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Changes in the planktonic community structure related to trophic conditions: The case study of the northern Adriatic Sea

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ABSTRACT

Differentiation of the plankton food web structure was studied during the 2003–2008 period, in situations when the system of the northern Adriatic Sea, one of the most productive area in the Mediterranean, switched from low nutrient to higher nutrient regime. The biomass distribution between autotrophs, bacteria, protozoans and metazoans showed that within the upper part of the water column the microbial food web was developed during the stratification period (May–September) in oligotrophic conditions, with a larger heterotrophic/autotrophic (H/A) ratio in the western (1.4–1.7) than in the eastern part (1.2–1.5). Classical food web patterns (H/A 0.3–0.7) were observed when additional nutrient supply by freshwater (stratification period) or/and by mixing throughout the water column (November–March) occurred. However, while the stratification period with freshets (originated from the Po River outflow) was characterized by an increased biomass of autotrophs and heterotrophs, there was a reduction of biomasses during the mixing period, indicating increased carbon export from the area. In the bottom layer heterotrophs were not able to use the excess of autotrophic production, hence probably a part of autotrophs sank to the sediments fuelling benthic communities. Moreover, recurrently higher metazoans than protozoans biomass ratios suggested the occurrence of herbivorous and microbial grazing modes of metazoans.

1. Introduction

One of the important aims of the community ecology is to understand the carbon flux through the trophic levels. There is evidence that the transfer of organic carbon through the trophic levels differs between regions with diverse productivity. The plankton from unproductive regions is characterized by high relative heterotrophic biomass resulting in an inverted biomass pyramid, whereas the plankton from productive areas is characterized by a smaller contribution of heterotrophs and a broad autotrophic base (Gasol et al., 1997). The northern Adriatic is one of the most productive regions of the Mediterranean Sea at several trophic levels, from phytoplankton to fish (Vollenweider et al., 1992). Particularly, high but variable plankton standing crop and production was quantified off the Po River delta and related to the spreading of its plume (Gilmartin and Revelante, 1981). All plankton biomasses show a decreasing eastward gradient from the Po River and southward from the northern Adriatic (Fonda Umani, 1996). The microzooplankton composition was characterized by the dominance of ciliates other than tintinnids (Revelante and Gilmartin, 1990), while the mesozooplankton was dominated by strictly neritic copepod and cladoceran species (Fonda Umani, 1996; Fonda Umani et al., 2005). Copepod nauplii of the smallest size fractions were revealed as the major mediators of material transfer between primary producers and higher trophic levels (Kršinić et al., 2007; Lučić et al., 2003).

As in many coastal systems worldwide influenced by external nutrient load, the productivity level in the northern Adriatic presents marked spatial and seasonal changes. These were related to the alternating influence of freshwater from the western coast and advection of central Adriatic water (CAW) along the eastern coast. The prevalence of cyclonic circulation during winter causes the inflow of oligotrophic CAW into the region and the outflow of more eutrophic riverine waters along the western coast ("open" circulation), while in the late spring and summer the formation of gyres causes a lower exchange with the more southern parts of the Adriatic Sea ("closed" circulation) (Hopkins et al., 1999). During the winter enrichment of upper waters with nutrients regenerated in deeper waters is superimposed to the CAW inflow. In contrast, in late spring and summer months a stable pycnocline does not permit nutrients from deeper waters to reach upper waters where nutrient pools are consumed sustaining phytoplankton growth, thus creating oligotrophic conditions. These conditions are occasionally interrupted by the freshwater supply of new nutrients. Due to above described complex hydrodynamics and freshwater influence the entire area is sensitive to

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pollution, eutrophication and undesirable phenomena: mucilage and anoxia events (Giani et al., 2005; Travizi, 2000), jellyfish blooms (Kogovšek et al., 2010), harmful algal blooms (Nincevic Gladan et al., 2011) and noxious organism invasions (Occhipinti-Ambrogi and Savini, 2003). All of these disturbances are reflected to the main activities of the socio-economic development of the Northern Adriatic Region: tourism, fisheries and aquaculture, making it vital for us to study underlying dynamics of these imperils.

Since the relative biomass distribution between heterotrophs and autotrophs is regulated by nutrient supply (Duarte et al., 2000), the objectives of the study were to evaluate the functioning of the microbial food web in two characteristic situations. First when the freshwater supply of nutrients caused the production of new organic matter (mainly eutrophic conditions), and second the situation without a new input of nutrients (mainly oligotrophic conditions) in which microbial growth was based on a constant recycling of the once produced organic matter. Furthermore, the periods in which the produced organic matter was retained in the system were compared to the periods in which it was mainly exported from the system of the northern Adriatic. One of the objectives was also to establish if there were differences in the trophic pyramid between the mainly oligotrophic eastern area and the more eutrophic western area. Food web characterisation was allowed by an appropriate data set collected monthly from 2003 to 2008 that included broad changes in trophic state.

2. Material and methods

2.1. Sampling strategy and area description

Measurements were performed at three stations at the Po River delta–Rovinj transect located in the northern Adriatic (Fig. 1) between 2003 and 2008 on a monthly scale. During all periods temperature and salinity were determined with an SBE 25 CTD probe (Sea-Bird Electronics, Inc., Bellevue, Washington, USA), while other parameters were measured at five depths (surface, 5 m, 10 m, 20 m, and 1 m

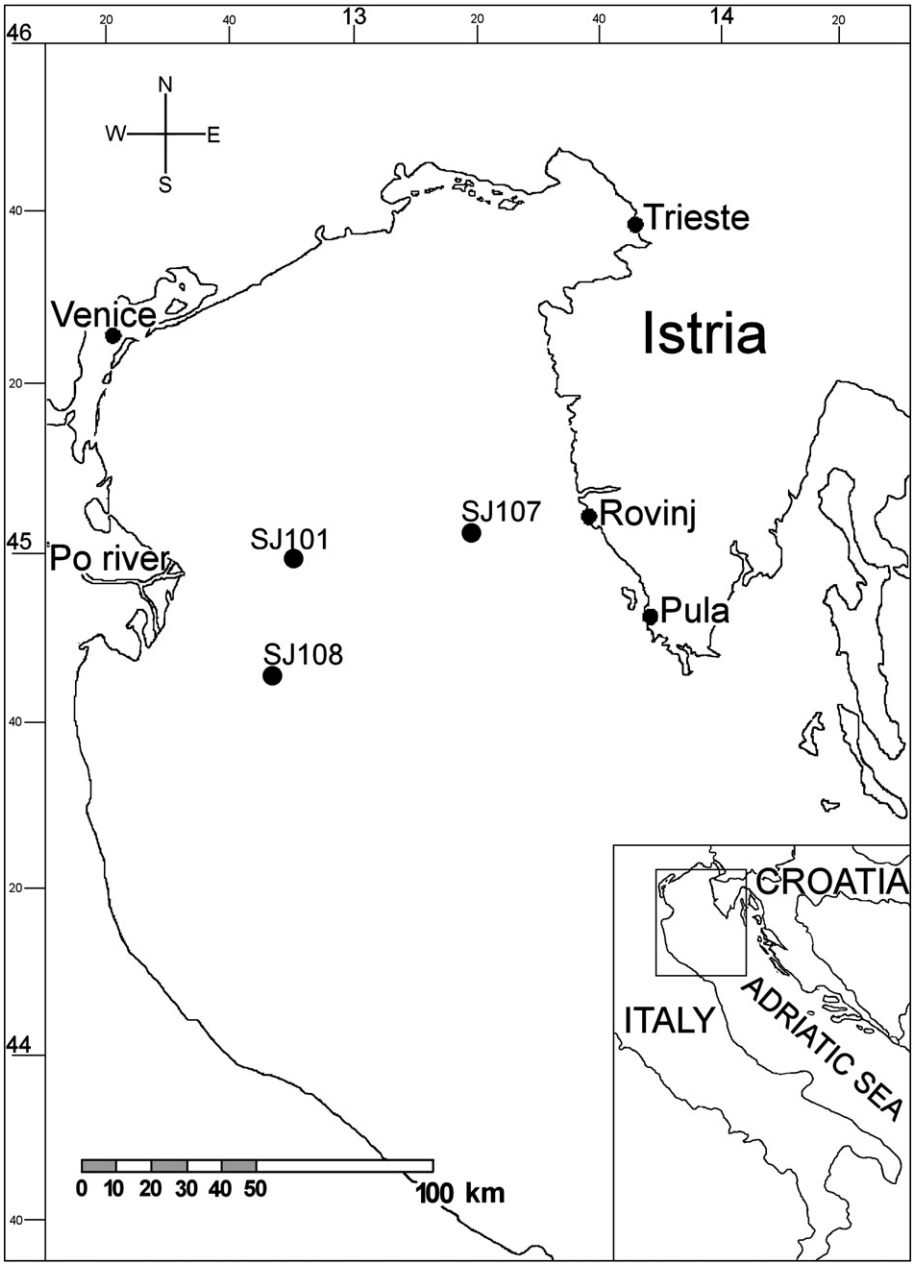

Fig. 1. Research area and sampling stations in the northern Adriatic Sea.