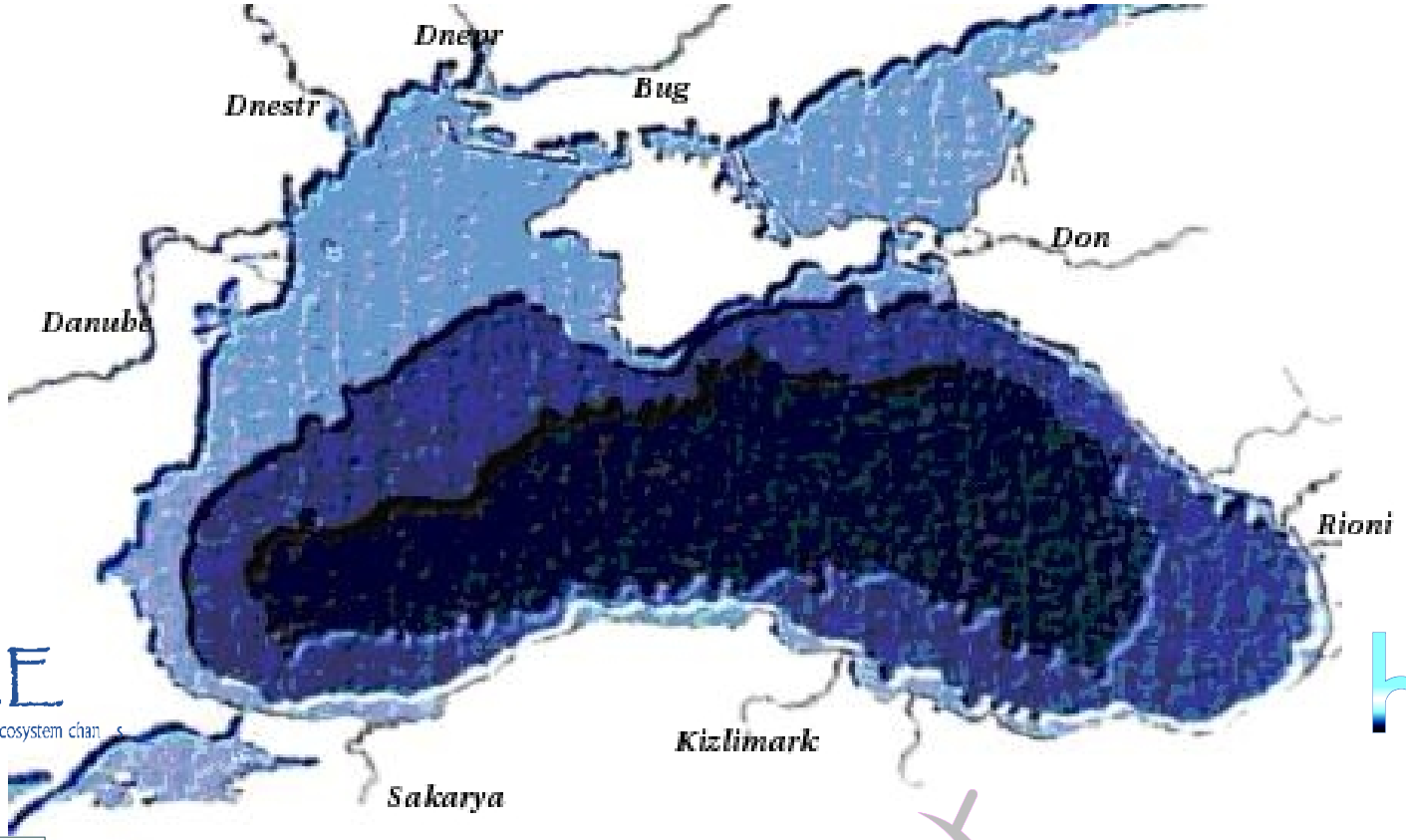
3D MODELLING OF THE BLACK SEA NORTH WESTERN SHELF ECOSYSTEM :



SESAME
Southern European Seas: Assessing and Modelling Ecosystem chan
WP 4 - 6

hypox

Université de Liège

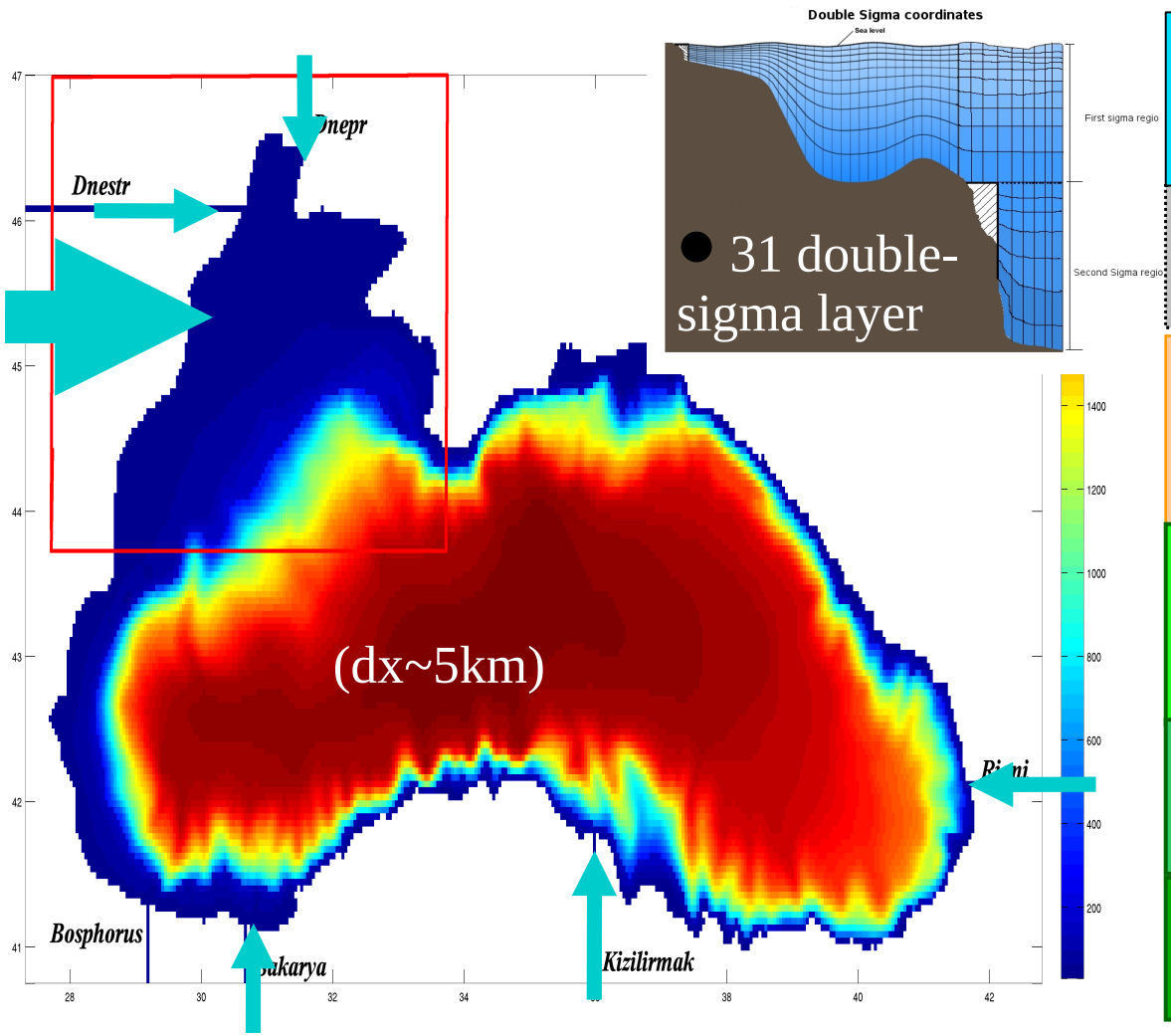
MARE
INTERFACULTARY CENTER FOR MARINE RESEARCH - LIEGE UNIVERSITY

GHER
GeoHydrodynamics and Environment Research

FNRS

Capet Arthur, Grégoire M, Beckers, JM.,Joassin P., Naithani J., Borges A.V., Soetaert K., Meysman F.

The Model



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

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

36 States variables

Physics (5)
Currents, T°, Salinity,
Surface elevation, Turbulence

Oxygen and Dissolved Inorganic Carbon (2)

Inorganic nutrients (5)
SiO,NO3,NH4,PO4,"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

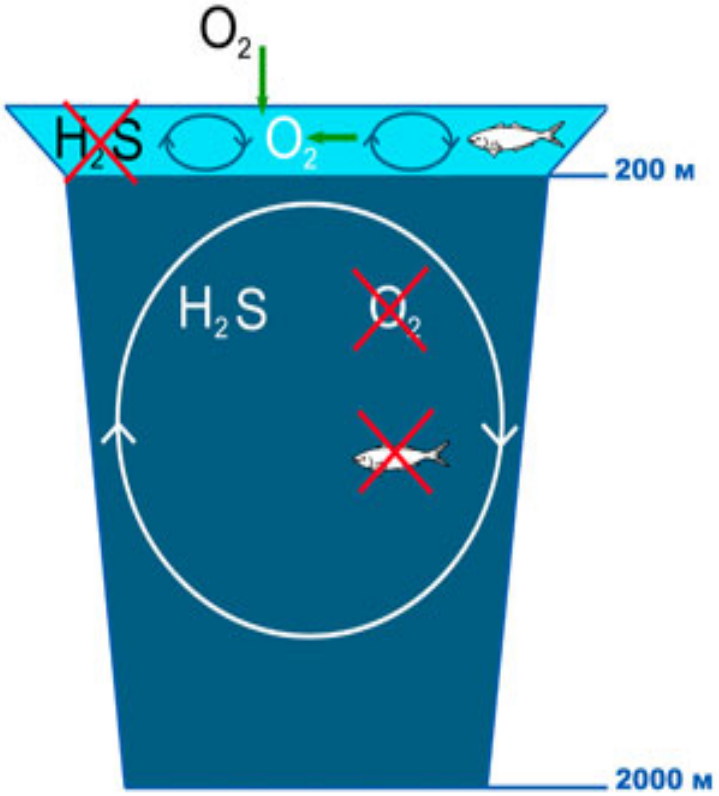
Bacteria(1)

Model's Specificity

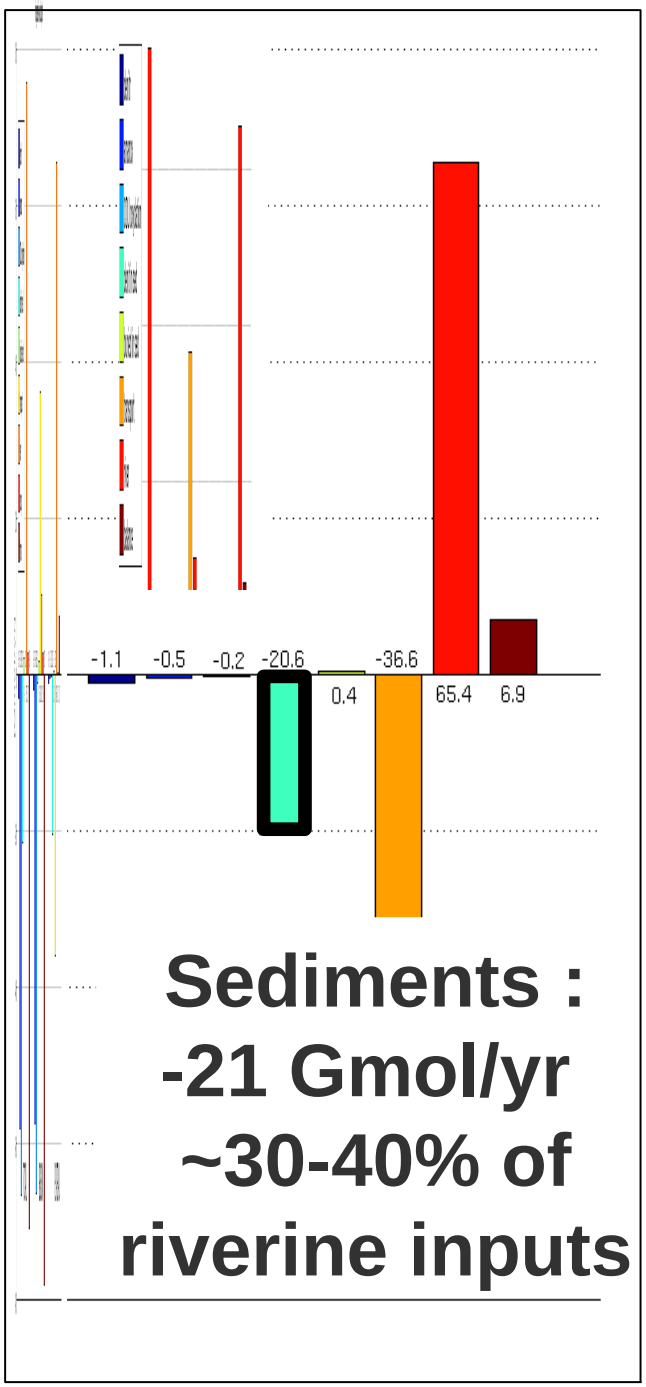
- No data assimilation : Necessity to construct specific Bosphorus representation to ensure conservation of volume and total salt content.

- Anoxic waters : The biological model explicitely includes anoxic chemistry trough the use of a variable 'Oxygen demanding Units', as a proxy for reducers acting in the anoxic zone.

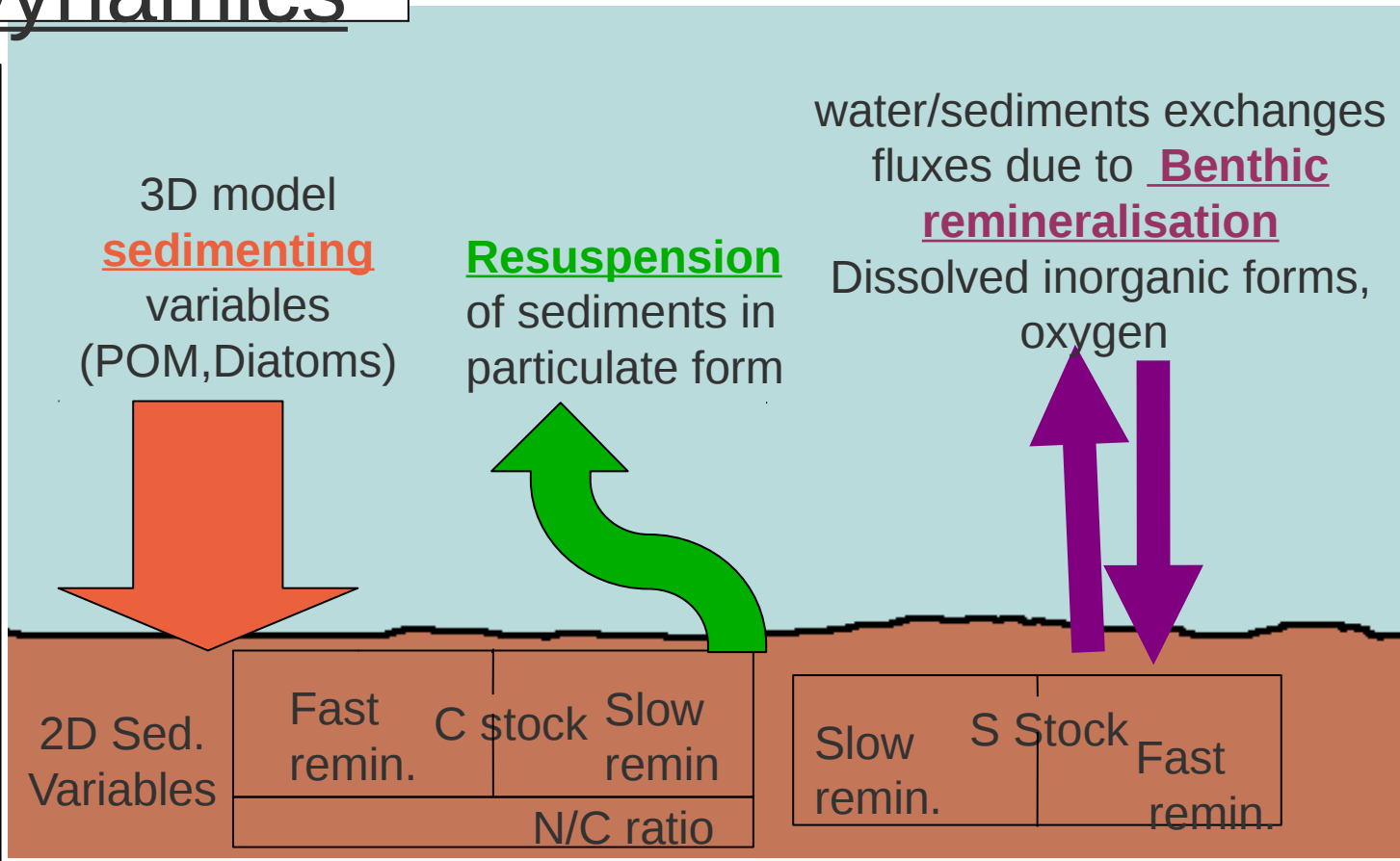
- Sediments compartiment



Sediments Dynamics

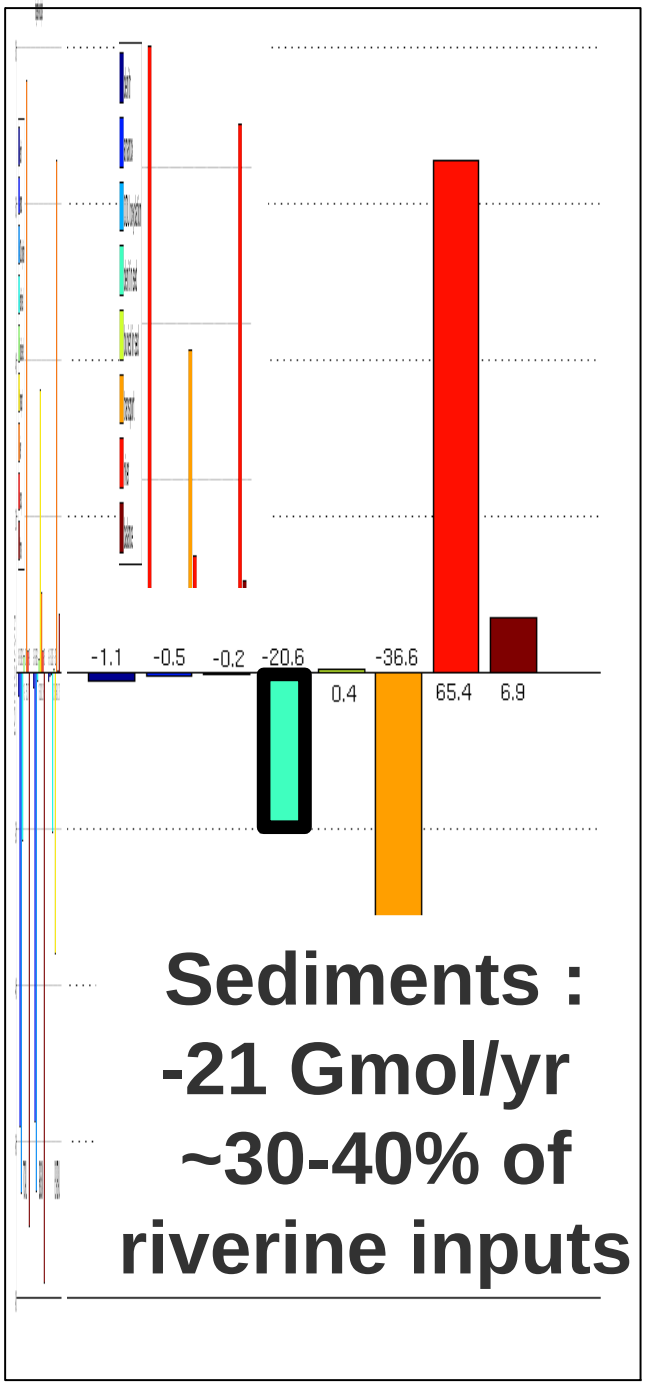


Sediments : -21 Gmol/yr ~30-40% of riverine inputs



- Sedimentation is driven by an aggregation models [*Kriest 2002*] (typically ~2/3 m/d).
- Resuspension is the effect of bottom stresses du 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*]

Sediments Dynamics



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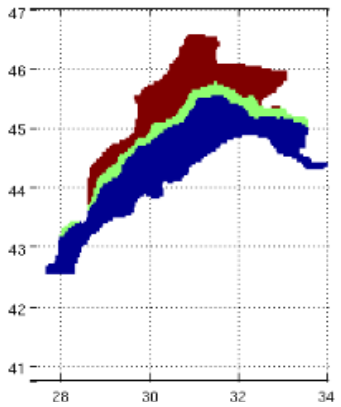
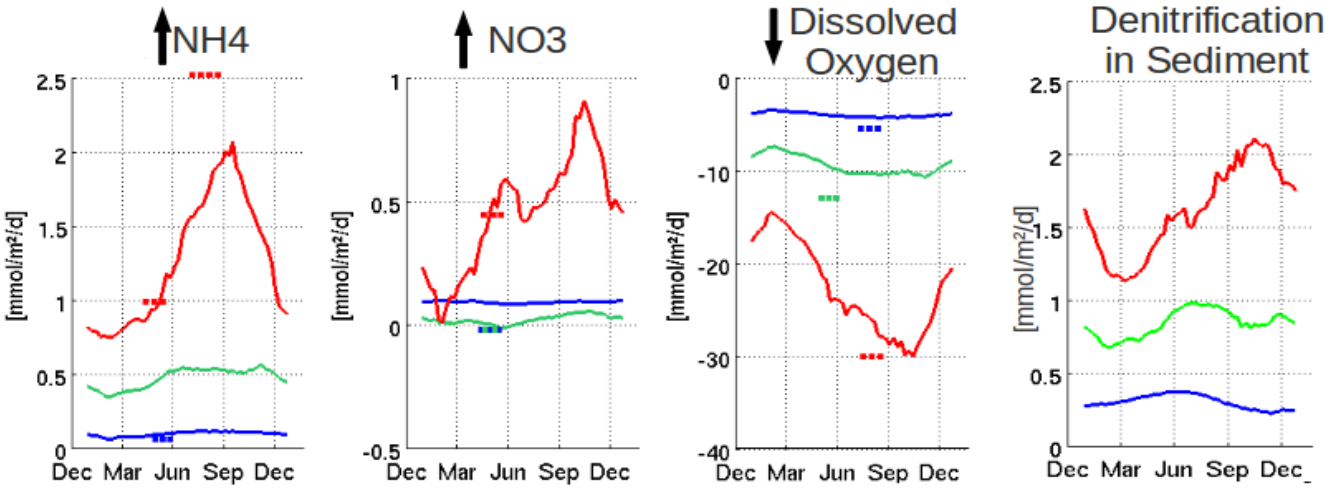


Climatological run. 1996 → 2000

The dotted bars indicates value from EROS21 [Wijsman, *Spatial distribution in sediment characteristics and benthic activity on the north-western Black Sea shelf.* , Mar Ecol Prog Ser **39**



- 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

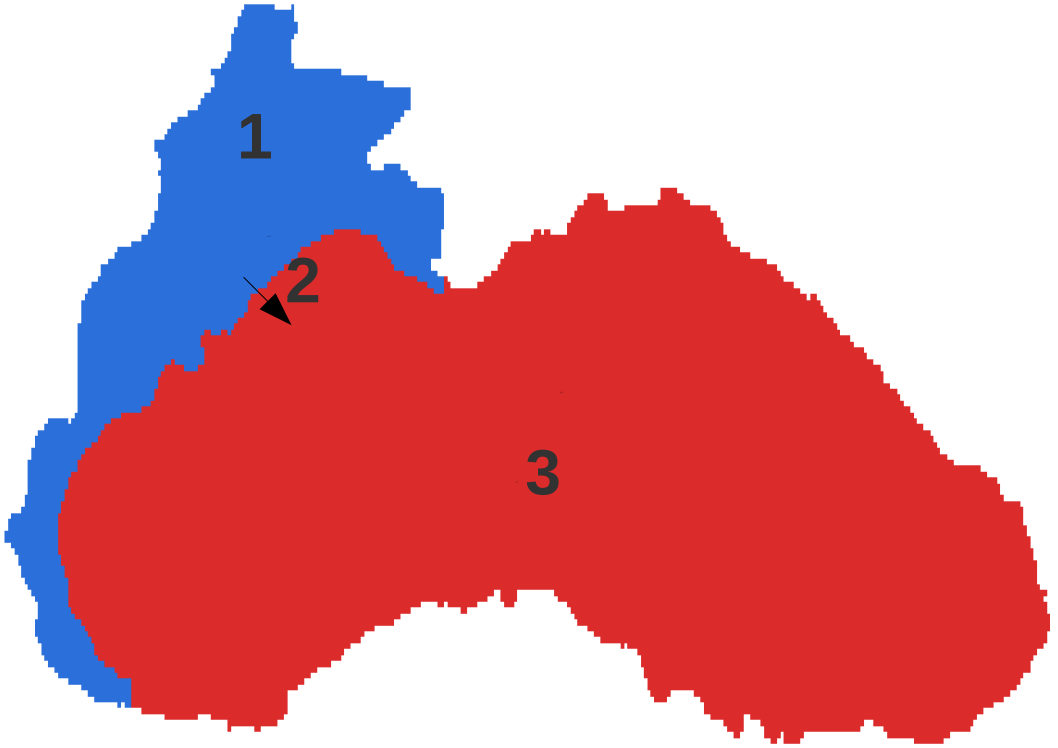
Analysis

Coupled run from 1985 to 1999.

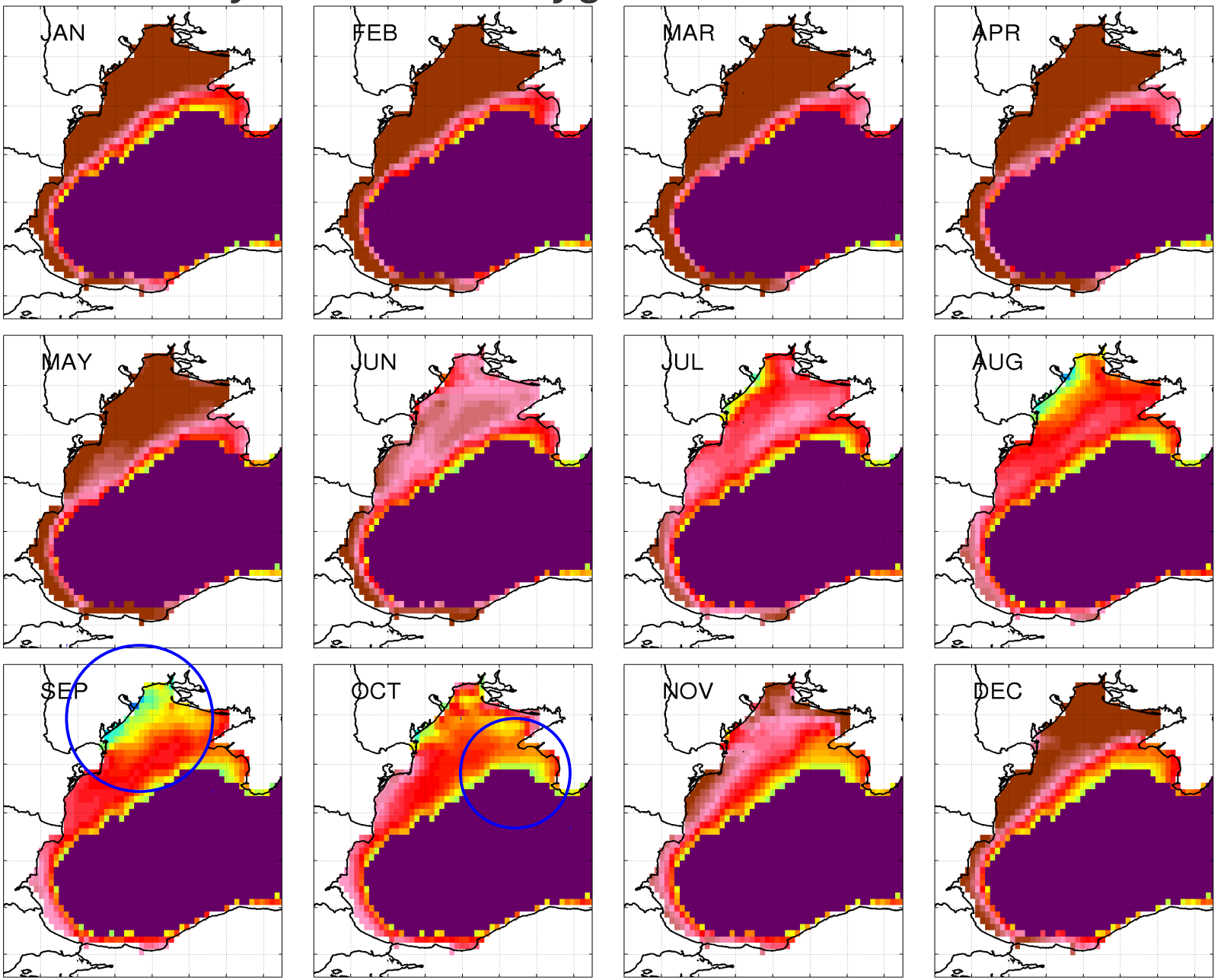
- 1. North Western Shelf (NWS) .
  Seasonnal hypoxia, Oxygen budget, interannual variability.

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

- 3. Open Basin
  Oxicline depth, budget, regionalisation, Bosphorus plume.

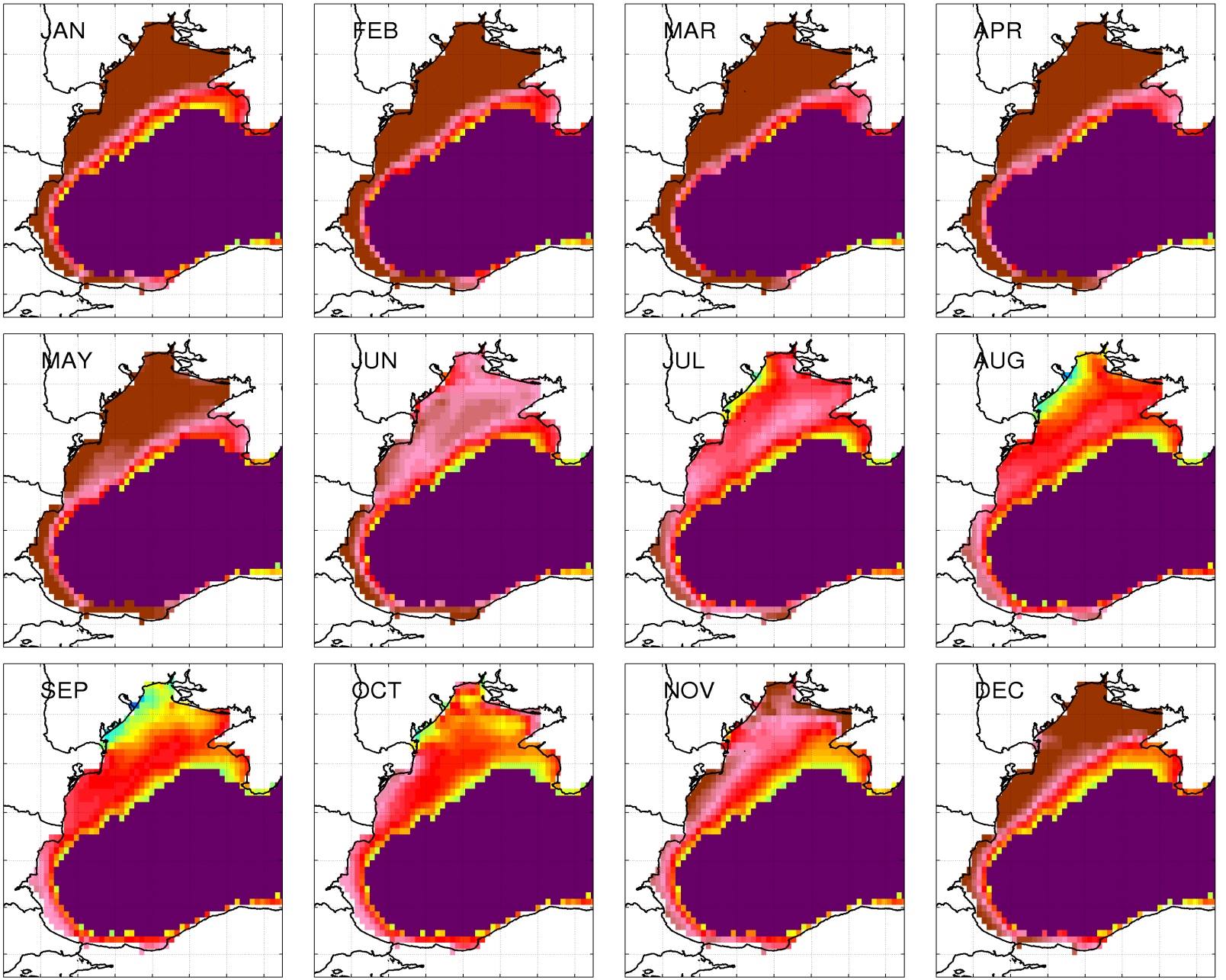


Climatological seasonnality of Bottom Oxygen conditions on the NWS

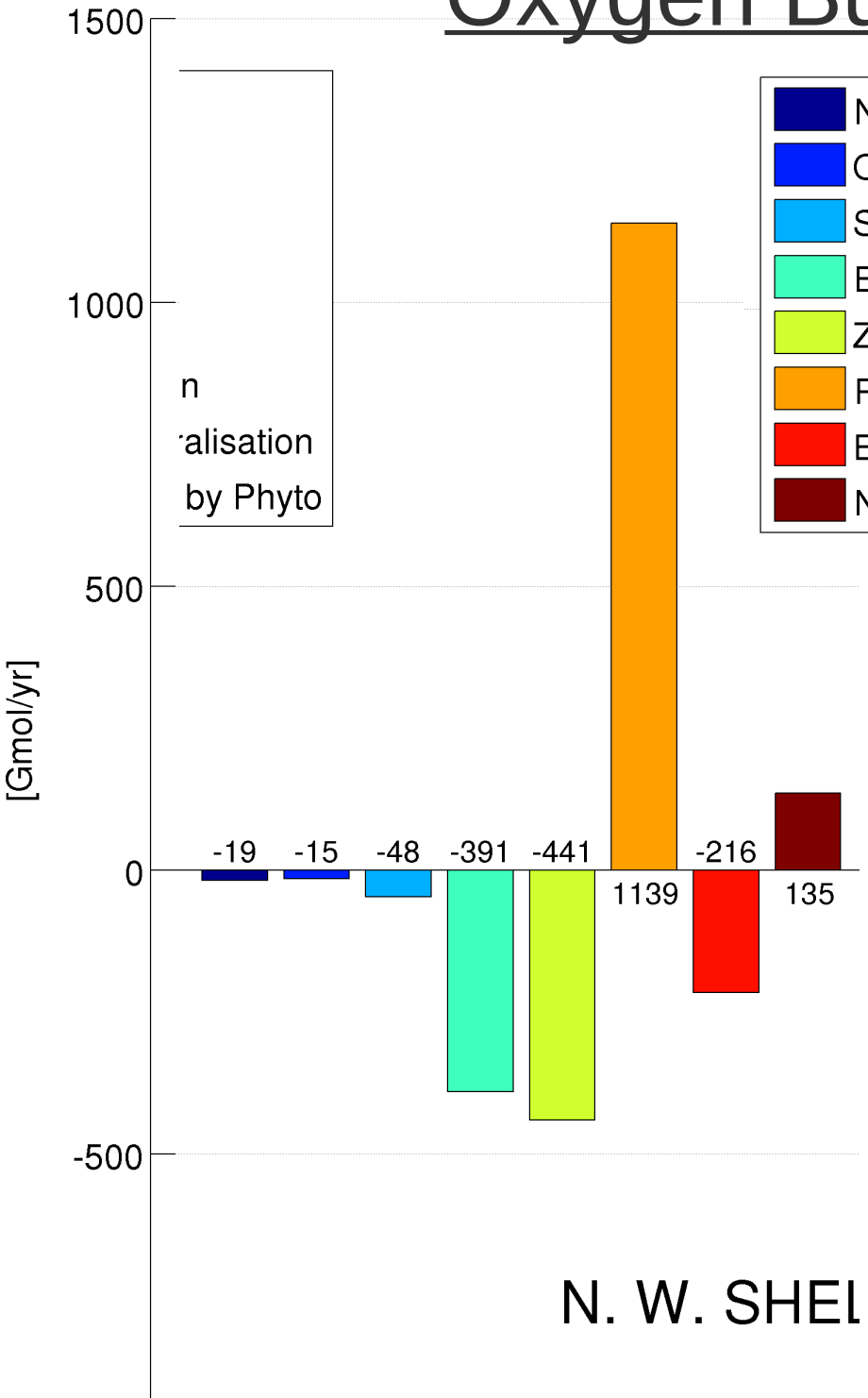


Climatological seasonnality of Bottom Oxygen conditions on the NWS

Y.Zaitsev , V. Mamaev,
Marine biological diversity in the Black Sea : A study of changes and decline
UN publication, 1997



Oxygen Budget on the NWS

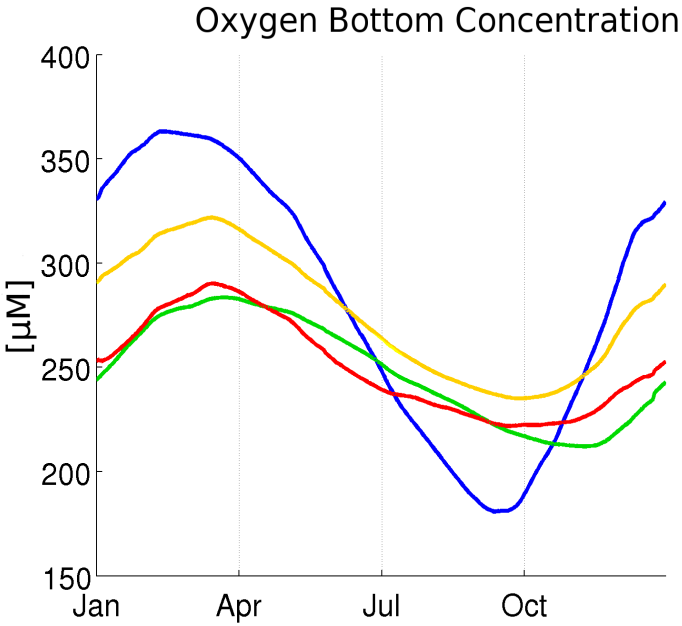


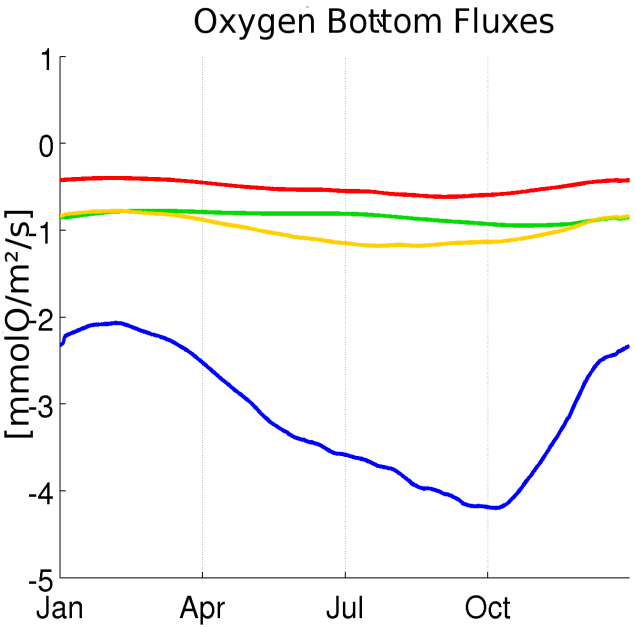
- Net autotrophic ecosytem -> export toward the open basin.
- Sediment consumption as high as Zooplankton respiration, and almost twice of pelagic remineralisation.

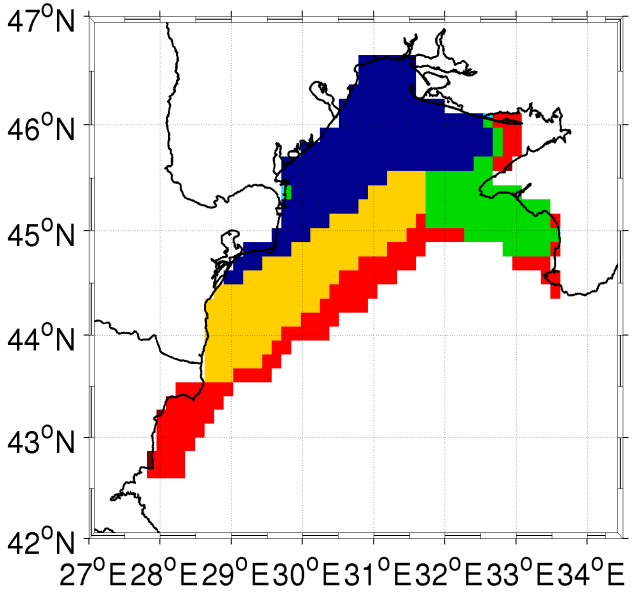
Automatic regionalisation procedure (Self Organizing Map *[Allen 2007]*)

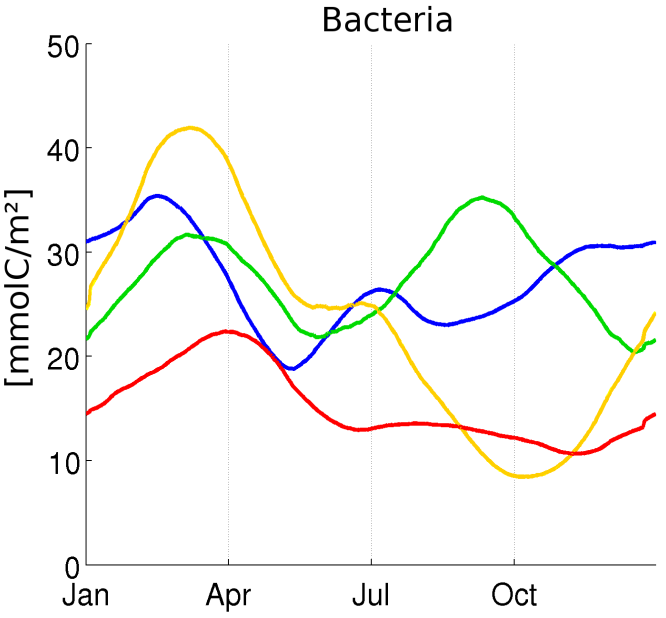
- NW corner bottom oxygen concentration, associated to benthic fluxes.

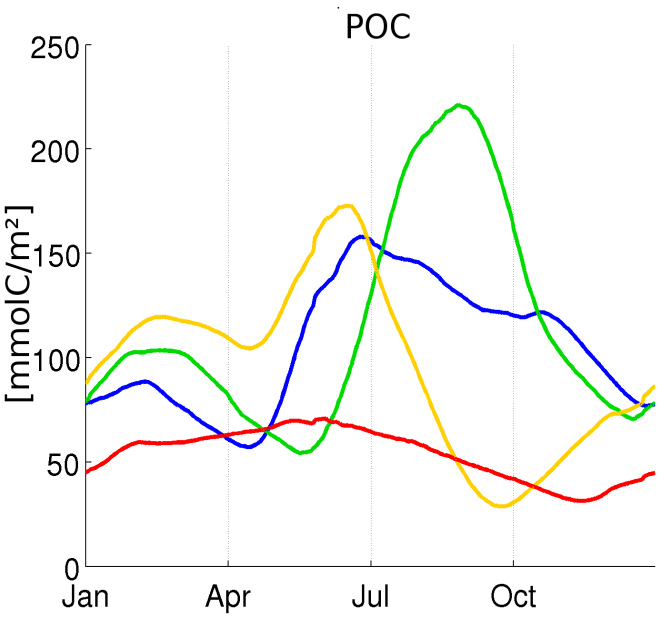
- Crimea zone is affected by POC accumulation,



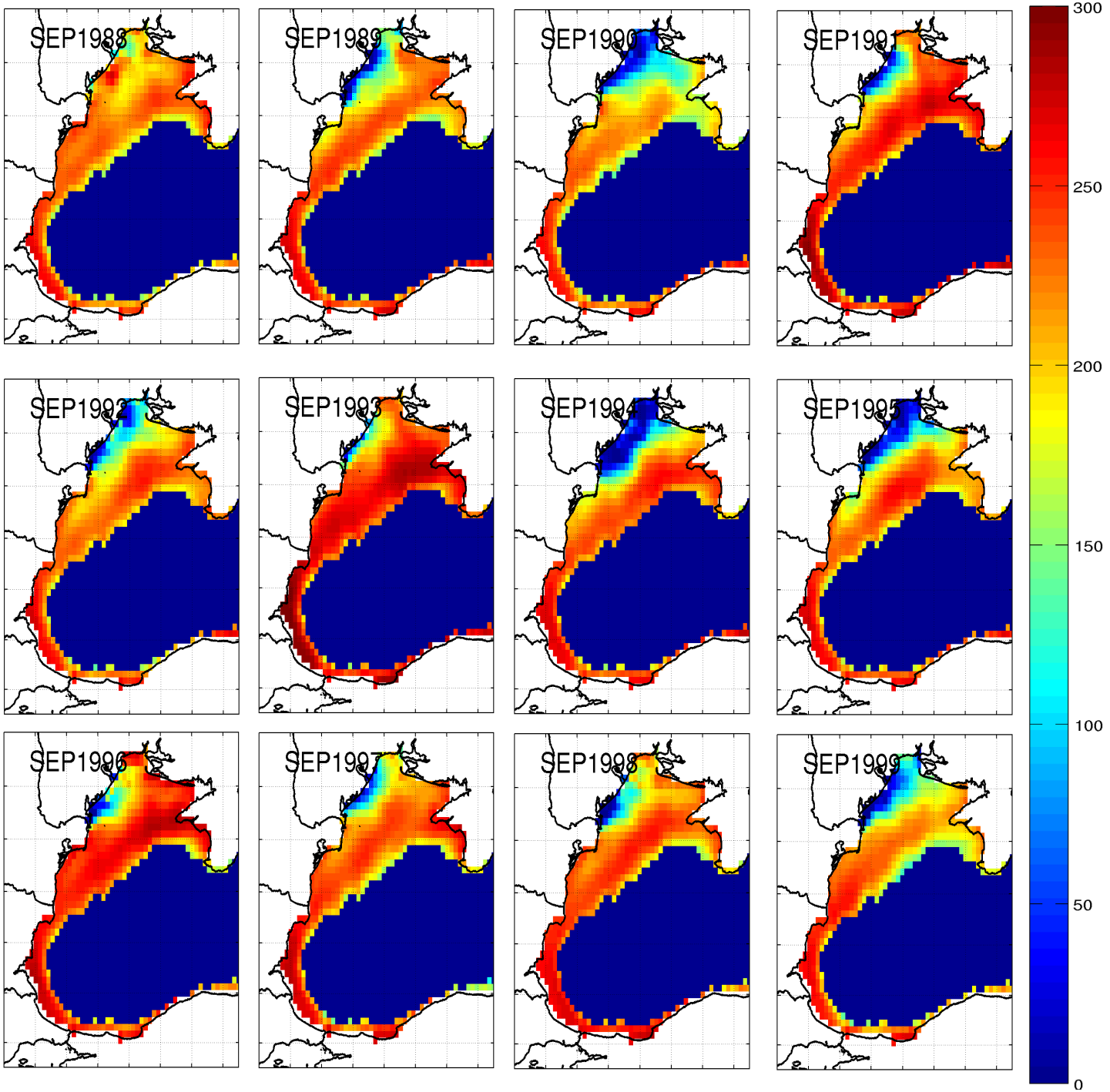




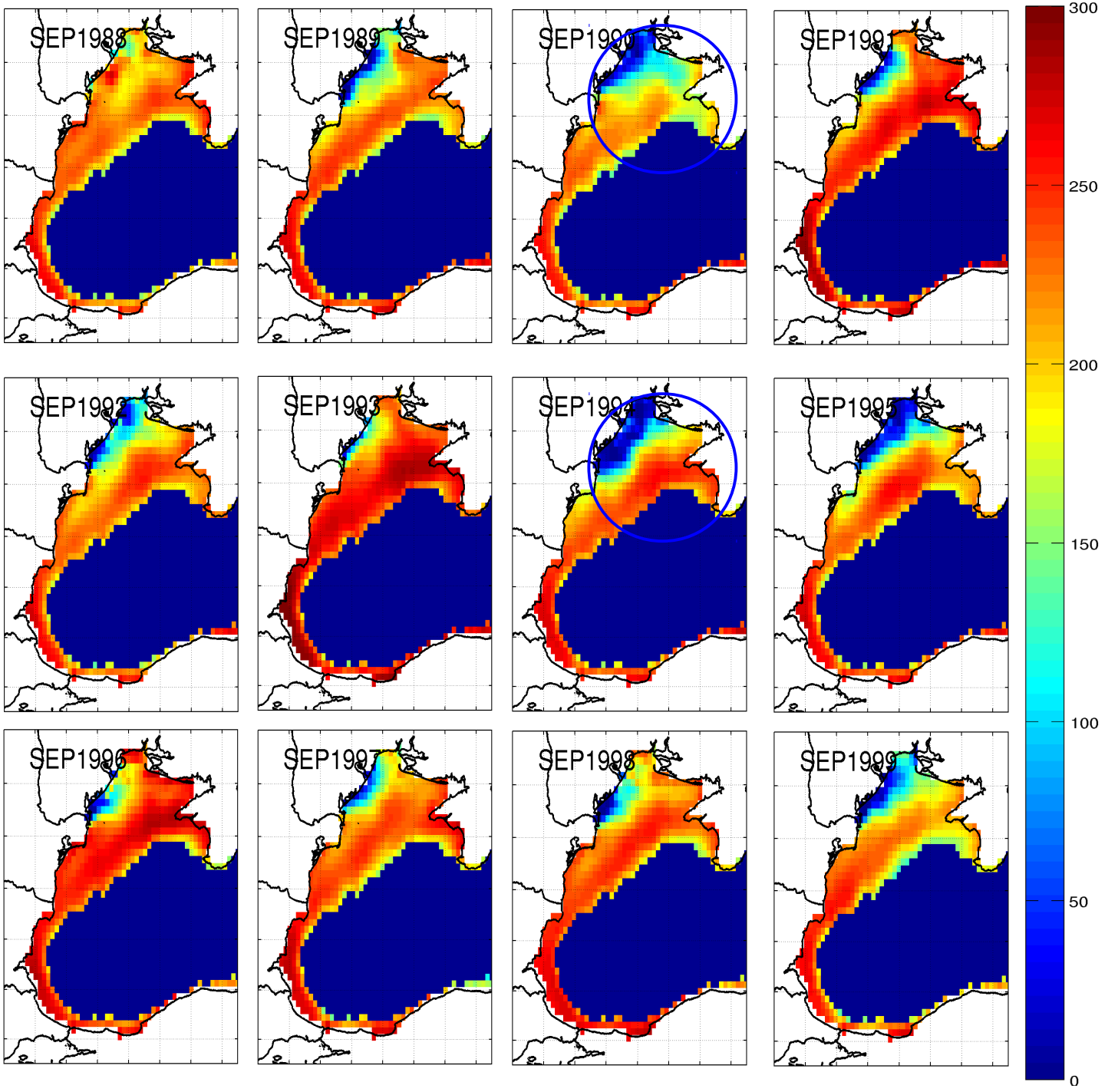




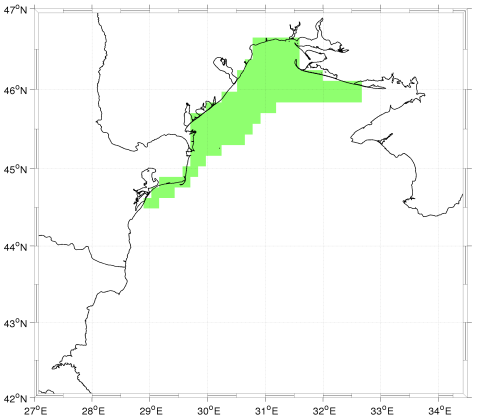
Interannual variations

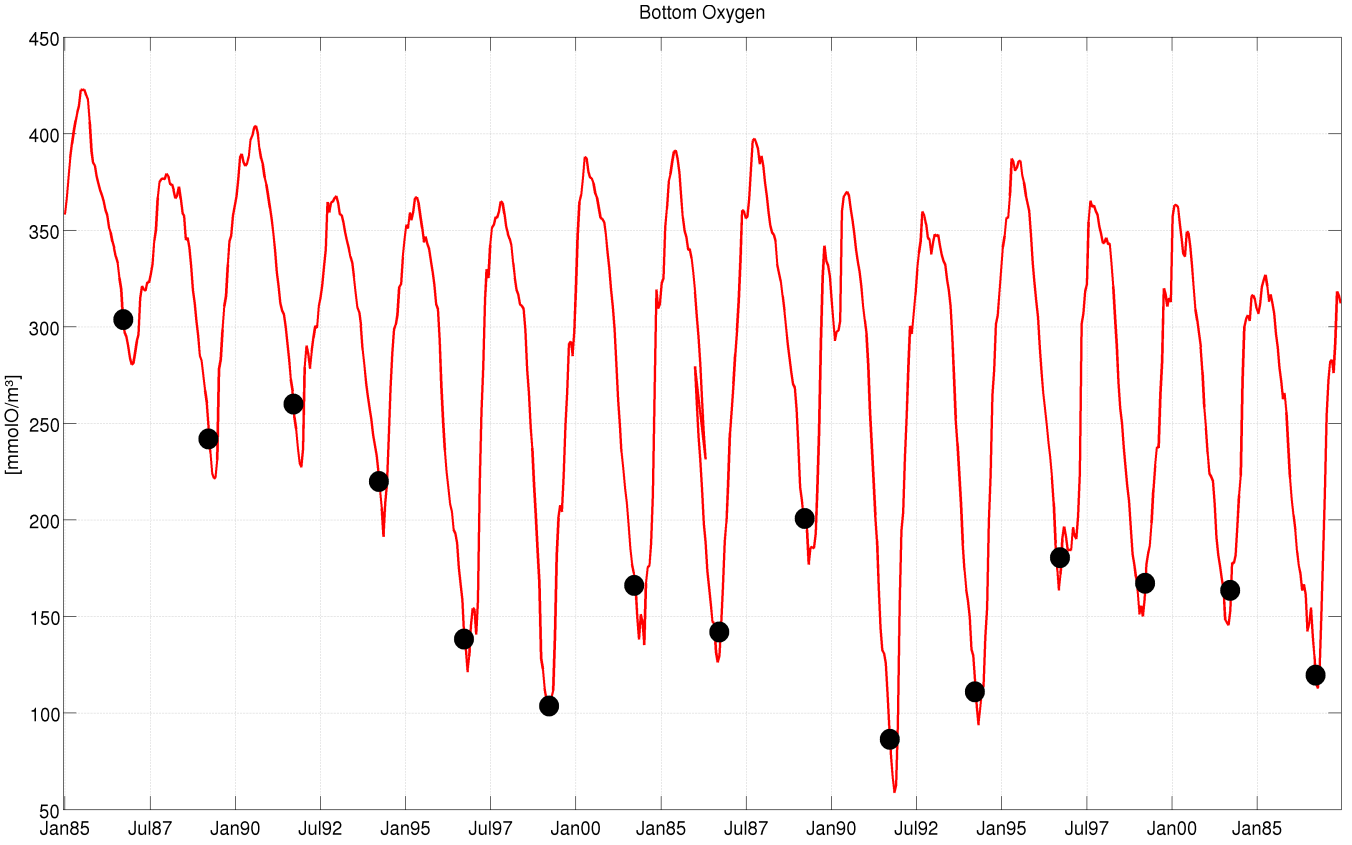


Interannual variations

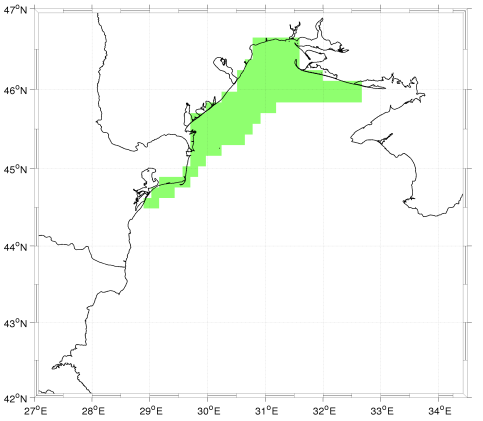


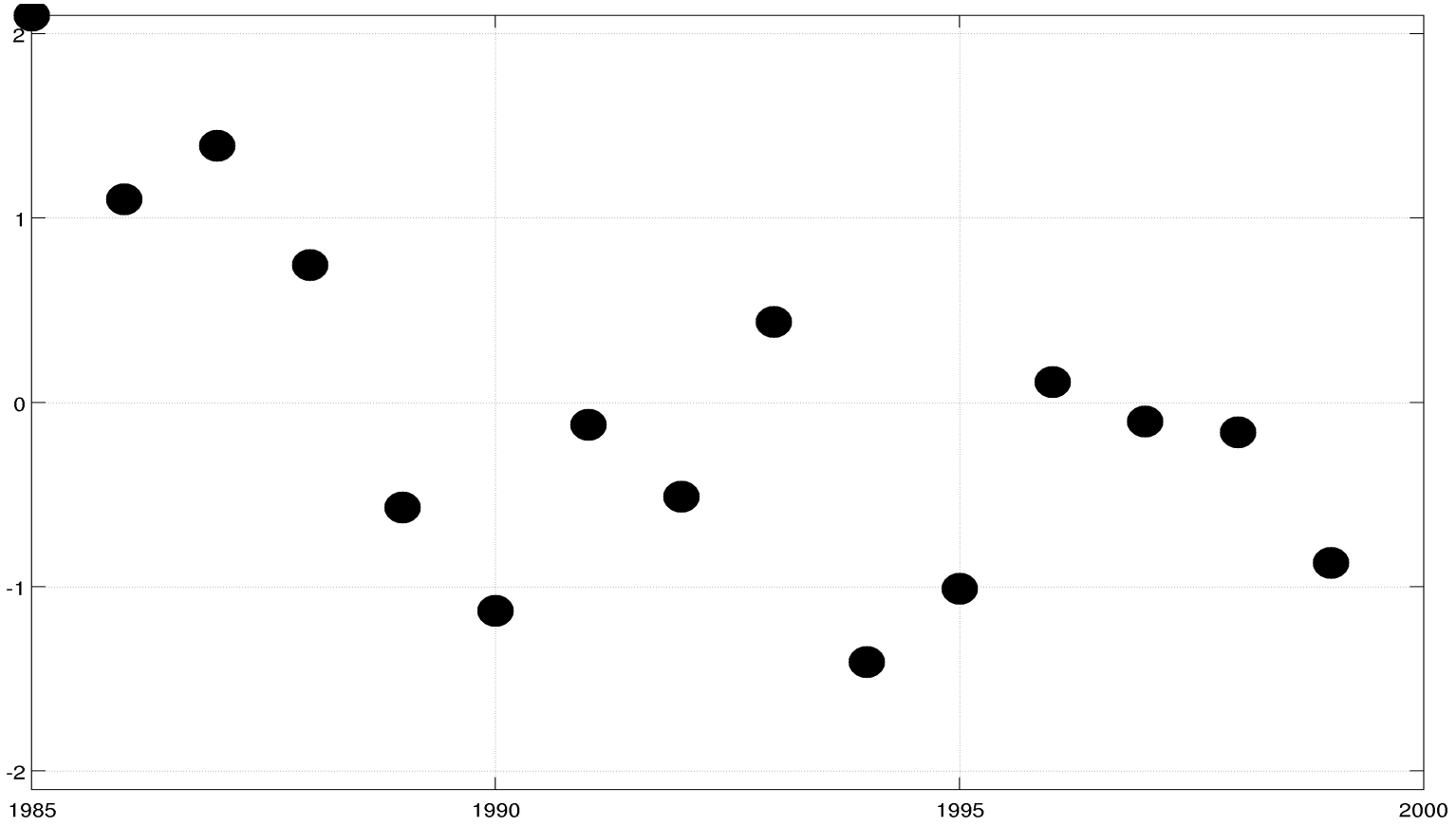
Looking for drivers



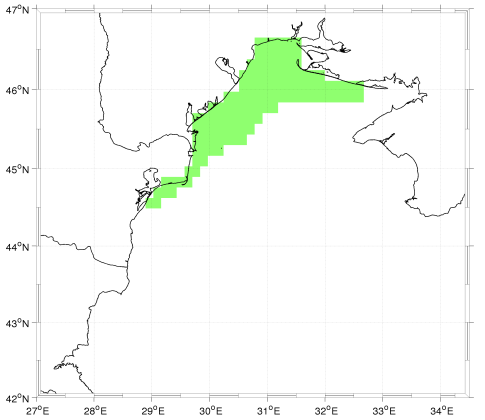


Looking for drivers

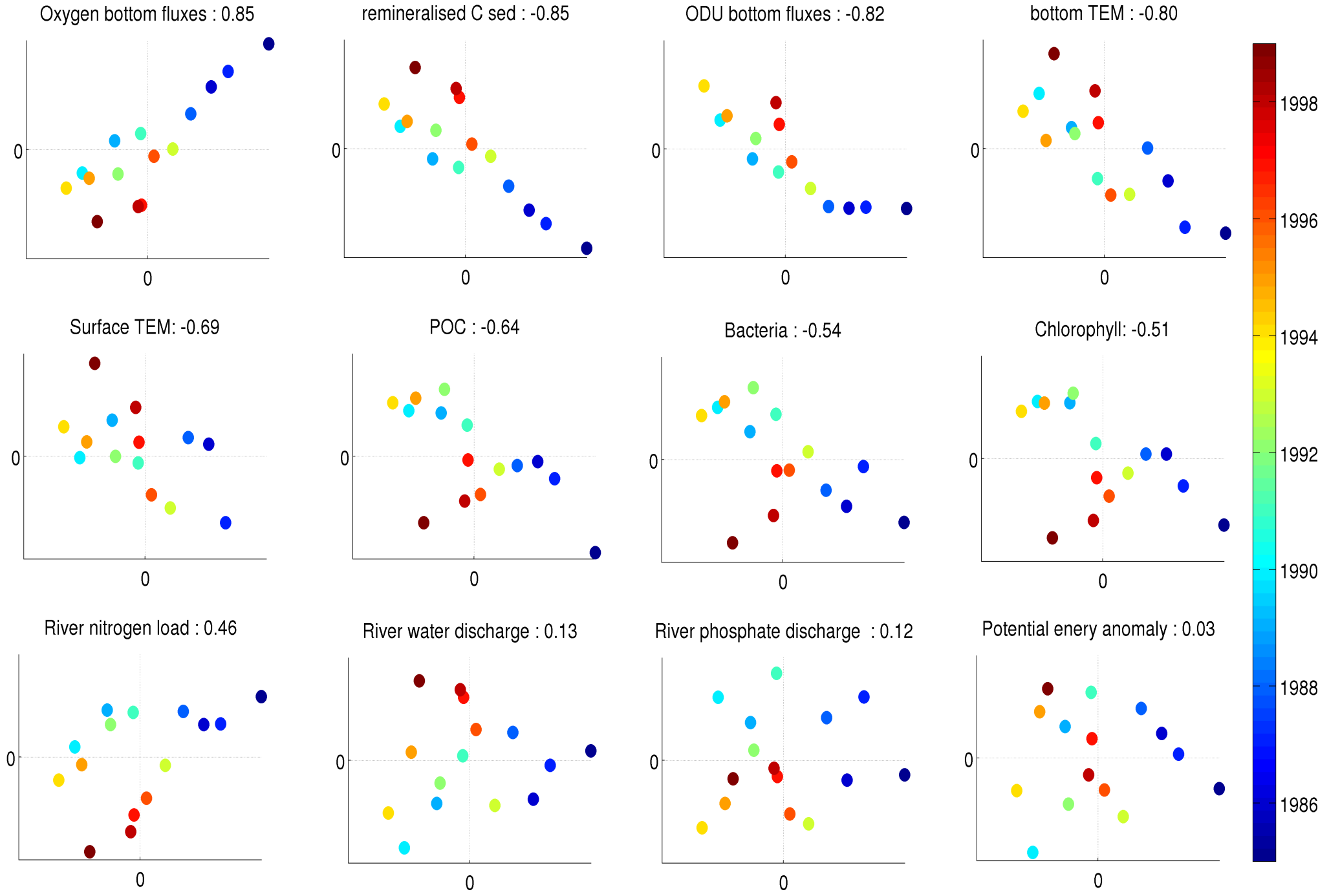




Looking for drivers



- 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.


Oxygen bottom fluxes : 0.85
remineralised C sed : -0.85
ODU bottom fluxes : -0.82
bottom TEM : -0.80
Surface TEM: -0.69
POC : -0.64
Bacteria : -0.54
Chlorophyll: -0.51
River nitrogen load : 0.46
River water discharge : 0.13
River phosphate discharge : 0.12
Potential enery anomaly : 0.03
0
1998
1996
1994
1992
1990
1988
1986

NWS : Conclusions

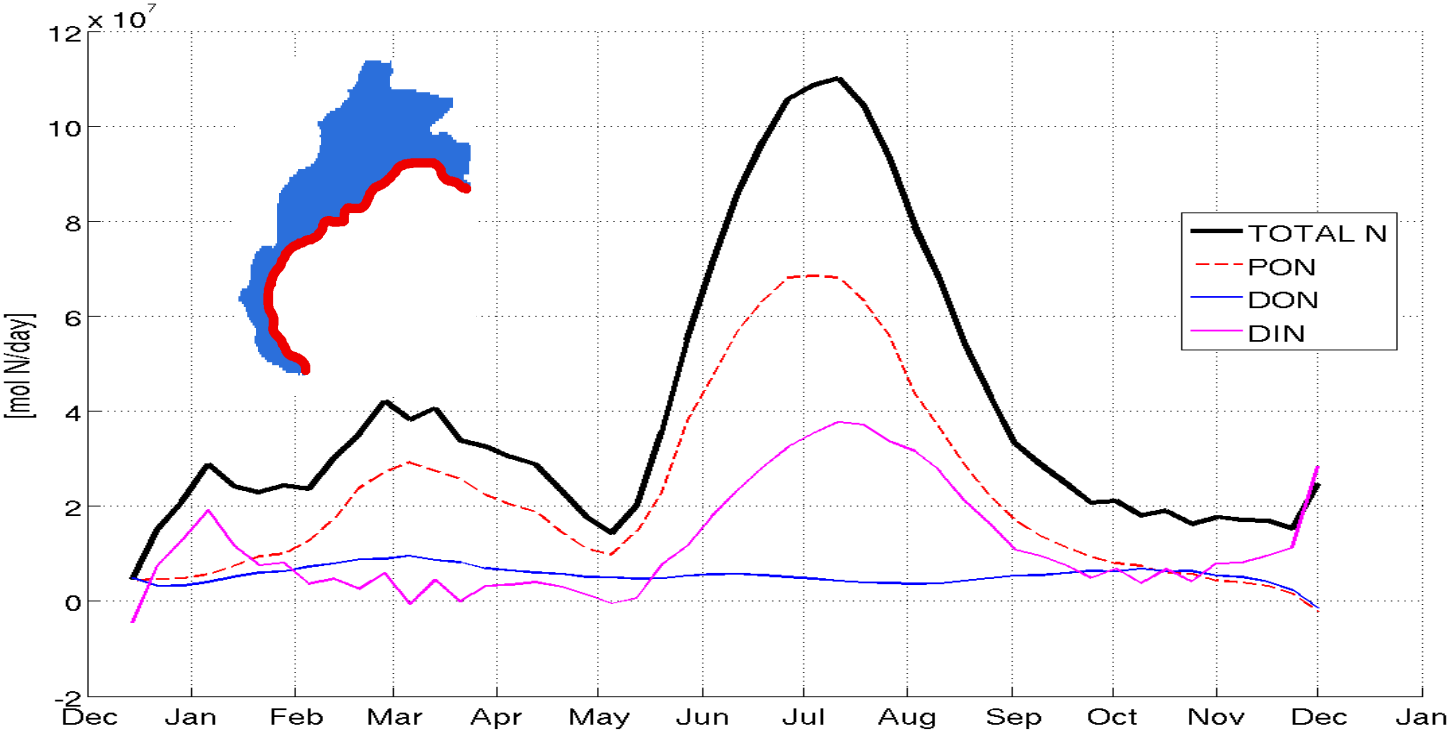
- Seasonnal hypoxia events occurs on the NWS with a peak in september.

- 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.

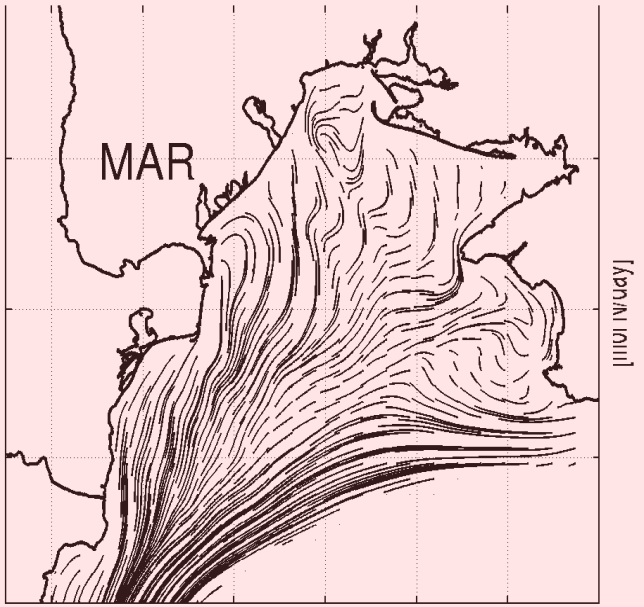
Export to open sea

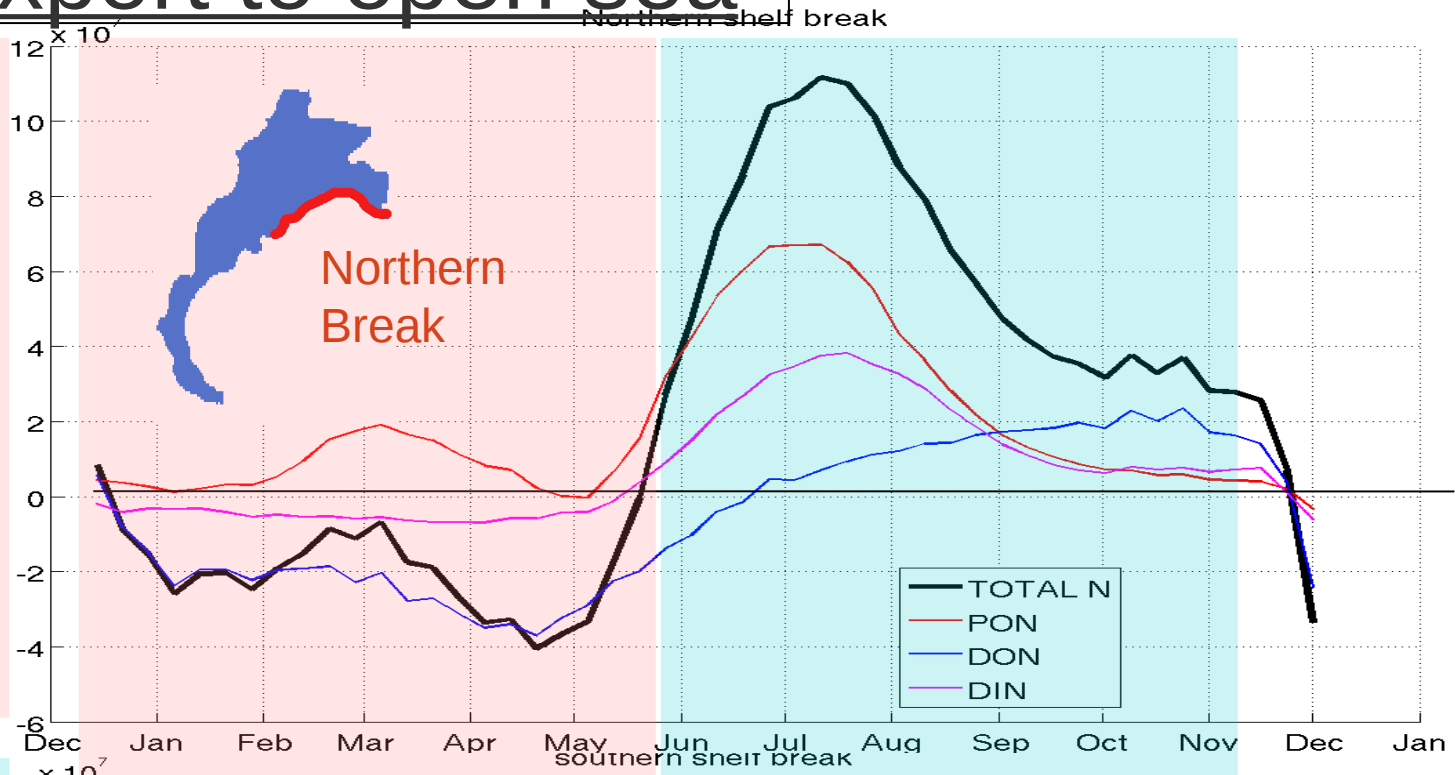


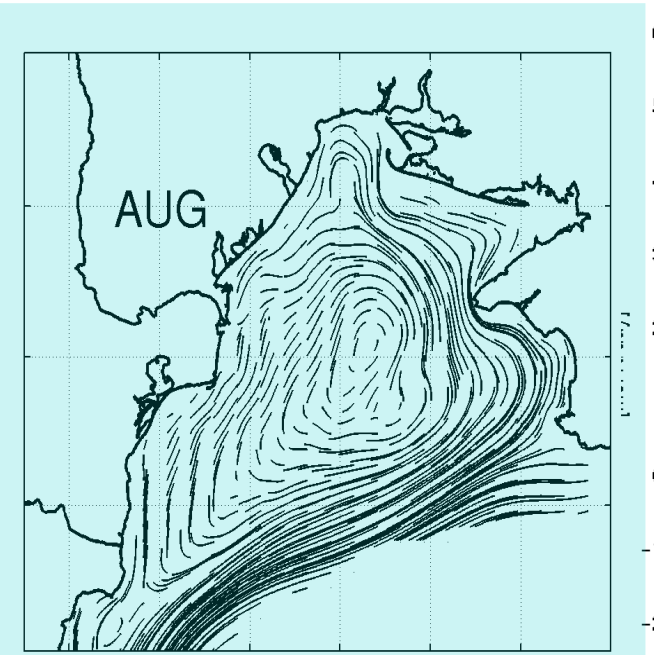
Integrated along the shelf break

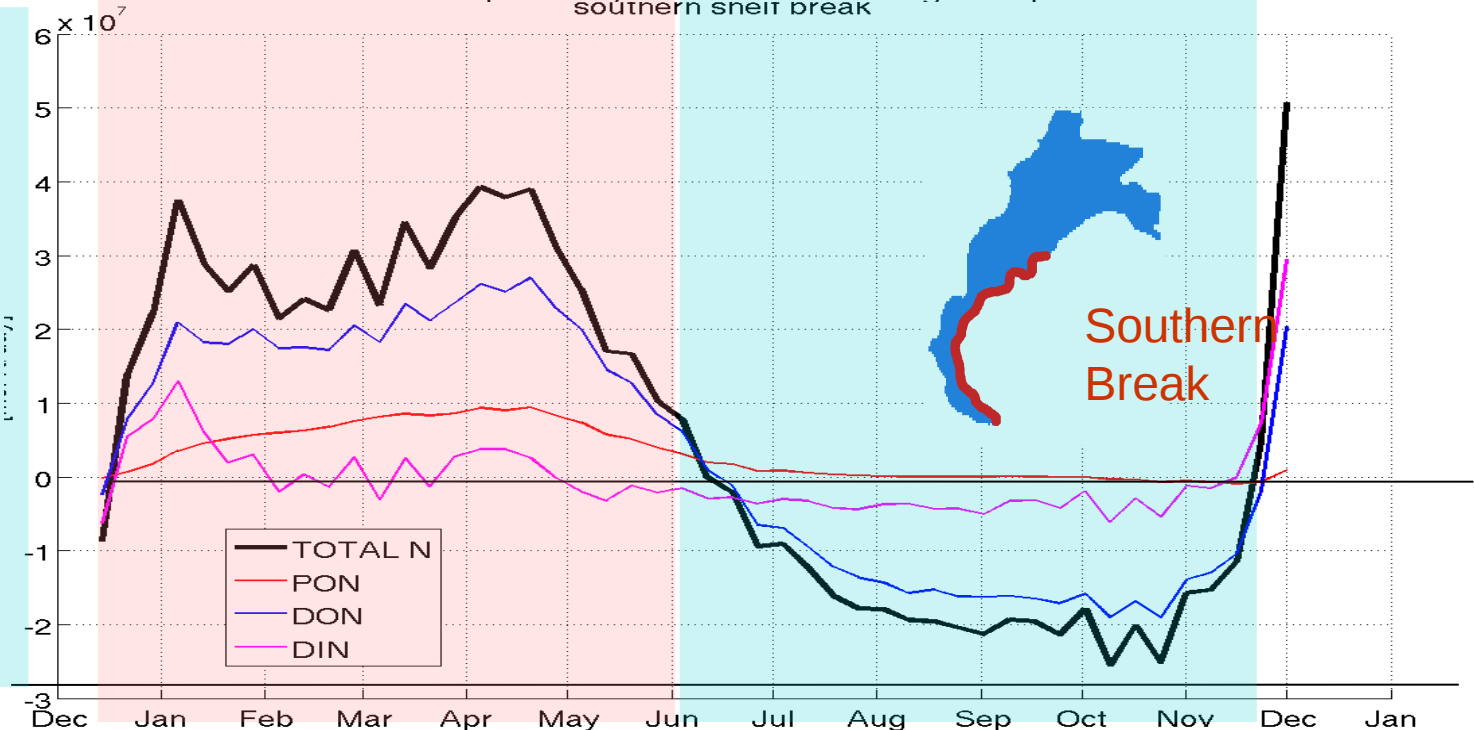
Detailled between PON DON and DIN.

Export to open sea

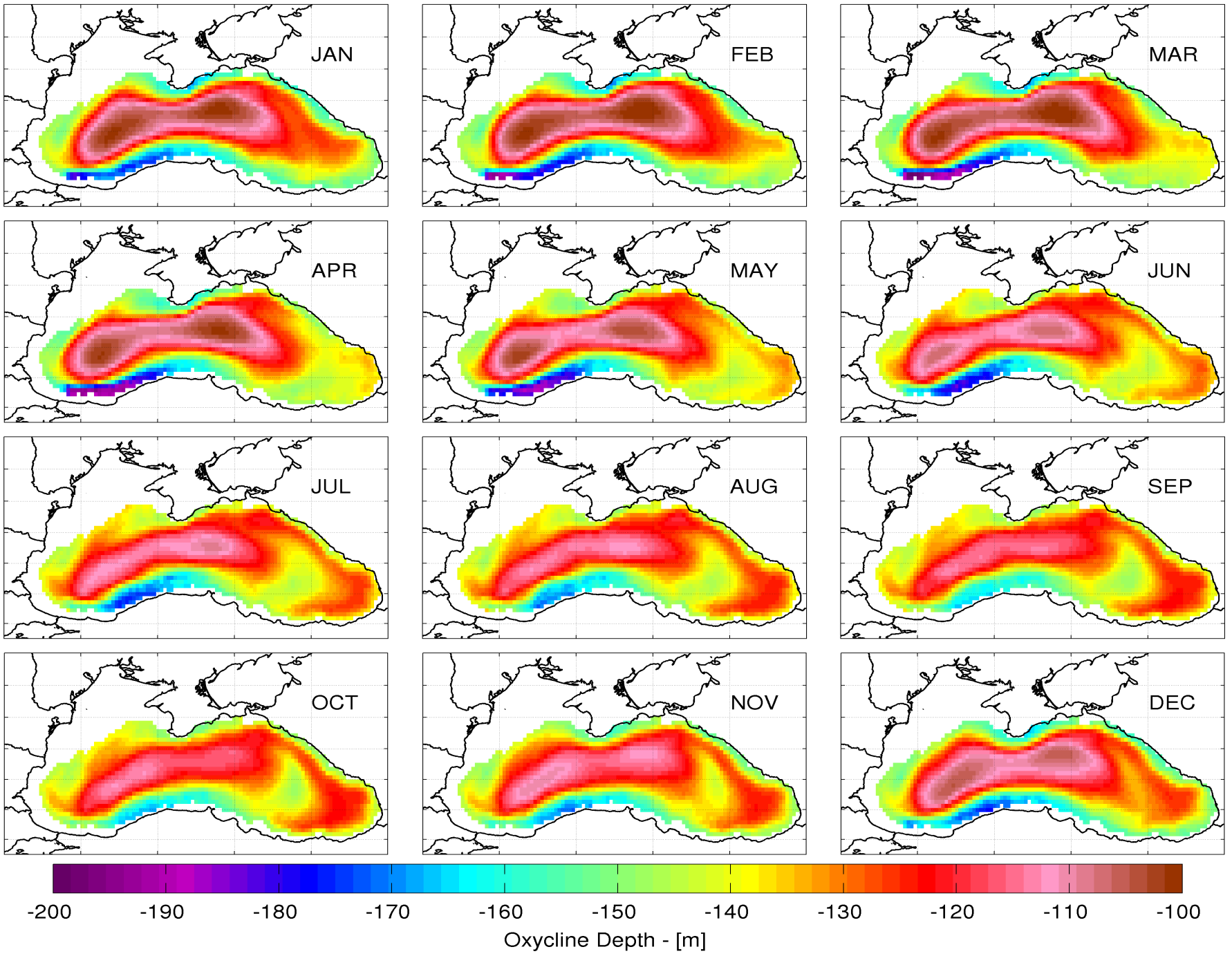


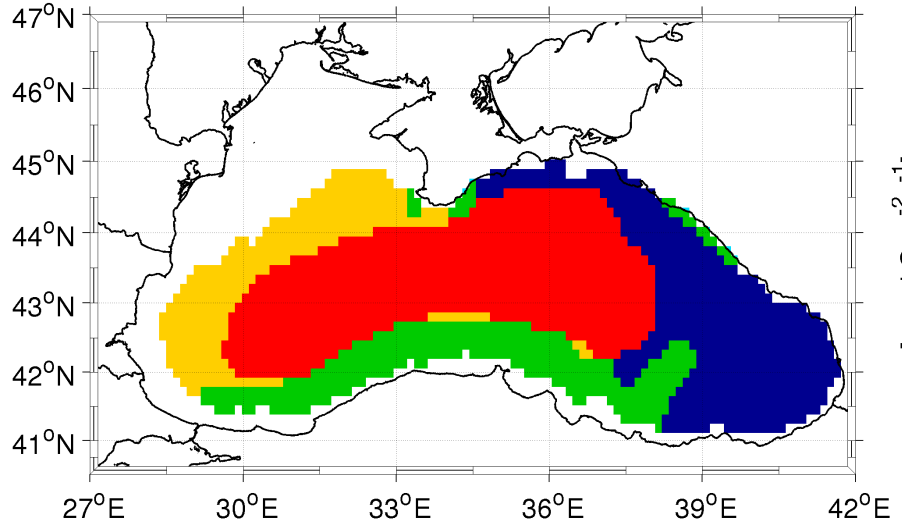


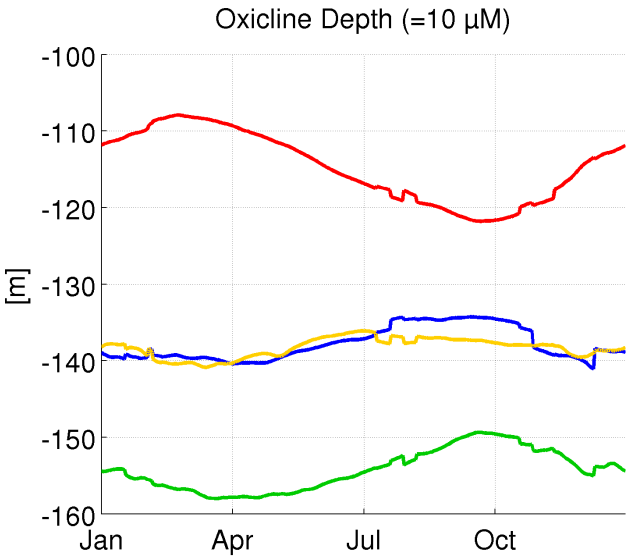


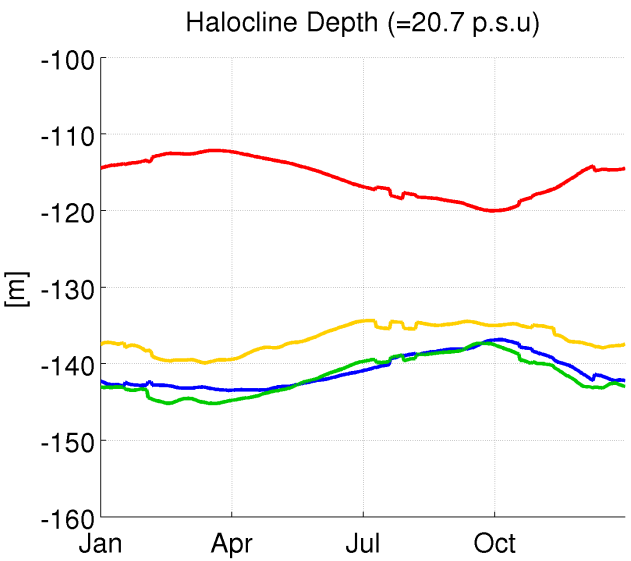


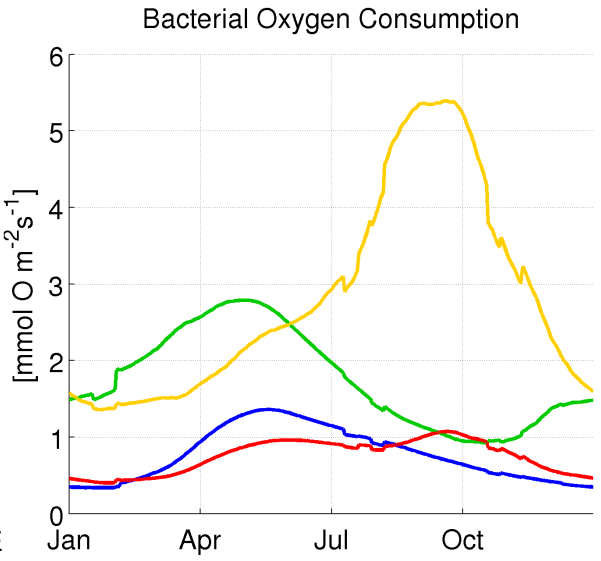
Climatological seasonnality of Oxicline depth in the open basin

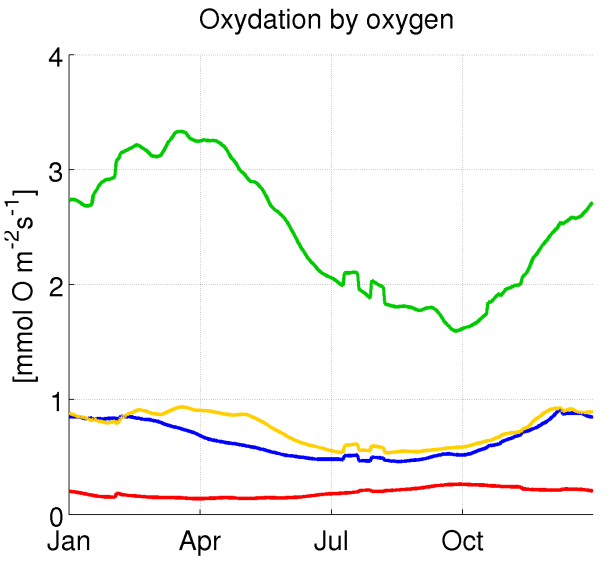



47°N
46°N
45°N
44°N
43°N
42°N
41°N
27°E
30°E
33°E
36°E
39°E
42°E


Oxicline Depth (=10 µM)
[m]
-100
-110
-120
-130
-140
-150
-160
Jan
Apr
Jul
Oct


Halocline Depth (=20.7 p.s.u)
[m]
-100
-110
-120
-130
-140
-150
-160
Jan
Apr
Jul
Oct


Bacterial Oxygen Consumption
[mmol O m-2s-1]
6
5
4
3
2
1
0
Jan
Apr
Jul
Oct


Oxydation by oxygen
[mmol O m-2s-1]
4
3
2
1
0
Jan
Apr
Jul
Oct

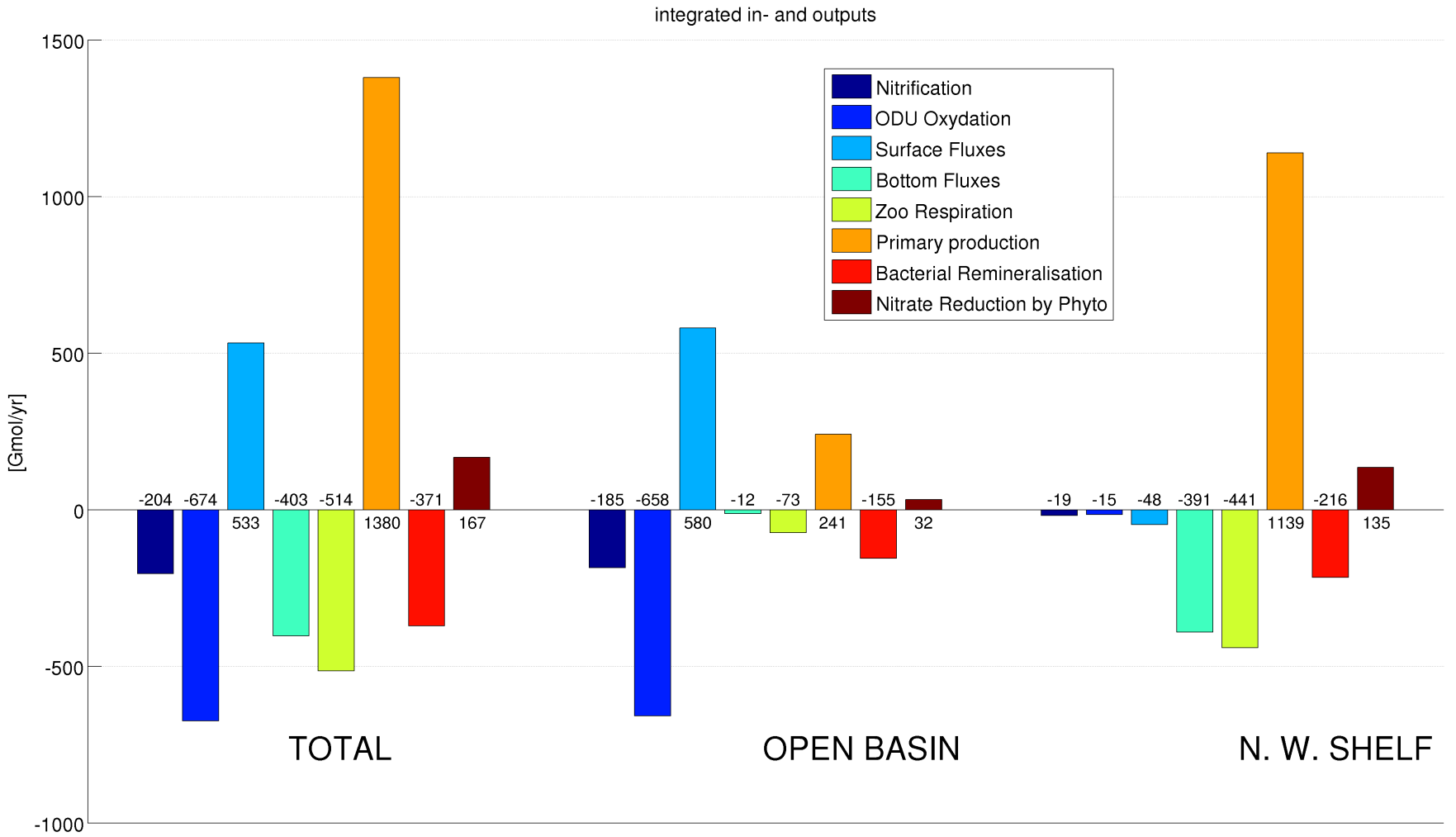
Open basin : Conclusions

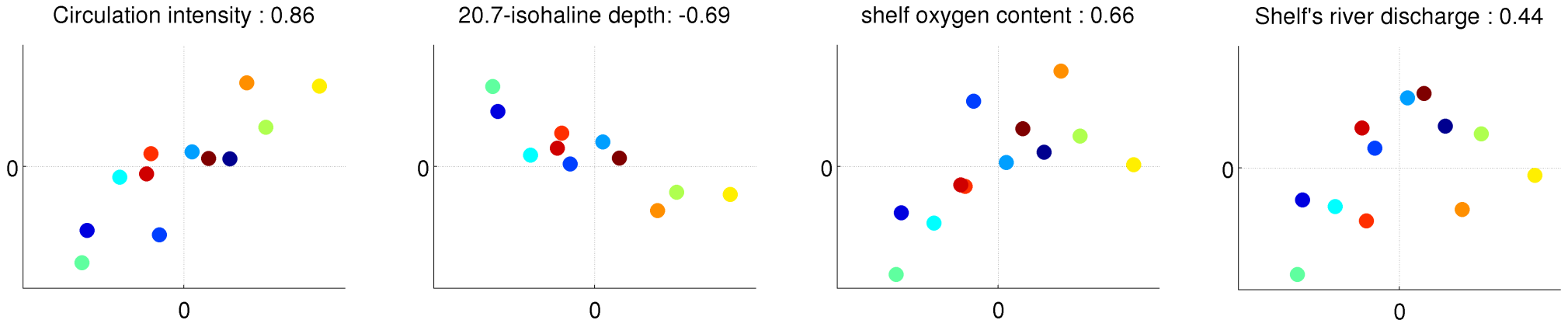
- Seasonnal hypoxia events occurs on the NWS with a peak in september.

- 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.

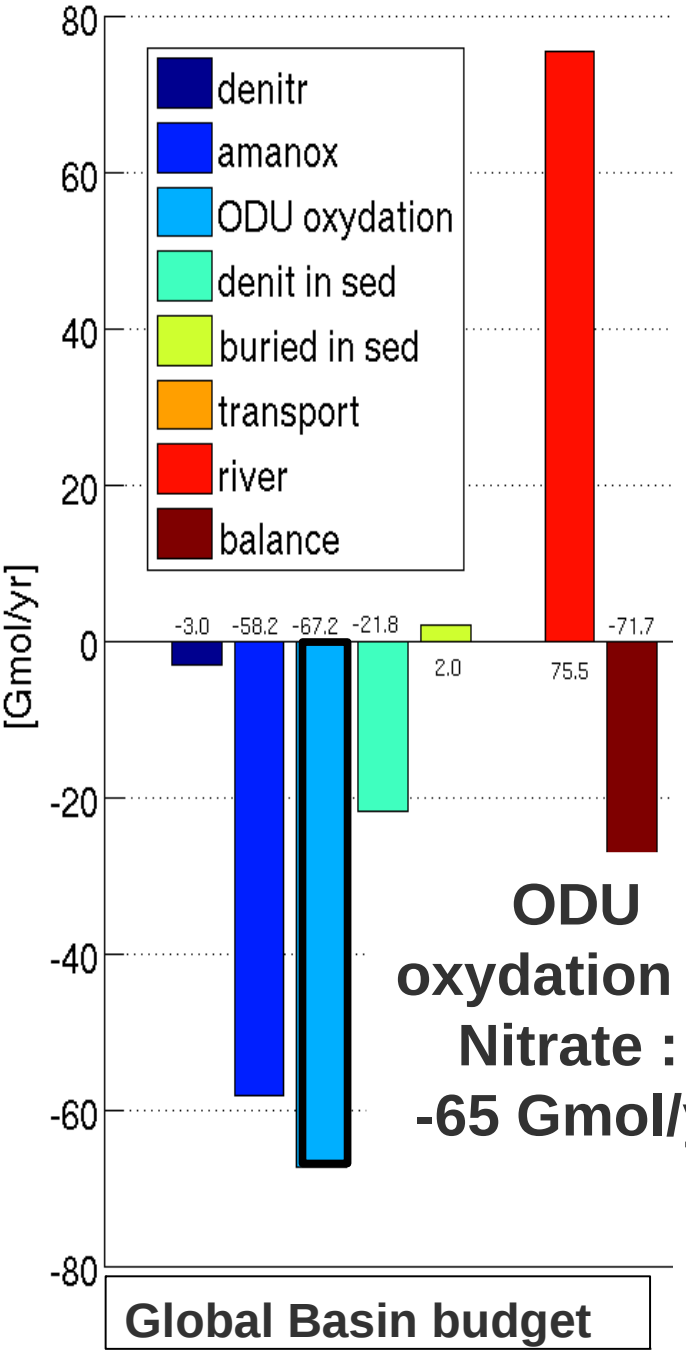

integrated in- and outputs
[Gmol/yr]
1500
1000
500
0
-500
-1000
Nitrification
ODU Oxydation
Surface Fluxes
Bottom Fluxes
Zoo Respiration
Primary production
Bacterial Remineralisation
Nitrate Reduction by Phyto
-204
-674
533
-403
-514
1380
-371
167
-185
-658
580
-12
-73
241
-155
32
-19
-15
-48
-391
-441
1139
-216
135
TOTAL
OPEN BASIN
N. W. SHELF


Circulation intensity : 0.86
20.7-isohaline depth: -0.69
shelf oxygen content : 0.66
Shelf's river discharge : 0.44
0
0
0
0
0
0
0
0

Thanks for your attention …

The Black Sea, P. Alechinsky

Nitrogen consumption in the suboxic layers



[*Konovalov, 2006, Deep-Sea Reseach II*]

~ 40 Gmol/yr for oxydation by Sulfide and manganese

~ 30 Gmol/yr for ANAMOX

[*McCarthy,2007, Estuarine, Coastal and Shelf science*]

~ 52 Gmol/yr for ANAMOX

Mainly resulting from Shelf's export entrained by the Bosporus plume