Benthox Kick-Off Meeting

Liège, November 2015

Context & Previous works
- The Black Sea
- The Model(s)
- Diagenetic variability
- Hypoxia

Benthox

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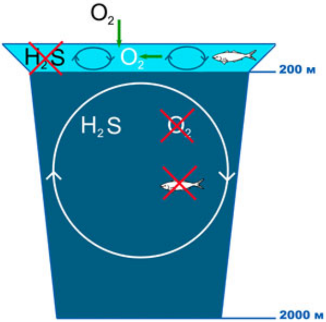
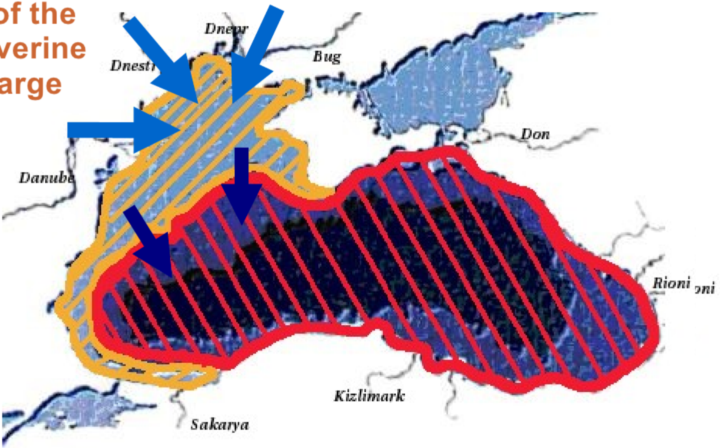
The Black Sea

- Enclosed
- Large river discharge
- stratification



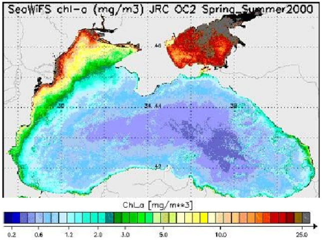
North Western Shelf
87 % of the
BS Riverine
Discharge

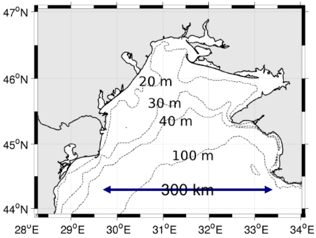


Open Sea : Production driven by the
Shelf-Open Sea Export

To understand biogeochemical cycling in the Black Sea basin, one should understand

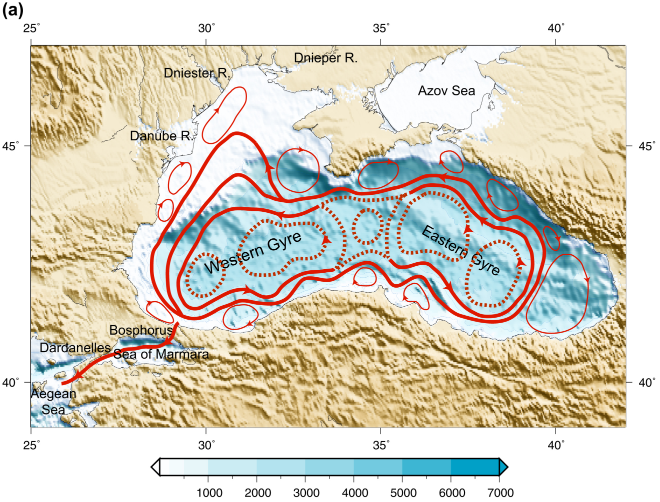
- the shelf "filtering" of terrestrial inputs.





To understand biogeochemical cycling in the Black Sea basin, one should understand

- the shelf "filtering" of terrestrial inputs.
- the exchanges between coastal and central basin.



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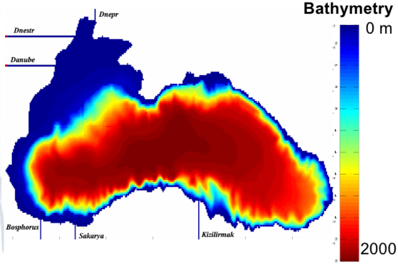
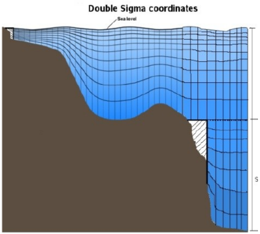
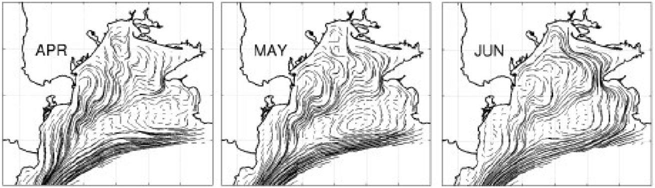
GHER 3D Hydrodynamic Model

Hydrostatic model, Double Sigma coordinates, Real time forcings (ECMWF)
Provides : T, S, TKE, U, V, η

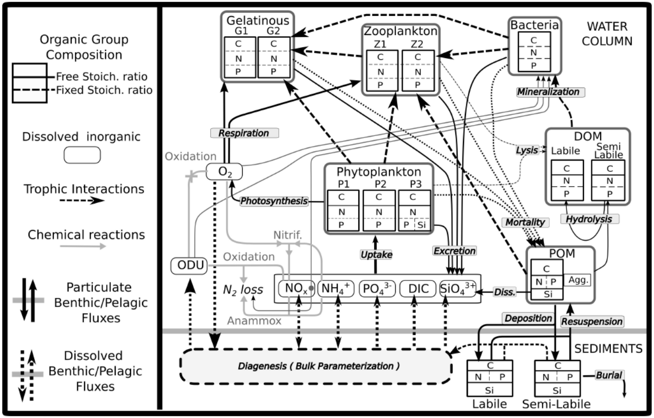






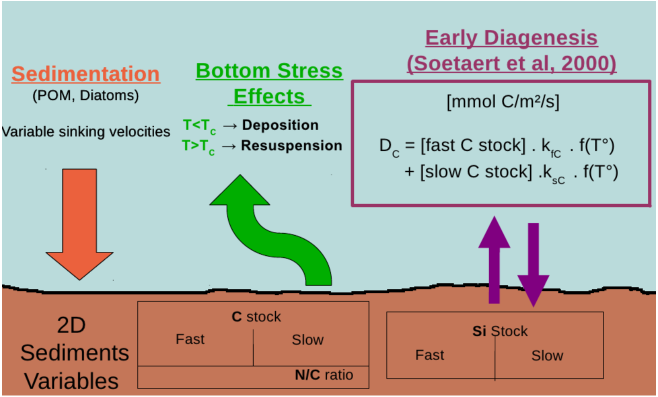
GHER 3D Biogeochemical Model

Provides : C, N, P, Si, O2 cycling through various forms.



Benthic-Pelagic coupling

Provides : Fluxes at the sediment water interface.



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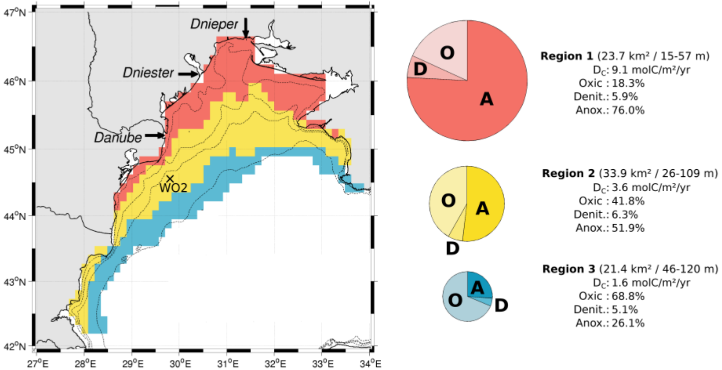
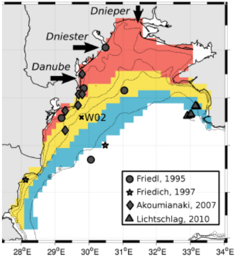
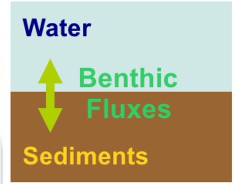
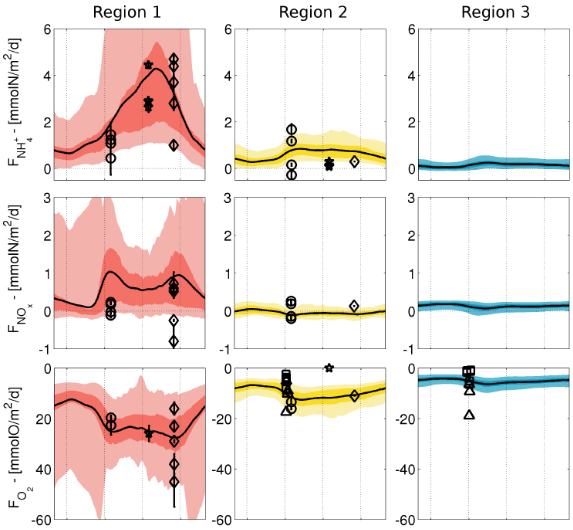
Diagenetic variability



Fluxes Validation







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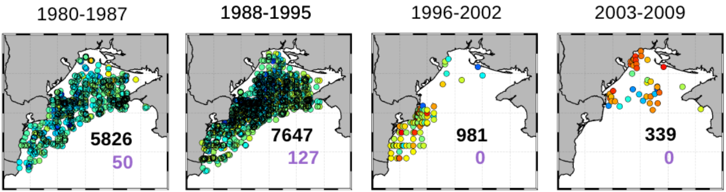
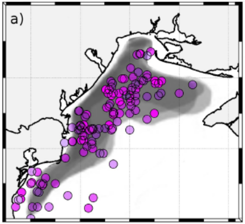
Hypoxia

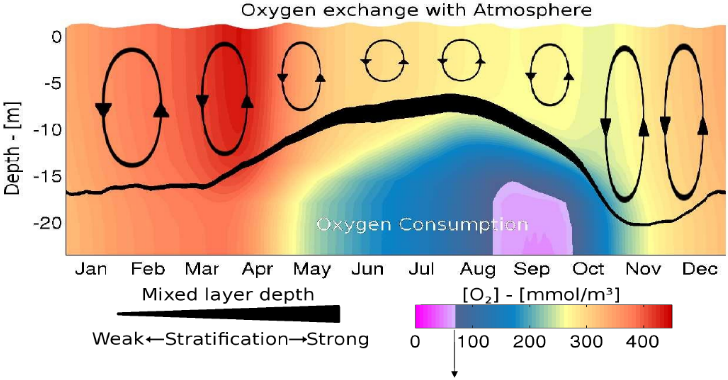


Oxygen records
(World ocean atlas, Seadatanet, Black Sea Comission data)

Hypoxic records
(<62 mmol O/m³)



Hypoxia



Hypoxic thresold : [O_2] < **62 mmol/m³ (2 mg/l)**

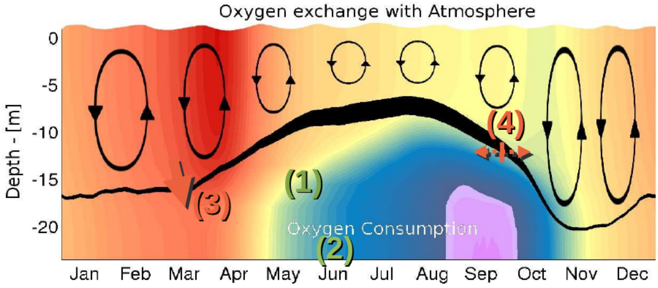
Hypoxia

(1) High nitrogen riverine discharge enhance the influx of organic matter to bottom waters

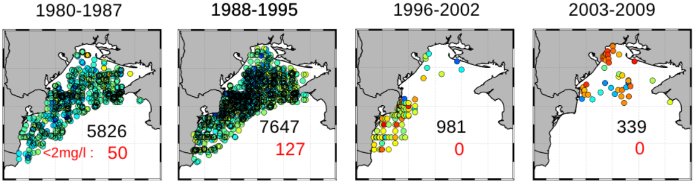
(2) High sedimentary organic carbon content enhances the benthic oxygen consumption.

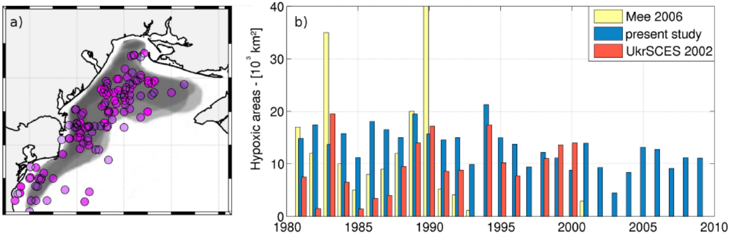
(3) Warm springs reduce the ventilation and set summer bottom temperature.

(4) Warm summers extend the duration of the stratified period.

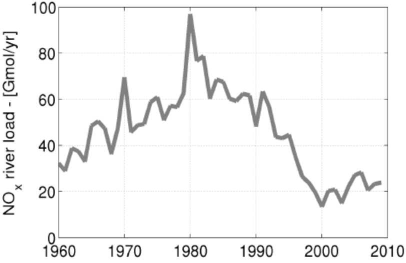


Hypoxia

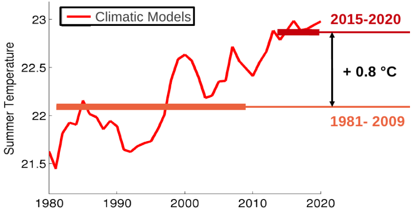

1980-1987
1988-1995
1996-2002
2003-2009
5826
<2mg/l : 50
7647
127
981
0
339
0


a)
b)
Hypoxic areas - [10³ km²]
Mee 2006
present study
UkrSCES 2002
0
10
20
30
40
1980
1985
1990
1995
2000
2005
2010

Hypoxia

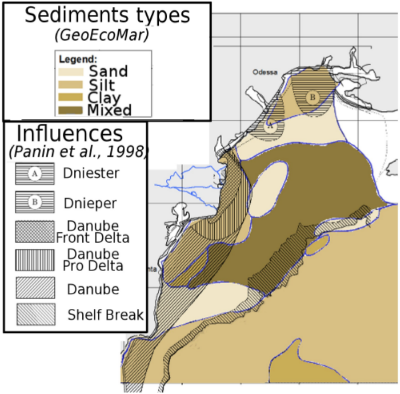


NO_x river load - [Gmol/yr]
100
80
60
40
20
0
1960
1970
1980
1990
2000
2010

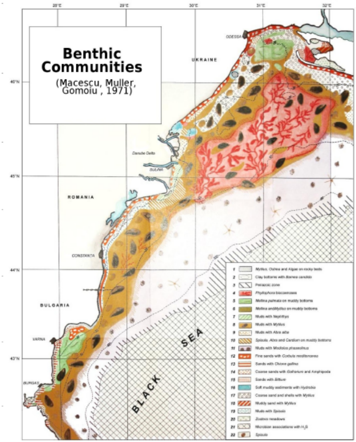


Climatic Models
2015-2020
+ 0.8 °C
1981- 2009
Summer Temperature
23
22.5
22
21.5
1980
1990
2000
2010
2020

Missing !



Sediments types
(GeoEcoMar)
Legend:
Sand
Silt
Clay
Mixed
Influences
(Panin et al., 1998)
Dniester
Dnieper
Danube Front Delta
Danube Pro Delta
Danube
Shelf Break
Odessa
A
B



Benthic Communities
(Macescu, Muller, Gomoiu , 1971)
ODESSA
UKRAINE
ROMANIA
CONSTANTA
BULGARIA
VARNA
BURGAS
Danube Delta
SULINA
BLACK SEA
1 Mytilus, Ostrea and Algae on rocky beds
2 Clay bottoms with Barnea candida
3 Pelagic zone
4 Phyllophora biocoenoses
5 Modiolus phaseolinus on muddy bottoms
6 Mollina and Mytilus on muddy bottoms
7 Muds with Nephthys
8 Muds with Mytilus
9 Muds with Abra alba
10 Spisula, Abra and Cardium on muddy bottoms
11 Muds with Modiolus phaseolinus
12 Fine sands with Corbula mediterranea
13 Sands with Chione gallina
14 Coarse sands with Gafrarium and Amphipoda
15 Sands with Bittium
16 Soft muddy sediments with Hydrobia
17 Coarse sand and shells with Mytilus
18 Muddy sand with Mytilus
19 Muds with Spisula
20 Zostera meadows
21 Microbian associations with H2S
22 Spisula

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Key Questions

1. What is the impact of bottom hypoxia on benthic nutrient cycling, benthic-pelagic fluxes and the activity of benthic organisms?
2. Which (paleo)-proxies can be used to reconstruct the long term history of hypoxia?
3. Which tools can be used to provide management strategies that will control the level of bottom hypoxia and preserve the Good Environmental Status (GES) of marine waters?
4. Which tools can be used to investigate and differentiate the drivers of bottom hypoxia?

Flows between Work Packages

Gantt

Benthos → Hypoxia I

Mediation of diagenesis

Benthos $\rightarrow$ Hypoxia II

Which formalism for bioirrigation ?

1D Diagenetic Model Calibration

- Porosity : impacts on diffusion (tortuosity), interpretation of solid/dissolved transfer, Adsoprtion
- DIC, OC, O2 and DIC flux : Mineralization rates, lability distribution
- Radio Tracers: sedimentation rate, mixed layer depth
- DIC, NOx, NH3 : Nitr/Denitr
- Incubation Fluxes : Bio-Irrigation
- Macrobenthos : Bioturbation, Bio-irrigation
- Phosphate and Metals : P-cycling

Community Bioturbation Potential

Trait-based approach intending to set a tractable link between benthic biology, and biogeochemical studies.

$$BP_c = \sum_{i=1}^{n} \sqrt{B_i/A_i}.A_i.M_i.R_i \tag{1}$$

B_i	biomass of species/taxon i
A_i	abundance of species/taxon i
M_i	Mobility (1) Fixed tube ; (2) Limited movements; (3) Slow, free movements through sediment matrix, (4) free movement through burrow system
R_i	Reworking: (1) Epifauna ; (2) Surficial modifiers; (3) Upwards and downwards conveyor (4) Biodiffusor (5) Regenerators

Not quantitatively related to D_b but innovative tool to exploit historical datasets.

P Cycling I

- Mineralization(I,II) (k_G, G_∞)
- Reversible Eq. P adsorp. (I,II) ($K_{eq,I,eq,II}$)
- Reversible kin. P adsorp. on Fe-O (I) (k_s, C_s)
- Dissolut. of Fe-O (II) $\rightarrow$ release of Fe-bound P (k_M, M_∞)
- Precipitation of Ca-P (e.g Apatithe) (II) (k_A, A_∞)

P Cycling II