

RESEARCH ARTICLE

Application of biotic indices and body size descriptors of phyto- and zooplankton communities in Varna lagoon for ecological status assessment

V. Alexandrova, S. Moncheva, N. Slabakova, K. Stefanova, V. Doncheva.

Institute of Oceanology, Bulgarian Academy of Sciences, 9000 Varna, Bulgaria

Abstract

The present paper is aimed at:

- 1 - application of biotic indices to assess the ecological state of Varna lagoon by investigating the response of biota to the gradient of environmental pollution
- 2 - test applicability of individual body size class distribution of plankton communities as innovative quality element descriptor analyzed against routine plankton quality attributes. Quantitative assessments, seasonal variations and distribution of the plankton community have been analyzed.

Introduction

Transitional waters are defined as critical zones due to their position at terrestrial, freshwater and marine interfaces (Levin *et al.*, 2001, Schizas and Stamou, 2007, Briske *et al.*, 2005). The Varna Lake - Varna Bay system is an area influenced by domestic and chemical industrial waste water emissions preconditioning a clearly pronounced nutrient gradient and related impacts on the biota (Moncheva *et al.*, 2003). While the WFD sets the basics of ecosystem ecological quality assessment the identification of consistent descriptors remains still a scientific challenge.

The importance of organism size in ecology and physiology has been recognised for a long time, the growth (Niklas, 2004) and sinking rates of phytoplankton, as well as their susceptibilities to grazing (Hansel *et al.*, 1994) are all functions of cell size.

The study explore the body size concept as one of the most important traits of an organism, determining the type and strength of ecological interactions to which individuals are subjected (Melton, 1997) in order to test its relevance in Varna lagoon case study.

Methods

The analysis was based on data collected during three field surveys (XII- 2004, V and VIII-2005) at 5 stations: Varna bay (VB)-2 station, Varna Canal (C)-2 station and Varna Lake (VL) – Fig. 1. The sampling and laboratory analysis of phytoplankton and *Chl a* were performed according to unified procedures (Moncheva and Par, 2005). The following attributes have been analyzed: phytoplankton-taxonomic composition, dominant species, abundance, biomass and body-size structure; sub-samples for phytoplankton biomass fractionation (*chl. a*) treated by serial filtration (GF/F 0.45µm, 20µm and 2µm filters; and zooplankton - taxonomic composition abundance and biomass.

In addition to T° and S, samples for O₂, and nutrients (N-NO₂, N-NO₃, NH₄, P-PO₄, Si-SiO₄) were analyzed by routine methods (Stereva *et al.*, 1998) along with Biotic indices (Species richness (S), Evenness (J) Shannon-Weaver (H) (abundance and biomass). Trophic State Index (TRIX) was calculated as an integrated measure of the level of eutrophication (Moncheva *et al.*, 2002). Relationships between population density and body size were plotted in linear logarithmically transformed scales, normally the

slopes of these relations expected to approximate -0.75, using ordinary least squares regression (Damuth, 1987).

Results and discussions

The plankton communities manifested high variability in the taxonomic spread, dominant

species, abundance and biomass, generally following uniformly the environmental gradient of nutrients only in autumn; in spring this trend was less clear, while in summer - in contrast - the abundance and biomass were decreasing along the eutrophication axis – Fig.1.

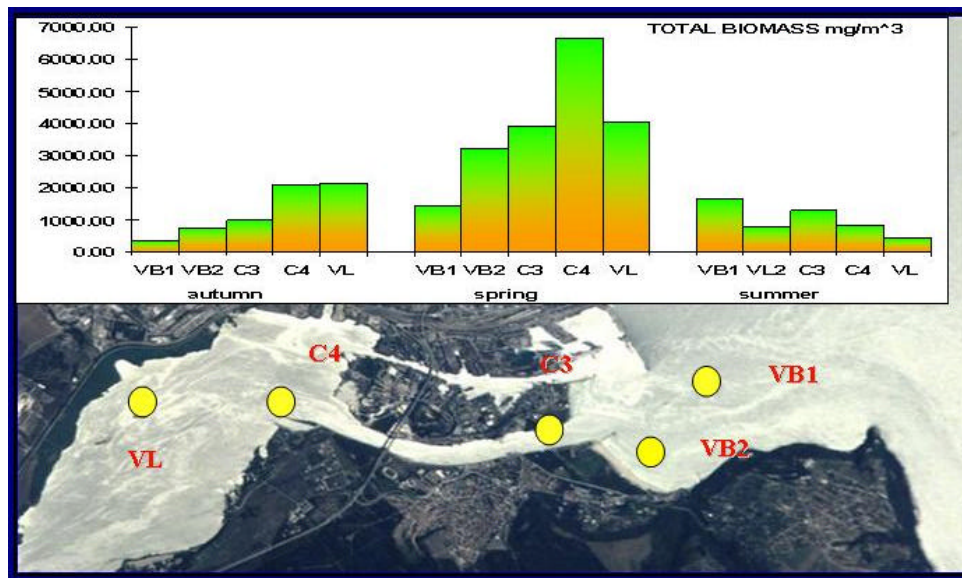


Figure 1. Varna lagoon - sampling sites and phytoplankton biomass seasonal distribution [mg/m³]

A steady decrease of eutrophication along the VL-VB sites during all seasons was manifested both by TRIX and *chl. a*, the latter was about 5 times higher in VL as compared to VB (25.2 – 6.56 µg/l in spring and 16.23 – 3.38 µg/l in summer).

Bacillariophyceae and Dinophyceae species were the dominant taxonomic groups in the abundance and biomass during late autumn and spring, while in summer Haptophyceae (*Phaeocystis pouchettii*) dominated the numerical abundance especially in the Canal (82.77%). The general trend was an increase of Bacillariophyceae from the Bay to the Lake stations representing the bulk of the biomass irrespective of the season (Tab. 1). The spring Bacillariophyceae:Non-Bacillariophyceae biomass ratio considered a relevant indicator of phytoplankton communities alterations under the eutrophication stress, demonstrated spatial

variability corresponding to the nutrient gradient. As expected the total biomass (Fig. 1) increased along the eutrophication axes, the values in VL exceeding 3-5 times those measured in the Bay (Tab. 1). The phytoplankton heterogeneity was featured by the differences in the dominant species along the gradient: *Heterocapsa triquetara* in VB and *Rhizosolenia fragilissima* in VL (autumn), *Cyclotella caspia* (VB), *Heterocapsa triquetra* (Canal) in spring, and *Pseudonitzschia delicatissima* (VB) and *Phaeocystis pouchettii* (Canal) and *Gloeocapsa sp.* (VL) in summer.

An increasing trend of zooplankton biomass and abundance from the Bay to the Lake was registered during all periods. The highest values were determined in late autumn and summer when the copepods were prevailing. During the spring the structure of mesozooplankton abundance was altered as a result of

Meroplankton and Rotatoria proliferation, while the density of copepods was considerably lower. The presence of class Rotatoria, typical for the

Lakes, could well be used to discriminate the regions under study.

Table.1 Seasonal variation of major environmental parameters and biological characteristics of the phytoplankton communities in Varna Bay-Varna Lake system

	Station	T°	S‰	O ₂ [ml/l]	N total [µg/l]	Ptot [µg/l]	Si [mg/l]	TRIX	Total biomass [mg/m ³]	Bacillario phyceae %	NonBacillario Phyceae %	S*	J*	H*
autumn	VB1	10.0	17.5	6.88	108.51	18.60	293.48	4.88	352.7	33.1	68.9	24	0.5	2.4
	VB2	9.0	17.0	7.15	661.70	73.79	628.88	6.12	759.2	75.0	25.0	19	0.4	1.8
	C3	9.0	16.5	7.4	999.56	132.21	922.36	5.85	1002.5	97.5	2.5	16	0.2	0.7
	C4	8.3	16.2	7.59	1963.61	141.43	1362.58	6.39	2094.9	99.0	1.0	12	0.2	0.6
	VL5	10.5	15.3	6.72	3191.16	415.07	2263.97	7.97	2141.8	98.0	2.0	19	0.2	1.0
spring	VB1	15.8	17.3	7.46	82.18	13.68	104.88	5.55	1450.8	33.0	67.0	22	0.65	2.90
	VB2	16.0	17.1	8.03	152.04	25.21	83.85	6.26	3202.9	10.3	89.7	23	0.60	2.72
	C3	15.5	16.4	8.21	522.65	56.88	167.70	6.79	3930.0	21.8	78.2	18	0.70	2.91
	C4	15.5	16.4	8.18	595.38	59.19	1152.95	7.28	6665.2	9.3	90.7	10	0.76	2.4
	VL5	19.6	14.6	7.19	1841.27	465.03	628.88	8.49	4068.4	80.1	19.9	11	0.55	1.91
summer	VB1	25.0	17.1	2.82	55.14	18.6	25.15	4.55	1636.1	34.1	65.9	27	0.71	3.40
	VB2	25.0	16.5	1.81	137.43	107.61	125.78	6.68	812.9	31.0	69.0	22	0.58	2.60
	C3	25.0	15.9	1.27	275.78	107.61	377.33	7.61	1291.9	69.5	30.5	18	0.56	2.31
	C4	25.0	15.5	2.40	465.95	138.36	486.33	7.60	842.2	57.6	42.4	14	0.55	2.06
	VL5	24.0	15.4	0.58	594.02	173.71	578.57	8.02	433.5	62.5	37.5	28	0.59	2.79

The values of applied biotic indices followed the pattern of pollution gradient. The number of phytoplankton species decreased toward the Canal system and then increased in the Lake. The Sannon-Weaver diversity index was decreasing to below the critical value 2 (Tab. 1). Albeit the high similarity of biotic indices (about 80% between stations established trough cluster analyses), MDS plot (Fig. is not shown) display discrimination among the lake and bay sites.

The spatial and temporal patterns of phytoplankton body size distribution were affected by the disturbance pressure in a way consistent to the response of the most examined phytoplankton quality elements. Generally width distributions (Fig.2) were reduced parallel

to increased abundance of smallest organisms, total biomass and nutrient enrichment from less to most polluted sites in autumn and spring, while in summer this pattern was maintained irrespective of the decreasing trend of the biomass, due to the very high share of small-size species. There were no significant differences between the slopes in community size spectra. The observed slopes varied negative (under -0.75) in all seasons, and phytoplankton body-size class distributions were right skewed toward the smaller size classes with more negative skew in Varna lake stations in autumn and spring. In summer the positive skweness decreased toward the Varna lake (Fig. 2).

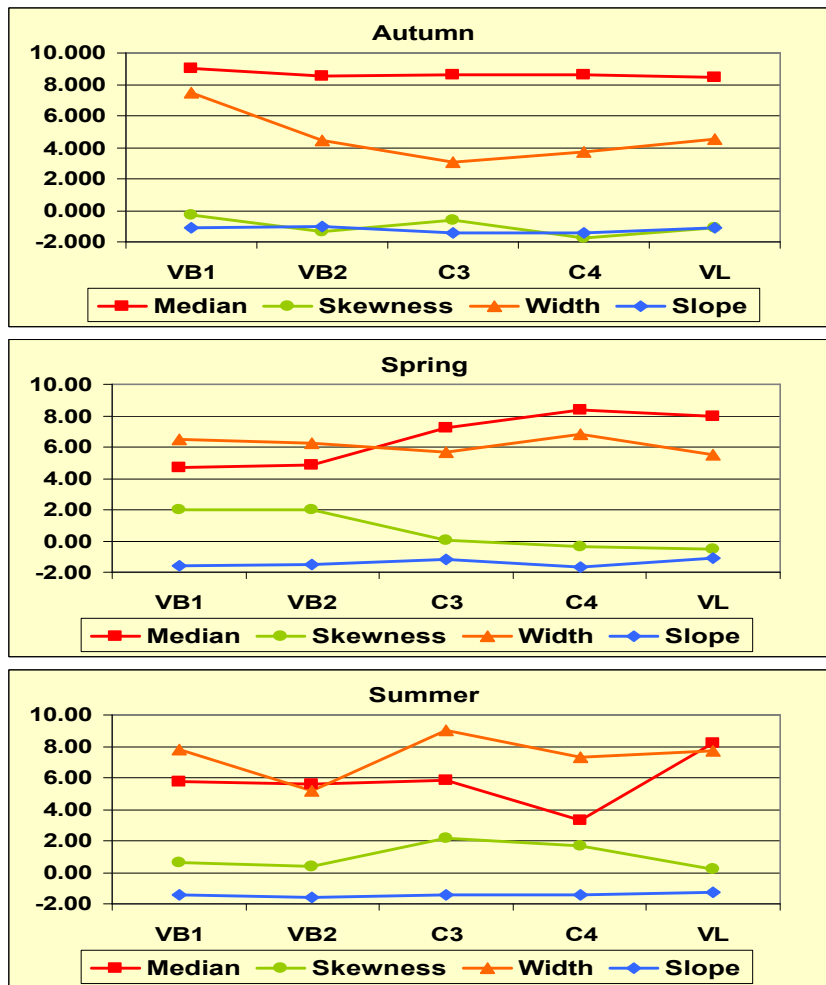


Figure 2. Seasonal variation of statistical metrics along the sampling sites (x-axis) across trophic gradient in Varna Bay-Varna lake system.

As evident from the statistical summary of the environmental parameters, the five sites along the Varna lagoon manifest insignificant differences in the biotic indices, temperature and salinities and as expected high variability in nutrients gradients. According to subdivided vector space (four quadrants) defined by average TRIX and TRBIX (Tab. 1.) as indicators of WQ (Vollenweider *et al.*, 1998), the sites could be ranked as follows: Relatively High WQ - Varna Bay and Canal stations during winter and spring, Moderate WQ - transitional zone between lake and Bay, Bad WQ - Varna Lake station in all seasons. (PCA and TRIX-TRBIX WQ diagrams are not shown). The bay sites are distinguished as of lower eutrophication level by chlorophyll a

concentration that increased in the lake sites as the most impacted by anthropogenic activities. The transitional sites show variability of biotic descriptors more scattered between the seasons depending on abiotic parameters (winds, tides and currents) of the environment.

The selected biotic indices Pielou's evenness index and Sannon-Weaver diversity index readily discriminate the sites and could be considered as indicators of ecological quality (EcoQ).

Conclusions

The spatial and temporal patterns of phytoplankton body size distribution demonstrate a clear response to the disturbance

pressure (small size classes dominating the eutrophicated sites) – best expressed at the most and less affected stations along the environmental gradient. The results provide enough evidence on the reliability of plankton body-size class distribution as an innovative quality descriptor for monitoring the ecological status of transitional waters and potential to be applied in extensive comparative studies.

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