3D MODELLING OF THE BLACK SEA NORTH WESTERN SHELF ECOSYSTEM:

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Monthly RIVERS fluxes and nutrients flows (from L. Wolfgang & A. Cociasu)

6h-atmospheric forcings from ECMWF (1.125°). (from ERA40)

The Model

36 States variables

Physics (5)
Currents, $T^\circ$, Salinity, Surface elevation, Turbulence

Oxygen and Dissolved Inorganic Carbon (2)

Inorganic nutrients (5)
SiO, NO$_3$, NH$_4$, PO$_4$, ”Reducers”

3 Phytoplankton (6) (free C/N)
Diatoms, Flagellates, Small Flagellates

Zooplankton (2)
Micro-, Meso-

Gelatinous zooplankton(2)
Omnivorous , Carnivorous

Detrital matter (8)
Particulate, Semi-labile and Labile forms Silicious Detritus, Aggregates

Bacteria(1)
Model's Specificity

• **No data assimilation**: Necessity to construct specific Bosphorus representation to ensure conservation of volume and total salt content.

• **Anoxic waters**: The biological model explicitly includes anoxic chemistry through the use of a variable 'Oxygen demanding Units', as a proxy for reducers acting in the anoxic zone.

• **Sediments compartment**
Sediments Dynamics

Sedimentation is driven by an aggregation models [Kriest 2002] (typically ~2/3 m/d).

Resuspension is the effect of bottom stresses due to bottom currents and (mainly) waves. [cf. pres. of R. Kandilarov]

Remineralization is computed according to stocked quantity of sediments, and bottom concentrations [Soetart et al., 2000, Earth-Science reviews]
Main conclusion about shelf sediments:

- Detailed remineralisation parameterization is essential in terms of budgets (50% of deposited PON).
- If resuspension is not taken into account, up to 80-90% of riverine N is denitrified on the Shelf.
- As benthic fluxes are function of stocked sediments and not of bottom fluxes, the slow remineralisation time of refractory component introduce strong hysteresis in the system.

Sediments:
-21 Gmol/yr
≈30-40% of riverine inputs
Analysis

Coupled run from 1985 to 1999.

1. North Western Shelf (NWS).
   Seasonnal hypoxia, Oxygen budget, interannual variability.

2. Export from NWS to open basin.
   Spatial and seasonnal variability.

3. Open Basin
   Oxicline depth, budget, regionalisation, Bosphorus plume.
Climatological seasonnality of Bottom Oxygen conditions on the NWS

Bottom Oxygen Concentration - [µM]
Oxygen Budget on the NWS

- Net autotrophic ecosystem -> export toward the open basin.
- Sediment consumption as high as zooplankton respiration, and almost twice of pelagic remineralisation.
Automatic regionalisation procedure (Self Organizing Map [Allen 2007])

- NW corner bottom oxygen concentration, associated to benthic fluxes.
- Crimea zone is affected by POC accumulation,
Interannual variations

Bottom oxygen concentration - [µM]
Interannual variations

Bottom oxygen concentration - [µM]
Looking for drivers
Looking for drivers
Looking for drivers

- Bottom Oxygen fluxes.
- Bottom ODU fluxes.
- Bottom Temperature.
- Integrated Chlorophyll content.
- Integrated Bacteria content.
- Integrated POC content.
- Sea surface temperature.
- Potential energy anomaly.
- Riverine water discharge.
- Riverine Nitrogen discharge.
- Riverine Phosphate discharge.
NWS : Conclusions

• Seasonnal hypoxia events occurs on the NWS with a peak in september.

• 2 zones are concerned (NW corner and Southwest Crimea) but for different causes.

• NW corner intensity of hypoxia depends on sediment process, linked to eutrophication but modulated by bottom temperature, and buffered by sediments hysteresis.

• Southwest crimea is affected by POM accumulation and pelagic oxygen consumption.
Export to open sea

Integrated along the shelf break

Detailed between PON DON and DIN.
Export to open sea
Climatological seasonnality of Oxicline depth in the open basin
Open basin: Conclusions

- Seasonal hypoxia events occur on the NWS with a peak in September.

- 2 zones are concerned (NW corner and Southwest Crimea) but for different causes.

- NW corner intensity of hypoxia depends on sediment processes, linked to eutrophication but modulated by bottom temperature, and buffered by sediments' hysteresis.

- Southwest Crimea is affected by POM accumulation and pelagic oxygen consumption.
Circulation intensity : 0.86
20.7-isoahline depth: -0.69
shelf oxygen content : 0.66
Shelf’s river discharge : 0.44
Thanks for your attention ...

*The Black Sea, P. Alechinsky*
Nitrogen consumption in the suboxic layers

- Nitrate oxidation: ~65 Gmol/yr
  - Mainly resulting from Shelf's export entrained by the Bosporus plume

- Nitrogen consumption in the suboxic layers:
  - ~40 Gmol/yr for oxidation by Sulfide and manganese
  - ~30 Gmol/yr for ANAMOX
  - ~52 Gmol/yr for ANAMOX

References:
- Konovalov, 2006, Deep-Sea Research II
- McCarthy, 2007, Estuarine, Coastal and Shelf science