NITROGEN FIXATION, PRIMARY AND BACTERIAL PRODUCTIVITY RATES IN TWO DISTINCT WATER PROVINCES IN THE LEVANTINE BASIN

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Abstract
Nitrogen fixation, bacterial and primary productivity rates were measured along an 12 eutrophication gradient at two distinct provinces in the Levantine basin: the Shikmona 13 gyre (SG) and the Rhodes gyre (RG). Primary productivity in the euphotic zone ranged 14 from 0.37 mmol C m-3 d-1 for oligotrophic SG to 1.67 mmol C m-3 for moderately 15 mesotrophic RG. Bacterial productivity ranged between 0.08 µg C L-1 d-1 at surface and 16 5.11 µg C L-1 d-1 at the bottom depths of the SG, while the RG showed extremely high 17 rates, ranging from 6.3 to 87.8 µg C L-1 d-1 at the surface and bottom, respectively.
Keywords: Levantine Basin, Nutrients

The Levantine basin in the east Mediterranean Sea is one of the most oligotrophic, low nutrient low Chlorophyll (LNLC) seas especially during stratification periods. The deep waters of the Levantine basin have an anomalousy high nitrate to phosphate ratio (DIN:DIP) (28:1) and all its input sources, particularly atmospheric sources ([1]), show a high N:P ratios (>16:1) ([2]). In addition, its P turnover time (<5h, 26 [3]) is typical for P deficient water systems. Thus, it is expected that these properties do not favor significant N-fixation rates. Indeed, routinely monitored stations in the ultraoligotrophic waters off the Israeli coast (2006-2008), showed extremely low or undetectable rates of N-fixation (0-1.3 nmol N L-1 d-1) (Yogev et al., - in prep). Low N2 fixation rates were also recorded in the Gulf of Aqaba, Red Sea, during fall (stratified, oligotrophic) and spring (deep mixing, mesotrophic) seasons with maximum rates of 1 ± 32 0.1 nmol N L-1 d-1 in the fall and 1.9 ± 0.2 nmol N L-1 d-1 in the spring ([4]).

Theoretically, nitrogen fixers (i.e., large colonial cyanobacteria in the genus *Trichodesmium* and the heterocystous endosymbiont *Richelia*) could prosper in environments which supply phosphorus and iron to feed the energetic and enzymatic demands for the Fe-rich nitrogenase and N fixation process. Such conditions may occur along a eutrophic gradient in specific areas in the Levantine Basin. Indeed, an order of magnitude higher N fixation rates were measured in Haifa bay during May 2009 (8 nmol 40 N L-1 d-1) representing a more mesotrophic environment. To understand the factors controlling this process we explored N fixation rates, primary and bacterial production in two distinct water provinces in the Levantine basin, the ultra-oligotrophic Shikmona Gyre and the mesotrophic Rhodes Gyre.
The Shikmona gyre (SG), also referred to as the Cyprus eddy, is a warm-core eddy with an anti-cyclonic circulations patterns and is characterized with nitrate and phosphate values close to the conventional analytical detection limits in the surface waters (a few nanomolars during stratified period, [5]), development of deep chlorophyll maximum (125 m) and low values of primary productivity (0.37 mmol C m-3 d-1). TheRhodes gyre (RG) is a cyclonic feature of the eastern Mediterranean circulation and characterized with constant upwelling with relatively high nitrate and phosphate concentration at surface (0.2 µM and 0.02 µM, respectively), shallow chlorophyll maximum (60 m) and relatively higher rates of primary productivity (1.67 mmol C m-3 d-53 1).

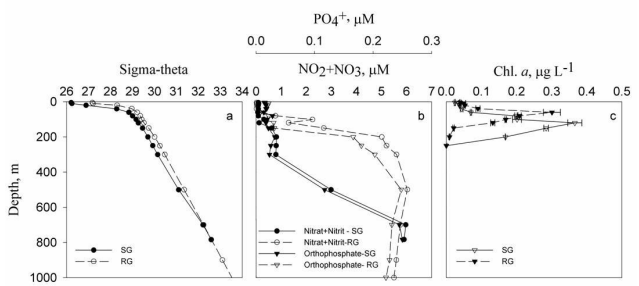

Fig. 1. Depth profiles measured during July 2009 from the Shikmona and Rhodes gyres showing changes in water density (a), dissolved concentrations of nitrate+nitrite and orthophosphate (b) and concentrations of extracted Chlorophyll *a* (c)

Water was collected on July 2009 at the above locations onboard the R/V 55 Mediterranean Explorer, during the ISRLEV cruise. Rates of nitrogen fixation were measured on field samples using the 15N2 assimilation technique ([6]). Bacterial production was estimated using 3H-Leucine (Amersham, Specific activity: 160 Ci/mmol) incorporation method ([7]). Photosynthetic carbon fixation rates were estimated by means of the 13C technique ([8]).

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