DETERMINATION OF LIMITING NUTRIENT FOR PHYTOPLANKTON GROWTH IN THE OMBLA ESTUARY

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Abstract
The method of determining the limiting nutrient for phytoplankton growth in estuarine waters, at any salinity, was applied for the Ombla estuary. The results indicate that P is a limited nutrient at any salinity along the longitudinal axis of the estuary, except at higher salinities (salinity values $\geq$38.4), when there is a transition from P to N limitation.
Keywords : Estuaries, Phytoplankton, Salinity.

Introduction
The spring of the karstic 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 in depth, while the lower reach is up to 25 m depths. The discharge measurements of the Ombla River show that the average outflow equals 26 m^3s^{-1} (discharge varies between 2.3 and 112 m^3s^{-1}).The scope of this paper is to determine which nutrient might be responsible for the limitation of phytoplankton growth along the longitudinal section of the Ombla estuary, at any salinity.

Results and discussion
Samples for the analysis of hydrographic, chemical and biological parameters were collected bi-weekly (1999/2000) at three stations (Ombla 1, Ombla 2, Ombla 3) along the estuary. Temperatures rose from March to end-May and were more or less constant until September. In October, the water column began to cool, especially in the surface layer. A sharp halocline persisted throughout the year and delimited the low salinity surface layer, as well as the saline bottom layer. Salinity in the surface layer throughout the estuary oscillated from 9.68 - 37.54. The salinity in the bottom layer was quasi constant throughout the year, with most values around 38 and a range from 33.3 - 38.88. Forty per cent of the samples had salinity values $\geq$38.4. Oxygen saturation indicated good aeration, with most saturation values at around 1. The concentration of all nutrients decreased throughout the estuary for most of the year. Maximal nutrient values, excluding ammonia, were found in the surface layer. The nutrient concentrations in the surface layer oscillated far more than in the bottom layer, especially total inorganic nitrogen TIN=(NO_3+NO_2+NH_4) and SiO4. TIN and PO_4 are the main forms of N and P that are readily bio-available for phytoplankton growth and these have a Redfield atomic ratio of N:P=16:1. In the Ombla estuary the Redfield ratio values were appropriate for phytoplankton growth from April to August. The Redfield ratio increased throughout the estuary, almost due to decreased PO_4 concentrations (<0.01 μmol dm^{-3}). The method of determining the limiting nutrient for phytoplankton growth in estuarine waters, at any salinity, is based on nutrient ratios in the water, using overlaid graphs for nutrients vs salinity [1]. This method was applied for the Ombla estuary, using TIN vs salinity and PO_4 vs salinity. The results (Fig.1) indicate that P is limited nutrient at any salinity along the longitudinal axis of estuary, except at higher salinities (salinity values Âş38.4), when there is a transition from P to N limitation (the trendlines for N and P intersect at salinity $\geq$38.4). Two peaks of microphytoplankton (cells longer than 20 μm, MICRO) were noted throughout the year. The first peak of MICRO occurred during end-May. The population was composed mostly 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, [2]. A second peak appeared at end-August. 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* [3].
The phytoplankton abundance decreased along the estuary, as well as throughout the water column [4]. Phytoplankton abundance was greater at lower salinity and maximal 2.8 x 10^5 cells L^{-1} was found at a salinity 29.21. P is a limiting nutrient throughout the Ombla estuary, and N may become a limiting nutrient at salinity values $\geq$38.4. A lower phytoplankton abundance at higher salinities is probably caused by N limitation in this estuary.

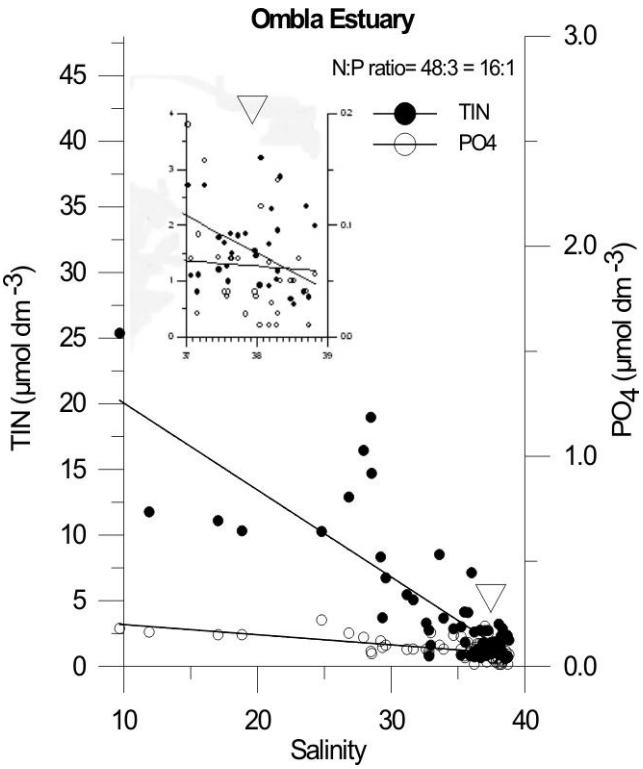

Fig. 1. Overlaid nutrients vs salinity graph for the Ombla estuary.

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