PHYTOPLANKTON PHOTOSYNTHETIC RESPONSES IN A HIGHLY DYNAMIC FRONTAL AREA (NORTHERN ADRIATIC SEA)

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Abstract
Photosynthetic parameters of phytoplankton assemblages in the frontal area off the Po river (Northern Adriatic Sea) were measured in different seasons. Changes in biomass concentrations and a high variability in phytoplankton photosynthetic capacity occurred on small spatial scales and were related to the notable differences in freshwater and nutrient discharge and in the complex circulation patterns of the Northern Adriatic.
Keywords : Adriatic Sea, Phytoplankton, Pigments, Primary Production.

Introduction
The northern Adriatic is among the most productive Mediterranean areas; the basin is one of those coastal ecosystems where seasonal and inter-annual variability of phytoplankton is mainly driven by the freshwater flow of major rivers(s) (e.g. [1], [2]). However, vast areas are essentially oligotrophic; phytoplankton biomass and primary production levels are relatively modest in the northern Adriatic as compared to other coastal embayments and estuaries with similar hydrological characteristics and/or nutrient inputs.

Material and Methods
From 1996 to 1998 seven oceanographic campaigns were carried out covering all seasons in the area off the Po River delta. Data on phytoplankton physiology is lacking for the Northern Adriatic Sea and the main aim of our study was to measure photosynthetic parameters in highly variable conditions ranging from eutrophic to oligotrophic areas, including a not well-understood frontal zone between them. CTD recordings were performed and size-fractionated chlorophyll a (Chla) concentrations were measured. HPLC analyses were performed for diagnostic pigments and degradation products. PvsE experiments were conducted on samples collected over the study area and at different depths. We discuss photosynthetic parameters taking into account phytoplankton size classes and the capacity of phytoplankton assemblages to respond to physical variations on small spatial scales.

Results and Discussion
The Po River strongly affects the thermohaline circulation in the area. Two different subsystems can be identified in a restricted area off the Po delta, separated by an ever-changing haline front. Recurrent algal blooms occur in the coastal area that is strongly influenced by the Po River, and low biomass characterizes the area outside the front. The different location of the frontal zone roughly coincided with the separation between diatom-dominated (fucoxanthin) and phytoflagellate-dominated (e.g.19'-hexanoiloxyfucoxanthin) areas. PvsE experiments showed a clear relationship between the physiological response of phytoplankton populations and the changing hydrographic conditions caused by variations in the Po River flow.
At surface in the coastal area, directly influenced by the river plume, the photosynthetic capacity varied tenfold, P^Bmax up to 20 mgC (mgChla)$^{-1}$h^{-1} was recorded, that is among the highest ever reported in marine systems, and comparable to values reported in land-locked ecosystems (e.g. $P^B{}_{max}$ =22, [3]). With the exception of such maximum value, the $P^B{}_{max}$ reported here are similar to those found in temperate coastal waters. At the offshore stations, $P^B{}_{max}$ between 2 and 9 mgC (mgChla)$^{-1}$h^{-1}, indicated that the phytoplankton assemblages of mainly small cells were well adapted to the low nutrient conditions of this area.
The variability in $P^B{}_{max}$ was much less pronounced in the subsurface layer where environmental conditions were more stable. No correlation was found between salinity and $P^B{}_{max}$; the light history is of major importance for phytoplankton photosynthetic performance.
Variations in PvsE parameters may be associated with differences in the size-structure and taxonomic composition of phytoplankton populations [4]. Our findings suggest some caution, however, as rapidly changing environmental conditions may not allow for the replacement of phytoplankton that are better adapted to the instantaneous conditions. In fact, high biomass and mainly large diatoms were occasionally associated with low photosynthetic performance suggesting accumulation at low hydrodynamic conditions. However, the Po delta area is characterized by discontinuous pulses of nutrient-enriched freshwater [5]. Thus any prediction of phytoplankton blooms and production in the Po delta area must be based on a physical model.
The relatively modest phytoplankton biomass reported in the eutrophic northern Adriatic may to some extent be due to the high but extremely unbalanced nutrient load being discharged into the area. Recurrent phytoplankton blooms are observed year-round in the Po river plume and accumulation of very high phytoplankton biomass occur inside the front. The phytoplankton turn-over rate may be very low due to the persistent vertical stratification of the water column and low grazing pressure as shown by the low phaeophorbid concentrations. At low Po River discharge the water circulation slows down in the plume area and nutrient limitation will occur imposing severe limits to the photosynthetic capacity of the phytoplankton.

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