ENVIRONMENTAL CONDITIONS AND PHYTOPLANKTON IN A STRATIFIED ESTUARY OF THE OMBLA RIVER. SPRING AND SUMMER

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Abstract

The low salinity surface and saline bottom layers were delimited by a sharp halocline in the Ombla River estuary during spring and summer. Maximum nutrient values were found in the surface layer, excluding ammonia. The first peak of microphytoplankton and nanophytoplankton cell numbers and chlorophyll a concentrations was noted at the end of May, when temperatures reached 22.45°C. The second peak of microphytoplankton and nanophytoplankton cell numbers was noted at end-August, coinciding with the annual minimum of freshwater runoff and with the stabilization of thermohaline conditions. There were no significant differences in the nutrient concentrations during both phytoplankton peaks.

Key words: hydrography, stratification, phytoplankton, estuaries, Adriatic Sea

Introduction

The spring of the Ombla River is located on the Adriatic coast near Dubrovnik. The spring discharges at sea level, forming the Ombla River, and almost immediately flows into the sea to form a small, 4-km long, highly stratified estuary. The estuary's upper reach is about 6 m deep, while the lower reach is up to 25 m deep. Highly stratified estuaries are typical of areas where high volumes of river discharge combine with low tides (1). Such phenomena are well-known throughout the Mediterranean and along the eastern Adriatic coast. Estuaries are highly productive habitats and dynamic nutrient transformation zones at the interface between freshwater and marine environments (2). The physico-chemical and ecological processes at the contact zone of karstic and sea waters are generally unknown, representing an attractive area of investigation. This paper aims to determine the environmental conditions, phytoplankton abundance and taxonomic structure of the Ombla River during the period of rising and quite constant water temperatures.

Material and methods

Samples for the analysis of hydrographic, chemical and biological parameters were collected at station Ombla-2, maximum depth of 12 m, during nine cruises from March to August 2000. Water samples were taken every two meters, from surface to bottom. Parameters were determined by standard oceanographic methods (3, 4, 5). The data were processed with analysis of variance (ANOVA) and SNK tests (6).

Results and discussion

The Ombla River discharge varied from 6.8-49.1 $m^3 s^{-1}$ during this period. A sharp halocline, frequently at 2-4 m depths, delimited the low salinity surface and saline bottom layers. Table 1 summarizes the physical and chemical properties of both two layers. Maximal nutrient values, excluding ammonia, were found in the surface layer. For most nutrients, the great differences between minimum-maximum values and the lower-upper quartile, as well as the mean and median, indicate the existence of extreme values, the so-called "outliers". These differences are the most pronounced for NO_3 and SiO_4, especially in the surface layer ($P<0.001$).

No significant differences in temperature existed between layers. Temperatures rose from March to end-May and were more or less constant until September. The surface layer salinity differed significantly with that of the bottom layer. The oxygen saturation of both layers indicated a good aeration. Secchi disc transparency varied between 5-8 m depths. A lowest transparency occurred at the end-May and end-August. It must be mentioned that nutrient concentrations in the surface layer oscillated much more than in the bottom layer. Following high nutrient values in the surface layer in March, the April values showed a concentration minimum for TIN and PO_4, and a concentration maximum for SiO_4. A probable explanation for these nutrient patterns in April could be an increase in MICRO cell number just above the halocline. In both layers, most of the MICRO population (>90%) was made up of the coccolithophorids *Syracosphaera pulchra* and *Calyptrosphaera oblonga*, and the dinoflagellate *Scrippsiella trochoidea*.

The first, greater, peak of MICRO cell numbers and Chl a concentrations, including a NANO peak occurred during end-May, a time when temperatures in both layers reached their high rising value, and when nutrient concentrations in the surface layer were high. The MICRO population in both layers was mostly composed of dinoflagellates (>89%), mainly the species *Prorocentrum triestinum* (max. 1.3 x 10^5 cells l^{-1}), whose intensive development has been noted before in this estuary during May (7). The contribution of dinoflagellates was mostly greater in the surface than in the bottom layers. A second, lower, MICRO peak and a greater NANO peak appeared at end-August, during a period of stable thermohaline conditions in the surface layer. In this layer, most of the MICRO population (>85%) was made up of the dinoflagellates *Scrippsiella trochoidea* and *Prorocentrum triestinum*, and the euglenophyte *Eutreptia lanowii*. In the bottom layer, the species *Oxytoxum sceptrum, Dinophysis acuminata* and *Ceratium pentagonum* were found alongside the species *Prorocentrum triestinum*.

According to our results, the intensive development of phytoplankton in May and August was strongly related on temperature and elevated nutrient concentrations.

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Table 1. Physical and chemical characteristics of the seawater in the estuary of the Ombla river.

SURFACE	Temperature	Salinity	O_2/O_2'	c(NO_3)	c(NO_2)	c(NH_4)	c(PO_4)	c(SiO_4)
MIN-MAX	13.60-23.50	25.59-37.07	0.73-1.16	0.34-7.71	0.02-0.11	0.35-1.27	0.03-0.21	1.99-16.78
Mean	20.15	33.10	1.05	3.02***	0.06	0.63	0.09	5.91***
STD	3.15	3.93	0.11	2.56	0.02	0.27	0.05	3.81
Low-Upp Q	18.61-22.43	30.31-36.19	1.01-1.12	1.18-4.94	0.05-0.07	0.41-0.71	0.05-0.12	3.13-7.21
MEDIAN	21.37	34.73	1.09	2.10	0.06	0.57	0.08	5.27
BOTTOM								
MIN-MAX	13.04-23.1	36.12-38.60	0.56-1.12	0.04-1.90	0.02-0.09	0.29-1.48	0.02-0.14	0.76-3.78
Mean	19.19	37.77***	1.03	0.38	0.05	0.63	0.05	2.11
STD	3.35	0.63	0.11	0.38	0.02	0.27	0.03	0.87
Low-Upp Q	18.22-22.10	37.39-38.30	0.98-1.08	0.15-0.49	0.03-0.06	0.42-0.74	0.03-0.07	1.42-2.70
Median	20.19	37.86	1.03	0.21	0.05	0.62	0.04	2.02

*(MIN-MAX) - range, (STD) - standard deviation, (LOW-UPP Q) - lower-upper quartile, (c) - µmol dm^{-3}, (O_2/O_2') - oxygen saturation The means in the same column followed by *** are significantly different $P<0.001$ (ANOVA, SNK-test).*