

PHOSPHORUS VERSUS NITROGEN LIMITATION IN THE MIDDLE ADRIATIC SEA

Ilija Vukadin* and Lambe Stojanoski

Institute of Oceanography and Fisheries (IOF) Split, Croatia - Vukadin@izor.hr

Abstract

This paper reports on a nearly 30 years seasonal survey to determine which nutrient limits primary productivity in the middle Adriatic Sea. Containing 1884 data points, the depth and temporal variation of the N/P ratio ranged from 2 to 305 with mean values ranging from 28 to 41. The reason for the high N/P ratio in the middle Adriatic Sea can be ascribed to phosphorus poor fresh water runoff and to more rapid utilisation of phosphorus by phytoplankton compared with nitrogen. In general, we assume that the large excess of N over P related to phytoplankton demand which results in phosphorus being, the limiting factor in middle Adriatic Sea.

Keywords: Nutrients, phosphorus and nitrogen, Adriatic Sea.

Introduction

As is well known, N and P are the basic elements of primary production which transport and cycling is an essential feature in the marine ecosystem. Although nitrate (NO₃-N) is generally considered to limit organic productivity in most of the world's oceans, previous studies have suggested the Adriatic Sea may be an exception. To determine which element (N or P) limits phytoplankton production in the middle Adriatic Sea, we present data of PO₄-P, NO₃-N and dissolved inorganic nitrogen, DIN, (NO₃+NO₂+NH₄), and offer a plausible explanation of the processes that may be important in controlling the observed limitation.

The Adriatic Sea is one of the most oligotrophic marine systems, and thus most of the nutrient inputs from Po River (over 75%, 1) and other smaller rivers, which are taken up close to the estuary and little reaches the open sea. Both inorganic N-salts and P-salts are depleted in the Adriatic Sea compared to the adjacent Mediterranean and other world seas. Several studies carried out in the Adriatic basin have shown that phosphorus is probably the principal limiting nutrient (1 - 3).

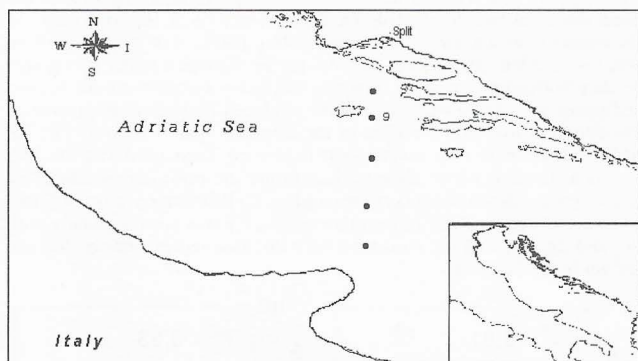


Figure 1. The study area with station, Stoncica-9, in the middle Adriatic.

Material and Methods

Research was carried out at one station in middle Adriatic Sea, (Stoncica-9) which is located on the Split-Gargano transect (Fig. 1). Data used in this paper span the period from 1970 to 1999 and were collected regularly on a monthly basis. The maximum station depth was 100 m. Cruises were performed monthly and samplings were carried out at standard oceanographic depths (0,5,10,20,30,50,75 and 100m). Basic hydrographic parameters, e.g. temperature, salinity, pH and oxygen content were determined on board immediately after sampling, while the nutrients were measured in the chemical laboratory in IOF-Split. Standard oceanographic methods were used. (4).

Results and Discussion

Various natural factors affecting the productivity of this area have been studied. Changes of hydrographic parameters were noted, i.e. water exchange between the Ionian and Adriatic Sea, as well as the climatic factors and influence of water from the northern Adriatic. Study of nutrient salt levels, changes in the annual cycle of plankton communities (5, 6) and concentrations of some physiological groups of heterotrophic bacteria have also been studied (7). An understanding of the mechanisms which control the nutrient relationship as well as competition for nutrients have been considered as one of the major mechanisms determining species dominance, and both the temporal and spatial succession in the phytoplankton community (3).

In this paper we report nearly 30 years of seasonal data, in order to determine which nutrient limited productivity in water of middle Adriatic Sea. In surface water layers (0 - 30 m) supersaturated with oxygen, values of DIN concentration range from 0.2 - 6.21 μM with a mean of 1.68±1.07 μM. Corresponding orthophosphate concentrations were 0.0 - 0.77 with a mean of 0.076±0.055 μM. In mid-depth and near-bottom

waters (50 - 100 m) undersaturated with oxygen, inorganic nitrogen ranged from 0.31 - 13.0 μM with a mean concentration of 1.95±1.8 μM DIN. The concentrations of inorganic phosphorus did not vary much with depth, and values over time ranged from 0.0 - 0.72, with a mean of 0.074±0.06 μM.

Table 1. Ranges (R) and mean values (\bar{x}) of relationship among dissolved inorganic nitrogen and orthophosphate (N/P), with standard deviation (sd) and number of analysed data (n) in two water layers at the station Stoncica-9 in the middle Adriatic Sea.

Season	Layers		N / P	Layers		N / P
Winter	0-30 m	R	2.0-183	50-100 m	R	5.6-305
		\bar{x} ±sd n	35.4±26 285		\bar{x} ±sd n	41.2±42.5 178
Spring	0-30 m	R	2.3-305	50-100 m	R	2.5-201
		\bar{x} ±sd n	36±35 288		\bar{x} ±sd n	33.8±30 180
Summer	0-30 m	R	1.5-116	50-100 m	R	2.7-101
		\bar{x} ±sd n	27.8±18.4 335		\bar{x} ±sd n	30.4±17.2 206
Autumn	0-30 m	R	2.1-179	50-100 m	R	1.8-151
		\bar{x} ±sd n	28.5±22 224		\bar{x} ±sd n	36.7±26.6 148

Based on the 1884 data points, the depth and temporal variation of the N/P ratio ranged from 2 to 305 with mean values ranging from 28 to 41 (Table 1). Statistical analyses show that during the investigated period, roughly 11% of the values lay below 16:1, and 2% below 5:1. If one accepts the concept of Redfield's ratio being indicative of nutrient limitation (8), then the limiting factor would have been nitrogen in less than 40 cases, and phosphorus in 1650 cases based on all data. The difference is the cases where either phosphorus or nitrogen would have been limiting. Krom *et al.* (9) found an unusually high nutrient ratio in the eastern Mediterranean and attributed this to the removal of P from water column by inorganic processes, i.e. adsorption on to Fe-oxyhydroxides. The reason for the high N/P ratio in the middle Adriatic Sea can be ascribed to phosphorus-poor fresh water runoff and to the more rapid utilization of phosphorus by phytoplankton compared to nitrogen. The N vs. P relationship was similar during all seasons and in both water layers. There were no any significant differences with respect to depth. In general, we assume that the large excess of N over P is related to phytoplankton demand which maintains phosphorus as the limiting factor in the middle Adriatic Sea.

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