OXYGEN, AN ALGAL GROWTH INHIBITOR IN THE HISTORICAL SCHELDE ?

Lindsay Geerts[1], Koen Ooms[2], Tom Maris[1] and Patrick Meire[1] (lindsay.geerts@ua.ac.be)

ECOSYSTEM MANAGEMENT RESEARCH GROUP

The Schelde, a history of hypoxia and anoxia: a delay in recovery

Historically the Schelde estuary is characterized by high organic and inorganic waste pollution. In the seventies the Schelde was often hypoxic, to seasonally anoxic. It is only since the nineties water quality is improving again. Recently chlorophyll concentration has been shown to increase in the tidal freshwater part of the Schelde estuary, despite decreasing nutrient input and increasing zooplankton abundance. Differences in light and residence time do not give any explanation for previous algal growth limitation. Therefore it was recently opted that rather low oxygen concentrations (hypoxia), possibly combined with ammonia toxicity and other harmful substances (Fig. 1) in such a reduced environment, were inhibiting algal growth, delaying recovery to a state of net oxygen production.

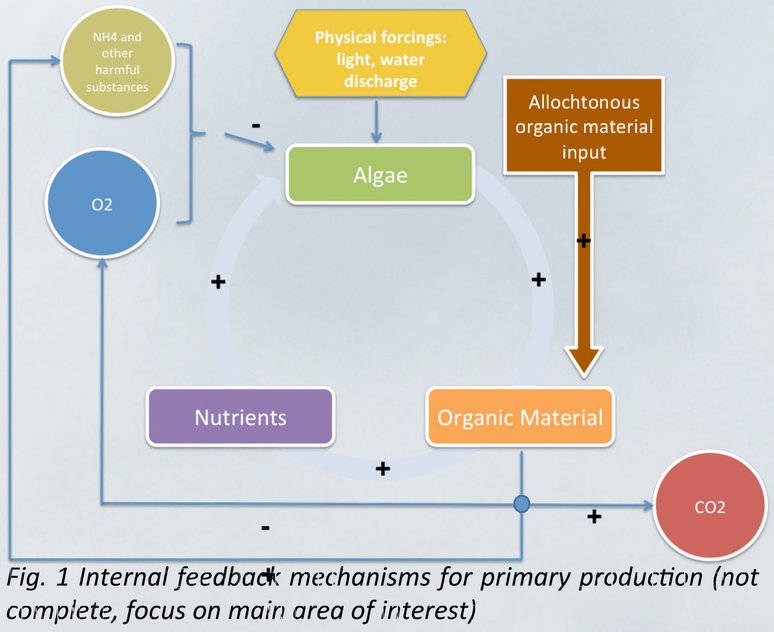

Fig. 1 Internal feedback mechanisms for primary production (not complete, focus on main area of interest)

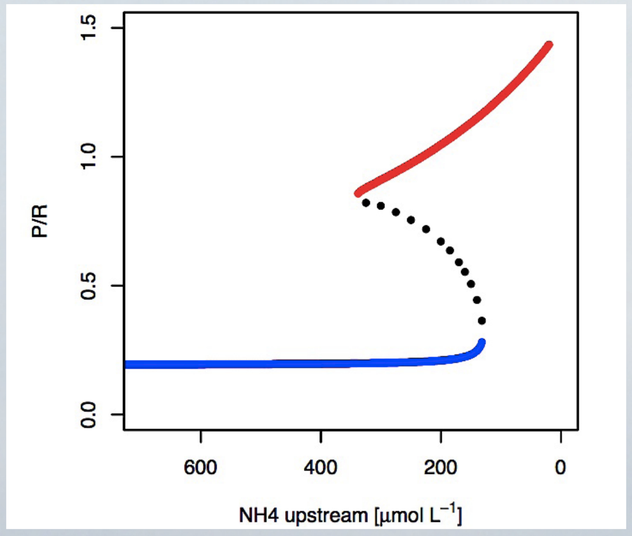

Fig. 2 Two alternative stable states occuring over a similar range of ammonium input (according to a mathematical model of Cox et al. 2009)

A mathematical model according to Cox et al. (2009), incorporating the assumption of algal growth inhibition by low oxygen concentrations, revealed two alternative stable states for similar ammonium concentrations (Fig. 2).

BLUE: high ammonium input, low algal biomass, net oxygen consumption

RED: low ammonium input, high algal biomass, net oxygen production

Ammonium is used as key indicator since it is a source for nitrification as well as for primary production, the two major processes in the Schelde estuary.

However, effect of oxygen as a stressor on algal growth is rather poorly understood. Studying the effect of hypoxia on current flourishing populations might provide new insights and support for this apparent regime shift in the Schelde estuary.

Hypothesis

At low oxygen concentrations, algae cannot compensate oxygen loss by its own oxygen production and are inhibited in their growth, despite other favorable growth conditions (e.g nutrients, optimal light conditions). Oxygen can be considered the primary factor to regulate algal growth.

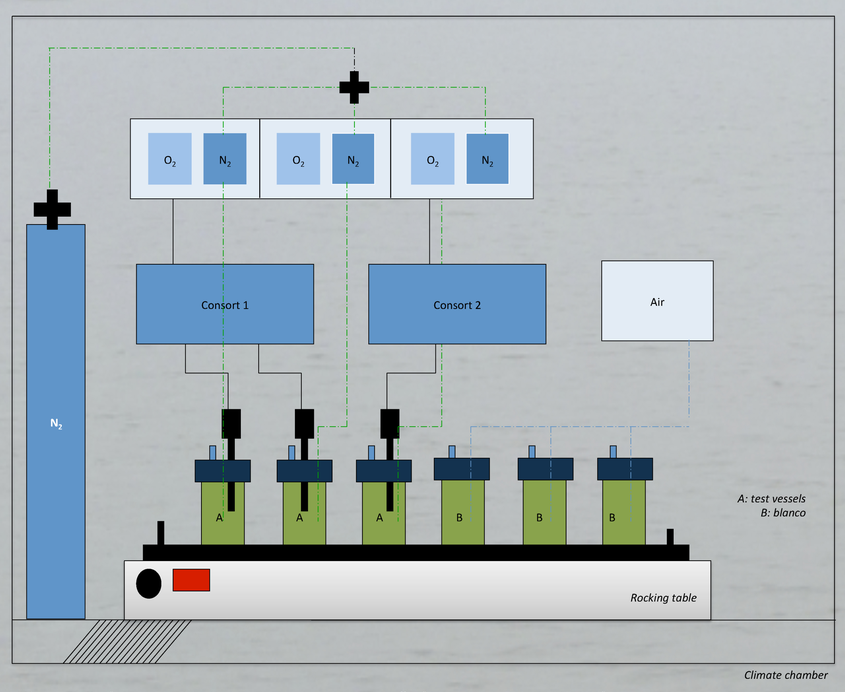

Fig. 3 Schematic representation of the experimental set-up

Experimental set-up

The first step was to develop an experimental set-up to create a controlled hypoxic environment for the algae. A Consort R362 was used to continuously regulate oxygen saturation, by controlled nitrogen supply. Installation of one-directional valves at the test vessels was performed, to ensure that no atmospheric oxygen could re-enter when nitrogen is gassed through. This final adjustment allowed a minimal use of nitrogen gas, opening the path towards a well-designated three-replicate experiment for algal growth for at least three different controlled oxygen saturation concentrations.

Test species

Pseudokirchniriella subcapitata is a well-known and often applied algae in toxicity tests and was therefore used in these first tests for experimental set-up.

Oxygen growth inhibition

First successful test (Fig.4) revealed a growth inhibition of about 75.6 ± 7.8 % (coeff var = 10.3 %) for a reduced environment of 1 – 5 % oxygen saturation (approximately 0.1 – 0.4 ppm) after 36h.

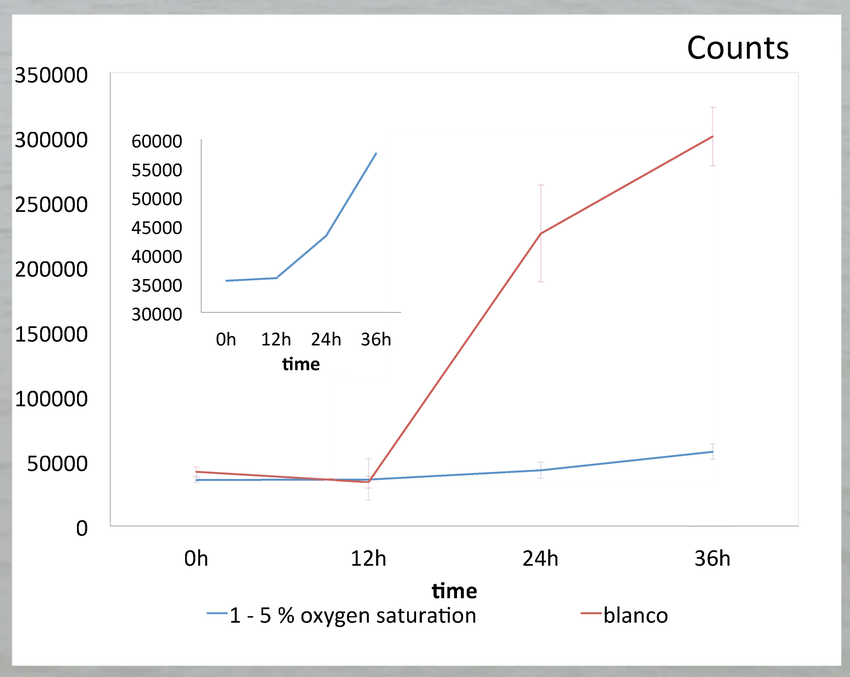

Fig. 4 Algal growth inhibition test for Pseudokirchniriella subcapitata – counts according to time for 1- 5 % oxygen saturation (T = 22 ± 2 °C) and blanco (error bars represent standard deviation; n=3)

To be continued…

- Diatom communities representative for the Schelde estuary (other growth media required)
- Optimal carbon dioxide addition for growth
- Three replicate experiment for three different oxygen saturation concentrations to define EC50 for O_2 for algal growth of diatoms
- Dark-light cycles simulating day-night and mixing regime to study the combined effect of photo-inhibition and hypoxia

Universiteit Antwerpen