How do viruses and bacteria coexist in the Atlantic Ocean?

A journal for students by students

Key Terms

Virus:
An particle containing genetic information, which can only replicate by infecting other organisms, like animals or microbes, including bacteria

Bacteriophage:
A type of **virus** that infects bacterial cells and uses them to reproduce

Bacteria:
A large group of single-cell organisms within Prokaryotes, which lack organelles and a nucleus

Biogeochemistry:
The study of how biology, geology, and chemistry interact, in which ask questions like how does the Earth shape life and how can life shape the Earth?

SAR11:
A clade (group) of bacteria within *Alphaproteobacteria*, abundant throughout surface ocean

Epifluoresence:
A technique used to visualize microscopic organisms

Water mass:
Bodies of water which move together and have unique properties, such as temperature and salinity

Regression:
A mathematical technique used to tell how two variables are related (e.g. latitude and temperature, or salinity and bacterial abundance)

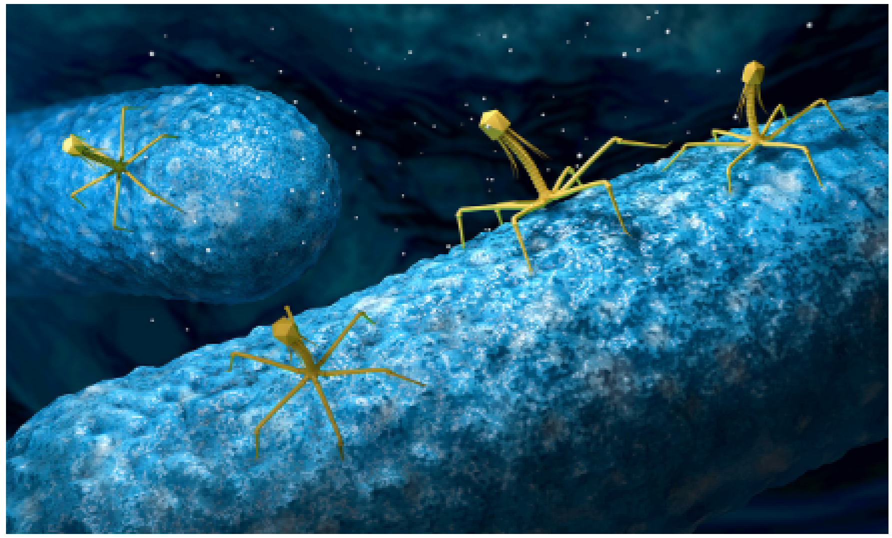

Figure 1: An artistic depiction of a **bacteriophage** infecting a **bacterial** cell. Replicating only as a parasite, the phage lands on the surface of the bacterial cell in order to inject its DNA. Image courtesy of University of Texas.

ABSTRACT

Viruses are an important and abundant part of the marine ecosystem. **Bacteriophage** viruses interact with bacterial communities when they inject their genetic material into a cell (**Fig. 1**). Studying the way that viruses and bacteria interact in the ocean is an important piece of describing how the whole ecosystem functions. Viruses play a role in regulating **biogeochemistry** of the environment, as they have an impact on the way that nutrients are cycled throughout ocean ecosystems.

The researchers focused on two genetically different types of **bacteriophage** that infect **SAR11 bacteria**, which are common throughout ocean surface waters. They observed the number of viruses and bacteria throughout depth in the water column and at different locations in the South Atlantic Ocean. In doing this, the researchers found that there was a relationship between the number of viruses and the number of bacteria at these different sites. This supports the hypothesis that bacterial communities and viruses are linked and can impact one another.

MARINE VIRUSES: STUDYING THE "INVISIBLE"

In the ocean, **viruses** are more common than any other life form. Marine **viruses** play an important ecological role, often impacting the way that nutrients are cycled throughout the ocean as well as the communities of **bacteria** which also live in the ocean. The process of transferring nutrients like carbon, nitrogen, and phosphorous within the ocean is called **biogeochemical** cycling, and it can determine the limits of life and growth of organisms in the ocean ecosystem. **Bacteriophages,** viruses which infect **bacteria**, can even help maintain diversity in these bacterial communities by allowing these bacteria to swap genes with one another--an interaction which occurs constantly (**Fig. 1**).

How are viruses and bacteria different?

Virus

- not living
- genetic material not within a cell
- requires a living organism to replicate.
- Size: usually <0.5 um

Bacteria

- living
- single-celled organism
- genetic material contained in a cell
- Size: average between 0.2 and 2um

ONE IMPORTANT QUESTION THE RESEARCHERS WANT TO ASK IS: HOW ARE THE COMMUNITIES OF BACTERIA AND VIRUSES IN THE OCEAN RELATED?

METHODS

The researchers followed the cruise track shown at right, sampling seawater at different depths and latitudinal locations in the South Atlantic Ocean (**Fig. 2**). Because viruses are microscopic, scientists studying marine viruses must capture them by filtering seawater samples with extremely fine filters (<0.5um). The same can be done for bacteria. The group quantified the virus particles and bacterial cells, which were visualized with **epifluoresence** microscopy. They also took measurements to describe the environment at each sample, including temperature and salinity.

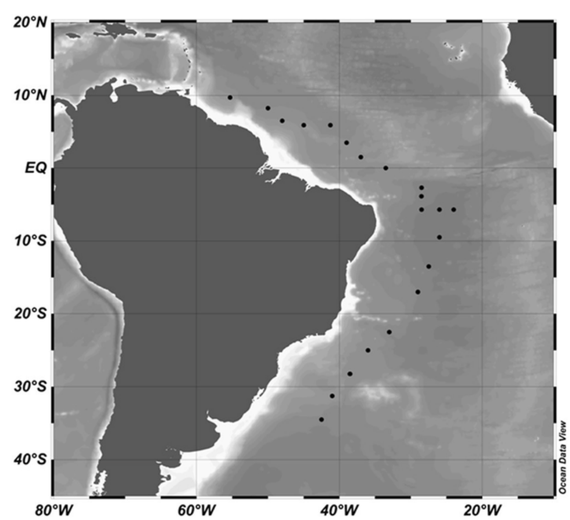

Figure 2. The cruise track in the South Atlantic Ocean is shown, with sampling sites in March and May of 2013 represented by black dots.

RESULTS

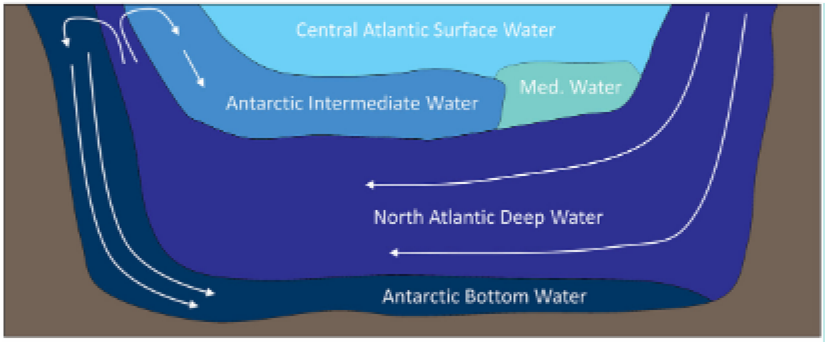

Figure 3. Diagram showing major Atlantic **water masses**, or bodies of water which move together and have unique properties, such as temperature and salinity.

Water masses move as a unit within the ocean, originating from different locations and carrying with them unique conditions from the surrounding environment (**Fig. 3**). Overall, the numbers of viral particles and bacterial cells were greatest near the ocean's surface and decreased with depth in the water column. The mean viral abundance, or the number of virus particles in a 1 mL sample of seawater, was 6.50 × 10^5 units per ml in Antarctic Bottom Water (AABW) and 1.17 × 10^7 units per ml in surface water. The mean bacterial abundance also ranged widely across depths, with a mean of 2.45 × 10^4 cells per ml in AABW and 1.52 × 10^6 cells per ml in surface water.

Counting bacterial cells and viral particles in samples of seawater revealed that the abundance of bacteria and viruses is correlated (**Fig. 4**). Based on the data, the researchers used the correlation to predict how viral and bacterial abundance are related. This is called a regression. The researchers saw a linear regression, where the points appear to fall along a line, which has a particular equation (e.g. y = mx + b). If we know the bacterial abundance, we can use the equation of this line to try to predict the viral abundance. They found that this line can explain about 87.54% of the variability in viral abundance from place to place (**Fig. 4**).

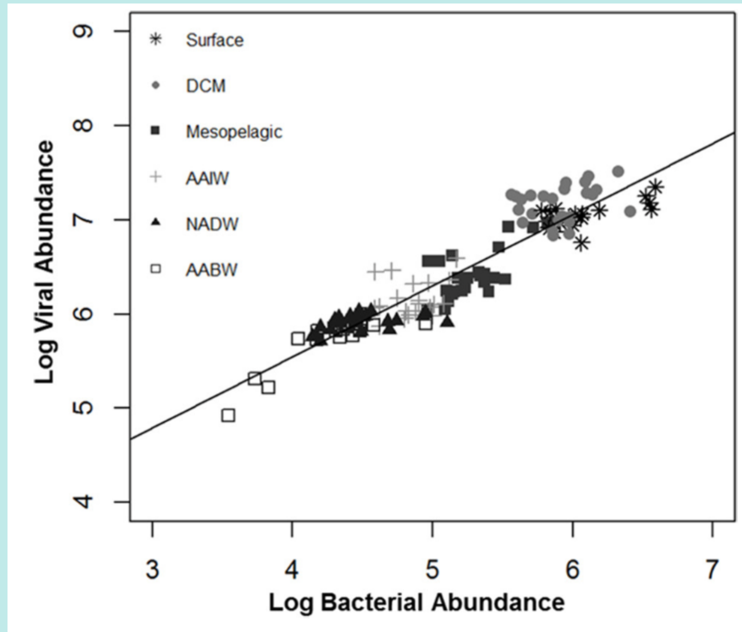

Figure 4. The relationship between bacterial abundance (x-axis) and viral abundance (y-axis) is shown. Numbers are log-adjusted so that a linear relationship can be seen.
Different shapes refer to the different water masses described in the legend.
DCM: deep chlorophyll maximum (just below the surface), **AAIW:** Antarctic Intermediate Water, **NADW:** North Atlantic Deep Water, **AABW:** Antarctic Bottom Water

Some of the differences in bacterial and viral abundance observed could be predicted by the water mass as well as the salinity. The environmental conditions can be unique to a water mass and can help define the microbial community there.

DISCUSSION

- The number of marine bacteria and viruses are correlated with one another in the South Atlantic Ocean.

- The quantity of bacteria may actually explain more about the number of viruses than we have previously thought! The type and number of bacteria present in a region may influence the viral populations.

- Water masses, like Antarctic Bottom Water (AABW) and North Atlantic Deep Water (NADW), often carry with them their own environmental features, including temperature, salinity, and oxygen concentration. These water masses act like moving ecosystems and can support unique bacterial and viral communities!

- Viruses and bacteria are both a natural and important part of the marine ecosystem. We might think of human viral infections as a negative thing, but many virus and bacteria interactions are not harmful.

- Future studies might try to adress the interactions between viruses and other organisms besides bacteria. How do you think that the types of viruses which infect other organisms, for example plants or animals, would be similar or different to the **bacteriophages** in this paper?

- What effects do you think it could have on a marine ecosystem if the abundance of one type of bacteria or virus shifted (due to environmental or human-induced changes)?

Adapted by Laura Blum from "Abundance of two *Pelagibacter ubique* bacteriophage genotypes along a latitudinal transect in the North and South Atlantic Oceans" by Erin Eggleston and Ian Hewson. Frontiers in Microbiology, 2016.