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Palmer LTER: Aquatic virus abundances near the Antarctic Peninsula

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The recent discovery of high abundances of viruses in non-polluted sea water at temperate latitudes (Bergh et al. 1989; Proctor and Fuhrman 1990) suggests that virus attack is important to the dynamics of the microbial community. Viruslike particles have been reported at abundances up to 60 times the concentration of the bacteria (Proctor and Fuhrman 1992). In addition, the occurrence of rapid increases in viral abundance during the decline of planktonic bacterial and algal blooms (Bratbak et al. 1990) indicates that virus infection might be an important source of bacterial and algal mortality in the sea.

During cruise 92-09 of the R/V *Polar Duke* (November 1992), we had an opportunity to initiate what we believe is the first study of viral ecology in Antarctica. Our objective was to determine whether viruses are present and, if so, whether they are important in the microbial ecology of the southern oceans.

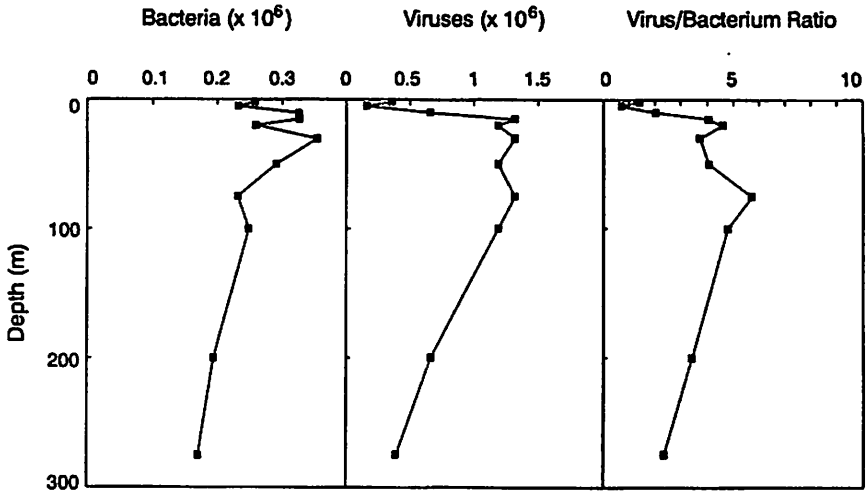
Our primary goals were to count free-living viruses in the water column, to follow their dynamics through time, and to determine viral infection rate of bacteria. Additional field experiments addressed other aspects of viral population dynamics, specifically loss rates by adhesion to and sedimentation by sinking particles and damage by ultraviolet (UV) light. These studies were designed to evaluate whether viral activity could explain the lack of correlation between bacterial population size and algal biomass in antarctic coastal ecosystems (Karl et al. 1991; Karl 1993).

Sampling was carried out along the long-term ecosystem research (LTER) transect line 600 (Waters and Smith 1992) and in Paradise Harbor (64°51'S 62°54.5'W). At the latter site, water samples [0–200 meters (m)] for bacteria and virus enumeration were collected twice daily at 0400 and 2000 hours for a period of approximately 5 days. Samples were fixed with EM-grade glutaraldehyde and stored in polypropylene vials. Viruses were counted by transmission electron microscopy following direct sedimentation onto formvar-coated EM grids. The centrifuge used was the Beckman airfuge with an EM-90 rotor, which was designed especially for viral enumeration and which avoided the biases due to convection and uneven distribution that create problems when using larger ultracentrifuges. The airfuge was used on board the R/V *Polar Duke* when sea conditions were calm.

The phytoplankton community was sparse during the period of this cruise (2 November to 20 November 1992) and consisted largely of nanoflagellates with rare large diatoms. Bacteria were also relatively sparse, ranging from 9×10^4 to 3.6×10^5 cells per milliliter (mL), characteristic of pre–spring-bloom communities (Bird and Karl 1991). By contrast, however, the pack-ice algal community was visibly more abundant whenever ice was encountered.

Viral and bacterial abundances are shown for a profile at Paradise Harbor (17 November 1992, figure). Bacterial abundances declined slightly with depth. Bacteriophages were present at from 0.7 to 6 times the abundance of bacteria. The virus-to-bacteria ratio was especially low in the upper 5 m of the water column (figure) where viral abundance was minimal.

The decline in viruslike particles in the surface waters could be the result of lower production rates or to higher loss rates, or both. Bacterial production experiments using radioactive precursors were also performed on these water



Profiles of bacterial and viral abundances and the virus-to-bacterium ratios measured for the upper 300 m of the water column in Paradise Harbor, Antarctica. The water samples were collected on 17 November 1992.

samples, but the analyses are not yet completed. Alternatively, decreased near-surface viral abundance might be caused by ultraviolet light radiation damage at the depths in question (Smith et al. 1992; Helbling et al. 1992).

Another factor conceivably involved in viral abundance is differential rate of formation of and adsorption to marine snow particles, which is a major viral loss factor at lower latitudes (Suttle and Chan 1992). Sedimentation rate of viruses measured during short-term deployments (approximately 1 day) of a free-floating sediment-trap array was between 1×10^{12} and 3×10^{12} per square meter per day on 12 November 1992, at a depth of 60 m. This means that virus loss due to adsorption and sinking was about 4 percent per day during this period.

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