UNCOUPLING BETWEEN DINITROGEN FIXATION AND PRIMARY PRODUCTIVITY IN THE EASTERN MEDITERRANEAN SEA

E. Rahav [1], B. Herut [2], . Stambler [1], E. Bar-Zeev [1], M. R Mulholland [3] and I. Berman-Frank [1]*
[1] Bar Ilan University, - ilana.berman-frank@biu.ac.il
[2] Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa., Israel
[3] Department of Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, Virginia, USA

Abstract

We measured dinitrogen (N_2) fixation and primary productivity (PP) during the stratified summer period in different water regimes of the Eastern Mediterranean including the Cyprus Eddy (CE) and the Rhodes Gyre (RG). Low N_2 fixation rates were measured throughout the basin excluding 10 fold higher rates in the RG and CE. Corresponding PP increased from east to west with relatively higher productivity recorded in the RG and CE. These measurements demonstrate that N_2 fixation in the photic zone contributes only negligibly by direct inputs to PP (i.e. cyanobacterial diazotrophs) and is in fact uncoupled from PP. In contrast, N_2 fixation was significantly coupled to bacterial productivity (BP) and to net-heterotrophic areas suggesting that heterotrophic N_2 fixation may in fact be significant in this ultraoligotrophic system.

Keywords: Cyanobacteria, Phytoplankton, Primary production, Bacteria, Levantine Basin

N_2 fixation controls total nitrogenas the supply of new nitrogen (N) to the N poor surface waters of the ocean by diazotrophs usually stimulates both the autotrophic and heterotrophic communities of the planktonic and microbial food webs [2]. Thus, N_2 fixation should be positively correlated to PP in two ways: 1) Directly, via photoautotrophic diazotrophs currently assumed to be the dominant component of the diazotrophic community in the photic zone with sunlight providing the required energy for the energetically expensive process of N_2 fixation. 2) Indirectly via the contribution and recycling of the products of this “new N” (i.e. either assimilated N; ammonia leakage, breakdown of diazotrophic blooms, etc.) stimulating PP by non-diazotrophic photoautotrophs. In this study we evaluated the contribution and relationship of N_2 fixation from the photic layer to PP in different water provinces of the Eastern Mediterranean. To this end we measured *in-situ* N_2 and carbon fixation from different depths within the photic zone and performed on-board microcosm experiments in 11 different locations throughout the Levantine basin, including the cyclonic RG and anti-cyclonic CE, over 3 consecutive years (2007-2009) during the stratified period. Measured PP rates across the Levantine basin revealed an east-west gradient with lowest values at the easternmost stations getting progressively higher toward the western Levantine stations (~200 and > 2000 µmol C m^{-2} d^{-1} respectively). In contrast, areal N_2 fixation rates did not exhibit the spatial trend observed for PP and were low throughout the whole basin (0.8 to 3.2 µmol N m^{-2} d^{-1}), except for the CE and RG where rates higher by an order of magnitude were measured (~ 20 µmol N m^{-2} d^{-1}). Furthermore, the percent contribution of the biologically fixed N to PP ranged from 0.7 to 2 % (n=96) except for both gyres (> 6 %, n=24). Our results show that during the stratified period, excluding the RG and CE, N_2 fixation was uncoupled from PP across the Levantine basin (P= 0.3, n= 19, Figure 1), which contrast studies from varying oceanic regions demonstrating a positive correlation of PP with N_2 fixation in the photic illuminated layer under stratified conditions (R^2= 0.54, P = 2 x 10^{-6}, n= 26). This uncoupling in the Eastern Mediterranean may be explained by examining the characteristic composition and structure of the pelagic primary producers and the resulting microbial food web. We suggest that in this system, where heterotrophic bacteria compete with the primary producers for the limited nutrients [3], heterotrophic N_2 fixation can be significant and may extend also deep into the aphotic depths.

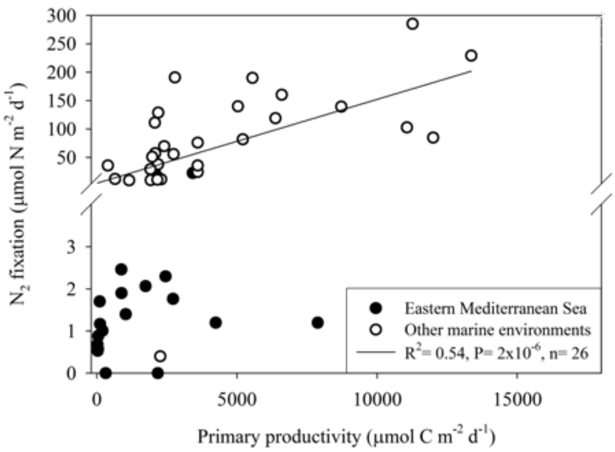

Fig. 1. Correlation between N_2 fixation rates and PP for the illuminated photic depths of varying marine environments, including the Eastern Mediterranean Sea, anti-cyclonic eddies within the Mediterranean Sea, DYMAMED station in the Western Mediterranean Sea, Station ALOHA near Hawaii, South China Sea, the tropical and subtropical western North Pacific, the Gulf of Mexico, Atlantic Ocean, the Baltic Sea, and the south Pacific Gyre.

References

1 - 1. Carpenter, E. J., and D. Capone, (2008). Nitrogen Fixation in the Marine Environment in D. Capone, A. D. Bronk, R. M. Mulholland and E. J. Carpenter (eds), *Nitrogen Fixation in the Marine Environment*, Elsevier, Academic Press, San Diego, pp. 141-1982 .