Study identifies whale blow microbiome

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A humpback whale feeds in waters off Vancouver. Image taken from an unmanned hexacopter, with a research license issued by Fisheries and Oceans Canada #2014-5 SARA-327. Credit: John Durban (NOAA), Holly Fearnbach (SR3) and Lance Barrett-Lennard (Coastal Ocean Research Institute).

A new study by the Woods Hole Oceanographic Institution (WHOI) and colleagues identified for the first time an extensive conserved group of bacteria within healthy humpback whales' blow—the moist breath that whales spray out of their blowholes when they exhale. The research

published Oct. 10, 2017, in *mSystems*, an open-access journal of the American Society for Microbiology.

The discovery of this shared respiratory "microbiome" could serve as an important framework for monitoring the health of this and other whale species. Just like with humans, scientists say the assemblages of microorganisms that live in and on whales—known as microbiomes—may play a crucial role in their overall health, from maintaining a healthy immune system to fighting off disease.

"The pulmonary system is a common site for bacterial infections in whales," says WHOI researcher Amy Apprill, lead author of the study. The collaborative research team also included scientists from the National Oceanic and Atmospheric Administration (NOAA), SR3 Sealife Response, Rehabilitation and Research and the Vancouver Aquarium.

"We see evidence of respiratory illnesses frequently in stranded and deceased animals," Apprill adds. "Until now, little has been known about the normal respiratory microbiome of healthy whales."

To collect a sample, traditionally researchers use a small boat to track the whale. Once close enough, they collect a sample by holding a long pole with a large petri dish at its tip, as close to the blowhole as possible. It is an efficient approach, but there's the potential to change the whale's behavior and stress level with the boat approach.

The collaborative team wanted a less intrusive way to gather the necessary data for assessing the health of whales in the wild, so they turned to the skies and some high-tech equipment—a custom-made, remotely controlled, six-rotor hexacopter.

After collecting their first sample in Patagonia in early 2015, WHOI

biologist Michael Moore, NOAA researcher John Durban and SR3's Holly Fearnbach were repeatedly successful in using this technique to sample the blows from humpback whales off Cape Cod late that year.

"We were using the drone to take aerial images of the whales, so that we could assess body conditions," says Durban, a coauthor of the paper. "Because of the stable flight performance of our hexacopter, we quickly learned that we could reliably fly through whale blow without disturbing the animals."

Once the whale is visible in the frame of the camera that is mounted on the bottom of the hexacopter, high-resolution aerial images are taken for later analysis of body conditions and overall health.

With the help of Fearnbach's specific positioning directions, which are called out in a rapid pace that would rival that of a veteran auctioneer, Durban pilots the hexacopter several feet above the blowhole. Some of the blow lands on a sterilized petri dish that is attached to the top the drone.

"The whales don't seem to know the aircraft is there," says Moore, a coauthor of the paper. "We want to study whale health, but not affect their behavior. The drone helps us do just that."

Blow samples were collected from two different humpback populations: 17 from whales in coastal waters off Cape Cod, Ma. and nine from whales in waters around Vancouver Island, Canada. The team then sequenced the genetic material found in the blow samples to determine what kinds of microorganisms are living in a whale's respiratory tract.

"We were surprised to find a microbiome that looked very different from seawater," Apprill says. "That's really exciting because it demonstrates that we are obtaining a clear signal of a microbiome that's

coming from the animal."

Apprill and WHOI laboratory colleague Carolyn Miller identified 25 bacterial groups present in all of the whale samples—a conserved or "core" microbiome.

"This strongly suggests that regardless of where the animal lives, or even their age or sex, they have a shared blow microbiome," Apprill says.

Within the core group of 25 microbial species, the researchers found 20 sequences similar to microbes associated with other marine mammals. The most shared characteristics were found in a microbiome dataset that came from the blowholes of bottlenose dolphins, which is also the most comparable dataset available at this time.

Next, the researchers will take samples from whales with poor body condition, possibly indicative of illness, to compare microbes found in their blow to that of the healthy whales. They'd also like to expand the sequencing effort to include viruses and fungi, since this study focused solely on bacteria and archaea, single-celled microorganisms similar to bacteria.

"From this study, we have a good idea of what a normal, healthy whale microbiome looks like. Now we need to understand what the microbiome of an unhealthy whale looks like," Apprill says. "This comparison is critical for health monitoring and disease detection."

It may also prove to be crucial to the survival of these endangered whales. The past year has been particularly difficult for both humpbacks and North Atlantic right whales. In the past 19 months, at least 53 humpbacks died along the Atlantic coast, prompting NOAA to declare an "unusual mortality event."

An unusual mortality event has been declared for the North Atlantic right whale as well. At least 15 North Atlantic right whales have died since mid-April in a population that is now fewer than 450.

More than half of right whiles die in collisions with ships or by becoming entangled in fishing gear. In addition, climate change and a warming ocean may be reducing and shifting the location of their main source of food—tiny crustaceans called copepods—leaving some right whales undernourished and less able to reproduce.

"There are very few ways to gather useful data from live large whales at sea," Moore adds. "This tool has the potential to broaden our perspective of large whale health."

Provided by Woods Hole Oceanographic Institution