Modeling Marine Phosphorus and Nitrogen cycles in the Cretaceous:
What triggered ocean anoxia?

Itzel Ruvalcaba-Baroni, Caroline P. Slomp,
Faculty of Geosciences, Utrecht University, Netherlands
i.baroni@goe.uu.nl

Introduction

In the late Cretaceous, severe oxygen depletion occurred in oceanic bottom waters and organic matter accumulated. These so called Oceanic Anoxic Events (OAEs) may have been triggered by an increase in nutrient delivery to the surface ocean resulting in a cascade effect causing complete oxygen depletion in deep sea waters (*e.g.* Mort et al., 2007; Tsandev and Slomp, 2009, Tsandev and Slomp, 2009). In the other hand, most of long time scale marine biogeochemical models assume N_2-fixation compensation for denitrification and a phosphorus (P) limited primary production (PP). As yet, neither this relationship nor the relative roles of Nitrogen (N) and P availability in controlling PP during anoxia are fully understood.

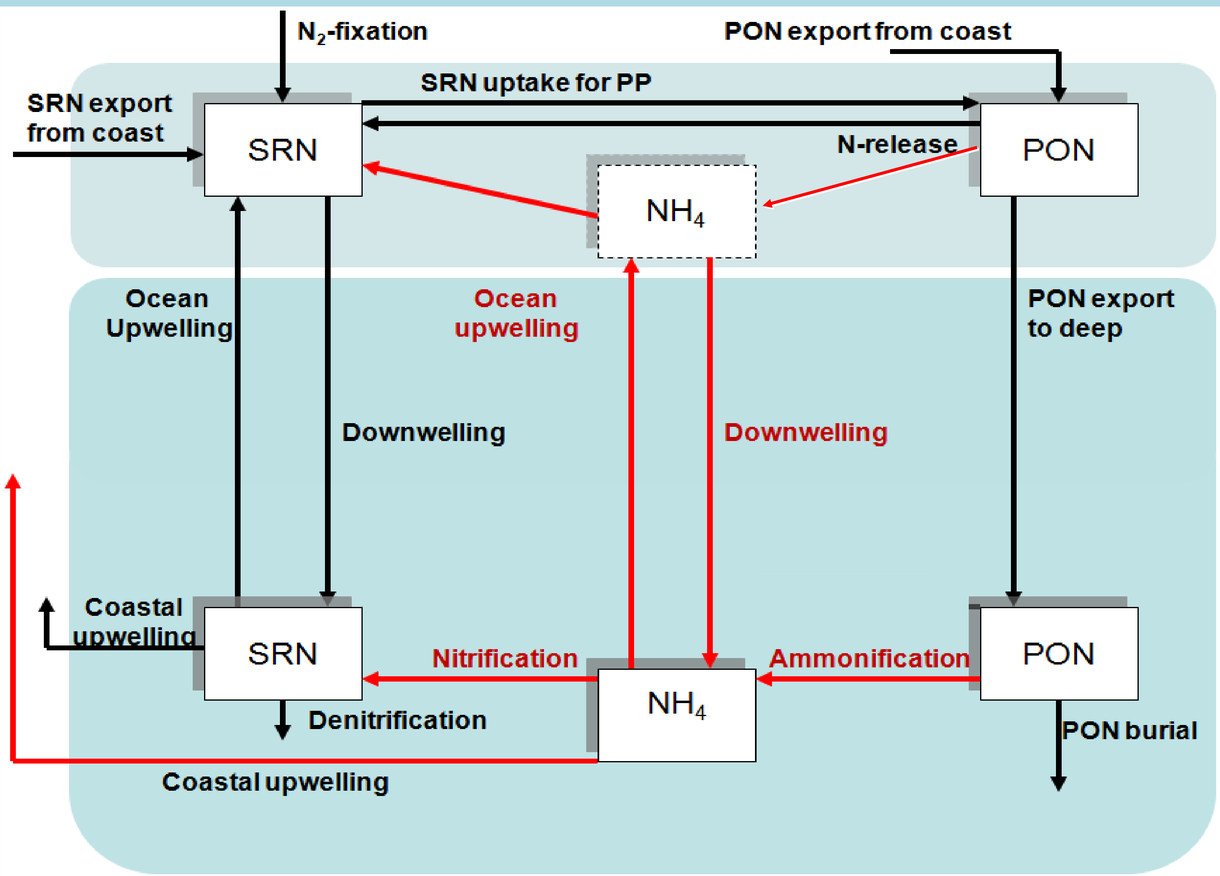


Figure 1. Open ocean N cycle as included in the model. SRN = soluble reactive N, NH_4 = ammonium and PON = particulate organic N. Nitrification is assumed to be dependent on oxygen while availability.

Aim

In this study, we assess the relative roles of nitrogen (N) and phosphorus (P) availability in controlling primary productivity during oceanic anoxia

Model

A global box model of the marine P, carbon and oxygen cycles (Slomp and Van Cappellen, 2007) is expanded with the N cycle (Fig. 1). We specifically assess whether enhanced availability of P can fuel N_2-fixation and can compensate oceanic N loss through denitrification under low oxygen conditions.

Here, we present results of steady state simulations where the ocean is driven to anoxia by reducing oceanic mixing.

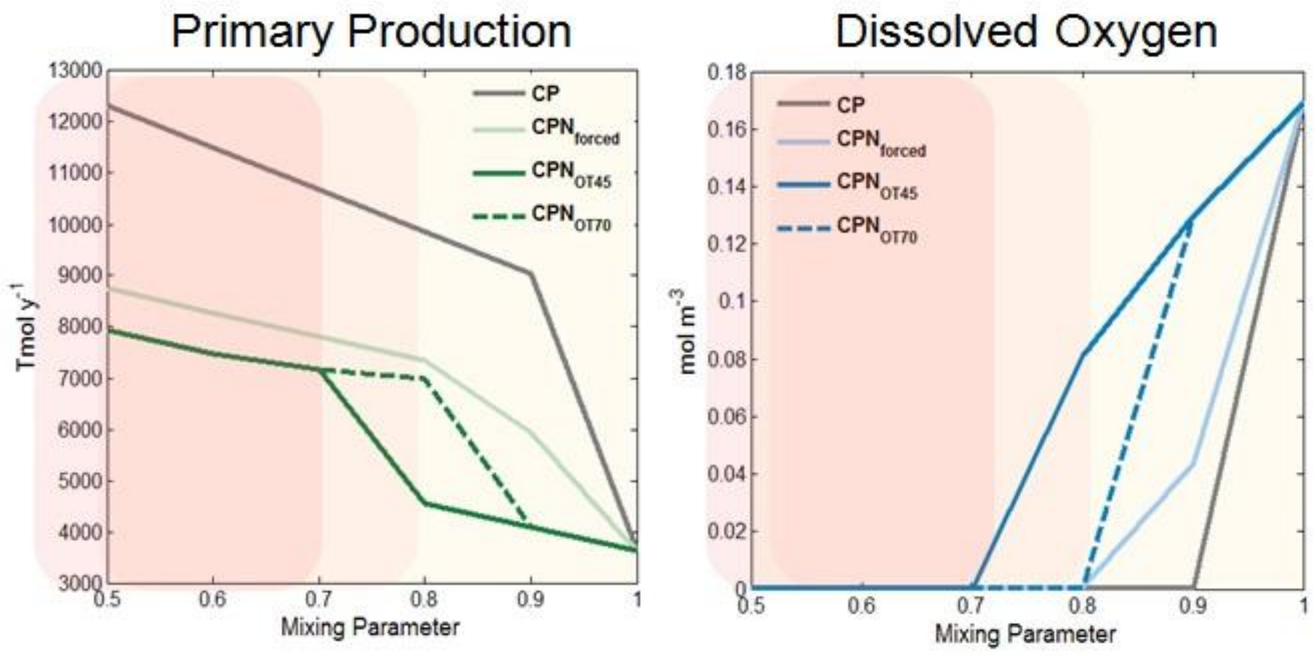
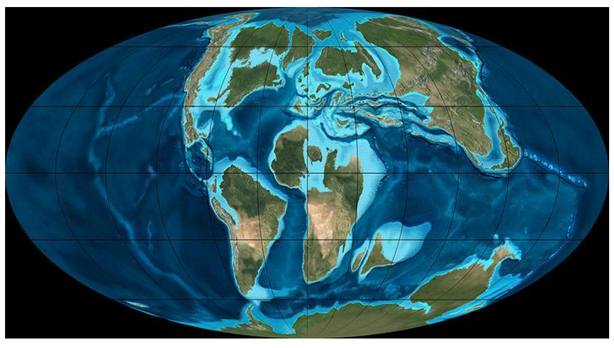


Figure 2. Primary productivity and dissolved oxygen as a function of oceanic mixing for scenarios where (1) P is the only limiting nutrient (CP),
(2) both N and P can act as limiting nutrients
Note that the mixing parameter is 1 for the modern ocean and that a value of 0.5 implies a 50% reduction in oceanic circulation.

Results

When P is the only limiting nutrient in the model, primary productivity in the ocean increases with reduced mixing because of the efficient positive feedback between increased P availability, enhanced productivity and anoxia.

When both N and P can act as limiting nutrients, the oceans may become N limited because N_2-fixation cannot compensate for all N loss through denitrification. As a consequence, primary productivity remains lower.



Current and future work

➔ Development of a biogeochemical box model for the proto-Atlantic (95 Ma) using a water budget from a general circulation model.

➔ Implementation of the marine N cycle in a biogeochemical ocean general circulation model (HAMOCC2) to study spatial variability

➔ Comparison of model results to sediment records

References:
Mort et al., 2007. Geology paper. Phosphorus and the roles of productivity and nutrient recycling during oceanic anoxic event 2, Geology, 6, 483-486
Slomp, C.P. Van Cappellen, P., 2007. The global marine phosphorus cycle: sensitivity to oceanic circulation. Biogeosciences, 4, 155–171
Tsandev, I., Slomp, C.P., 2009. Modeling phosphorus cycling and carbon burial during Cretaceous Oceanic Anoxic Events, Earth Planet. Sci. Lett., doi:10.1016/j.epsl.2009.06.016