IMPORTANCE OF ALKALINE PHOSPHATASE IN THE NORTHERN ADRIATIC

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Abstract
Northern Adriatic waters are poor in PO_4, and DOP usually contributes more than 80% of the phosphorus pool. During 2004 APA was measured in these waters to establish if microbial communities use this enzyme to avoid phosphorus limitation. During the period of water column stratification APA in the upper 10 m was high (up 6.6 μmol L^{-1} h^{-1}) and correlated with microbial biomass, indicating that microbes used alkaline phosphatase to avoid PO_4 limitation. During the period of water column mixing, APA was low everywhere (<0.2 μmol L^{-1} h^{-1}) and was not correlated with microbial biomass.
Keywords : Adriatic Sea, Enzymes, Phosphorus.

Introduction
In the productive northern Adriatic waters the N/P ratio is markedly unbalanced for microbial requirements, being about 60 during the 1970's [1], and further increased since the mid-1980's [2]. The strongly unbalanced N/P ratio and a low PO_4 concentration suggest that phosphorus is the limiting element for microbial growth. DOP concentration generally exceeds PO_4 concentration [3, 4], and may be an important source of phosphorus. To establish the role of alkaline phosphatase in supplying phosphorus from DOP in various ambient conditions, APA was measured in different seasons at a profile where conditions change from oligotrophic to eutrophic.

Methods
Measurements were carried out at six stations at the Po River delta-Rovinj profile in the northern Adriatic during 7 cruises, from May to December 2004. Water samples were collected at 0, 5, 10, 20, and at the bottom. Alkaline phosphatase activity (APA) was measured in unfiltered water immediately after sample collection. Measurements were performed using methyllumbelliferyl-phosphate [5] in triplicate, and during incubation samples were kept in darkness at the *in situ* temperature. Nutrient analyses, dissolved organic phosphorus (DOP), chlorophyll *a* (chl *a*) and bacterial abundance (BA) were performed using methods widely used in oceanography.

Results and discussion
In the northern Adriatic APA showed marked seasonal changes (Fig. 1a). From May to September DOP strongly predominated the phosphorus pool (>90%) in surface waters and N/P ratio was markedly unbalanced (Fig 1b). A similar situation was found down to 10 m depth. In those waters APA was high (0.4-6.6 μmol L^{-1} h^{-1}) and correlated with chl *a*and BA (p«0.005), indicating that microbes used this enzyme to avoid PO_4 limitation. The highest APA was found in May (Fig. 1a) during the spring freshet due to the strongly deficient PO_4 versus inorganic nitrogen supply from freshwater. In October mixing processes in the water column drastically reduced APA in the upper waters (<0.2 μmol L^{-1} h^{-1}), as shown for the surface (Fig.1a). From October to December APA in the upper waters was not correlated with chl *a* and BA (p»0.005), even at the end October during the largest phytoplankton bloom found in the investigation period. This was probably due to a balanced nutrient supply from bottom waters where the N/P ratio was close to optimal for microbial growth during most part of the investigation period (Fig. 1d).
In the waters below 10 m APA was always several times lower, as shown for the bottom (Fig. 1c), concomitant with a less unbalanced N/P ratio (Fig. 1d). In these waters APA was not correlated to chl *a* and BA (p»0.005) suggesting that these communities were not PO_4 deficient.

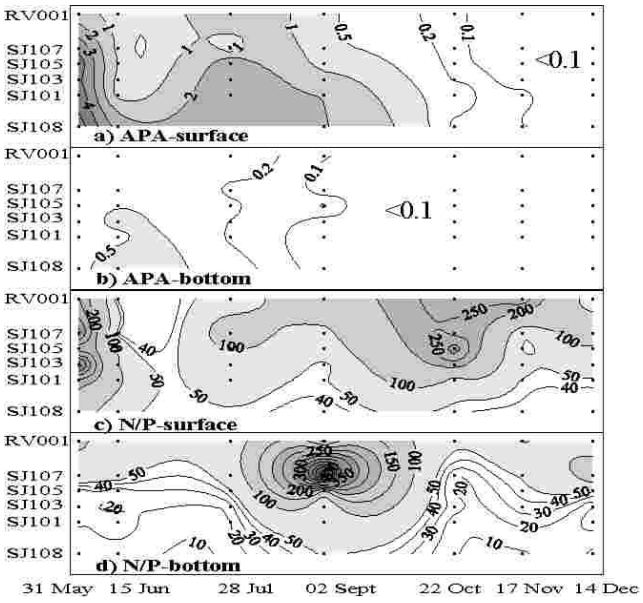

Fig. 1. APA (μmol L^{-1} h^{-1}) and N/P ratio distribution in surface (a,c) and bottom (b,d) layer at the Po-Rovinj profile in the northern Adriatic during cruises in 2004.

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