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Researchers identify bacteria and viruses ejected from the ocean

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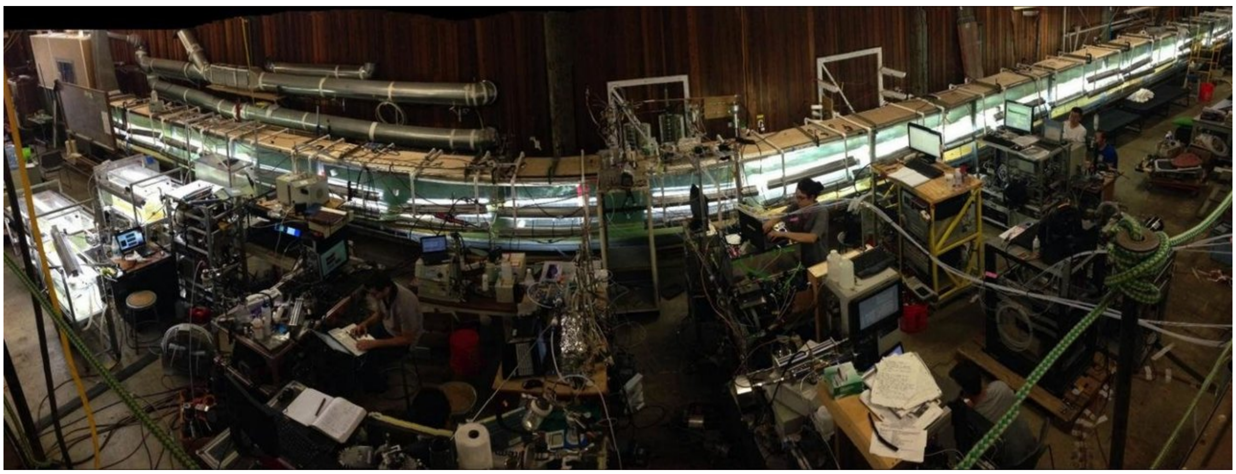

Researchers determined what bacterial taxa are most prone to being ejected into the air from breaking waves after simulating ocean conditions at this facility at Scripps Institution of Oceanography at UC San Diego. Credit: Christina McCluskey/Colorado St. Univ.

Certain types of bacteria and viruses are readily ejected into the atmosphere when waves break while other taxa are less likely to be transported by sea spray into the air, researchers reported May 22.

An interdisciplinary team of scientists from Scripps Institution of Oceanography, the University of California San Diego, and the J. Craig Venter Institute (JCVI) reached this conclusion after replicating a phytoplankton bloom in a unique ocean-atmosphere wave facility developed by scientists in the National Science Foundation-funded Center for Aerosol Impacts on Chemistry of the Environment (CAICE) on the Scripps campus. They found that bacteria and viruses coated by waxy substances or lipids appear in greater quantity and are enriched in sea spray aerosols. According to researchers, the results suggest that the water-repellent properties of the surfaces of these microbes are what make them more likely to be cast out of the ocean as waves break at the sea surface.

The team in the National Science Foundation-funded study included chemists, oceanographers, microbiologists, geneticists, and pediatric medicine specialists who are attempting to understand how far potentially infectious bacteria and viruses can travel and if those that pose the greatest risks to public health are among those most likely to escape the ocean. In previous studies, individual members of the team have characterized sea spray aerosols, which form when waves break and bubbles burst at the ocean surface.

"Some of the bacteria we detected have been found on skin as well as in your gut, so they could be affecting your health—at this point, no one really knows the health effects of breathing in ocean microbes," said Kim Prather, who has a joint appointment at UC San Diego's Scripps Institution of Oceanography and the Department of Chemistry and Biochemistry. "We are trying to understand sources of environmental microbes using the unique ocean-atmosphere facilities we have developed here at Scripps. By breaking waves in fresh seawater in an isolated wave channel, UC San Diego is the only place in the world that can directly measure the microbes transferred from the ocean to the atmosphere."

Prather's research group has previously shown how microbes have a nearly worldwide reach, able to travel tens of thousands of kilometers on the wind, sometimes re-entering the ocean and re-emerging from it along the journey. As they do, their chemical attributes, their ability to infect, and their effects on cloud formation and precipitation can evolve.

"In CAICE, we realized that many of the chemical components found in the aerosols are derived from living microorganisms in the ocean, so one of our first goals was to find out which ones are present in the water and then understand which of them are able to hitch a ride on the aerosol particles," said Michael Burkart, a researcher at the Department of Chemistry and Biochemistry at UC San Diego.

The study tapped into techniques developed in the Earth Microbiome Project, which was founded by co-author Rob Knight and others in 2010 to sample as many microbial communities as possible to understand the ecology of microbes and their interactions with humans.

"In the Earth Microbiome Project a key challenge is to model microbes across the planet," said Knight, a UC San Diego professor of pediatrics and computer science and engineering with the UC San Diego Center for Microbiome Innovation. "The ocean spray results provide a completely new and unexpected mechanism for dispersal that we will have to take into account for a full understanding of Earth's microbial biosphere."

The researchers conducted the experiment by establishing blooms of phytoplankton over a 34-day period. They did this inside an ocean-atmosphere facility housed at the Hydraulics Laboratory at Scripps Oceanography. After several days, the replicated ocean, which scientists call a mesocosm, began emitting into the air bacterial taxa such as Actinobacteria and Corynebacteria. Viruses contained in the aerosols that became airborne were few relative to bacteria, but the strains that were detected in the air such as Herpesvirales had a similar kind of water repelling surface that enables them to be transferred from the ocean to the atmosphere.

The potential human health effects of the ocean microbes most often found in the sea spray aerosols will now begin to be studied by the team at UC San Diego. There is little known about the health effects— good or bad—of breathing ocean air enriched in microbes and other biological material. The researchers reported the presence of strains not often found in seawater such as Legionella and an avian strain of E. coli, which they said could be evidence of contamination in certain coastal waters. Knowledge of which pathogens occurring in pollution runoff become aerosolized could help improve the understanding of human exposure pathways for those living near the coast.

"No one expected that it might be an evolved strategy for particular bacteria and viruses to get themselves into the ocean spray," Knight said. "Our next challenge is to figure out why they're doing it, and when it's good or bad for our health, or even for the planet's climate."

The study, "Taxon-specific aerosolization of bacteria and viruses in an experimental ocean atmosphere mesocosm," which appeared May 22 in the journal *Nature Communications*, was supported by CAICE, which is led by Prather and designated in 2013 as an NSF Center for Chemical Innovation.

More information: Jennifer M. Michaud et al, Taxon-specific aerosolization of bacteria and viruses in an experimental ocean-atmosphere mesocosm, *Nature Communications* (2018). [DOI: 10.1038/s41467-018-04409-z](http://dx.doi.org/10.1038/s41467-018-04409-z)

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