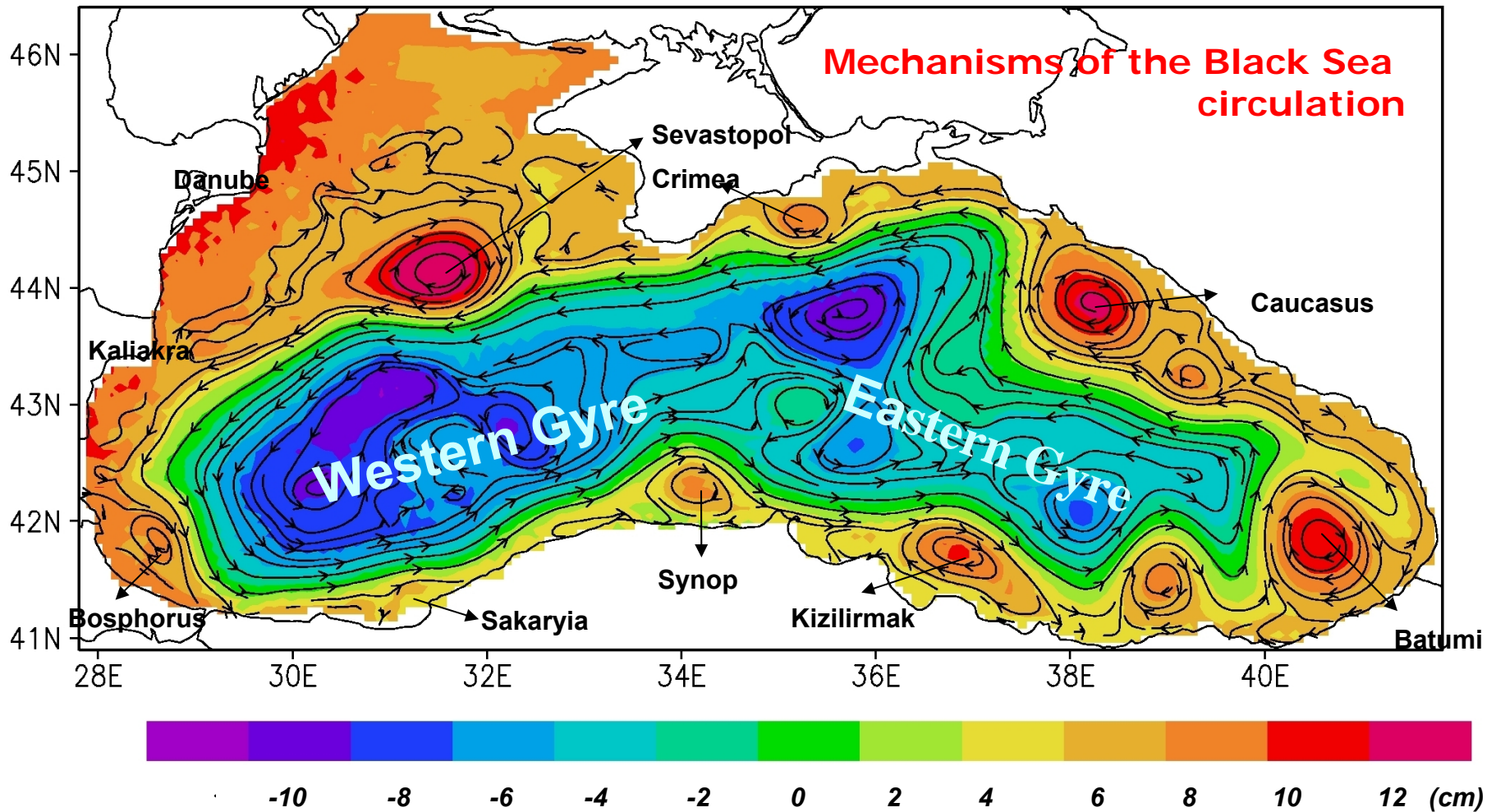


Black Sea Oxygen Dynamics as Seen in Continuous Profiling Floats Observations and 3D Numerical Simulations

E. V. Stanev

With contributions of Y. He, J. Staneva and E. Yakushev

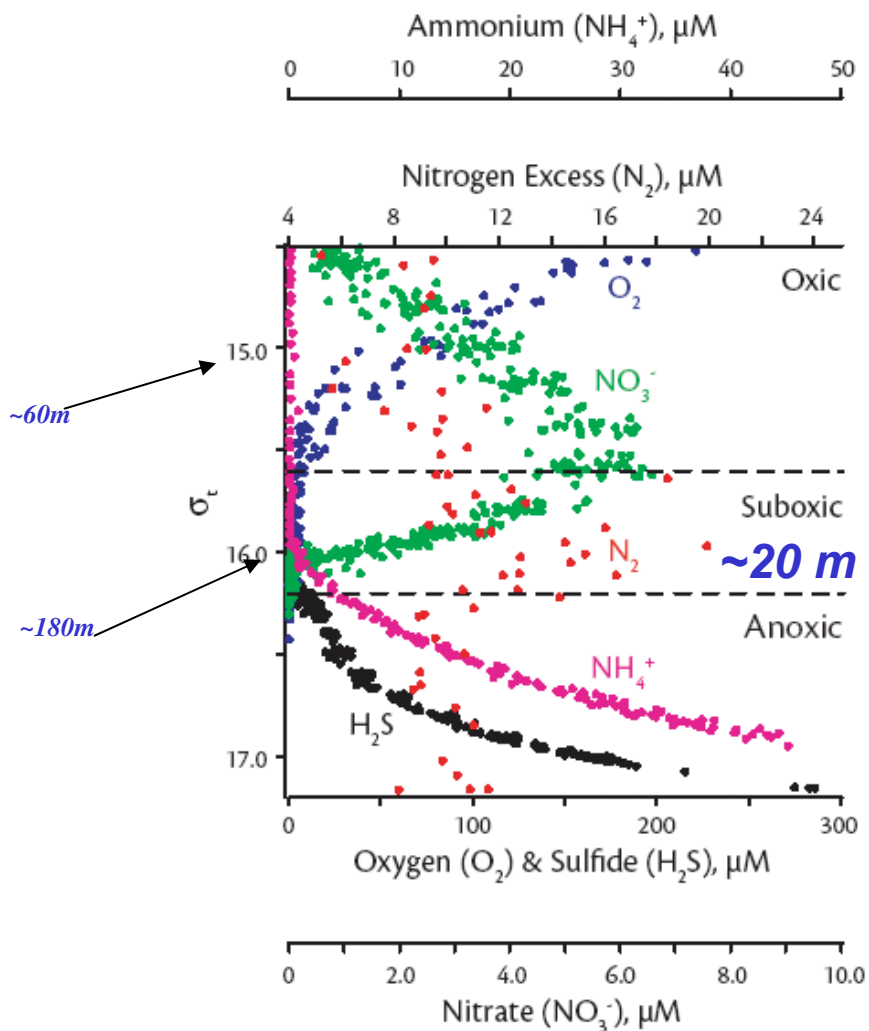
About the Black Sea: Two-gyre circulation plus anticyclonic coastal circulation



Seasonal amplitudes: ~ 10 cm, winter intensification

Staneva et al. (2001, JMS)

About the Black Sea: unique biogeochemistry



Konovalov et al. (2005, Oc. Magazine)

The biggest anoxic body on Earth

The Challenges

- Continuously measured oxygen are needed
- Study of diapycnal mixing

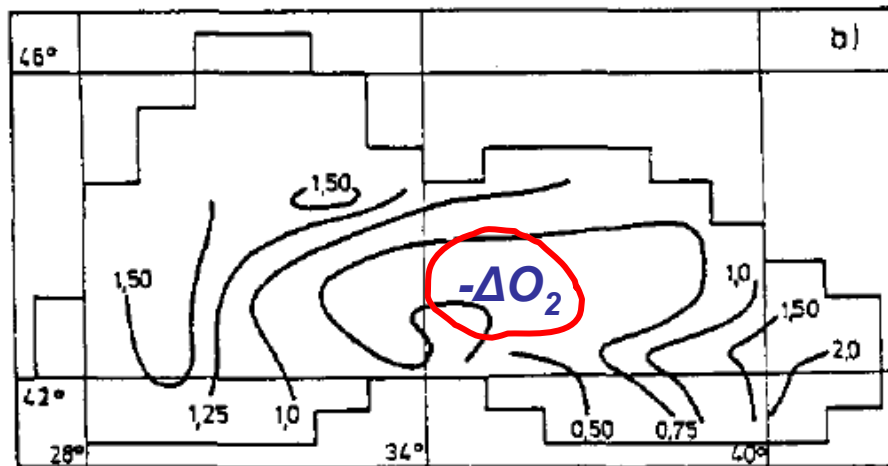
The contribution of numerical models

Deep-Sea Research, Vol. 36, No. 7, pp. 1053-1067, 1989.
Printed in Great Britain.

0198-0149/89 \$3.00 + 0.00
© 1989 Maxwell Pergamon Macmillan plc.

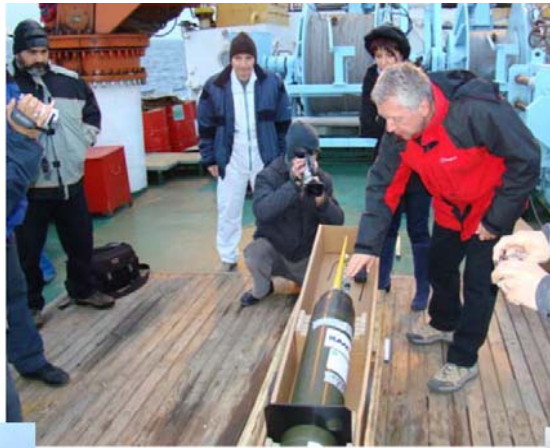
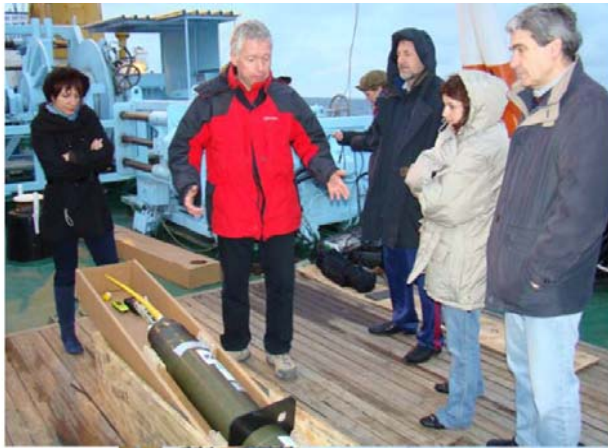
Numerical modelling of the circulation and the hydrogen sulphide and oxygen distribution in the Black Sea

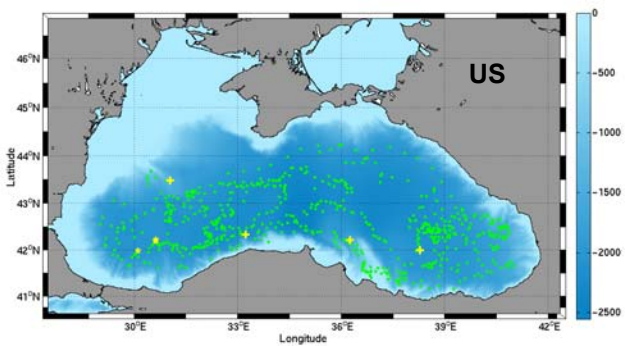
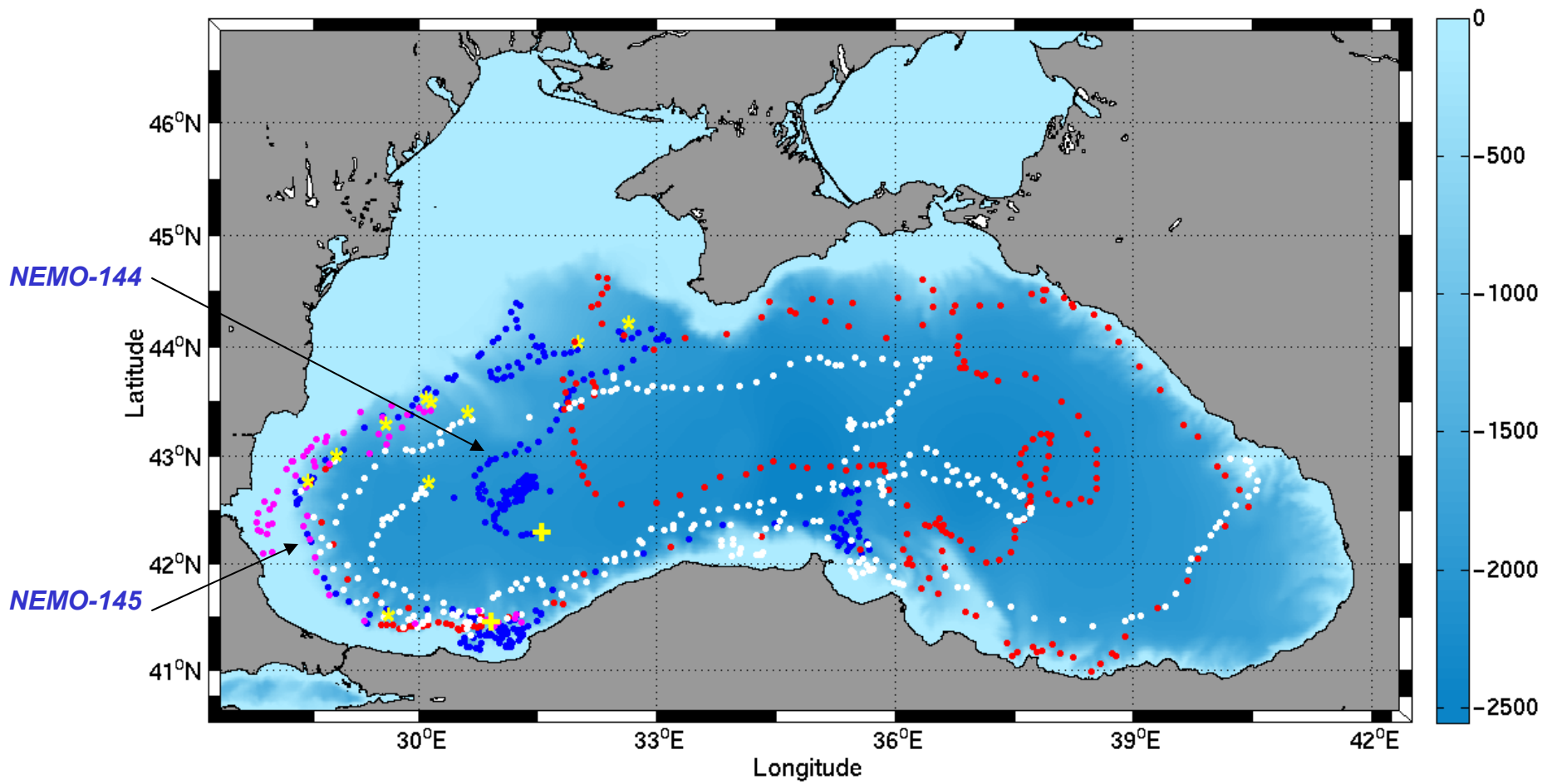
EMIL V. STANEV*



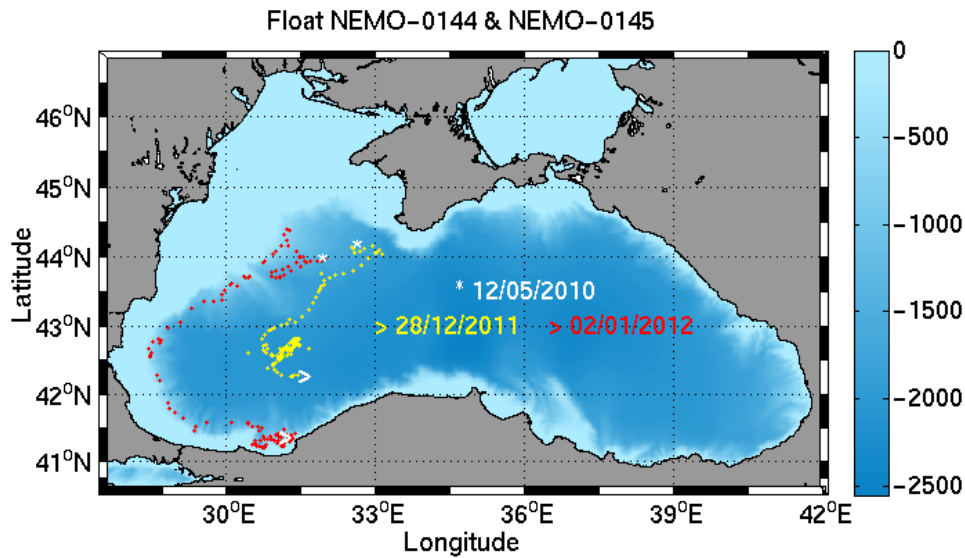
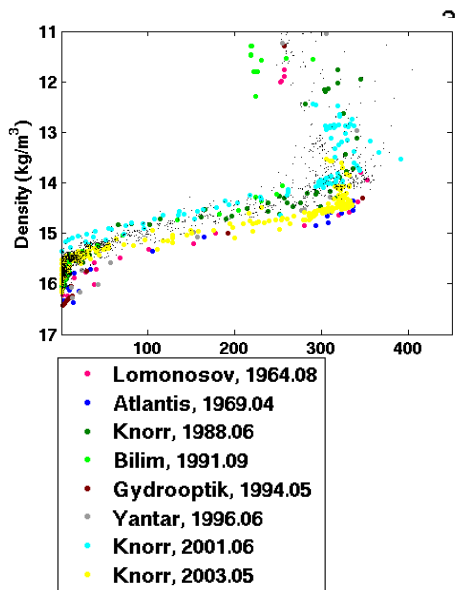
The Model Development
Oguz,
Gregoire
Yakushev

Deployment of a Provor float (Kaliakra) on 8 Dec 2009 in the western Black Sea from Bulgarian R/V Akademik





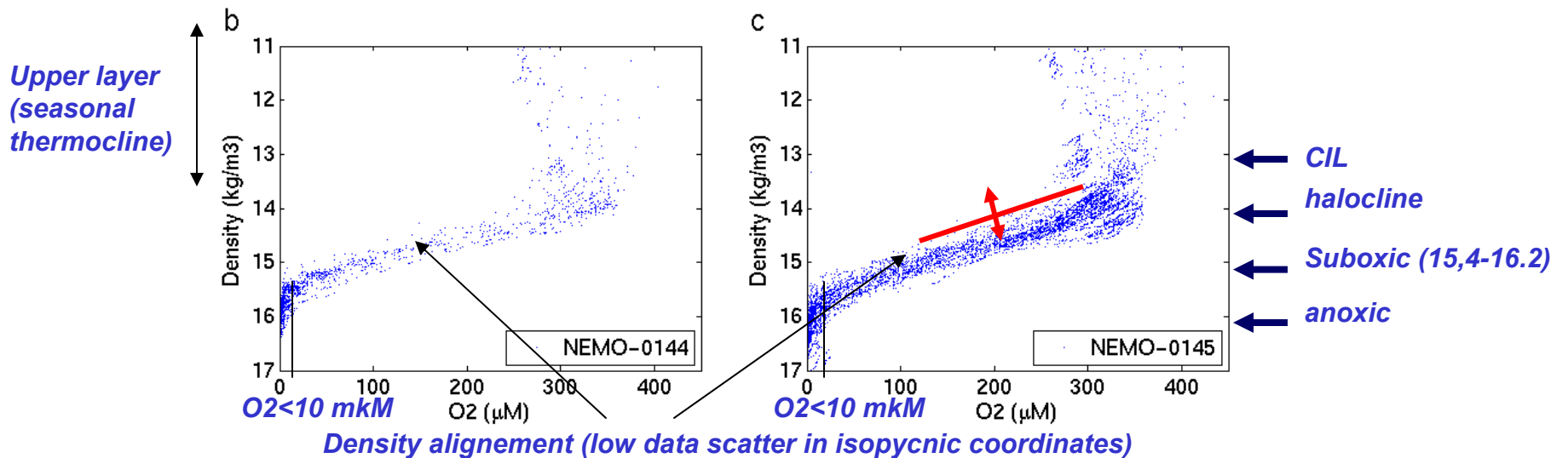
France	PROVOR
● France	PROVOR +
● Germany	NEMO +
● Germany	NEMO
Bulgaria	APEX
● Bulgaria	APEX
Bulgaria	APEX
Italy	ARVOR
Italy	ARVOR
Italy	ARVOR

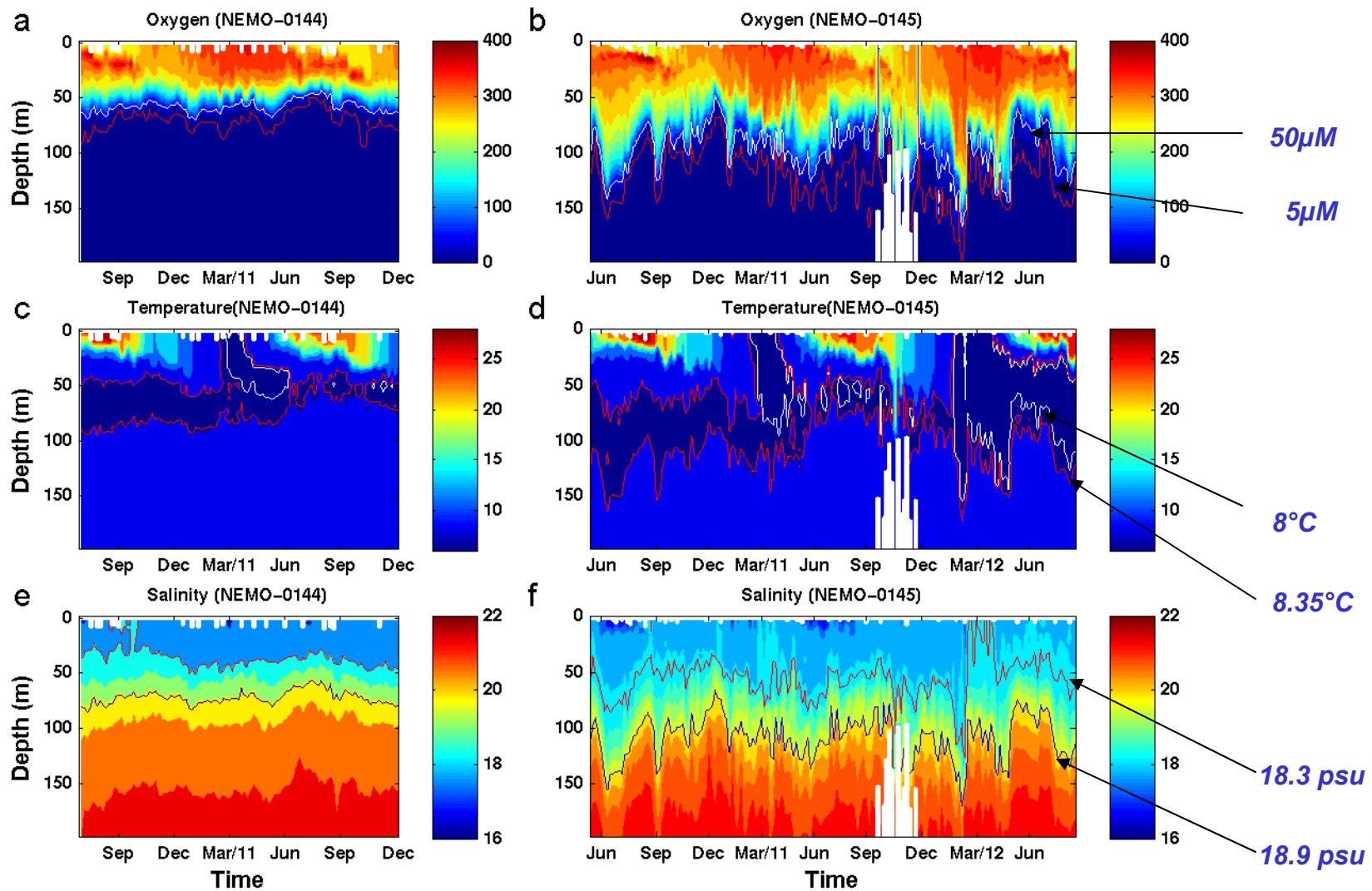


Possible under-sampling problems in the past observations

1. $rms=1.82 \mu\text{M}$ for NEMO-0144 and $4.73 \mu\text{M}$ for NEMO-0145 at $\sigma=16$, mean values at these levels of $2.13 \mu\text{M}$ and $6.85 \mu\text{M}$

2. Different density alignment in suboxic zone.

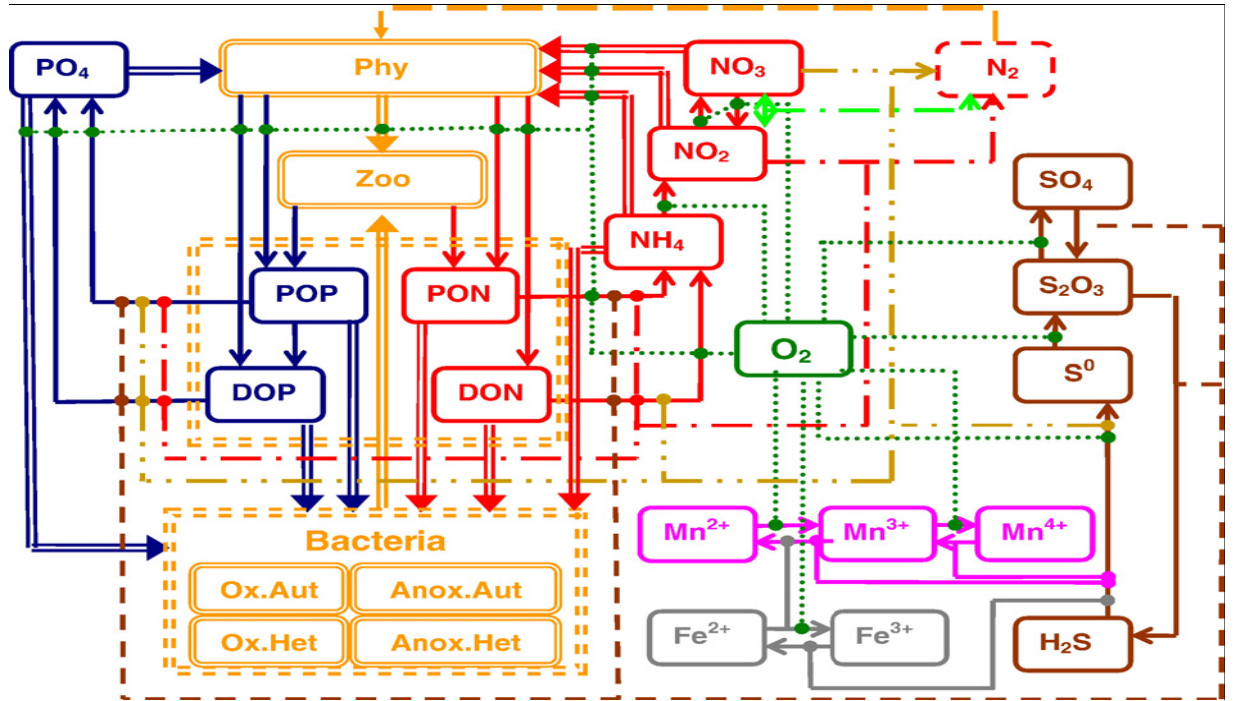




**Numerical
Model
Redox Layer
Model
(ROLM)**

**coupled
with the**

**General
Estuarine
Transport
Model
(GETM)**



- **Includes**
 - 24 biochemical state variables
 - nitrogen and sulphur cycles
 - manganese cycling
 - the particulate manganese is used for oxidizing the H₂S,
 - the dissolved manganese is oxidized by oxygen
 - formation of organic matter during both photosynthesis and chemosynthesis

Model setup

- *Parameters*

- *horizontal resolution: 1/12°*
- *vertical resolution: 2m, upper 200m*
- *k-ε GOTM*
- *Min $A_{V^{T,S}} = A_{V^M} = 1.2 \times 10^{-5} \text{m}^2 \text{s}^{-1}$*
- *Chemical parameters as in Yakushev et al. (2007; 2009)*

- *Boundary Conditions*

- *ECMWF air temperature, air humidity, sea level pressure, 10 m wind and total cloud cover*
- *Fluxes at sea surface*
 - $Q_{O_2} = k_{660} * (Sc/660)^{-0.5} * (O_{2sat} - O_2)$
 - *PO4 and NO*
- *BBC- Isopycnal extension of 1D profiles*

- *Integration:*

- *After the spin up for Argo period*

Conclusions

- *Continuously measured oxygen profiles shed a new light into the oxygen dynamics*
- *Earlier theories (isopycnal alignment of properties) were coarsely applicable to suboxic zone*
- *The dynamics of the oxic-anoxic interface was dominated by rigorous mesoscale processes.*
- *The control of dynamics on the Black Sea ecosystem is very different for summer and winter (gyre transport versus mixing dominated controls).*