about these large creatures.

The new research, being presented at the Ocean Sciences Meeting 2020 in San Diego this week, found size, not shape, matters most to efficient forward motion by blue, humpback and minke whales, but all the whales are highly efficient swimmers.

The new research is one of the first to measure the thrust and propulsive efficiency of whales swimming in their natural environment. To gather data from whales in motion, researchers from Stanford University suction-cupped small devices about the size of two smartphones to the backs of blue, humpback and minke whales, species of baleen whale representing a wide spectrum of sizes.

Understanding the physics of whale movement helps scientists calculate the giants' energy requirements and how efficiently they use their limited food supply to fuel long migrations.

"[The device] is not large at all and it has a lot of the same things that an iPhone has: magnetometers, gyroscopes, and accelerometers to measure speed, position, and orientation, as well as GPS and cameras so we can see what the whale's doing underwater," said Hayden Smith, a student at Southwestern University who is presenting the new research.

All whales propel themselves with up-down undulations of their large tails, an economical motion equivalent to the side-to-side oscillations of fish. The swimming mechanics of dolphins and smaller toothed whales have been observed in captive animals, but the largest whales cannot be studied in tanks.

The whale-cam devices used by the researchers collected information about the whales' movements and locations in the open ocean for minutes to hours, until the suction cups popped off. Overhead video of some of the whales complemented the on-whale data collection, giving the researchers a good estimate of the animals' sizes.

"I was expecting the humpback whale to have the lowest propulsive efficiency because of their body shape—they're much more rotund—but I was also expecting them to generate the most thrust, because they have the largest appendages, the largest flippers, the largest flukes, compared to the other animals in the study. But that wasn't what we found," Smith said.

Thrust, the force with which a whale propels itself forward through the water, is proportional to whale body size, the new research found. Bigger whales are capable of more thrust. Blue whales, the largest animals on Earth at up to 150 tons, produce more thrust than humpbacks, which produce more thrust than minkes.

But the researchers found the opposite pattern for propulsive efficiency, a measure of how effectively the energy required to beat the tail translates into forward swimming speed. Minkes, the smallest of the baleen whales at 10 tons, converted energy to motion more efficiently than the larger humpbacks.

Smith anticipated the extra drag created by the humpbacks' curves would require extra energy to overcome, but his results showed only a relationship to overall body size. The humpbacks had higher propulsive efficiency than the blue whales.

In general, propulsive efficiency was extremely high for all the whales, Smith found, at around 85-90%.

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