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SEA WATER CHARACTERISTICS OF THE VARNA BAY

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Abstract: *Water security is central in the transition towards a sustainable water future. The future of the Varna Bay's water depends on the joint efforts of decision makers, governments, international organizations, local governments, policy makers, service providers, stakeholders - politicians, water professionals, business leaders, academics, economists, and in terms of that, this paper provides scientific data and shares knowledge about seawater characteristics of the Varna Bay that can be used to help to be bridged science, practice and society to develop water future of the Varna Bay.*

Keywords: *hydrology, sea water; water environment; Varna Bay; Black Sea.*

Introduction

Ecological balance goals are long-term goals and can be tracked via regular investigations. Conservation efforts occur with the right practices, at the right scale, at the right time and need systems-based approach to achieve the largest specific environmental benefits to the water body of concern.

Contributing to achieving ecological balance goals and ecosystem health in the water body, research in 2001 and writing of this paper ascertain seawater characteristics of the hydrologically sensitive area of the Varna Bay and discuss high priority water issues. Important long-term datasets were used [3], as well, and relevant factors were considered.

The system of the Beloslav and the Varna lakes, the Varna region's large water body, suffering from water quality problems, including hypoxia and sometime anoxia in the bottom layer during the summer [7], drains into the south area of the Varna Bay while river transformed waters that come from north of the bay strongly influence mainly in the spring [5]; [6].

Water security is central in the transition towards a sustainable water future. The future of the Varna Bay's water depends on the joint efforts of decision makers, governments, international organizations, local governments, policy makers, service providers, stakeholders - politicians, water professionals, business leaders, academics, economists, and in terms of that, this paper provides scientific data and shares knowledge about seawater characteristics of the Varna Bay that can be used to help to be bridged science, practice and society to develop water future of the Varna Bay.

Material and Methods

Study area map (Figure 1) displays a specific location of the stations where research of seawater characteristics of the Varna Bay was carried out in 2001. According to the hydrological seasons, full coverage of the stations was done four times a year. Station B5 was assumed for Control Station where monthly investigations were performed between the seasonal coverage of the net of stations.

Data for sea temperature, sea salinity, dissolved oxygen and oxygen saturation were obtained by unified methods [9]; [16] and CTD 60 [13].

Samples were collected from surface and bottom waters to study nitrite nitrogen and nitrate nitrogen. Concentrations of nutrients were established by HITACHI-U 2001 UV/Vis Spectrophotometer [10].

Chemical oxygen demand (COD)-Mn in neutral medium was studied by sampling in surface and bottom waters of the Control Station B5.

Observations were performed aboard the IFR R/V Prof. A. Valkanov.

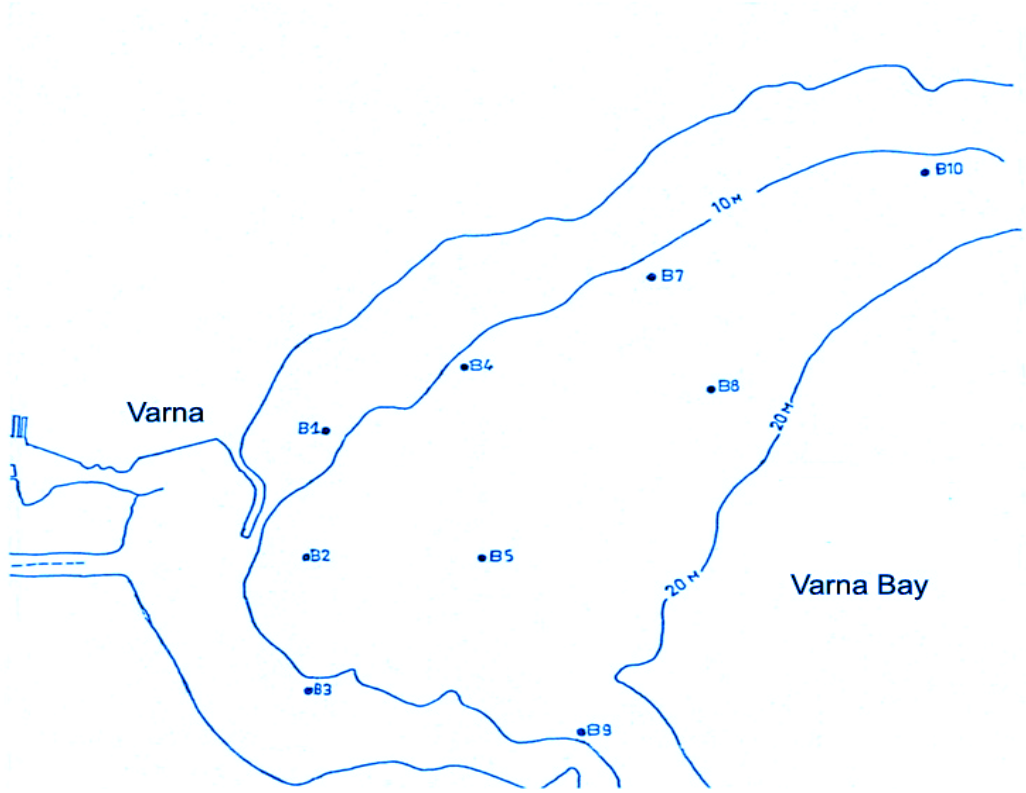


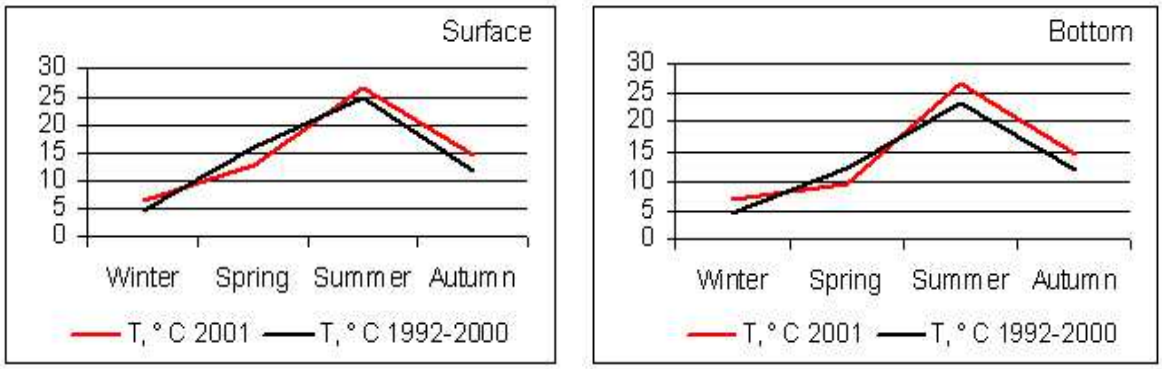
Figure 1. Map of the sampling stations in the Varna Bay in 2001.

Results and Discussion

The Varna Bay is relatively shallow, the deepest point being 20 m, so it is appropriate data for surface and bottom water to be presented.

About the Varna Bay as a whole, much of environmental benefits depend on the seasons so that sea temperature appears as an important characteristic. Figure 2 displays long-term seasonal variability of sea temperature both in 1992-2000 and in 2001. Except the spring, seasonal temperatures in 2001 were above the long-term average. Annual temperature in 2001 was above the long-term (1992-2000) average [3] throughout the surface-bottom layer, with 0.71°C at the surface and with 1.22 °C in the bottom layer (Figure 2). In the period 1995-2000 gradually the winters were becoming warmer, the springs colder and the summers were short and hot [2], and this tendency has continued in 2001. In 2001, monthly sea surface temperature was with a range from 6.90 °C to 26.77 °C and monthly sea bottom temperature has varied from 6.87 °C to 26.33°C. During February - September (Table 2), sea surface temperature (SST) was higher than sea bottom temperature with 0.03 °C (February) - 5.43 °C

(September) while sea bottom temperature was higher in January (with 0.38°C) and in November (with 0.34°C).



A. **B.**

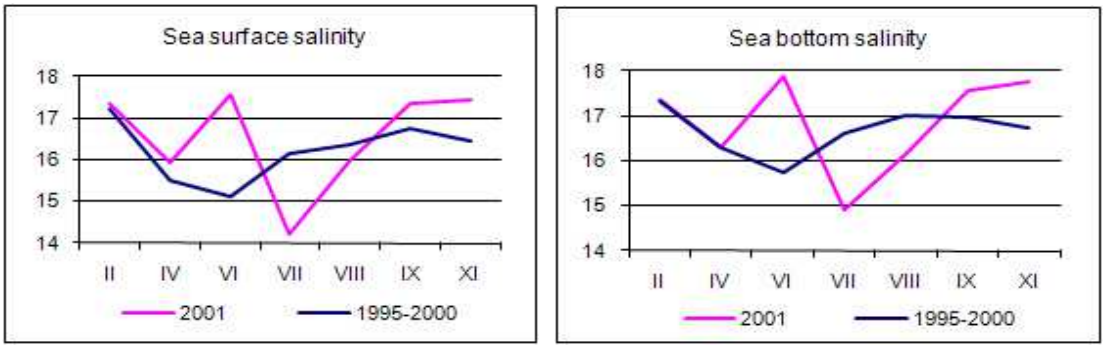
Figure 2. Long-term seasonal variability of temperature (°C) in the surface water (A) and in the bottom water (B) of the Varna Bay both in 1992-2000 and in 2001.

Other useful data source, given in Table 1 and in Table 2 that strengthens the research, includes sea salinity. Figure 3 shows long-term monthly variability of sea salinity both in 1995-2000 and in 2001. About 2001, consideration of this seawater characteristic points to unusual high salinity in June and not typical salinity minimum in July throughout the whole layer. There was a lack of second slight salinity minimum in the autumn. At average, salinity in 2001 was higher compared to 1990s, with 0.33 psu at the surface and with 0.16 psu in the bottom water. According to [15]; [12]; [3], the maximum of the range of annual fluctuations is in the surface waters and the investigation in the Varna Bay in 2001 pointed it out. Surface salinity was with a broader range, varying with 3.35 psu,while bottom salinity - with 2.97 psu.

Table 1. Seasonal variability of temperature (°C), salinity (psu), oxygen saturation (%), nitrite nitrogen (µM) and nitrate nitrogen (µM) in the Varna Bay in 2001.

Season	Depth	T	S	O_2	NO_2-N	NO_3-N
	m	° C	psu	%	µM	µM
Winter	0 m	6,60	17,31	105,91	0,02	5,24
	bottom	6,69	17,38	105,24	0,02	4,09
Spring	0 m	12,61	17,50	88,20	0,17	1,09
	bottom	9,49	17,79	64,56	0,01	0,13
Summer	0 m	26,58	16,00	100,90	0,00	0,43
	bottom	26,44	16,08	101,66	0,00	0,41
Autumn	0 m	14,49	16,86	92,68	0,05	0,64
	bottom	14,51	16,92	93,92	0,03	0,70

Oxygen saturation changes mainly depend on changes of temperature and salinity, water mixing, biological factors, as well as some chemical processes [4]. Over much of the year, comparatively good oxygen regime of the seawater was ascertained in the Varna Bay, with near-normal fluctuations in the winter, summer and autumn (Table 1). More significant drop in oxygen saturation has occurred in the bottom water in June and especially in September but there was no hypoxic area (Table 2).



A. **B.**

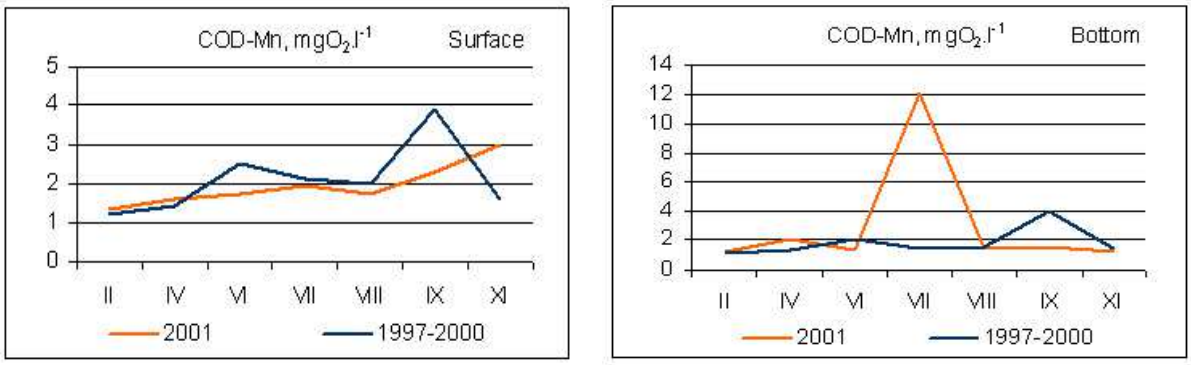
Figure 3. Long-term monthly variability of salinity (psu) in the surface water (A) and in the bottom water (B) of the Control St. B5 in the Varna Bay both in 1995-2000 and in 2001

About the whole area of the Varna Bay, nitrate nitrogen concentrations were at a low level in the bottom water in the spring and throughout the surface-bottom layer during the summer and autumn (Table 1). There were nitrite traces in the bottom water in the spring while during the summer there was a lack of nitrite nitrogen. Monthly nutrients' variability at the Control St. B5, given in detail in Table 2, points to a low level of nitrate nitrogen over much of the year - from April to November and a lack of nitrite nitrogen both in August in the whole layer and in November in the bottom water.

Table 2. Monthly variability of temperature (°C), salinity (psu), oxygen saturation (%), nitrite nitrogen (µM), nitrate nitrogen (µM) and chemical oxygen demand (COD)-Mn in neutral medium ($mgO_2.l^{-1}$) at the Control St. B5 in the Varna Bay in 2001.

Parameter	Depth		M	O	N	T	H		
	m	I	II	IV	VI	VII	VIII	IX	XI
T,°C	0 m	7,34	6,90	12,56	12,14	25,22	26,77	18,06	14,63
	bottom	7,72	6,87	11,23	9,30	24,59	26,33	12,63	14,97
S, psu	0 m	17,12	17,36	15,94	17,57	14,22	15,96	17,37	17,44
	bottom	17,25	17,36	16,3	17,87	14,90	16,13	17,56	17,75
O_2, %	0 m	94,07	105,81	101,02	90,64	100,7	104,08	110,74	97,55
	bottom	91,16	104,05	101,03	66,33	107,91	89,56	42,37	96,68
NO_2-N, µM	0 m	0,02	0,01	0,01	0,08	0,03	0,00	0,02	0,07
	bottom	0,01	0,01	0,02	0,01	0,02	0,00	0,01	0,00
NO_3-N, µM	0 m	4,91	1,88	0,61	0,38	0,45	0,41	0,68	0,68
	bottom	3,53	1,14	0,37	0,05	0,51	0,50	0,70	0,70
COD-Mn, $mg.l^{-1}$	0 m	1,33	1,33	1,62	1,70	1,95	1,74	2,32	3,00
	bottom	1,33	1,17	2,02	1,37	12,04	1,43	1,60	1,22

According to [1]; [14]; [11]; [8], the integral concentration of organic matter in water can be determined by chemical oxygen demand (COD)-Mn. Figure 4 gives the picture of COD-Mn variability under multiple organic enrichment sources. A significant pressure on the bottom seawater resources was ascertained in July, with much higher COD-Mn than the long-term mean. At average, COD-Mn in 2001 was almost on a level with 1997-2000 at the surface but with 1.15 $mgO_2.l^{-1}$ higher in bottom water.



A. **B.**

Figure 4. Long-term monthly variability of COD-Mn in neutral medium ($mgO_2.l^{-1}$) in the surface water (A) and in the bottom water (B) of the Control St. B5 in the Varna Bay both in 1997-2000 and in 2001.

Conclusions

Except the spring, seasonal temperatures in 2001 were above the long-term average in the Varna Bay. Annual temperature in 2001 was above the long-term (1992-2000) average throughout the surface-bottom layer, with 0.71°C at the surface and with 1.22 °C in the bottom layer. During February - September, sea surface temperature was higher than sea bottom temperature while sea bottom temperature was higher in January and in November.

Unusual high salinity in June and not typical salinity minimum in July throughout the whole layer was ascertained. Also, there was a lack of second slight salinity minimum in the autumn. Surface salinity was varying with 3.35 psu while bottom salinity - with 2.97 psu. Salinity in 2001 was higher compared to 1990s, with 0.33 psu at the surface and 0.16 psu in the bottom water.

Comparatively good oxygen regime of the seawater was ascertained, with near-normal fluctuations in the winter, summer and autumn. More significant reduction in the dissolved oxygen content in seawater has occurred in the bottom water in June and especially in September but there was no hypoxic area.

Dry year 2001 contributed to low levels of nutrients over much of the year and a lack of nitrite nitrogen both in the summer in the whole layer and in November in the bottom water.

There was an environmental problem related to natural and introduced organic matter that brought about significant pressure on the bottom seawater resources in July: COD-Mn peak of 12.04 $mgO_2.l^{-1}$ exceeded the maximums during the second half of 1990s. Chemical oxygen demand-Mn in 2001 was almost on a level with 1997-2000 at the surface but with 1.15 $mg.l^{-1}$ higher in bottom water.

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