The ventilation of near-bottom shelf waters in the north-western Black Sea

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1. Introduction

The state of the Black Sea ecosystem is subject to both anthropogenic and natural impacts and stronger influenced by climate than previously thought. Benthic ecosystems (down to the onset of permanent anoxia at 130m depth) are controlled by the supply of oxygen to near-bottom waters.

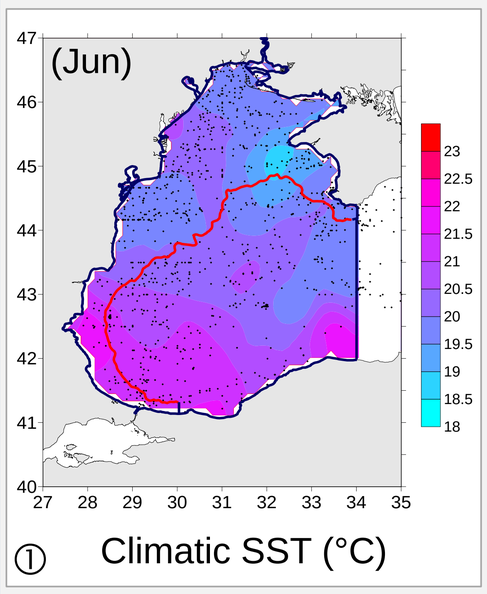
The focus of this work is on the long-term temperature variability of near-bottom waters separated from the oxygen-rich upper mixed layer by the seasonal pycnocline during the warm season (here defined as May-November).

2. Aims

- Assess the long-term variability of the physical state in the shelf bottom layer.
- Identify areas of the shelf bottom where water masses are isolated from effects of surface processes.
- Quantify the role of horizontal exchanges in the ventilation of near-bottom water masses.

3. Data & Methods

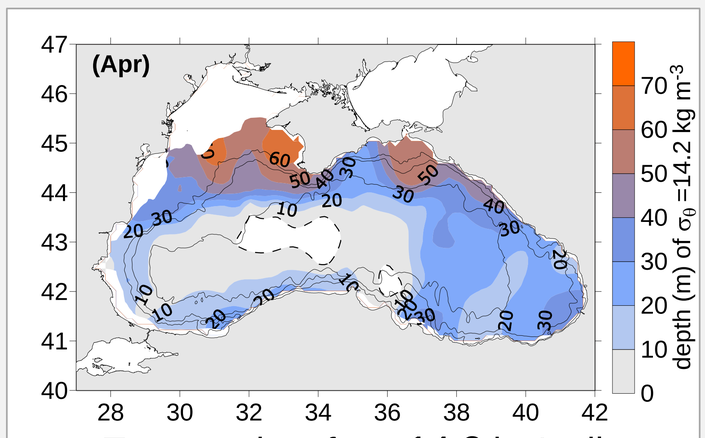
High-resolution monthly climatology of temperature and salinity is compiled from >17,000 stations in the 20th century (→①) using a dense horizontal grid of 0.25° to calculate temperature anomalies from the climatic mean (Shapiro *et al.*, 2010) which are aggregated into spatial compartments (shelf ≤ 150m) and seasonal bins (May-Nov).



① Climatic SST (°C)

The near-bottom shelf waters that are separated from the oxygen-rich surface layer are defined as below the density boundary σ_θ=14.2 (→②).

The potential energy approach confirms a robust link between density and the penetration depth of convective mixing energy (W_{mix} →③) during the summer when near-bottom waters are 'locked' and have limited exposure to atmospheric forcing.



② Topography of σ_θ=14.2 in April

$$W_{mix} = g\left[z_1 \int_{z_1}^{0} \sigma_\theta(z)\,dz - 2\int_{z_1}^{0} \sigma_\theta(z) z\,dz\right]$$

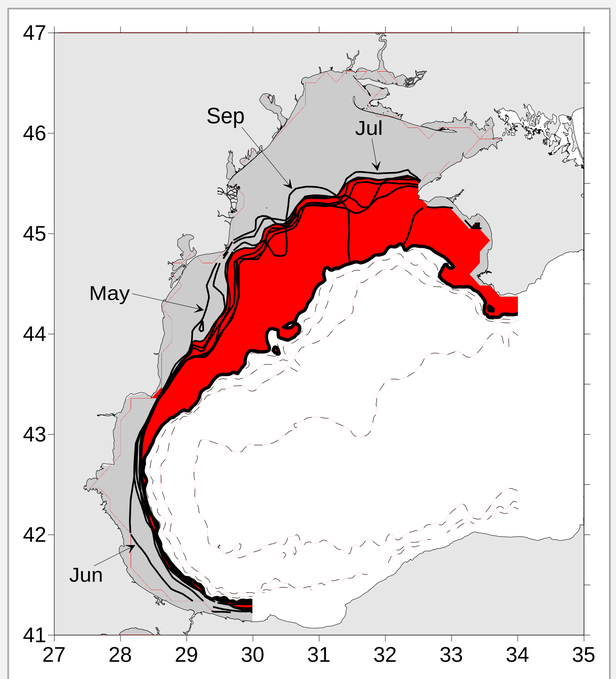
③

The benthic area occupied by the locked water body during the summer is unlikely to be mixed vertically until the following winter. The near-bottom waters can however be ventilated horizontally with deep-sea waters through isopycnal exchanges across the shelf break.

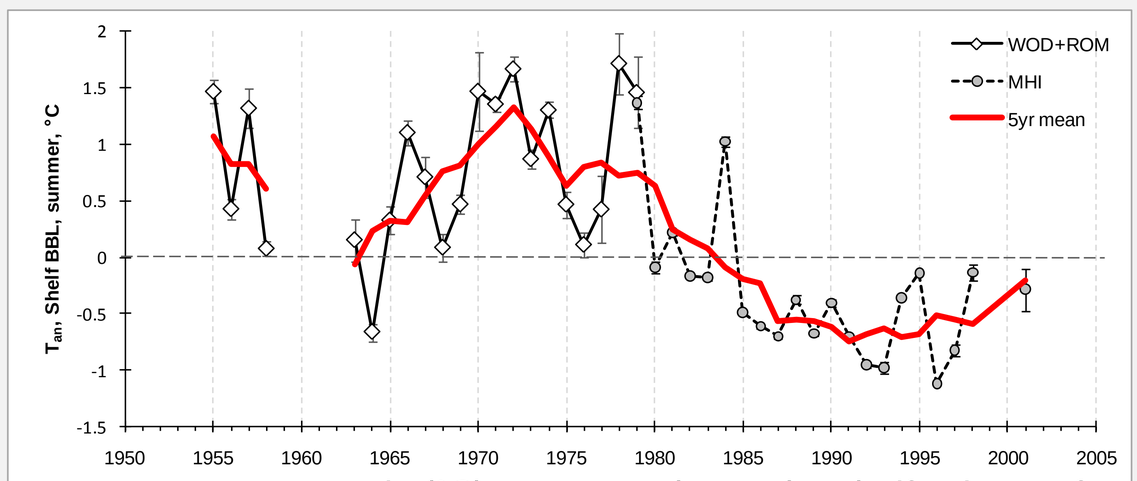
4. Results & Analysis

Half the shelf bottom area is occupied by locked waters during May-Nov (→④).

The potential of these areas to be ventilated by horizontal exchanges during that period is assessed by a long-term time series of temperature anomalies. Interannual temperature variability is greater than intra-annual variability, which allows aggregation into a seasonal value per year (→⑤).



④ Inter-annual variability of locked water coverage on the shelf

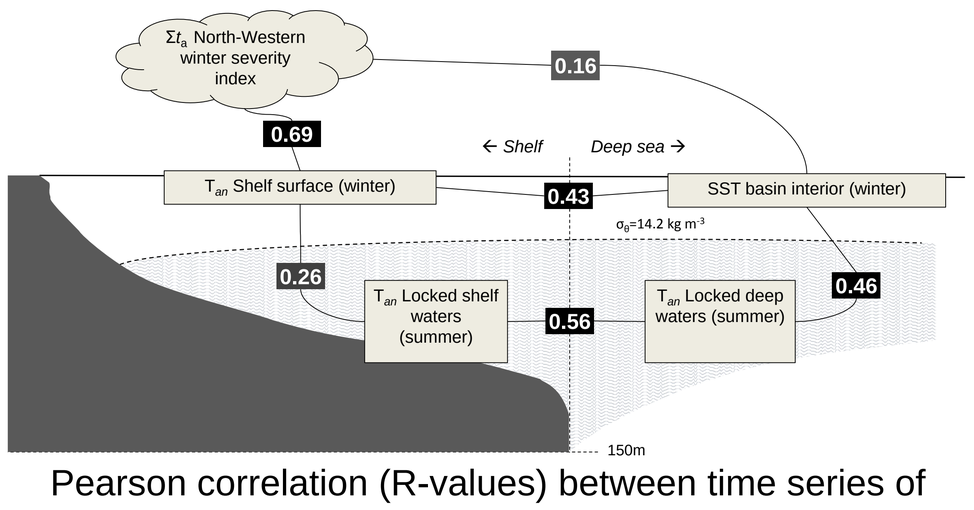


⑤ Temperature anomaly (°C) aggregated over the shelf volume of 'locked' waters (averaged over May-Nov)

The temperature variability in the BBL on the shelf shows:

- warm phase (1960s - 1970s)
- cold phase (1980s - 2000s)

Correlations between various time series show low memory of winter cooling in locked waters and quantify the relative importance of horizontal exchanges vs. vertical mixing (→⑥).



⑥ Pearson correlation (R-values) between time series of temperature of various water masses and meteorology.

5. Conclusions

Isopycnal shelf-deep sea exchanges are shown to be more important for the ventilation of deeper shelf waters (by controlling interannual variations of summer temperature) than winter convection on the shelf itself.

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Acknowledgements:

This study was partially supported by the following grants: EU FP6 SESAME, EU FP7 MyOcean, RFBR-07-05-00240 and the NATO Environmental Security Grant ESP.NUCR.CLG.982285. The authors are grateful to D. Aleynik for providing climatic data and A. Cociasu for providing historical observational data over the Romanian shelf.