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The (un)coupling between viruses and prokaryotes in the Gulf of Trieste

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A B S T R A C T

Viruses and prokaryotes represent the smallest and the most abundant biological entities in marine environments. The interest for viruses and their interactions with marine organisms is continuously rising but the studies are generally limited to short-time investigations. This study conducted in the Gulf of Trieste on monthly resolution investigates for the very first time relationships between viruses and prokaryotes (both heterotrophs-HP and autotrophs-AP) over ten years (2000–2010). From our results emerged that no clear relationship between the abundances of viruses and prokaryotes is observed unless for rather restricted time intervals. Some of the sporadic peaks of viral abundances can be attributable to infections occurred during the autumn phytoplankton blooms, thus probably contributing to the end of the bloom. We infer that the general uncoupling between viruses and prokaryotes in the Gulf of Trieste is due to the variety of factors that regulate viral infection, proliferation and persistence such as the diversity of viral life cycles that are determined by environmental factors, the abundance and the physiological status of their hosts.

1. Introduction

Viruses are pervasive components of aquatic ecosystems with abundances that are generally an order of magnitude more abundant than prokaryotes (Jacquet et al., 2010). Most of marine viruses infect prokaryotes determining their lysis and the consequent release of cell content, which is transformed in organic detritus. This process limits the direct transfer of microbial biomass to higher trophic levels (Wilhelm and Suttle, 1999). The ecological consequence of viral shunt includes profound impacts on microbial population sizes and biodiversity, horizontal transfer of genetic materials and cycle of organic matter (Suttle, 2005).

Viral infection is a stochastic process, thus largely depending on the abundance of viruses and hosts. To maintain a steady state concentration of a virulent phage population it is required that a single progeny survives to infect and replicate (Fuhrman, 1992; Murray and Jackson, 1992). As the concentration of host cells declines, the theoretical time for a host-virus to make successful contact increases. Based on this particle diffusion model, Wilcox and Fuhrman (1994) defined a threshold value of virus and bacterial (i.e. heterotrophic prokaryotes - HP) population abundance of 10^{12} mL^{-2} as the minimum virus-host product for lytic production. Lytic infection thus represents a density-dependent form of regulation playing a major role in the control of prokaryote abundance by controlling the most competitive and numerically dominant strains through ‘killing the winner’ strategy (Thingstad and Lignell, 1997). Therefore, viral and prokaryotic abundances result important for the virus-prokaryote encounter rates (Wiggins and Alexander, 1985; Murray and Jackson, 1992; Murray and Eldridge, 1994; Maranger and Bird, 1995), determining the prevalent life strategy over different seasons.

The dynamics in abundance and distribution of viruses and prokaryotes have been extensively studied worldwide at different time resolutions such as seasonal (Weinbauer et al., 1999; Brum et al., 2005), monthly (Fonda Umani et al., 2007; Clasen et al., 2008), daily (Winget and Wommack, 2009) or diel (Weinbauer et al., 1995; Winter et al., 2004; Payet and Suttle, 2007; Parada et al., 2008; Winget and Wommack, 2009). The findings reported in these studies which are limited to relatively short-term intervals support the claim that there are different drivers of viral abundances and evidenced that different environments appear to be influenced by different biotic and abiotic variables.

In the Northern Adriatic Sea several studies documented the dynamics of virioplankton and bacterioplankton on different timescales (Weinbauer et al., 1993, 1995; Weinbauer and Peduzzi, 1995; Corinaldesi et al., 2003; Stopar et al., 2003; Fonda Umani et al., 2007) with the evidence of seasonal shifts but there is still little

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