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Short communication

Structural dynamics of bacterioplankton assemblages in the Lagoon of Venice

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ABSTRACT

In this study we examined the spatial and temporal dynamics of planktonic bacterial assemblages at four different sites in the Lagoon of Venice. Samples were collected in January, April, July and October 2005 and several parameters (temperature, salinity, dissolved oxygen, chlorophyll *a*, dissolved macronutrients, dissolved and particulate organic carbon, viral and heterotrophic nanoplanktonic abundances) were determined in order to highlight the most important factors which are implied in shaping such assemblages. Furthermore we tested the relationship between similar assemblages and the patterns of activities (prokaryotic carbon production and several hydrolytic activities) that they perform in order to establish if, in this highly variable environment, similar assemblages behave in analogous ways. Results indicate that seasonality act as the main forcing on the communities. Moreover, we found a mismatch between community structure and patterns of activity possibly as a consequence of the heterogeneity of the lagoon which can affect in turn the assemblages' metabolic requirements (and thus their responses).

1. Introduction

Some unique habitat attributes (e.g.: the shallowness and the connectivity with both land and sea, the tidal cycle, the close benthic–pelagic coupling) characterize the transitional environments and their plankton communities (i.e. Cloern and Jassby, 2008) which are therefore intrinsically highly variable. The definition of the typical plankton assemblages of these ecosystems, their spatio-temporal succession patterns and the shaping environmental variables represent, therefore a challenging task.

In transitional waters non-phytoplanktonic sources of organic carbon, as leachates from plants and exudates from macrophytes, can be important autochthonous sources of dissolved organic carbon, together with pore water from sediments. High bacteria biomass and bacterial production may therefore occur, leading respiration to exceed phytoplankton photosynthesis, and secondary production to be based on bacterial mobilization of preformed organic matter, rather than on contemporaneous phytoplankton photosynthesis (Gaedke and Kamjunke, 2006; Berglund et al., 2007).

Due to the complexity of interactions and the variety of stressors simultaneously occurring, the lagoon of Venice presents high variability in most environmental parameters and high habitat heterogeneity (Ravera, 2000). Indeed, different partitions have been proposed in order to identify homogeneous areas (Solidoro et al., 2004; Marchini and Marchini, 2006) and this aspect is still a matter of debate.

In this highly variable environment, the planktonic system is known to undergo complex spatial and temporal dynamics. In a recent paper Bandelj et al. (2008) indicate seasonality as the main ruler for successions of phyto-, protozoo- and metazooplankton assemblages and found river inflows, exchanges with the sea and benthic–pelagic coupling to be important in shaping those communities and defining their spatial distributions. Although a lot is known about the ecology of the largest planktonic fraction in the Lagoon of Venice (see for example Sorokin et al., 1996; Bianchi et al., 2003; Acri et al., 2004), the prokaryotic compartment have been largely neglected, being only sporadically studied (Sorokin et al., 1996, 2002) and mainly focussing on picocyanobacteria (Sorokin et al., 2004; Paoli et al., 2007). However, bacteria are known to play a very important role in the lagoon, as a bacteria-based food web can prevail for most of the year and the basis of the trophic web is more often sustained by prokaryotic production rather than by primary production (Pugnetti A., unpublished data). Furthermore, to the best of our knowledge, only one study took into account the structural composition of prokaryotic assemblages in the lagoon so far (Danovaro and Pusceddu, 2007) but it focussed on sediment communities.

In this study we examined the spatial and temporal dynamics of planktonic bacterial assemblages at four different sites in the Lagoon of Venice and we tried to identify the most important factors (e.g. seasonality, seawater or freshwater influence, organic load, etc.) which are implied in shaping such assemblages. Furthermore we

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tested the relationship between similar assemblages and the patterns of activities (prokaryotic carbon production and several hydrolytic activities) that they perform in order to establish if, in this highly variable environment, similar assemblages do behave in analogous ways.

2. Materials and methods

2.1. Study area

The Lagoon of Venice is a large Mediterranean lagoon with an area of ~500 km^2, located in the Northern Adriatic Sea (Fig. 1). It has an average depth of less than 2 m and it is morphologically characterised by the presence of large shallow areas and by a network of deeper (5–10 m) channels. It is connected to the Adriatic Sea by three inlets, through which tidal currents drive water exchanges. The tidal amplitude is ±100 cm, with maxima up to 150 cm. The lagoon can be classified as polyhaline (salinity between 18 and 30). Twelve main tributaries annually carry about 35 $m^3 s^{-1}$ of freshwater in the lagoon (Zuliani et al., 2005); nitrogen and phosphorus load are in the order of 4000 t N y^{-1} and 230 t P y^{-1} (Collavini et al., 2005). General circulation results from the superposition of tide, wind, and topographic control (Solidoro et al., 2004; Gačić et al., 2005), and the effective renewal of water is on the order of a few days for the area closest to the inlets and up to 30 d for the inner area (Solidoro et al., 2004; Cucco and Umgiesser, 2006). The four stations sampled in this study (Fig. 1) present some peculiar features: San Giuliano (SG) is highly affected by urban and industrial wastewaters; Marghera (M) is close to a petrol-chemistry plant and is interested by high heavy metals and aromatic polycyclic hydrocarbons concentration; Palude della Rosa (P) is subjected to high variations in salinity due to freshwater and marine inputs; Fanerogame (F) is the station mostly affected by marine inputs.

2.2. Analytical methods

Samples were collected at four stations (Fig. 1) in January, April, July and October 2005 at surface (~0.5 m), with horizontal 5 L Niskin bottles, at neap tide, in order to minimize the effects of tidal currents. Temperature, salinity and dissolved oxygen (DO) were measured with an Idronaut Ocean Seven 316 multiprobe. The water column was assumed to be well mixed, since the differences in surface and bottom salinity and temperature were minimal. Dissolved inorganic macronutrients (Dissolved Inorganic Nitrogen – DIN, silicate – S-SiO_4 and phosphate – P-PO_4) were determined according to Grasshoff et al. (1999) whereas chlorophyll *a* (Chl *a*) was determined spectrofluorometrically according to Holm-Hansen et al. (1965). Dissolved Organic Carbon (DOC) concentrations were measured using a Shimadzu TOC 5000 Analyzer with a 1.2% Pt on silica as catalyst at 680 °C, after filtration through glass fibre filters (GF/F, Whatman – Cauwet, 1994) and Particulate Organic Carbon (POC) concentrations were determined with a CHN Elemental AnalyzerFisons EA1108, after acidification with HCl (Nieuwenhuize et al., 1994) to remove the inorganic carbonate, with high reproducibility (<2%).

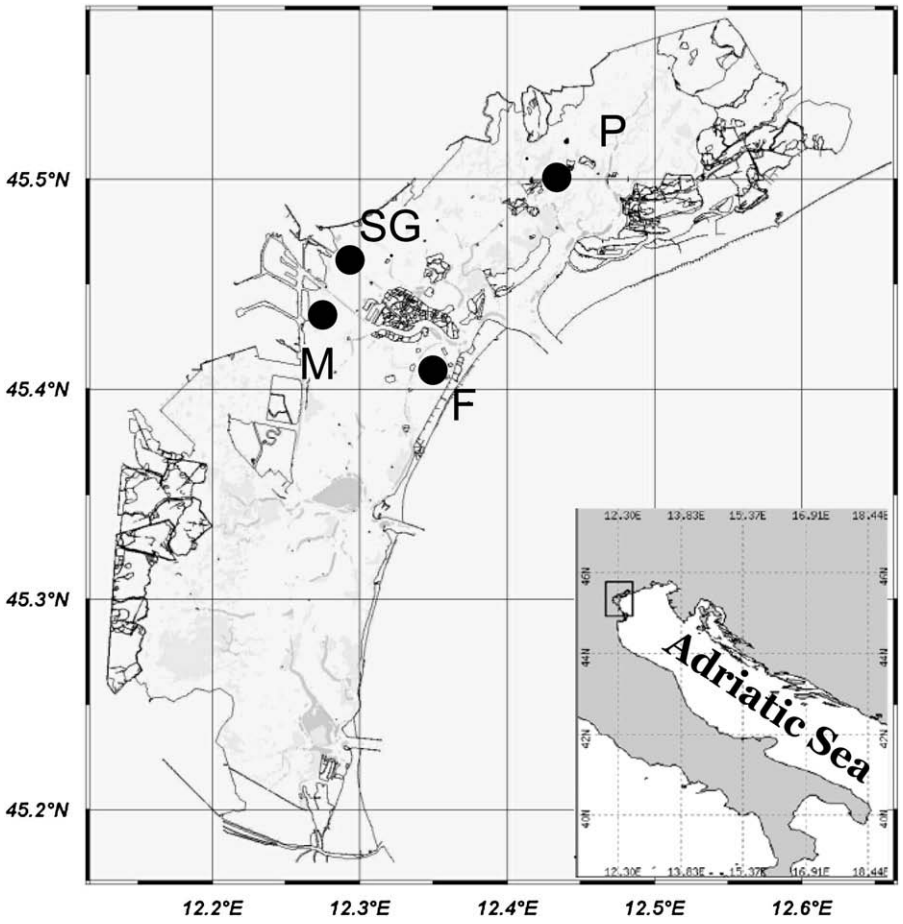

Fig. 1. The Lagoon of Venice and the four sampling stations. SG = San Giuliano; P = Palude della Rosa; M = Marghera; F = Fanerogame.