A DEB based analysis of growth and toxin elimination processes in mussels (*Mytilus edulis*) exposed to Diarrhetic Shellfish Toxins (DST)

R. Rosland[1]*, M. Alunno-Bruscia[2,3], A. Duinker[4], Ø. Strand[3], T. Strohmeier[3]

[1] Department of Biology, University of Bergen, 5020 Bergen, Norway; [2] Institute of Marine Research, PO Box 1870 Nordnes, 5817 Bergen, Norway ; [3] Ifremer/PFOM-PI, 11 presqu'île du Vivier, 29840 Argenton-en-Landunvez, France; [4] National Institute of Nutrition and Seafood Research, PO Box 2029 Nordnes 5817 Bergen, Norway;

Introduction

- Forced upwelling of nutrient rich deep water in Lysefjorden (Fig. 1) resulted in a threefold increase in phytoplankton biomass in 2004-2005 (Aure *et al.* 2007). Comparable effects were observed in 2010-2011 (Fig. 2).
- Forced upwelling enhance food availability to suspension feeding bivalves and stimulate detoxification by means of growth dilution.

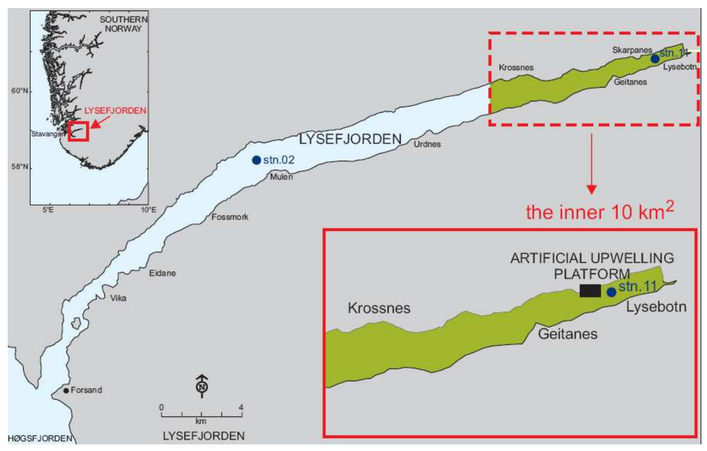

Fig. 1: Map of Lysefjorden (Norway). The area influenced by forced upwelling is indicated in green.

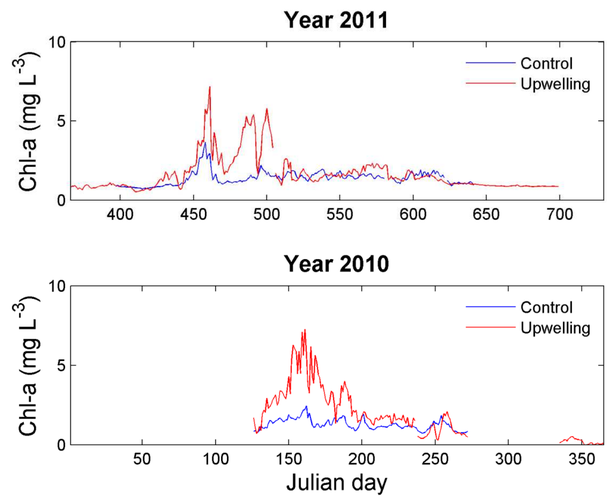

Fig. 2: Chl-*a* concentration at stations within (red) and outside (blue) the upwelling area during 2010 and 2011.

The GATE project 2010-2012 (www.imr.no/gate)

- Assess how enhanced food availability affect tissue growth and detoxification in mussels by experiments and modeling.
- A DEB-model, including a toxin component for structure and storage, was tested on data from toxin experiments at control and upwelling stations in Lysefjorden (2011) and toxin experiments on mussels from Sognefjorden (Duinker et al. 2007).
- Used model to assess the contributions from *growth dilution* and *toxin elimination* in 1 and 2 year mussels under different Chl-*a* regimes corresponding to: A) Control station in Lysefjorden, B) Upwelling station in Lysefjorden and C) Three times Chl-a levels at Control station. Mussel toxin concentration was initiated at 10 000 µg kg^{-1} dry flesh mass (DFM).

Results

- Model simulations with a toxin elimination rate of 0.033 d^{-1} explain observed growth and detoxification well (Fig. 3).
- Detoxification is driven by both toxin elimination and growth dilution (Fig. 3), but toxin elimination is the most effective of the two mechanism for all Chl-*a* levels tested here (Tab. 1; Fig. 4).
- The effect by increased Chl-*a* levels on growth dilution depends on mussel size (Tab. 1; Fig. 4).
- Time to reach safe consumption levels (800 µg kg-1 DFM) is not dramatically affected by changes in Chl-*a* levels (Tab. 1).

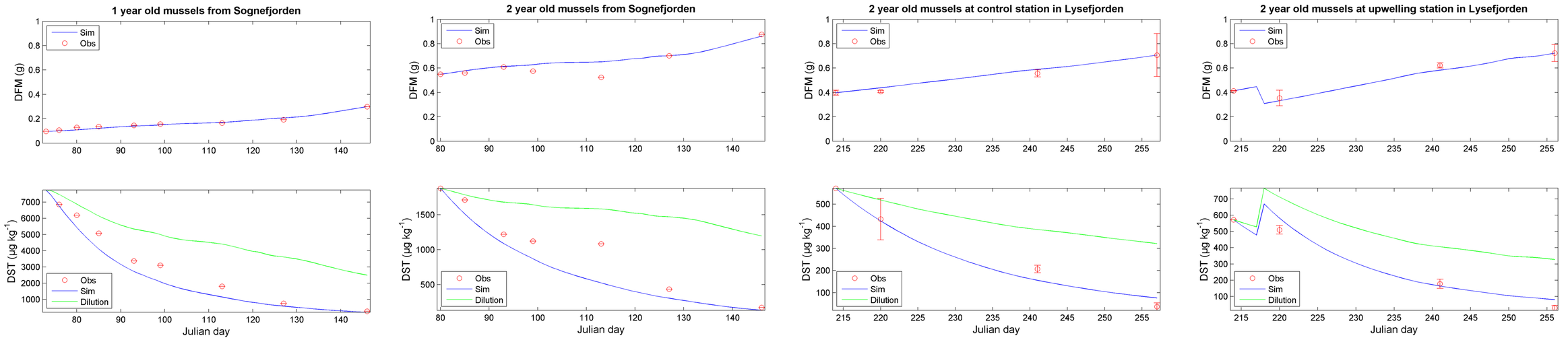

Fig. 3. Observed (red) and simulated (blue) growth in Dry Flesh Mass (DFM) and DST toxin concentration in 1- and 2-year old mussels from Sognefjorden (Duinker et al . 2007) and in 2-year old mussels at the upwelling and control stations in Lysefjorden 2011. The green line in the lower panels shows the relative change in DST concentrations resulting from growth dilution alone. The abrupt changes in DFM and DST concentration at the upwelling station in Lysefjorden is due to spawning and loss of gonad mass (which does not carry toxins).

Table 1: The effect of Chl-*a* regime and mussel age on: Time (*d*) to reach safe (800 µg kg^{-1}) toxin concentration; Ratio between DFM at time *d* and initially; Toxin concentrations (% of initial) at time *d* caused by Elimination only (E_d), growth Dilution (D_d) only, and the combination of both ($T_d=E_{d*}D_d$).

Chl-a regime; Mussel age	Time (*d*)	DFM-ratio (DFM_d/DFM_i)	Elimination (E_d)	Dillution (D_d)	Total ($T_d = E_d\ D_d$)
	(days)		(% of initial toxin concentration)		
CON; 2 year	68	131	10.6	76.4	8.1
CON; 1 year	54	210	16.9	47.7	8.1
UPW; 2 year	64	149	12.1	66.9	8.1
UPW; 1 year	50	233	19.3	42.9	8.3
3x CON; 2 year	61	167	13.4	59.9	8.0
3x CON; 1 year	48	259	20.7	38.6	8.0

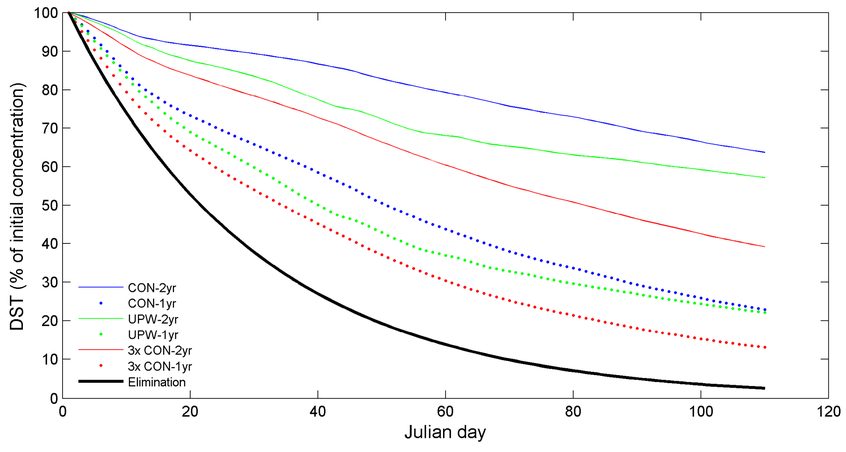

Fig. 4. Separate effects by Elimination and growth Dilution on toxin concentration over time for different mussel ages and Chl-*a* regimes.

References:

Aure, J., Strand, Ø., Erga, S.R., Strohmeier, T. 2007. Primary production enhancement by artificial upwelling in a western Norwegian fjord. Marine Ecol Prog Ser, 352:39-52

Duinker, A., Bergslien, M., Strand, Ø., Olseng, C.D., Svardal, A . 2007. The effect of size and age on depuration rates of diarrhetic shellfish toxins (DST) in mussels (*Mytilus edulis L.*) Harmful Algae 6(2): 288-300 .