UPWARD NUTRIENT FLUX IN THE WESTERN MEDITERRANEAN SEA

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SUMMARY

In large areas of the worlds oceans, mainly in tropical and subtropical zones, the surface layers are poor both in phytoplankton and nutrients while at some depth a large phytoplankton biomass may be found as nutrients become significant. Deep Chlorophyll Maximum (DCM) and Subsurface Chlorophyll Maximum (SCM) are terms often used in this context which probably refer to various phenomena. The depth at which DCM and SCM occur varies from 30 m to 75 m though sometimes it may be between 75 and 125 m. In the Western Mediterranean, a DCM is usually found during summer below 70 m. In most cases the DCM is a permanent feature in time.

DCMs have often been related to phytoplankton biomass maxima while no direct relationship has been found between chlorophyll maxima and photosynthesis maxima. They are always related to the "nutricline" and more specifically to the "nitracline", a region in which nitrate concentrations increase from 0.1 µg-at/l (often below detection limits) to values ranging from 1 to 5 µg-at/l. Oxygen and nitrite maxima are connected with the DCM but little has been said about the fine tuning between all these signals.

Changes in Phytoplankton carbon/Chlorophyll-a ratio with depth and in settling velocity of sinking phytoplanktonic cells when they reach the nitrate-rich waters or lack of grazing pressure due to the smallness of phytoplankton cells may contribute to the DCM formation. Lack of vertical turbulence is required at the DCM levels, although vertical motions could be a way of exposing the population to higher light levels. The need for a stable thermocline is obvious but often there is no connection between the thermocline and the nutricline. Self shading by phytoplanktonic cells may be important in controlling the DCM depth. Thus the greater the chlorophyll concentrations the shallower the DCM should be.

Theoretical considerations indicate that DCM may be explained in terms of upward flux of nutrients, light penetration and grazing pressure. A highly efficient DCM phytoplankton population may be responsible for all the "new" production and also for maintaining most of the "regenerated" production of the surface layers.

THE ROLE OF SEDIMENT NUTRIENT REGENERATION IN THE EUTROPHICATION OF THE VENICE LAGOON

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ABSTRACT

Nutrient exchange at the sediment-water interface and primary production dynamics in the Venice Lagoon were studied during 1984 and 1985. Very marked gradients were observed due to heavy eutrophication impact. Regeneration and release from the sediment varied significantly seasonally and may play an important role in controlling nutrient concentration in the shallow water column.

RESUME

L'échange des sels nutritifs à l'interface eau-sediment et la dinamique de la production primaire ont été étudiés dans la lagune de Venise en 1984 et 1985. Les gradients de concentration sont très marqués et sont causés par une intense eutrophisation. La régénération dans le sediment peut jouer un rôle important pour la concentration et la distribution des sels nutritifs dans la colonne d'eau.

INTRODUCTION

The lagoon of Venice is an enclosed embayment (550 km², avg. 1 m depth) in the northwestern Adriatic connected with the open sea through three narrow port entrances. The quality of the lagoon habitat is being seriously compromised by the development of contrasting human activities, and eutrophication is very intense. Regeneration in the sediments may represent an important source of nutrient for eutrophication processes (Degobbis et al., 1986a).

In this paper results on nutrients, phytoplankton primary production, and nutrient exchange rate at the sediment-water interface obtained in the Venice Lagoon are briefly described and discussed.

METHODS

The research was performed at 15 stations distributed in three areas selected in the central part of the lagoon to cover a eutrophication gradient. Area A, located between the industrial area of the Porto Marghera and the Venice historical center is the most heavily polluted. Area B, extending sourthward of Venice, is mainly influenced by the sewages of the city. Area C, behind the Lido port, is in close communication and directly exchanges its water with the open northern Adriatic Sea. The measurements were performed during 9 seasonal cruises in 1984 and 1985. Sampling, oceanographic parameters and nutrient analyses in water and sediments, as well as in situ measurements of the sediment nutrient exchange rate were described elsewhere (Degobbis et al., 1986b).

RESULTS AND DISCUSSION

High chemical and biological gradients were observed in the Venice Lagoon between the three investigated areas (Table 1).

TABLE 1

Parameter*	Concentration Ranges A	B	C
Lagoon water			
t/°C	5.3-26	5.8-25.9	4.7-22.4
$s \times 10^3$	21.0-33.8	28.4-34.1	25.5-34.4
DO/% sat.	57-229	61-165	70-133
c(RP)/mmol m^{-3}	0.6-55.3	0.1-3.0	0.0-2.0
c(TIN)/mmol m^{-3}	3-174	2-58	4-52
c(Chl a)/mg m^{-3}	0.1-51	0.1-49	0.1-2.0
PP (^{14}C)/mg m^{-3} h^{-1}	0.4-186	1.0-42	0.8-20
Interstitial water			
c(RP)/mmol m^{-3}	1.6-37	0.7-147	0.8-20
c(NH_4)/mmol m^{-3}	14-216	26-296	4-120

* t-temperature, s-salinity, DO-dissolved oxygen saturation, c(RP)-reactive phosphorus, c(TIN)-total inorganic nitrogen, and c(Chl a)-Chlorophyll a concentrations, PP-primary production (^{14}C uptake rates)

The nutrient concentrations were much higher in area A, and were at a maximum, particularly the nitrogen species, both when salinity was at a minimum (e.g. in October) and when biological utilization were negligible (e.g. in February). However, in spring and summer the inorganic nitrogen concentrations can be reduced by two orders of magnitudes to almost zero values during algal blooms.

The reactive phosphorus (RP) concentrations although reduced in April remained relatively high in area A throughout the year. Indeed, in summer it tended to increase again (up to 55 mmol m^{-3} in July 1985). However, in the other two areas, particularly in area C, the concentrations of this nutrient were always very low. Comparing RP values between the lagoon and interstitial water of the surface sediments revealed similar spatial and temporal trends. Exchange of phosphorus between the interstitial and the overlying waters may be the mechanism by which the sediments control, to a large extent, the reactive phosphorus content of lagoon waters.

Nutrient release rate from the sediments also varied seasonally. In June, July and October nutrient releases occurred at detectable rate (up to 24 and 1.6 mmol m^{-2} d^{-1} for TIN and RP, respectively). In February and April no significant release was observed. The seasonal cycle of the organic matter is probably the most important process driving nutrient exchange at the sedimet-water interface.

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