RESPONSE OF MARINE PHYTOPLANKTON TO P-LIMITATION

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Abstract
Phytoplankton abundance in the northern Adriatic during the summer 2008 indicated that the system was productive, in spite of low orthophosphate (PO_4) concentrations. Mechanisms by which phytoplankton adapted to PO_4 deprivation during the summer stratification were studied.

Keywords: Phosphorus, North Adriatic Sea, Organic matter, Plankton, Enzymes

A number of studies in the northern Adriatic (NA) evidenced that this region is currently P-limited [2]. This shallow (up to 50 m) coastal sea receive high amount of freshwater nutrients, mainly from the Po River. However, river waters provides a strongly unbalanced nitrogen (N) versus phosphorus (P) supply (inorganic N:P atomic ratio about 84:1) [2] for phytoplankton requirements (16:1). The state of the art presented in this work derives from five cruises performed from June to October 2008. During the summer phytoplankton (~10^5-10^6 cells l^{-1}) induced high alkaline phosphatase activity (APA; Fig. 1) to obtain P from the dissolved organic pool (DOP), and the P turnover by phytoplankton APA was very short (2 min-1.5 h). A combination of high affinity enzymatic activity (K_m 0.41-2.55 µmol l^{-1}) and high hydrolysis rates (V_{max} 0.5-36.4 µmol l^{-1} h^{-1}) enabled metabolic flexibility to the phytoplankton in this heterogeneous and fluctuating environment. Low APA in October (Fig. 1) suggests that phytoplankton did not use DOP to obtain P, probably to the constant supply of PO_4 from the bottom.

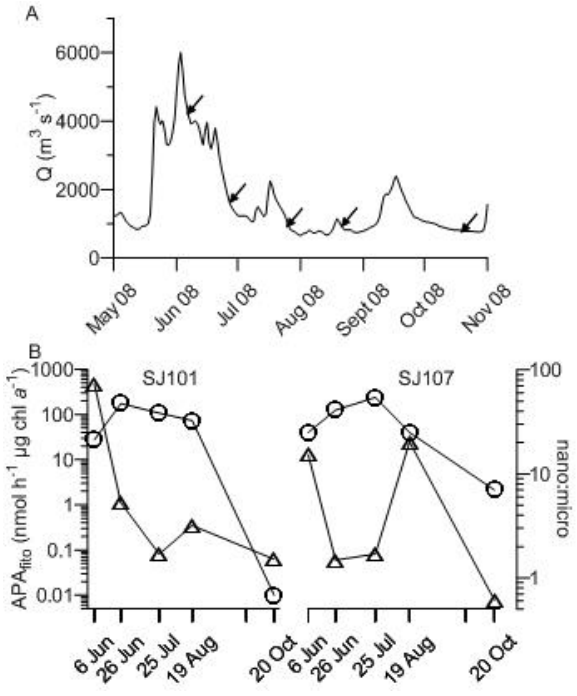

Fig. 1. (A) Daily mean of the Po River discharge rate (Q) with cruise dates denoted by arrows. (B) Changes of phytoplankton APA (open circle) and micro:nano ratio (open triangle) at surface of SJ101 and SJ107 during the year 2008.

A preferential synthesis of non-phospholipids (phospho:non-phospho lipid ratio; 0.4-0.7), which lasted still until October, indicated that the system was P stressed all the time. Only during the following winter months a preferential synthesis of phospholipids was observed (ratio about 1.5). Another possible mechanism of adaptation to the PO_4 deficit during the summer was a shift towards smaller cells. A higher nano:micro ratio was found during the summer than in October when microphytoplankton dominated or approached nanophytoplankton prevalence (Fig. 1). The highest ratios (up to 73.2) were found during the unbalanced nutrient freshwater supply. The smaller nanophytoplankton, supported by higher surface:volume ratios, were presumably able to produce more alkaline phosphatase, (ectoenzyme bound to the cell surface), and consequently were more successful in overcoming the P limitation. The PO_4 deficit during the summer could also contribute to changes in the microphytoplankton community. At the beginning of June this community was dominated by large diatoms and dinoflagellates (assemblage 1; Fig. 2).

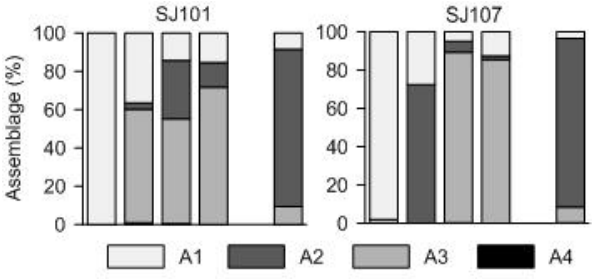

Fig. 2. Contribution of different assemblages in microphytoplankton community at surface of SJ101 and SJ107 during the year 2008.

During the summer the microphytoplankton was generally dominated by small species of Pseudo-nitzschia (assemblage 3). In October a shift towards bigger cells and a domination of assemblage 2 consisting of species of varying size, but larger than those of summer assemblage 3, was observed. The contribution of assemblage 4 with bentho-pelagic life-style in the microphytoplankton community was generally low. Preliminary results during the 2013 indicated that in P-limited conditions all species with considerable contributions to the microphytoplankton community expressed APA, rendering APA to be a very important prerequisite for success in the NA.

References
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