Modelling harmful algal events in the western English Channel applied to the *Karenia mikimotoi* bloom that occured in summer 2003

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Objectives

Satellital imagery (fig 1) and cruises managed by the CEFAS highlight that a spectacular bloom of the toxic flagellate *Karenia mikimotoi* occured in the waters of the western English Channel during summer 2003. SeaWIFS imagery shows that it appeared at the end of June in the central part and reached the French coasts during the first week of August. The IFREMER's coastal survey network observed fish mortalities and the concentration of *Karenia* reached 405'000 cells/l off the coasts of north Brittany on 15th August.

The aim of this study is to reproduce this bloom with a 3D-ecosystem model and to assess the role of physical processes in its starting up and its extension.

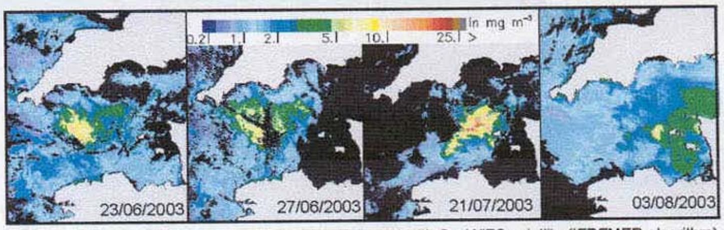

Fig. 1 Sea surface chlorophyll a concentration observed with SeaWiFS satellite (IFREMER algorithm).

Method

The 3D-model of the ecosystem

The model couples hydrodynamic, biological and hydrosedimental processes :

- the finite difference MARS 3-D hydrodynamical model (IFREMER) computes sea surface elevation, currents and state variables fields with a 4 km x 4 km horizontal grid. The water column is divided in 12 σ-layers.
- Sediment layers with erosion/deposition processes: Cugier and Le Hir (2000).
- The biological model is of NPZ type with four nutrients (NH4, NO3, PO4, Si(OH)4), two classes of primary productors (diatoms and dinoflagellates) and one class of zooplankton to close the system.
- A *Karenia mikimotoi* specific model is implemented (fig 2). It has been developped by Loyer et al. (2003) in the bay of Biscay context. The mortality equation (*m*) includes *Karenia*'s sensitivity to turbulent conditions (shear rate γ). The temperature influences the cells' stickiness, thus cells aggregate and sink (α). It's formulated as mortality. As grazing control on *K. mikimotoi* is probably not very efficient (Gentien, 1998), it isn't taken into account.

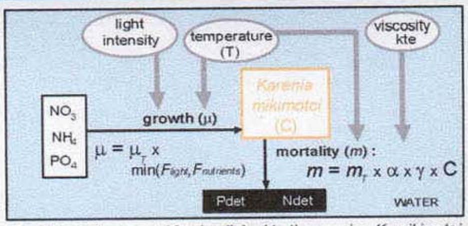

Fig.2 Direct fluxes and forcing linked to the species *K. mikimotoi*

Meteorological forcing

- wind, atmospheric pressure and air humidity : meteorological model ARPEGE (METEO-France)
- surface solar irradiance : satellital images METEOSAT (METEO-France; Brisson et al., 1996)
- nebulosity and air temperature at two coastal stations (METEO-France)

In situ validating data

The CEFAS managed 2 oceanographic campaigns in the western English Channel : from 26th June to 9th July and from 14th to 27th August 2003.
CTD profiles, water samplings and net hauls were performed. In this study we use :
- *Karenia mikimotoi* counts (S. Lyons, NUIG), no *K.* bloom during the 2nd cruise
- SST, nutrients and chlorophyll-a concentrations (L. Fernand, CEFAS)

Results

General validation

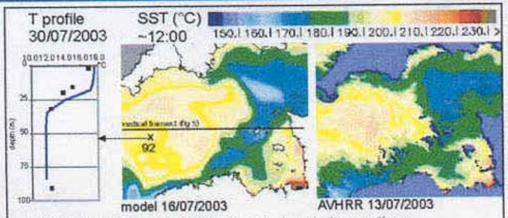

Fig. 3 Comparison of SST computed and observations

The modelled SST is closed to AVHRR data (fig 3). MARS 3D reproduces globaly well the hydrodynamical structures. A comparison with *in situ* data in a vertical plan highligths that the modelled thermocline is a bit deeper that the observed one.

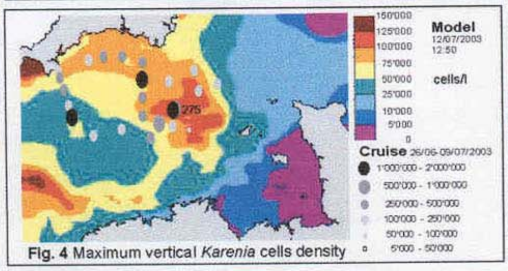

Fig. 4 Maximum vertical *Karenia* cells density

Factors controlling growth and death of *Karenia*

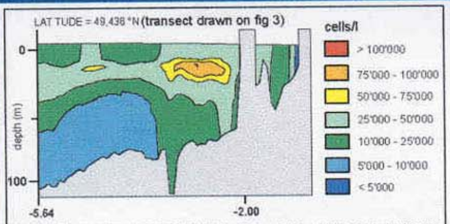

Fig. 5 Computed vertical distribution of *K. mikimotoi*, 12/07/03

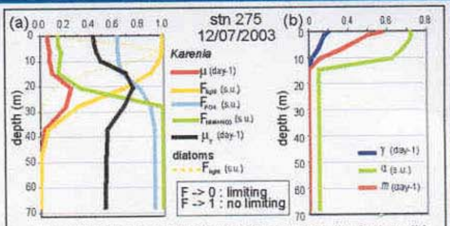

Fig. 6 Limiting growth effects (a) and mortality factors (b)

The z-maximum *Karenia* density is at depth around 20 m. There, the shear stress α is very low (fig 6b) and the nutrient availibility is less limiting (F > 0.5). *Karenia* founds at this level enough ligth intensity for its growth while the direct competitor, the diatoms, are limited under 10 m depth (fig 6a). The figure 6 also shows that the water temperature strongly controls *Karenia*'s growth (μ_T) and mortality (α).

The period of growth and the extension of the simulated bloom of *Karenia* are in quite good accordance with data (fig 4). Nevertheless, the model strongly underestimates z-maximum *Karenia* 's cells density, and in particular near the western open limit.

Spreading conditions of the bloom

In order to assess the role of transport processes in the propagation of the bloom, a specific run was done in which a passive tracer is initilized at 100 in the rectangular area of 23/06/2003 maximum chl a concentration (see fig 1).

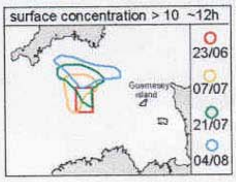

Fig. 7 Fate of a passive tracer.

The spill never reaches the Guernsey Island. It stays closed to the initial input. The residual tidal circulation can't explain the observed propagation of the bloom towards the French coasts.

Conclusion and Perspectives

Karenia takes advantage of the installation of a marked thermocline due to favourable climatological conditions. It's ability to grow at low light intensity allows it to be a good competitor of diatoms and to be the first primary producer to benefit of the rich subsurface waters. This had been even observed in the western English Channel during summers 1975 and 1976 (Holligan and Harbour, 1977). Advective and turbulent processes don't explain the apparent south-westwards transport of the bloom. It's development is only driven by spreading of propitious conditions of stratification linked to the heat budget.

As the maximum cell concentration is strongly linked to the steepness of the thermocline, the first way to better fit the model to data is to improve the modelling of the summer stratification, as far as it is possible. Further, a study of the sensitivity of the model to T-linked parameters will be done to arrive to a better parameterization.