Nitrification: Distribution and variability of a missing factor in the dilemma of the metabolic state of the ocean

Mayte Tames-Espinosa; May Gómez and Ted Packard

Applied Algology and Planktonic Ecophysiology Group, IOCAG, Universidad de Las Palmas de Gran Canaria, Campus Universitario de Tafira, 35017 Las Palmas de G.C., Canary Islands, Spain. (maytames@gmail.com)

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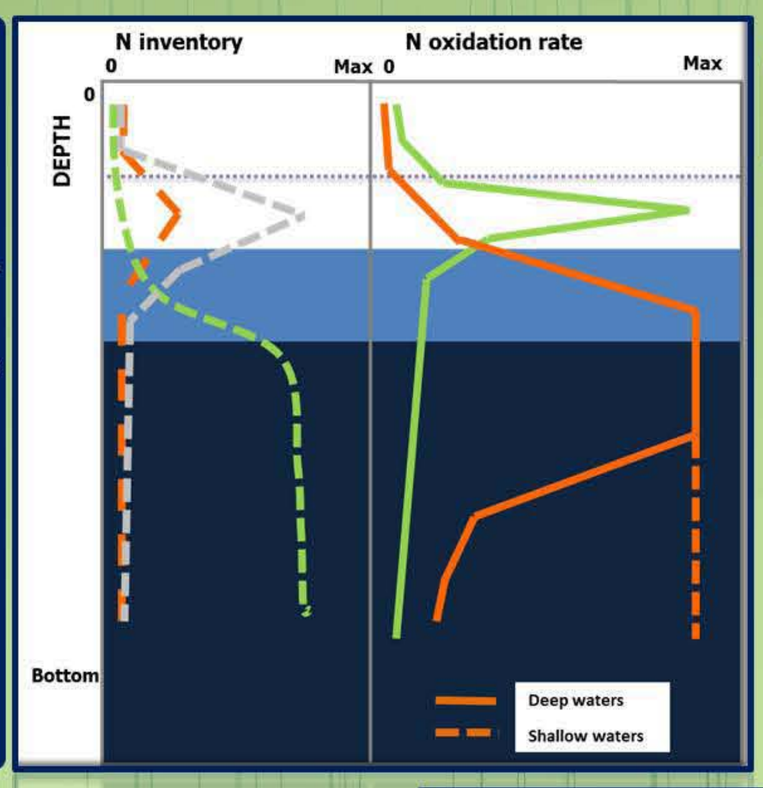
ABSTRACT

Light had been thought to limit microbial nitrification until recent studies reported nitrification within the euphotic zone. So now, in addition to occurring in the deep-dark ocean, it also occurs in the upper ocean. However, light is not the only environmental factor limiting the distribution of this process. Here we present a new conceptual model that not only considers light, but also stratification, trophic conditions, and even seawater ppO_2. This in turn, has a direct impact on the metabolic balance of the ocean and C-flux because it fixes carbon, consumes O_2 and regenerates in situ NO_3^-. The variability in nitrification impacts the N and C-cycles and it changes the basic concepts used in understanding C-flux. Accordingly, this new level of understanding, coupled with the variability of nitrification's distribution due to environmental changes, will be especially relevant in the current global climate change scenario.

SCENARIO A: Oligotrophic ocean



HIGH STRATIFICATION

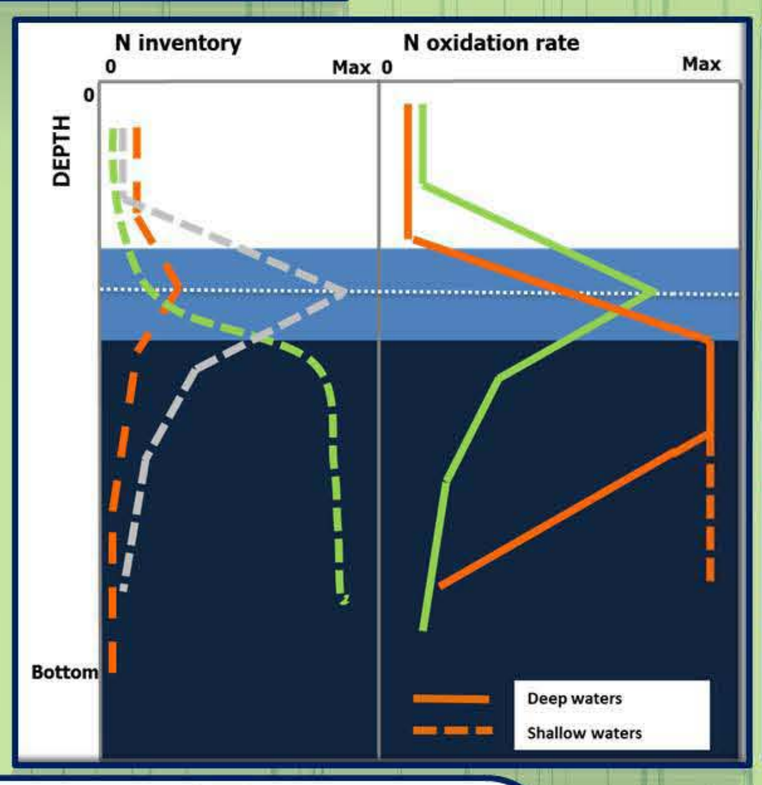
NH_4^+ OXIDATION HIGHER RATES WITHIN THE EUPHOTIC ZONE

NO_2^- OXIDATION ALSO BEGINS INCREASING WITHIN THIS ZONE

IMPACT ON:

AUTOTROPHY AND HETEROTROPHY STUDIES BASED ON $_{PP}O_2$ MEASUREMENTS

C-SINK ESTIMATIONS BY F.RATIO, NEW AND REGENERATED PRODUCTION
(EPPLEY AND PETERSON, 1967; YOOL ET AL., 2007)



SCENARIO B: Eutrophic ocean

- NH_4^+ inventory (max: 0,1µM) (Millero, 2006)
- NO_2^- inventory (max: 0,3µM) (Millero, 2006)
- NO_3^- inventory (max: 30µM) (Millero, 2006)
- NH_4^+ oxidation rate (max: 10 nmol $l^{-1}d^{-1}$) (Clark et al., 2008)
- NO_2^- oxidation rate (max: 30 nmol $l^{-1}d^{-1}$) (Clark et al., 2008)

Nitrification rates measurements vary between reports due to differences in methodology and sampling program. Clark et al.´s values are guidelines. Trends in distribution are one of the main contributions of this model

- Subeuphotic Zone (0,1- 0,001%sPAR)
- Aphotic Zone (< 0,001%sPAR)
- Oxygen Minimum Zone
- Mixed layer bottom

CONCLUSIONS

This new model reproduces the conditions where the nitrification is high within the euphotic zone demonstrating how nitrification can contribute to upper ocean autotrophy. Note that this influence is significant in a stratified ocean (Scenario A & B).

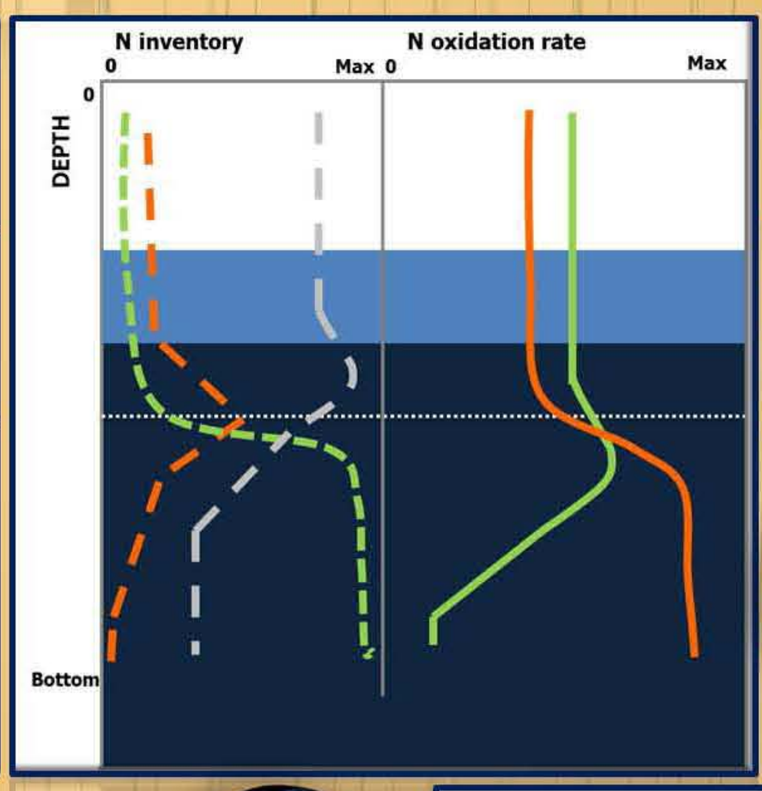
Nitrification fixes CO_2 and consumes O_2, so it has to be considered in assessing the metabolic state of the ocean, particularly when using ppO_2 measurements. This requires reconsideration of RQs, PQs, and their use.

The f-ratio of Eppley and Peterson (1979) is influenced by the magnitude of the euphotic nitrification, according to Yool et al., 2007. New Production is especially overestimated in oligotrophic waters because of nitrification. This affects the estimation of the carbon-sink capacity in the open ocean.

The ocean distribution of nitrification varies temporally due to the influence of environmental factors. Light, temperature, trophic state, and ppO_2 have to be considered while planning sampling programs. A new protocol in sampling planning should be developed considering this new conceptual model.

All these conclusions should be taking in account while studying the metabolic state of the ocean and nitrification especially considering the changing ocean scenario associated with climate change.

SCENARIO C: Deep mixed layer bottom



LOW STRATIFICATION

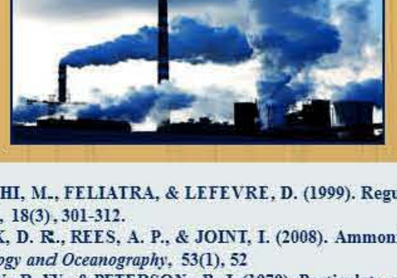
ALMOST CONSTANT NITRIFICATION RATES WITHIN THE MIXED LAYER,

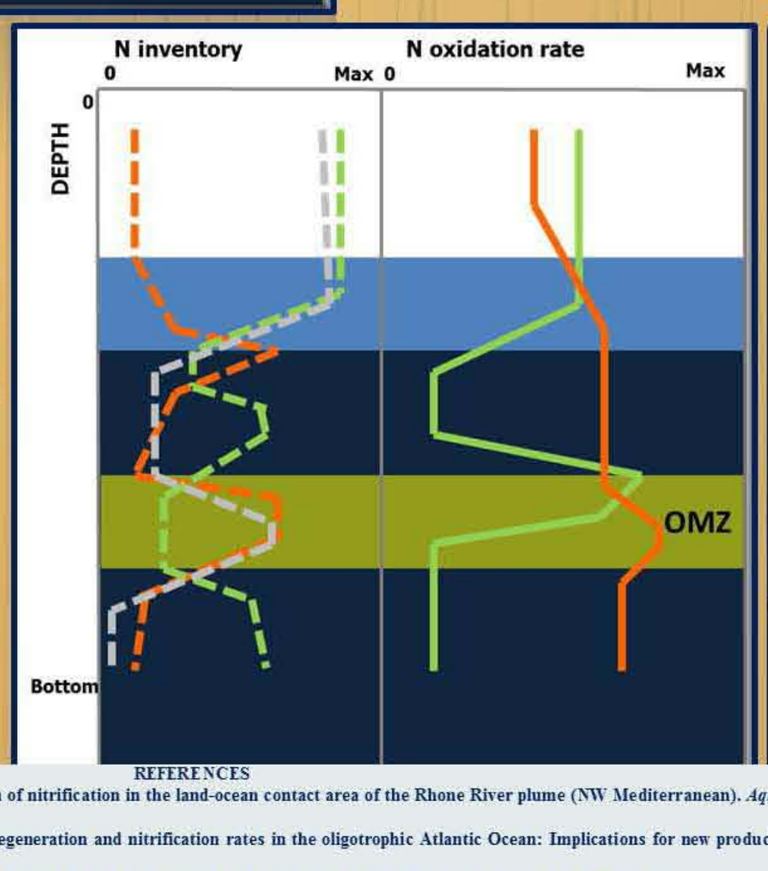
INDEPENDENT FROM LIGHT!!

OMZ:

SUBOXIC NITRIFICATION BY ARCHAEA INCREASES:

N_2O EMISSIONS!!!





SCENARIO D: Coastal Upwelling - OMZ

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