LONG-TERM CHANGES OF PHOSPHORUS AND NITROGEN COMPOUNDS IN THE NORTHERN ADRIATIC SEA

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Abstract

This paper aims to synthesize 29 years of data on nutrient concentrations in the northern Adriatic (1966 to 1995). A significant long-term decrease in phosphorus concentrations was detected since the mid-1980's. From the beginning of the 1980's total inorganic nitrogen concentrations were usually higher than in the previous period. The observed changes could be related to changes of phosphorus and nitrogen concentrations in the Po River waters.

Key-words: phosphorus, nitrogen, Adriatic Sea

Introduction

Obtaining knowledge of long-term changes of nutrients is a basic step in verifying eutrophication trends in shallow marine ecosystems such as that in the northern Adriatic. Preliminary research suggests that this ecosystem is sensitive to the anthropogenic nutrient load (1). Consequently, changes of inputs may significantly affect the primary production of the region. The principal external source of nutrients in the region is the Po River (~75% of the total inputs; 1) the waters of wich markedly influence the composition and activity of the plankton community in the sea (2, 3).

Since 1966 the Center for Marine Research in Rovinj (CMR) has investigated various aspects of primary production, plant nutrient environment, and associated hydrography in the northern Adriatic. This extensive data set allows estimating the long-term "mechanism" controlling nutrient concentrations in this area.

Material and methods

Long-term changes of phosphorus and nitrogen were studied from a data set obtained in the period 1966-1995 at five stations along the Rovinj-Po River delta transect (Fig. 1). Measurements were performed monthly, or at least seasonally. A total of about 7000 data for phosphorus and nitrogen compounds were collected.

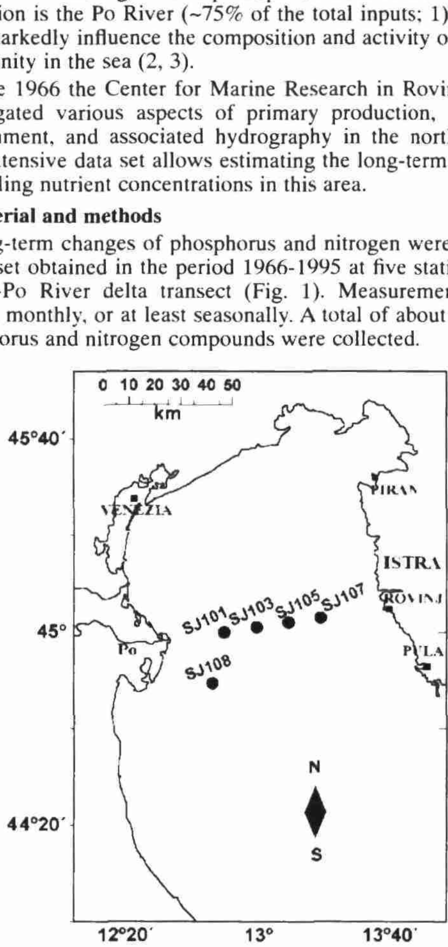

Fig. 1. Sampling stations in the northern Adriatic.

Water samples were collected with 5 l Niskin samplers from at least four depths (0, 10, 20 m and 2 m above the bottom). Nutrient analyses were performed aboard immediately after sample collection. Analyses were made by Beckman DU and Cecil CE 2040 spectrophotometers with methods widely used in oceanography (4)

Samples for total phosphorus were kept at -30°C for subsequent analyses ashore. Analyses were performed by chemical oxidation (before 1981) or UV-irradiation (after 1981) of samples (4). The results obtained for sea water samples using both methods were not different (5). Organic phosphorus was calculated as a difference between total phosphorus and orthophosphate values.

Data for the Po River discharge rate were kindly provided by Dr Alodi (Hydrological Office for the Po River in Parma), or originated from published sources (6). A total of 28000 data was collected.

Results and discussion

Based on the knowledge of seasonal cycles, data were grouped within five typical annual periods, each characterised by different prevailing hydrological (Po River discharge rates), oceanographic (stratification, circulation type) and biological (nutrient assimilation and regeneration) processes (7). During the period of July-August and December-January the Po River flow is minimal and, consequently, the data variability lower than in other periods. However, these two periods differ greatly. During summer the water column is highly stratified, and water exchange between the northern and central Adriatic is reduced compared to winter. During winter strong vertical mixing prevails. In this season the biological activity is minimal and assimilation and regeneration processes are approximately balanced. Contrary, during summer an active recycling of organic matter occurs in the upper water column, while in the bottom layer decomposition processes predominate.

The periods of February-April and September-November are characterised by higher variability, due to the increased freshwater input compared to winter and summer. However, these two periods are also substantially different. During February-April the stratification process starts. The weather conditions and imported nutrients favour phytoplankton blooms in the surface layer. An approximate equilibrium between assimilation and regeneration processes still persists through the remainder of the water column. In contrast, during September-November convective vertical mixing strongly reduces the water column stratification and brings into the upper layers nutrients regenerated in the deep waters. Regenerated nutrients, as well as "new" freshwater nutrients, stimulate phytoplankton blooms in the surface layer, while regeneration processes predominate in the bottom layer.

During May-June the freshwater input is maximal for the year, and the degree of stratification significantly increases. In the surface layer phytoplankton activity is maximal for the year, but regeneration processes start to occur in the bottom layer. Significant interannual concentration changes of phosphorus and nitrogen compounds in February-April and May-June, when the mean freshwater input is generally higher than in other seasons, can be related to the influence of the Po discharge. This influence combines both fluctuations of the discharge rate and nutrient concentration changes in the Po River waters. During February-April the freshwater input and orthophosphate (PO_4) and organic phosphorus concentrations in the sea were higher during the 1970's than in the 1980's (Fig. 2). Moreover, the most marked decrease of PO_4 and organic phosphorus concentrations in the sea was observed only since the mid-1980's, whereas the Po discharge rate during the 1980's did not change significantly (Fig. 2).

During May-June organic phosphorus concentrations in the surface layer were related to changes in the freshwater input (Fig. 3), but PO_4 concentrations were rather scattered. However, in the intermediate and bottom layers both organic phosphorus and PO_4 concentrations have decreased since the mid-1980's (Fig. 3).

Since the beginning of 1980's total inorganic nitrogen (TIN) concentrations in the surface layer were more frequently higher than previously and were independent of changes in the Po discharge rate (Figs. 2 and 3). In the intermediate and bottom layer TIN concentrations did not change significantly during the investigation period. The observed changes in phosphorus and nitrogen concentrations in the northern Adriatic may be related to composition changes of the Po