# Seasonal patterns of inorganic and organic nitrogen uptake by phytoplankton in the Eastern Mediterranean Sea


Coauthor: Alon Blachinsky, Mark Altabet, Michael .D Krom, Ilana Berman-Frank
Haifa University - Department of marine biology
School for Marine Science and Technology U Massachusetts Dartmouth New Bedford, MA USA


MORRIS KAHN MARINE RESEARCH STATION · LEON H. CHARNEY SCHOOL OF MARINE SCIENCES · University of Haifa · אוניברסיטת חיפה · جامعة حيفا · בית הספר למדעי הים על שם לאון צ'רני

## Introduction

Nitrogen (N) is a limiting nutrient for phytoplankton in many surface regions of the World's oceans and may be seasonally limiting in the Eastern Mediterranean (EMS) (1,2). Dissolved organic forms of nitrogen (DON) which include compounds such as urea and Dissolved Free Amino Acids, can supplement DIN and sustain phytoplankton growth. Our two years of study examined N uptake by the microbial community under two extreme states of the system in respect to the $NO_3$ supply. (Fig 1.)

## Research strategy

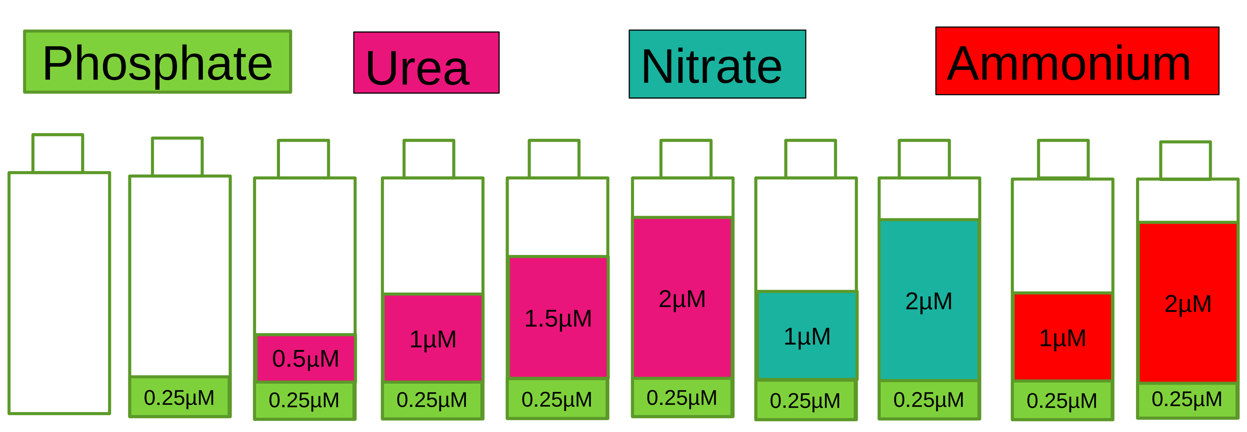
Two sets of Microcosm enrichment experiments with different N sources (urea, $NO_3$, $NH_4$) were performed to assess the seasonal changes in a) the potential uptake rates and b) the actual field uptake rates. As supporting data, we set out to characterize the nutrient dynamics of DIN and phytoplankton abundance during the sampling periods.

Our aim was to assess the relative importance of urea compared with DIN uptake for the base of the food web. To do this a method to determine urea was installed (3).

## Methods

**1. To compare the potential uptake of urea with DIN -**

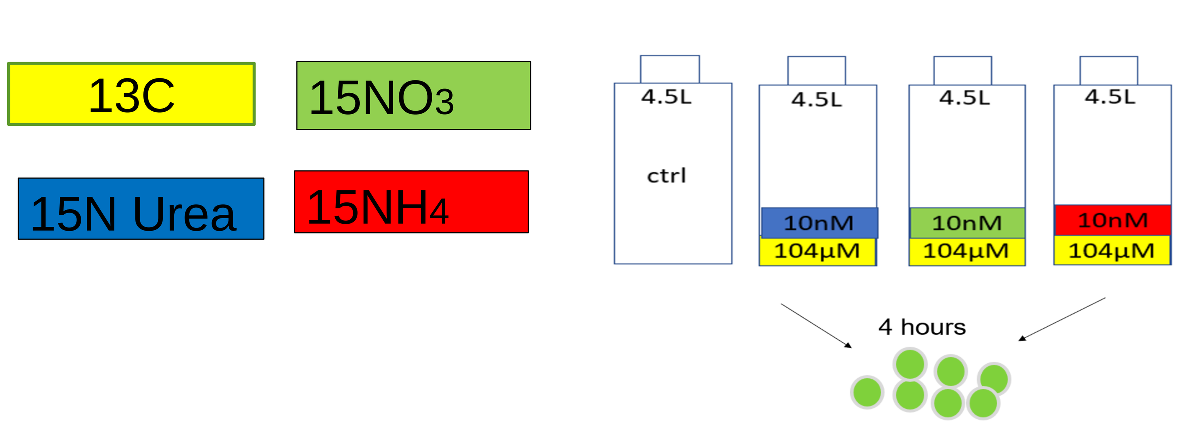
Seawater samples were collected from pelagic surface waters (10 m depth) over the entire seasonal cycle, filtered onboard using a 125-micron mesh, transferred into transparent bottles, spiked with N & P and incubated 48 hours under ambient light and temperature. **Desired concentration after spike:**



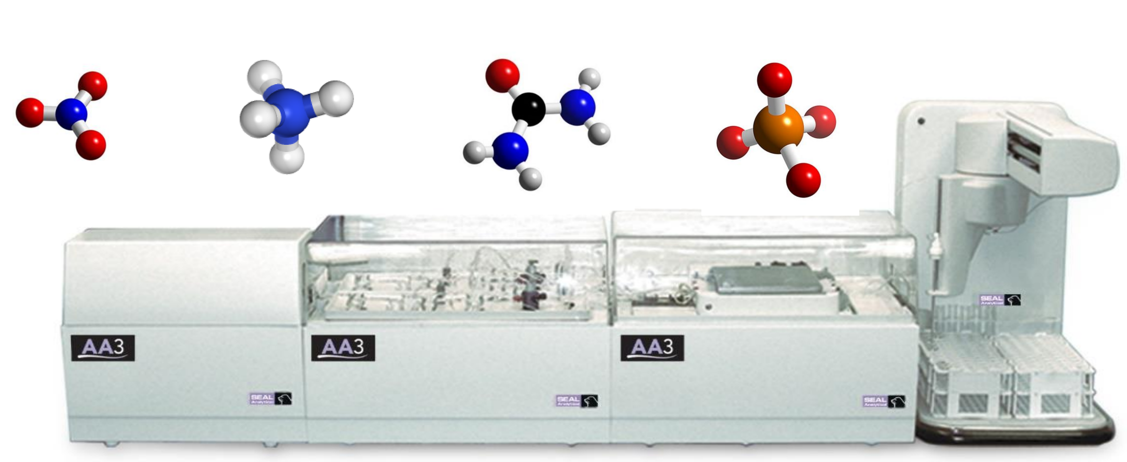

Parameters sampled at $T_0$ & $T_{48}$ for analysis were:

a) Chlorophyll *a*
b) Phytoplankton & Bacterial abundance
c) Dissolved nitrogen

2. **To assess the actual uptake rates of urea compared to DIN in the field** - 4 hours experiments were conducted onboard using filtered (125 µm) seawater from 25m depth. Bottles were labeled with $^{15}N$ (urea, NH4, NO3) and $NaH^{13}CO_3$). **Desired concentration after spike:**

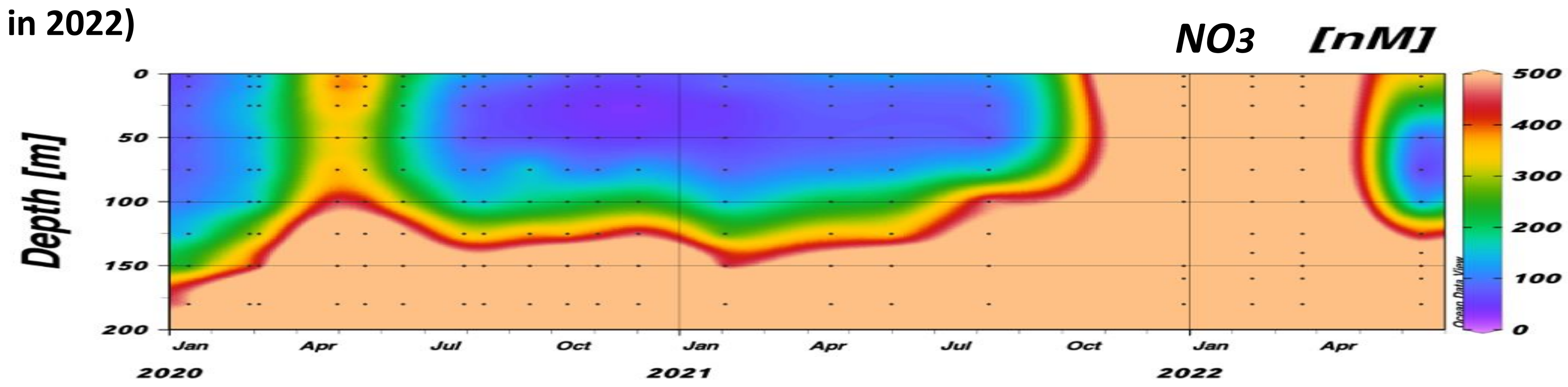



**3. Depth profiles (0-200m) of ambient dissolved nutrients ($T_0$)** were measured by SEAL – AA3 to assess the nutrient dynamics over the period of sampling.




## Results

**Figure 1. Nitrate concentrations in the upper water column at the 800m deep station showing two extreme states of nitrogen over the two years of study. Note the NO3 depleted phase (July 2020-2021) and $NO_3$ replete phase in 2022)**



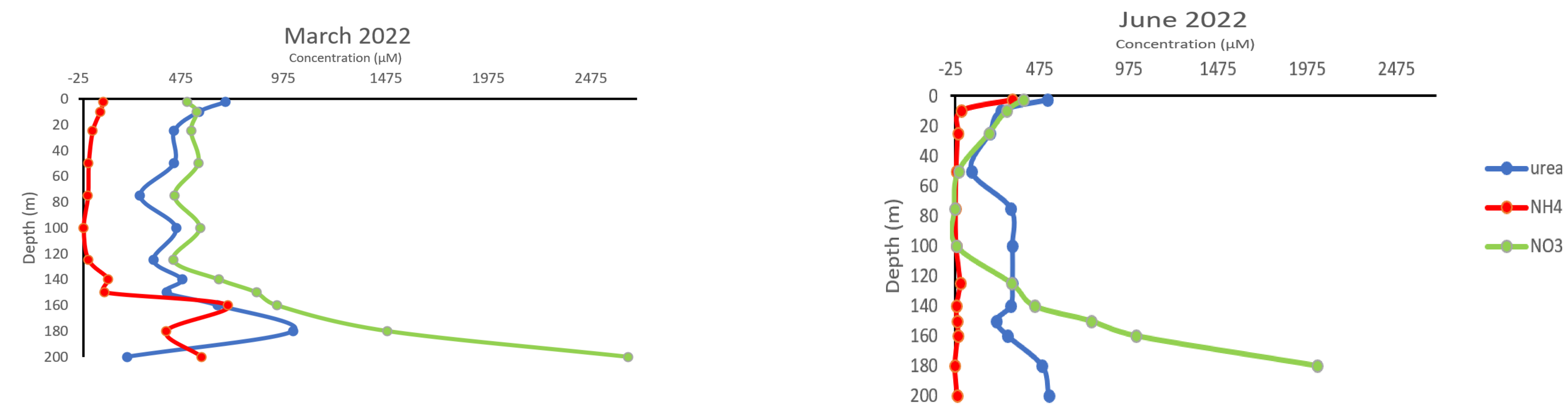




**Figure 2. Vertical distribution of urea (blue), NH4 (red), and NO3 (green) in depth profile from March 2022 and June 2022 showing the seasonal changes as nitrate is consumed in the seasonally stratified water column, while urea is measurable in the water column.**

**Figure 3. The potential uptake of urea compared with $NH_4$ & $NO_3$. Note that NH4 is the most bioavailable N, urea slightly more than $NO_3$**

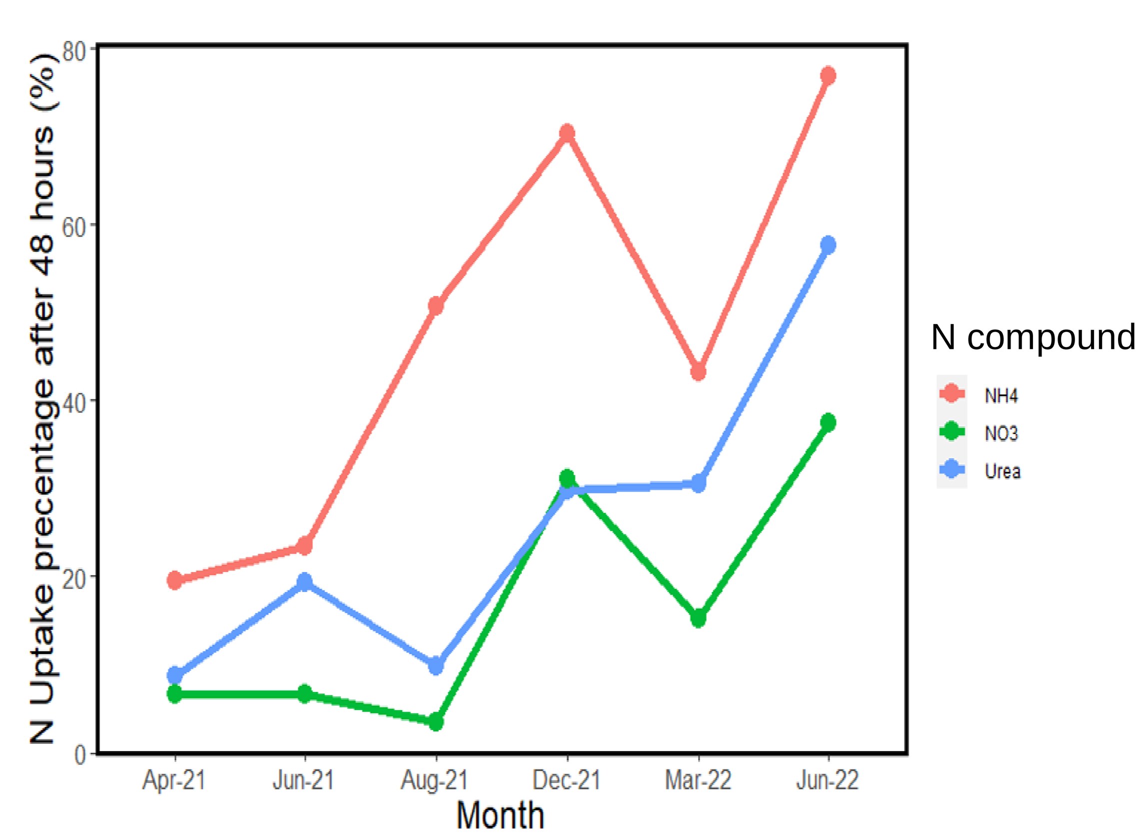



**Figure 3**. The percentage of N (%) consumed in the incubation, in all the enrichment treatments. This value was calculated by the equation $\frac{N(t=0)-(t=48h)}{t=0} * 100$ .

**Figure 4. Note the much lower uptake rates in November 2021 after 18 months of nutrient depletion. Dec 21 was 2 days after Storm Carmel while April 22 was during a period when high nutrients had been supplied by deep mixing.**

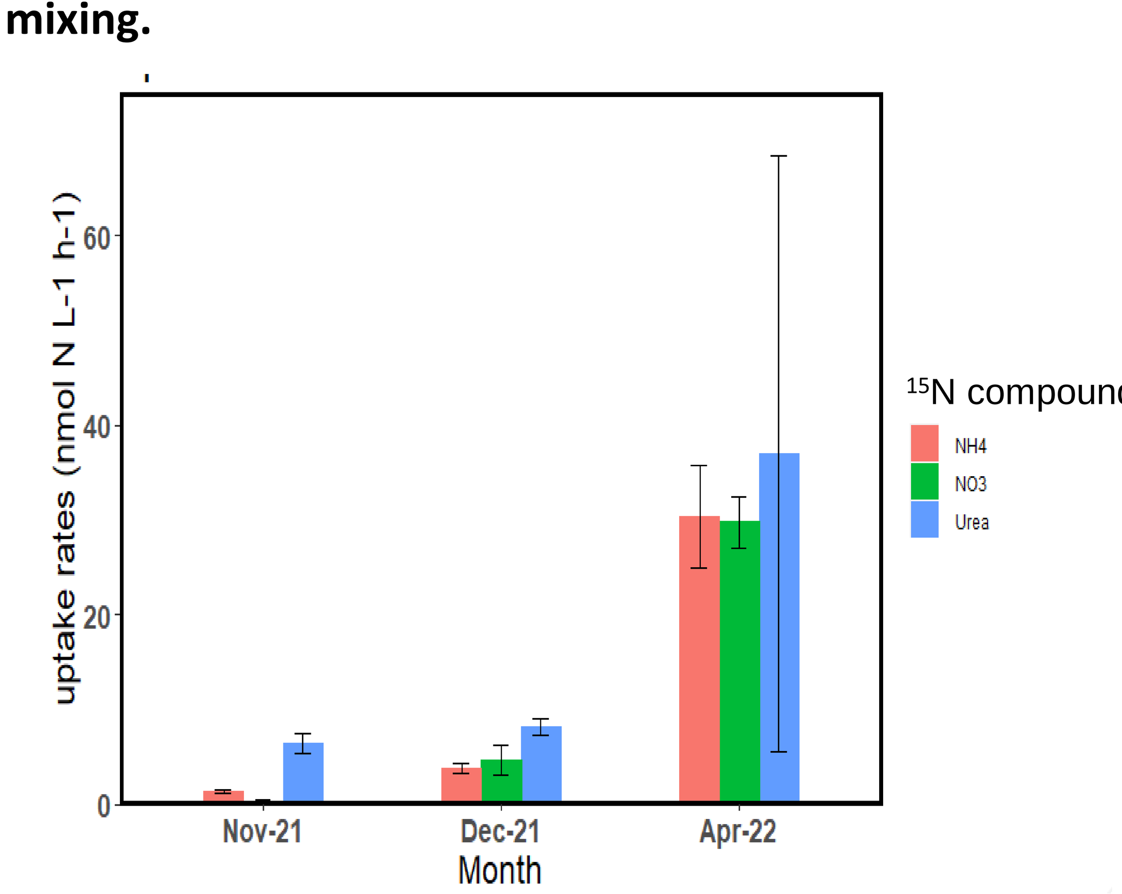



**Figure 4**. The field uptake rates during different seasons, stations, and varying ambient N concentrations.

Values were calculated by the equation (4):

$$\delta^{15}N(^{\circ}/_{\circ\circ}) = (\frac{(^{15}N/^{14}N)sample}{(^{15}N/^{14}N)standard} - 1) * 1000$$

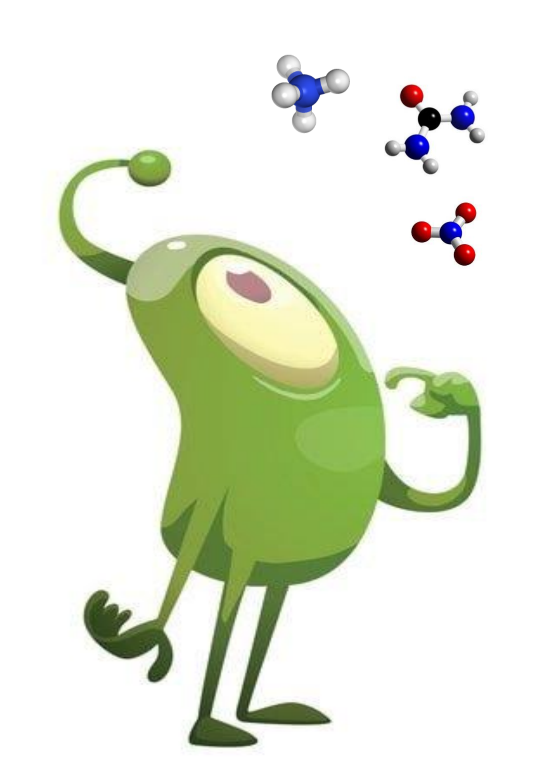
**Figure 3,4.** Despite higher potential uptake of $NH_4$ (Fig 3), the field uptake rate of urea was the most dominant over period of inorganic N depletion, due to its higher ambient concentrations and bioavailability. Nitrate appeared to be very limited (and the least consumed) for all the stratified months, but major source of N in April 22 when it was present in high concentrations in the water column. (Figures 1,2,3)

## Conclusions and further research

1) Urea, as a representative of bioavailable DON, is a significant source of N used by EMS phytoplankton for growth, and especially in periods when DIN is depleted.

2) Different nitrogen forms were utilized by EMS phytoplankton at different seasons.

3) The ambient DIN concentrations are controlled by the balance between production in the water column and uptake rates, with $NO_3$ dominantly produced below the photic zone and ammonia and urea by respiration in the photic zone.



**This pattern suggests a seasonality of N uptake the photic zone.**

## References


1. P. M. Vitousek, R. W. Howarth, Nitrogen limitation on land and in the sea: How can it occur? Biogeochemistry 13, 87–115 (1991).
2. Krom, M., Kress, N., Berman-Frank, I. & Rahav, E. in *The Mediterranean Sea* 49-68 (Springer, 2014).
3. L. Goeyens, N. Kindermans, M. Abu Yusuf, M. Elskens, A room temperature procedure for the manual determination of urea in seawater. *Estuar. Coast. Shelf Sci.* 47, 415–418 (1998).
4. Sigman, D.M., Casciotti, K.L., 2001. Nitrogen Isotopes in the Ocean. Encycl. Ocean Sci. 1884–1894. https://doi.org/10.1006/rwos.2001.0172