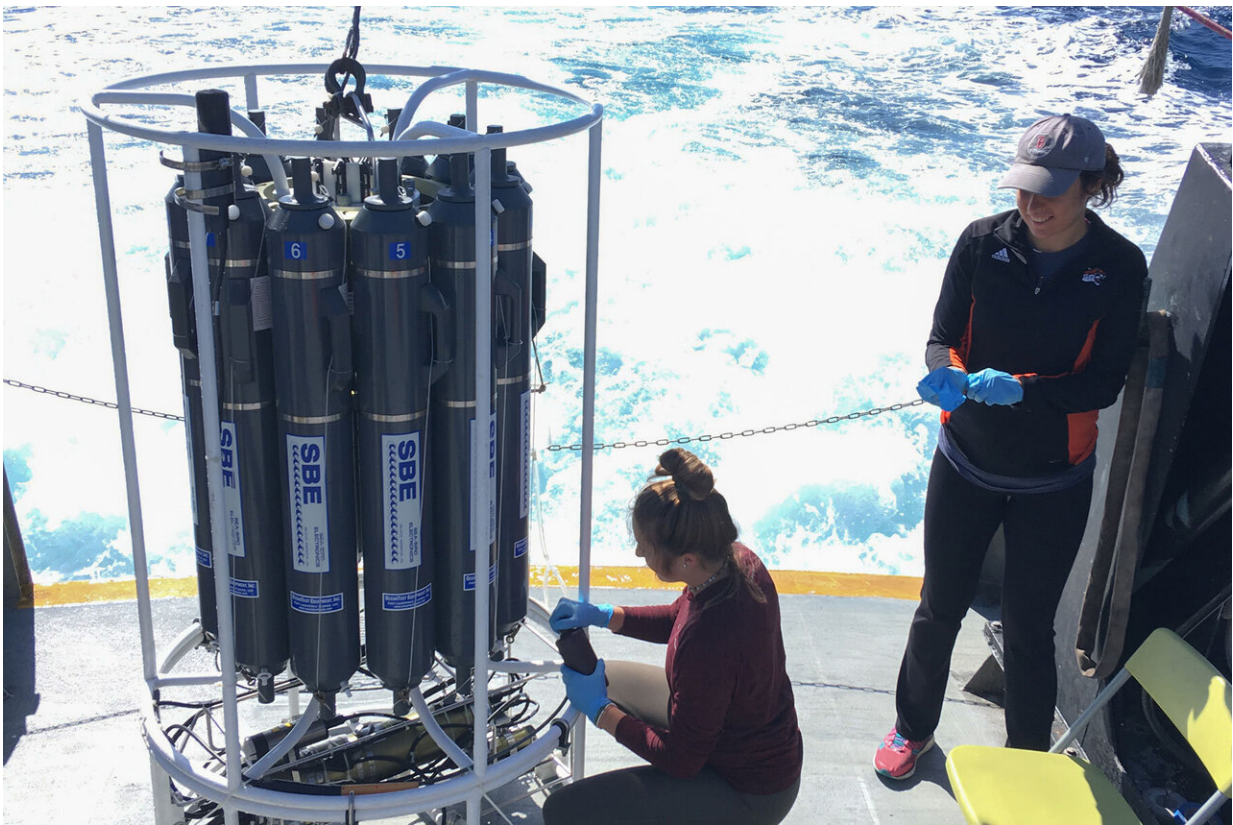


Scientists show evolutionary principle in microbes of offshore Southern California

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USC researchers test waters offshore Southern California to study how microbes adapt and evolve. Credit: Jennifer Beatty

In the waves offshore of Southern California, germ warfare occurs in a struggle as old as life itself.

It's where USC marine biologists completed a comprehensive new study that shows the tactics bacteria and viruses employ to gain advantages against each other. What they found is that an unlikely standoff occurs, regardless of time, season or location—proof of the evolutionary principle of the "Red Queen."

"The Red Queen concept in biology means a species running fast in place just to keep even, and that's what we found in these microbial communities," said Jed Fuhrman, lead author of the study and [marine biologist](#) at the USC Dornsife College of Letters, Arts and Sciences. "This is one of the modern tenets of evolutionary biology, and our observations fit nicely within the framework."

The research was published today in *Nature Microbiology*.

The battleground for this clash of microscopic organisms is a sliver of the Pacific Ocean between Los Angeles and Catalina Island. Those waters are immediately adjacent to some of the most popular beaches in the United States.

Oceans are full of viruses and bacteria; they are the oldest and most diverse creatures on Earth. Though small, if taken together in one lump they comprise 90% of the weight of all living creatures in the ocean. They perform essential functions in the ecosystem, recycle nutrients and influence the planet's climate. They've been in the ocean since the beginning of life, and they mostly don't bother swimmers and bathers. But they are not nice to each other.

Viruses are constantly trying to infect algae and bacteria. At first glance, the fight appears lopsided, because viruses vastly outnumber other marine organisms. A cup of ocean water can hold 1 billion [virus](#) particles. Yet, bacteria rely on countermeasures to protect themselves.

The USC scientists sought to explain why the struggle is a stalemate.

"It has been a puzzle how marine viruses, which are astoundingly abundant at about 10 million per milliliter of seawater, persist at such high abundances despite the ability of their hosts—mostly bacteria—to defend themselves," Fuhrman said.

The researchers sampled surface seawater almost every month for five years between the summers of 2009 and 2014. They analyzed more than 1 billion genetic sequences to sort the different types of viruses. They compared those findings to weather and ocean conditions and to [bacteria](#) populations.

Two key findings emerged:

- The virus communities remained stable. Some 95% of the same virus species were identified in nearly all the samples. The stability persisted over time and location. While similar findings have been reported previously, the new study is unique because no other study showed this extent of stability over such a long period.
- Within each virus species, there was constant churning of mutants, each of which dominated the populations for only a few months. The scientists say this churn allowed the viruses to stay one step ahead of host defenses, which means they need to keep changing in order to survive.

The dynamic occurring among microbes in the [ocean](#) "strongly resembles Red Queen dynamics, which are rapid changes of genotypes within a population from ecological and evolutionary mechanisms," the study says.

The Red Queen hypothesis proposes that organisms must constantly

adapt to spread or else die in a changing environment of competitors. The USC study is one of but a few to show this evolutionary dynamic anywhere in nature.

More information: Long-term stability and Red Queen-like strain dynamics in marine viruses, *Nature Microbiology* (2019). [DOI: 10.1038/s41564-019-0628-x](https://doi.org/10.1038/s41564-019-0628-x) , [nature.com/articles/s41564-019-0628-x](https://www.nature.com/articles/s41564-019-0628-x)

Provided by University of Southern California

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