PRELIMINARY RESULTS FROM A SUB-PYCNOCLINAL BOX MODEL OF THE ELNA OXYGEN DATA

Tom Sawyer HOPKINS[1], Viva BANZON[1] and Antonio ARTEGIANI[2]

[1] MEAS/NCSU, Raleigh, NC, USA
[2] CNR/IRPEM, Ancona, Italy

The annual cycle of dissolved oxygen below the pycnocline is dominated alternately by different physical and biological processes. Despite this complicated forcing, the resultant behavior of the dissolved oxygen concentration is a fairly well-behaved, time dependent function and is easily observable. HOPKINS and DELLAPORTA (1989) demonstrated how an empirical model could be used to forecast hypoxia in the Northern Adriatic.

In the present work, the authors use recently observed data (ELNA Project) to provide a validation test of the model. The box model is also used as a point of discussion of the relative importance of the various processes affecting the concentration of oxygen in the Northern Adriatic.

The Northern Adriatic is divided into eight compartments on the basis of its mean circulation and water-mass structure. Each compartment is ascribed characteristic values for: benthic and lower-layer oxygen consumption rates; seasonal variations in the depth of the pycnocline; sub- pycnoclinal photosynthesis; and an advection source term. The estimates of the benthic respiration are taken from the box-core incubation studies performed during the various ELNA cruises and from the results of other recent studies. Photosynthetic production below the pycnocline is also estimated from rates observed during the ELNA cruises. The advective source term is taken from the observed circulations and oxygen concentrations. In some cases, the estimates were taken from the historical data summaries compiled by ARTEGIANI and RUSSO (1994).

The results demonstrate the susceptibility of the western and northern areas to hypoxia. The bottom waters of these areas are obviously exposed to greater surface loading. For the period of late spring through early summer, the rate of oxygen decrease is controlled by bio/chemical respiration processes. The advective contribution is negligible until the horizontal differences in the *in situ* respiration have created significant oxygen gradients. By mid-summer, advective replenishment decreases due to a more sluggish circulation. Perhaps more significant is that oxygen preferentially decreases in the western areas that are downstream and offshore of the Po Plume. In late summer, re-supply occurs primarily through the deepening of the wind-mixed layer. This empirical modelling approach, when combined with selective monitoring, provides a valuable forecast capability for areas threatened by hypoxia/anoxia events.

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RECENT CHANGES IN THE BLACK SEA PYCNOCLINE

L. I. IVANOV[1], S. BESIKTEPE[2], E. OZSOY[2], M. DUMAN[3], V. DIACONU[4] and E. DEMIROV[5]

[1] Ukrainian Academy of Sciences, Marine Hydrophysicla Institute, 2, Kapitanskaya Str., Sevastopol 33500 Crimea, Ukraine
[2] Institute of Marine Sciences, Middle East Technical University, P.K. 28, Erdemli, Içel 33731 Turkey
[3] Institute of Marine Sciences and Technology, Dokuz Eylül University, 1884/8 Sokak, 10 Inciralti, Izmir, 35340 Turkey
[4] Romanian Marine Research Institute, 300 Mamaia bd, Constantza 8700, Romania
[5] Inst. of Oceanography, Bulgarian Academy of Science, POB 152, Varna 9000, Bulgaria

Possible changes in the Black sea pycnocline has been investigated by many authors (BLATOV *et al.*, 1984; CODISPOTI *et al.*, 1991, MAMAEV *et al.*, 1994; MURRAY *et al.*, 1991; BUESSELER *et al.*, 1994). Recent CDT measurements (basin-wide and partial surveys within the context of the CoMSBlack program and TU-Black Sea Project) in the Black sea provide a unique opportunity to study pycnocline structure and to understand the role of different mechanisms in its ventilation.

Direct ventilation appears to be confined above the mean position of the pycnocline (σ_t = 14,5 - 14,7) where convection and subsequent isopycnal injection is thought to be the major water mass formation mechanism (BLATOV *et al.*, 1984; MURRAY *et al.*., 1991; OVCHINNIKOV, 1981). Some ventilation of the upper pycnocline (down to σ_t = 15,6) appears to occur in winter in the central parts of the sea (IVANOV *et al.*,1994). Similarly, ventilation of the lower pycnocline can occur by entrainment of the Cold Intermediate Water (CIW) into the Mediterranean water near the Bosphorus and the subsequent injection below the pycnocline (σ_t = 15,8 - 16,2) intrusions of the resulting shelf modified waters (BUESSELER *et al.*, 1991).

The position of selected σ_t surfaces and the corresponding values of temperature are presented in the following for recent surveys. Both values are basin averaged quantities, filtering effects of local dynamics.

σ_t	average depth (m)				average temperature (°C)			
	1991	1992	1993	1994	1991	1992	1993	1994
14,8	65,6	70,4	72,1	74,7	7,30	6,94	6,33	6,58
15,0	71,0	76,5	80,5	81,4	7,50	7,20	—	—
15,2	77,0	82,1	86,5	87,7	7,66	7,53	7,31	7,18
15,4	84,0	88,8	92,8	94,2	7,81	7,76	7,62	7,47
15,6	92,5	96,9	100,2	101,8	7,96	7,95	7,88	7,74
15,8	102,5	107,0	109,0	111,4	8,13	8,10	8,08	7,98
16,0	115,9	119,8	121,6	124,8	8,30	8,27	8,25	8,19
16,2	135,1	138,2	139,3	143,3	8,46	8,43	8,42	8,38

The table shows considerable interannual variability in the thermohaline structure of the pycnocline. Gradual deepening of the isopycnal interfaces since 1991, together with cooling and freshening, has been registrated. Meteorological data reveal a decrease in the average winter air temperature for the region in 1991-1993. Although the winter of 1994 was warmer, the cooling in the lower part of the pycnocline appears to have continued during this period as a delayed response to the earlier surface cooling.

The cooling between σ_t = 15,2 -16,2 surfaces is partly due to Bosporous influence, evident from the isopycnal temperature distribution in the vincinity of the Strait. In 1994, when the most dramatic changes were observed, the mean temperature in the central part of the sea was higher than for the whole area. It is estimated that lateral advection along isopycnals from the near Bosphorus region resulted in 0,03°C temperature decrease for the lowerpart of the pycnocline. This allows to estimate the volume of laterally injected water in 1993-1994 to be about 2500km^3. More than 50% of temperature decrease is estimated as due to vertical mixing.

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