SEASONAL VARIATIONS OF THE NO3:PO4 RATIOS IN THE NORTHWESTERN ALBORAN SEA

T. Ramírez *, D. Cortés, J. Mercado, M. Vargas-Yáñez and M. Sebastián

Instituto Español de Oceanografía. Centro Oceanográfico de Málaga. Puerto pesquero s/n, Apdo. 285, 29640 Fuengirola, Malaga, Spain
* teodoro.ramirez@ma.ieo.es

Abstract

Seasonal variations of nutrient concentrations were studied in the northwestern Alboran Sea during 2002. On overall, the average NO_3^-: PO_4^{3-} ratios in the upper layers were lower than the Redfield ratio throughout all the year, indicating a NO_3^- deficiency relative to PO_4^{3-}. NO_3^- was removed to undetectable levels, particularly in summer and autumn, while PO_4^{3-} concentrations of ~0.15 µM remained unutilised. In contrast, in the deeper layers the N:P ratio was on average higher than 16:1, indicating a PO4 deficiency relative to NO_3^-. The mean N:P ratio for all data from the slope of NO_3^- vs. PO_4^{3-} was 23.78.

Key words: nutrients; ratio NO_3^-: PO_4^{3-}; Alboran Sea.

Introduction

The Alboran Sea has been object of a great number of studies on physical oceanography and mesoscale processes, however the number of works dealing with nutrients is scarce, particularly in the continental margin. In addition most of these studies has been carried out during spring or summer, when the weather conditions are more favourable. Therefore there is a lack of information about the seasonal cycles of nutrients in this area and their role on primary production. In a very simple approach the Alboran Sea could be considered as a two layer system, with the upper layer being occupied by the Atlantic Waters AW (more and less modified). Below this layer saltier Mediterranean waters flow towards the Gibraltar Strait (1). The Atlantic Water entering the Alboran Sea is depleted in nutrients (2), and the molar proportions of N:P are considered to be similar to that of Redfield (3) in the Atlantic side of Gibraltar, while they are lower than 16:1 in the layer of Atlantic water in the Alboran Sea (2). However, a recent study indicated that the N:P ratio in the Atlantic layer on the western side of Gibraltar was lower than 16:1 (4), indicating a deficiency of NO_3^- relative to PO_4^{3-}, while the in the eastern side of Gibraltar the AW were deficient in PO_4^{3-} (4) as occur in other areas in the Eastern Basin and in the NW Mediterranean (5).

The aim of this study is to analyse the seasonal variations of nutrient concentrations in the continental margin of the northwestern Alboran Sea, analysing the seasonal variations of the N:P ratios and their departures from the theoretical ratio of Redfield N:P (16:1). The sampling was carried out in February, April, July and October 2002, at 24 stations situated in six transects off the coast of Málaga (South of Spain). Seawater samples were taken at different depths with Niskin bottles, down to a maximum depth of 300 m. Nutrient analysis were carried out in a Bran-Luebbe AA3 autoanalyser.

Results

On overall, the highest concentrations of nutrients in the surface layers were found during the April cruise, coinciding with a generalised increase of salinity that was caused by upwelling events. During this season the mean concentrations in the top 20 m were 2.54 µM NO_3^-±1.98 (SD) and 0.21 µM PO_4^{3-}±0.76 (SD). In contrast, the lowest concentrations in the upper layers were found during the summer cruise. During this season a strong pycnocline was developed due to the combined effect of the seasonal thermocline and a marked halocline, the latter due to the intrusion of fresh Atlantic Waters (AW) with salinities lower than 36.5 psu. Thus, in most of the stations NO_3^- concentrations were below the detection limit (<0.05 µM). At those stations where NO_3^- was detected, the mean concentration in the upper 20 m was 0.24 µM±0.36 (SD). The mean PO_4^{3-} concentration in the top 20 m during this season was 0.13 µM±0.04(SD). In the deeper waters, 100-300 m, the lowest nutrient concentrations were observed in spring, while the higher concentrations were found in autumn. The vertical profile of nutrient concentrations suggested the occurrence of intense remineralisation processes in the water column during summer and autumn, leading to a relative maximum of PO_4^{3-} at 75 m and an increase of nutrient concentrations below the thermocline.

The mean N:P ratios in the upper layers (top 20 m), during all the cruises, were lower than the classical Redfield ratio of 16:1, indicating that there was a deficiency of NO_3^- relative to PO_4^{3-}. The lowest N:P ratios were detected during the summer, ranging from<0.32 to 5.15, with a mean of 1.28±1.51 (SD). During the summer and autumn cruises PO_4^{3-} concentrations ~0.15 µM were detected whereas NO_3^- levels dropped below the detection limit. In contrast, during the spring cruise the N:P ratios were closer to the Redfield ratio, due to the upwelling of deeper waters, with a higher N:P ratio. The N:P ratios in the top 20 m during the spring ranged from <0.32 to 16.69, with a mean of 9.19±5.87.

The N:P ratio increased with depth, reaching in general a maximum value at 200 m. In general, the N:P ratios of the deeper waters (200-300 m) were higher than 16:1, indicating a PO_4^{3-} deficiency relative to NO_3^-. The plot of NO_3^- vs. PO_4^{3-} concentrations for all the data gives a slope of 23.78, while the mean N:P ratio at 200-300 m was 18.99±2.32 (SD), which is slightly lower than the mean N:P ratios reported for the deep Mediterranean waters ~22-24 (3). The higher N:P ratios in the deep waters were found in spring 20.49±0.97 (SD), while the lowest values were found in autumn 17.63±1.41(SD). The low values of the N:P ratio found during the autumn cruise was due to the increase in PO_4^{3-} caused by remineralisation processes in the water column.

In general, the low NO_3^- concentrations observed during winter, summer and autumn, together with the low N:P ratios during all the cruises suggest that new primary production, in the northwestern Alboran Sea, could be potentially limited by NO_3^-. This NO_3^- deficiency would favour the development of phytoplankton communities based on recycled nutrients within the photic layer. This is consistent with a change in the phytoplankton community assemblages in the Northwestern Alboran Sea that has been observed to occur from 1994 to 2001 (6).

References

1 - Parrilla G., and Kinder T., 1987. Oceanografía física del Mar de Alboran. *Bol. Inst. Esp. Oceanogr.*, 4(1): 133-166.

2 - Minas H.J., Coste B., Le Corre P., Minas M., and Raimbault P., 1991. Biological and geochemical signatures associated with the water circulation through the Strait of Gibraltar and in the Western Alboran Sea. *J. Geophys. Res.*, 96(C5): 8755-8771.

3 - Bethoux J.P., Morin P., and Ruiz-Pino D., 2002. Temporal trends in nutrient ratios: chemical evidence of Mediterranean ecosystem changes driven by human activity. *Deep Sea Res.*, II, 49: 2007-2016.

4 - Dafner E.V., Boscolo R., and Bryden H.L., 2003. The N:Si:P molar ratio in the Strait of Gibraltar. *Geophys. Res. Lett.*, 30(10): 1506

5 - Krom M.D., Kress N., and Gordon L.I., 1991. Phosphorus limitation of primary productivity in the eastern Mediterranean Sea. *Limnol. Oceanogr.*, 36(3): 424-432.

6 - Mercado J.M., Ramírez T., Cortés D., Sebastián M., and Vargas-Yañez M., 2003. Temporal changes in phytoplankton communities in a upwelling area of the Alboran Sea. *J. Plankton Res. (submitted)*