An ecophysiological model of *Alexandrium minutum*. Effect of phosphorus on vegetative growth.

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Introduction

Alexandrium spp are poison-producing dinoflagellate species known to produce near-shore blooms and harmful to shellfish production in harvesting bans. Along French coasts, *Alexandrium minutum* (Halim) blooms were first recorded in estuaries of northern Brittany in June 1988 and since, the phenomenon is believed to have spread. In the Penzé estuary, a tidal flat estuary connected to the west part of Morlaix bay (Northern Brittany, France), proliferation events are strongly linked to neap tides of late spring/early summer. There, cell densitie may reach high levels (44,6 10^6cell.l^{-1} up-estuary in June, 1997).

Two major biological processes are involved in these blooms : firstly, the synchronous germination of cysts from sediment beds ; secondly, the ability of *A. minutum* to compete for nutrients in nutrient enriched coastal waters. The Penzé is a river strongly eutrophicated where nitrogen is always in excess but phosphorus may become limitant. For a better understanding of *Alexandrium* blooms, a numerical model, based on experimental culture datas (Probert, 1999 ; Erard et al., 2003; Labry et al., 2004), is built in order to reproduce the vegetative growth linked to phosphorus disponibility.

Methods

The data set / The simulation proceeding

The Labry culture experiments were conducted on *A. minutum* (AM89BM) in filtered seawater under optimal environmental conditions (T=18°C ; I=200 μE.m^{-2}.s^{-1} ; f/2/4 NO_3) and no PO_4.

Processes parametrization has been performed on semicontinuous cultures with a range from 0,05 to 0,5 dilution rate and a renewal medium containing f/2/4 PO4 (9 μM) and f/2 NO3 (880 μM). Model calibration has been performed on batch experiments with PO_4 enrichment with a 4 μM pulse at 1, 2, 3, 5, 7 and 10 days. Model validation has been performed on semicontinuous cultures with a 0,15 dilution rate for all parameters except PO_4 added each 1, 2, 4 or 6 days (in a corresponding input of 9 μM each day) and on batch culture from Erard (N, P concentrations related to *in situ* obervations) and Probert experiments.

Processes have been adjusted using the Matlab interface (curvefit in Curve Fitting toolbox).

The numerical model has been written under Stella software.

Results

1- Growth and P uptake parametrization

Growth rate (μ) is derived from Droop (Droop, 1698) :

$\mu = \mu max * (1-Qpmin/Qp)$

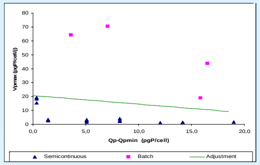
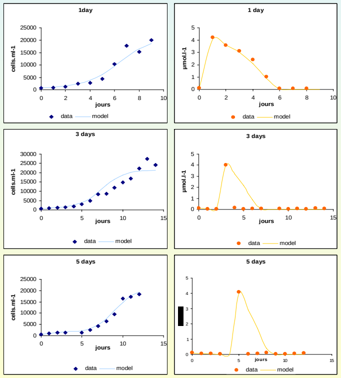


Figure 1 : Vmax parametrization

Uptake is adjusted following Labry experiments relating the P cell quota and Michaelis –Menten for [PO4] in the medium: $VP = VP_{max}.(P/(P+K_P))$. With $VP_{max} = -0,6183*(Qp-Qpmin) + 20,67$ (R^2=0,25).

2- Model calibration on batch culture experiments



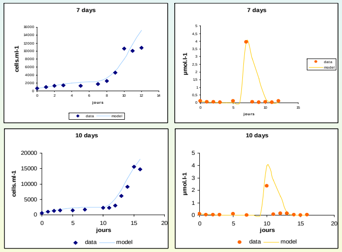


Figure 2 : Model Calibration on the Labry batch cultures. (*Alexandrium* in blue, PO4 in red)

	Parameters	Unit	Value
μmax	Maximal growth rate	d^{-1}	1,22
Qpmin	P minimum quota	pgP.$cell^{-1}$	6,49
Vpmax	P maximum uptake	pgP.$cell^{-1}$.d^{-1}	20,67
KP	Half saturation constant for PO_4 uptake	mmol.m^{-3}	0,933

Table 1 : Parameters used in the model

2- Model validation on culture experiments

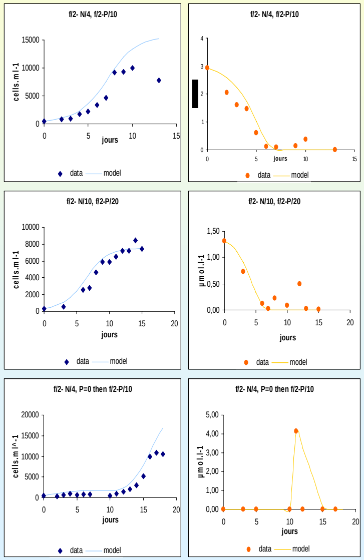


Figure 3 : Model Validation of Erard batch cultures. (*Alexandrium* in blue, PO4 in red)
f/2-N/4, f/2-P/10 : *in situ* conditions observed in May 1997
f/-N/10, f/2-P/20 : minimal conditions observed *in situ*

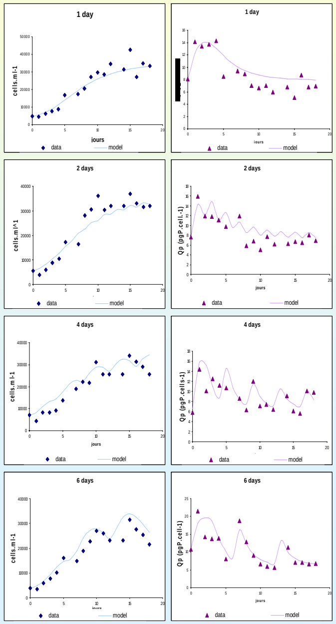


Figure 4 : Model Validation of Labry semicontinuous cultures. (*Alexandrium* in blue, P quota in violin)

Discussion

This model reproduces correctly both the population growth and the nutrient uptake in condition of P limitation for a large data set.

As it has been shown in the P uptake adjustement, it is difficult to reproduce the shift in P uptake for P limitation (low quota). This may be explained by the different evolution of these experiments. The adjustment may be not so adequate and it may explain, in the calibration as well as in the validation steps, the discrepancies between PO4 simulated and data after PO4 input in a limiting culture.

Validation on Erard cultures shows that the model surestimates the population yield. This may be due to an overestimate growth rate in this case as Erard found for these experiments a lower μmax (μmax=0,92 d^{-1}).

So, it may be important for future *Alexandrium* simulations (culture experiments or *in situ* simulations) to apply this model with a range for the parameters between parameters measurements and calibration.

	Unit	Range
μmax	d^{-1}	0,92 (Erard et al., 2003) - 1,44 (Probert, 1999)
Qpmin	pgP.$cell^{-1}$	5 (Labry, com.pers.) - 17 (Probert, 1999)
Vpmax	pgP.$cell^{-1}$.d^{-1}	20,4 - 71, 4 (Labry et al. 2004)
KP	mmol.m^{-3}	0,28 - 1,62 (Labry et al., 2004)

Conclusion

This ecophysiological model of *Alexandrium minutum* takes into account the influence of PO4 stress on vegetative growth. It has to be developed to take into account as well, nitrate, light and temperature control on vegetative growth as well as parametrization of sexual reproduction (see Chapelle et al., 2004).

To understand *in situ* the occurrence of *Alexandrium* blooms, simulations should be performed coupled to an hydrodynamical model giving currents, water stability, and an ecological label describing nutrients and coexistence/competition with other planktonic algae.

References

Chapelle A, Loquet N, Erard E., 2004. An ecophysiological model of *Alexandrium minutum*. Effect of nutrients on vegetative growth and sexuality induction., « HAB2004 » Cape Town, 15-19 novembre 2004

Erard E., Crassous M.P., Youenou A., Martin-Jezequel V. 2003. Etude de la compétition entre espèces lors du développement d'une efflorescence toxique à Alexandrium minutum. Rapport Ifremer, 25 pp.

Labry C., Erard-Le Denn E., Chapelle A., Youenou A., Crassous M.P., Martin-Jézequel V., Le Grand J., 2004. Etude écophysiologique et paramétrisation du rôle du phosphore sur la croissance d'*Alexandrium minutum*, espèce responsable d'eaux colorées toxiques en estuaire de Penzé, et de son principal compétiteur *Heterocapsa triquetra*. Rapport PNEC ART3 2003-2004, 32 p.

Probert, I. P., 1999, Sexual reproduction & ecophysiology of the marine dinoflagellate *Alexandrium minutum* Halim: These PhD, University of Westminster, p. 254 pp.

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