Application of eutrophication indices for assessment of the Bulgarian Black Sea coastal ecosystem ecological quality

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Abstract The present paper is an attempt to test the applicability of the trophic state index (TRIX) for scaling the eutrophication along the Bulgarian Black Sea coastal zone in concert with a number of chemical and biological descriptors aimed at selection of relevant indicators of marine coastal area ecological quality. The following environmental parameters have been considered: t°, salinity, nutrients – inorganic P, N and dissolved Si, dissolved oxygen and oxygen saturation, phytoplankton – taxonomic structure, abundance and biomass, chlorophyll a, zooplankton – taxonomic structure, abundance and biomass. Principal Component Analysis was applied in order to figure out and score the most relevant combination of parameters to discriminate between sites and select representative descriptors (pressure/state) of eutrophication. The following variables are defined as relevant descriptors for classification of the sites: nutrients (N, P, Si) and their molar ratios (N:P and Si:P), the capacity of the system to produce and sustain organic matter (chlorophyll a, phytoplankton biomass), phytoplankton taxonomic dominance (Bacilariophyceae:Dinophyceae biomass ratio), grazing pressure (phytoplankton:zooplankton biomass, Bacilariophyceae:Copepoda), plankton diversity index (Hb and Ha) and the trophic state index (TRIX). The investigated sites under a different anthropogenic impact are classified according to selected descriptors and their water quality state.

Keywords Black Sea; ecological quality; indices; phytoplankton

Introduction

During the last three decades anthropogenic eutrophication has been identified as a key ecological problem for the coastal Black Sea region (especially it's North-Western part subjected to the strong influence of freshwater input), resulted in dramatic alterations in the chemical and biological regimes (Mee, 1992; Zaitzev, 1992). A substantial shift in the structure of phytoplankton communities and increase in primary productivity and biomass, expansion of phytoplankton blooms and related hypoxia/anoxia conditions have been well documented, exerting an adverse effect on the functioning of the marine food web (induced alterations in zooplankton community structure, disturbance in the reproduction of commercial fish, deterioration of benthic communities). All these have been considered as a syndrome of anthropogenic eutrophication and a manifestation of the destroyed carrying capacity and ecological degradation of the coastal Black Sea area (Bodeanu, 1993; Moncheva *et al.*, 1995). Many authors claim the invasion of exotic species and their outbursts an indication of the negative changes in the marine environment (Vinogradov *et al.*, 1992).

In contrast to the economics where well developed indicators give managers powerful tools in planning their decisions, there are only very weak instruments to assess the quality of the marine environment (Hammond *et al.*, 1995). Similar to the field of human health protection, where indicators and regulations have been successfully employed the assessment and protection of environmental health requires an adequate system for monitoring,

Water Science and Technology **Vol 46 No 8 pp 19–28**

diagnoses and management. Despite the numerous investigations, this field of marine research is poorly exploited. GESAMP (1995) has published a list of biological indicators, but they are more applicable to long-term series to measure the biological response to the evolution of anthropogenic eutrophication. In 2000 EC adopted the Framework Directive on Water Resources as a basic guideline for the introduction of clear, unified criteria, indices and indicator categories for definition of the quality status of the marine environment and the protection of its physical and biological integrity. For the first time "quality status" is defined as an integration between "chemical status" and "ecological status", the latter still in need of further description. Hence eutrophication of marine coastal areas is of global importance, terms such as "oligotrophy", "mesotrophy" or "eutrophy", are more frequently encountered in the literature. Accordingly the interpretation of available data is biased by the lack of precision in determining "how productive" the examined waters are and where the boundaries between the trophic categories have to be set (Vollenweider *et al.*, 1998).

Thus an adequate approach to process trophic data in a unified form is crucial to consent various trophic conditions and to meet the necessity of introducing more indicators of Drivers, Pressure and State (according to the DPSIR concept, currently in use by the European Environment Agency). Recently a new trophic state index (TRIX) was proposed for classification of marine coastal waters with respect to pelagic trophic state (Vollenweider *et al.*, 1998) to replace OECD (1982) methodology which has mainly been used for freshwater but also applied to the marine environment (Giovanardi and Tromellini, 1992).

The present paper is an attempt to test applicability of TRIX for scaling the eutrophication along the Bulgarian Black Sea coastal zone in concert with a number of chemical and biological descriptors aimed at selection of relevant indicators of marine coastal area ecological quality.

Material and methods

Sampling area

The analysis is based on data from the summer period during 1994–2000 with a bimonthly to weekly sampling frequency, at 3 depths down the water column. The summer period was selected as the most vulnerable season to the evolution of anthropogenic eutrophication.

The data were collected from several sites along the Bulgarian Black Sea coast, selected according to the eutrophication pressure: 3 n.m off Cape Kaliakra (1995–1998) and Cape Galata (1995–1996), Varna Bay (1994–2000), the system Beloslav lake-Varna lake – Varna Bay at a standard sampling network (1998) – Figure 1.

Cape Kaliakra site is the Northeast location, where the influence of the Danube freshwater input along the Bulgarian Black Sea coast is the strongest and Cape Galata site is under the indirect impact of Varna lake-Varna Bay current. The system Beloslav lake-Varna lake – Varna Bay is an example of a cascade, introducing nutrients and pollutants of industrial (chemical industry), agricultural and sewage origin.

The data were collected during the monitoring programs of EROS'2000–EROS'21, Black Sea NATO SfP and NSF Projects.

Variables

The following environmental parameters have been considered: t^{o}, salinity (MINISAL), nutrients – inorganic P, N and dissolved Si (Methods…, 1978; Grasshoff, 1983), dissolved oxygen (DO – Winckler method) and oxygen saturation (OS), phytoplankton – taxonomic structure, abundance and biomass, chlorophyll a, zooplankton – taxonomic structure, abundance and biomass.

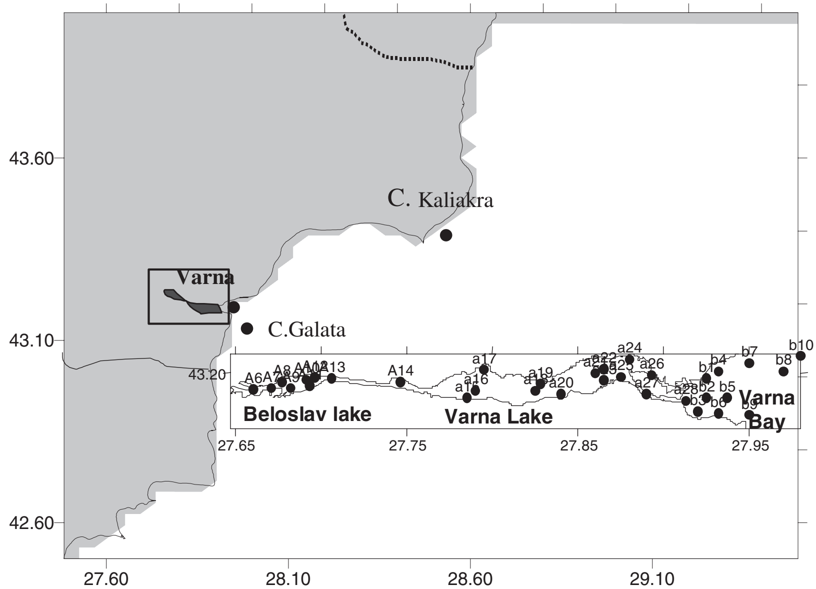

Figure 1 Map of sampling stations

The phytoplankton samples were processed applying standard methods (Utermol, 1958; Sournia, 1978). Species identification was performed under light microscope in Palmer –Maloney counting chambers and the biomass was calculated using the standard individual weights of each species (for the rare ones) and by geometric volumes (Edler, 1979) for the common species.

Chlorophyll a and phaeophytin were measured spectrophotometrically (Edler, 1979) by the equations of Jeffrey and Humphry (1975) and Lorentzen (1967).

Zooplankton samples were collected with a vertical plankton *Jeddy* type net (14.5 cm diameter and 150 μm mesh size), vertical hauls down the water column. The samples were fixed with 4% formaldehyde solution. Identification to species level was done under a binocular microscope. The quantitative analysis of species abundance was performed according to Dimov's method (Dimov, 1959). Biomass was estimated by using standard individual weights.

The structure of phytoplankton and zooplankton communities has been analyzed in terms of: taxonomic composition and their ratios, total numerical abundance and biomass. Special attention was paid to the dominant and red-tide species. The diversity index of Shannon-Weaver (1963) was calculated as a classical measure of stability. The data have been interpreted according to the parameters, recommended by GESAMP (1995) for evaluation of the environmental impact of anthropogenic eutrophication.

The Trophic State Index (TRIX) was calculated applying the formula proposed by Vollenweider *et al*. (1998), based on chlorophyll a data, OS, total inorganic P and N. A modification of TRIX index including dissolved Si as additional nutrient was also estimated. The following ratios were used in addition in the comparative analyses: Total phytobiomass:Total zoobiomass ratio (PhB:ZB), Bacillariophyceae:Copepoda biomass ratio (Bac:Cop), Dinophyceae:Copepoda biomass ratio (Din:Cop) and nutrients ratios (N/P, Si/N, Si/P). Statistical analysis and Principal Component Analysis (PCA) were applied to score and narrow down the selection of parameters and determine relevant descriptors.

Numerically TRIX is scaled from 0–10 covering a wide range of trophic conditions and defining 4 trophic categories: <4 – low trophic level; 4–5 – moderate trophic level; 5–6 – high trophic and >6 – very high trophic level. A high value (> 6 TRIX units) corresponds to very high nutrient levels, low transparency and recurrent hypoxia/anoxia in bottom waters. The general philosophy of an explicit trophic index is based on the following principles: component parameters of the index should be meaningful in terms of both primary production and productivity dynamics; encompass major causal factors; being a routine measurement in most marine surveys (Vollenweider *et al*., 1998). Originally the design of TRIX satisfies all these principles. As an integral index TRIX varies within the rate of actual productivity of the ecosystem (Chl.a*DO%) as well as within the range of its potential productivity (nutrients –(N*P), the interaction between these two main modules is expressed in relative units. This conforms to the general appreciation that the numerical values of neither nutrients nor phytoplankton biomass could be a relevant expression of eutrophication. What counts is the degree of deviation from the boundary conditions that define the "normal state" of an ecosystem, which alternatively is ecosystem specific. This scale was compared to the 5 category scale (excellent, very good, good, fair and poor) for WQS, based on regional Black Sea (Report, 1998) and national regulations (Regulation N8).

Results and discussion

General characteristics of the chemical and biological parameters

As is evident from the statistical summary of the environmental parameters the three sites along the Bulgarian Black Sea coast manifest insignificant differences in temperature and salinity and as expected high variability in all environmental parameters – Table 1, Table 2. In terms of both nutrients and Chl. a concentrations they are ranked in a decreasing order: Varna Bay, Cape Kaliakra, Cape Galata, the Varna Bay site with the highest values, and the other two sites rather similar. The average concentrations of phosphates by sites varied between 15.25–3.36 μg/l and the nitrates between 164.5–55 μg/l. The variation of chlorophyll a average is between 13.77–2.16 μg/l, the Varna bay average exceeding that of the other two sites more than 6 times, and maximum reaching values higher than 100 μg/l. The corresponding averages of the eutrophication index TRIX are 5.3, 4.6 and 4.0 and the sites maximums 7.9, 5.1 and 4.8 respectively.

The statistical summary of the biological variables by sites is presented on Table 2. Similar to the ranking by nutrients and Chl.a concentrations, the sites could be ranked in the same order in terms of total phytobiomass and abundance. In the system Beloslav lake, Varna lake total phytobiomass reached very high values (average about 100 mg/l and higher). Accordingly the phytobiomass:zoobiomass ratio as a measure of the grazing pressure far exceeds the classical ratio 10:1, respectively by a factor of 3 (marine sites) and more than 10 times (lake system).

The ratio Bacillariophyceae:Coppepoda and Dinophyceae:Coppepoda reflecting the selective grazing also differs significantly among the sites and maintained similar trends to that of the PhB:ZB ratio, a manifestation of the discrepancy between the primarily produced organic matter and its trophic utilization. The Bac:Din biomass ratio, considered normally as an indicator of the taxonomic structure of phytoplankton communities, the classical spring-summer value reported for an undisturbed system was 10:1 (Petrova – Karadzova, 1984; Moncheva and Krastev, 1997). As evident from Table 2 it is lower in all the three marine sites (Varna Bay – 7.3, C. Kaliakra around 3 and at C. Galata less than 2), suggesting the higher dominance of the opportunistic Dinophyceae species. The size phytoplankton community structure exhibit differences too, the small-size populations dominating in sites with the highest TRIX (Beloslav lake). The values of the Shannon-Weaver diversity index for phytoplankton (Ha and Hb) are lower than the critical value of 2 in the system Beloslav lake-Varna Bay and below 3 in C. Kaliakra and C. Galata sites. Almost the same trend is evident for this variable for the zooplankton, especially for biomass (Hb-zoo) – Table 2.

Table 1 Statistical summary of chemical parameters and indices

Site		T °C	S‰	O_2 ml/l	DO%	IDO%I	P[μg/l]	NO_2 [μg/l]	NO_3 [μg/l]	N total [μg/l]	Si [μg/l]	N:P	Si:N	Si:P	Chl a [μg/l]	TRIX
Beloslav Lake	av	25.57	14.57	11.52	153.2	53.25	24.74	169.85	1636.5	1806.3	47.88	244.8	0.06	3.24	122.04	6.7
	Me	25.50	14.61	11.13	147.2	47.20	27.37	180.82	1607.0	1787.8	37.38	144.5	0.06	3.24	119.68	6.7
	stdev	0.31	0.24	1.90	25.41	25.41	11.76	31.67	332.96	359.48	57.88	241.1	0.03	0.50	9.84	0.2
	min	25.30	14.28	9.85	131.8	31.80	8.25	123.36	1276.7	1400.1	5	86.21	0.04	2.89	113.40	6.5
	max	25.90	14.76	13.96	186.8	86.80	35.96	194.40	2055.2	2249.6	116.76	604.1	0.08	3.59	135.41	6.9
Varna Lake	av	26.43	16.66	8.33	113.6	53.96	87.92	24.24	209.56	233.79	161.38	12.10	1.02	2.80	64.93	6
	Me	26.50	16.69	9.19	121.8	56.90	41.85	12.15	78.40	92.60	60.76	5.80	0.55	2.00	62.82	6
	stdev	0.41	0.30	4.46	60.82	28.33	183.6	38.90	443.80	480.50	403.51	25.04	1.00	2.55	41.33	0.5
	min	25.70	16.19	1.10	15.00	11.46	14.35	0.00	23.60	25.00	8.12	1.42	0.04	0.38	6.55	5.03
	max	27.30	17.20	15.72	214.5	114.5	781.7	153.24	1892.9	2046.1	1704.4	108.3	3.25	7.67	129.67	6.8
Varna Bay	av	21.72	15.74	9.65	113.3	20.50	15.25	6.90	164.50	171.40	563.60	7.55	0.18	12.56	13.77	5.30
	Me	22.45	15.93	9.27	110.4	15.13	9.94	3.29	70.90	74.19	252.00	3.55	0.06	6.85	4.64	5.13
	stdev	3.39	1.42	2.03	23.57	17.47	20.36	11.50	244.83	256.33	571.16	10.35	0.21	17.76	28.28	1.16
	min	11.11	11.94	6.84	76.84	2.45	2.50	0.01	4.10	4.11	67.20	0.08	0.01	0.53	0.55	2.85
	max	27.50	18.09	15.43	176.2	76.17	114.7	61.10	1030.0	1091.1	1946.0	43.69	0.71	62.00	124.17	7.86
C. Galata	av	24.10	15.47	8.99	111.6	11.76	3.36	1.64	55.00	56.63	137.50	55.65	1.78	42.43	2.16	3.99
	Me	24.76	14.99	9.06	111.7	11.70	3.10	1.35	52.99	55.35	104.81	38.82	0.99	39.40	2.17	4.13
	stdev	1.89	1.75	0.59	8.35	8.09	1.57	1.64	21.07	20.97	143.02	56.79	2.53	34.24	1.07	0.68
	min	21.80	13.23	8.20	99.55	0.45	1.24	0.00	28.14	29.40	7.31	12.35	0.04	6.50	0.90	2.82
	max	26.20	17.73	9.57	120.8	20.76	5.27	4.72	92.40	93.84	401.83	167.6	6.81	84.12	3.78	4.82
C. Kaliakra	av	22.80	15.77	8.49	103.4	6.40	4.89	3.40	96.60	100.00	84.52	55.69	0.51	29.34	3.30	4.60
	Me	22.30	15.14	8.50	103.1	7.46	3.72	2.73	96.60	103.74	69.69	63.12	0.45	11.04	2.96	4.52
	stdev	1.62	1.55	0.69	6.99	3.50	2.90	2.39	42.45	42.32	86.48	28.69	0.45	31.83	1.30	0.41
	min	21.20	14.42	7.36	92.54	2.26	1.55	1.05	42.28	44.18	22.20	24.37	0.08	2.84	2.16	4.05
	max	24.80	17.67	9.17	109.6	9.62	8.62	7.14	156.52	157.57	233.51	93.79	1.12	75.55	5.43	5.07

Table 2 Statistical summary of biological parameters and indices

Site		Chl.a [μg/l]	Abundance [cells*10^6]	Bac:Din	PhB [mg/l]	Ha (phyto)	Hb (phyto)	TZB [mg.m-3]	PhBM:ZBM	Bac:Cop	Din:Cop	PhBM:PHAb	Ha (zoo)	Hb (zoo)
Beloslav Lake	av	122.04	661.37	78.49	84.89	1.09	0.97	876.94	91.13	66.57	1.72	0.13	1.95	1.58
	median	119.68	737.15	70.96	91.10	1.08	0.84	761.44	87.21	65.07	0.83	0.13	1.97	1.58
	stdev	9.84	155.94	67.92	15.77	0.03	0.27	486.37	35.05	56.41	2.37	0.01	0.20	0.56
	min	113.40	482.01	14.65	66.97	1.06	0.78	419.63	58.20	0.00	0.00	0.12	1.72	1.07
	max	135.41	764.93	149.86	96.61	1.12	1.28	1565	127.97	136.14	5.24	0.14	2.16	2.07
Varna Lake	av	65.63	15.34	1501	272.1	1.83	1.24	335.73	1106	5843	189.42	12.57	2.28	2.22
	median	62.82	5.55	19.01	62.88	1.98	1.20	194.46	216.40	417.31	9.20	12.95	2.25	2.19
	stdev	41.61	20.52	5156	426.4	1.18	1.18	366.98	1834	10957	579.65	7.31	0.37	0.41
	min	6.55	0.35	0.15	2.14	0.15	0.03	64.81	3.80	0.00	0.00	2.95	1.76	1.52
	max	129.67	60.89	20793	1326	3.62	3.47	1526	7131	42526	2347	21.78	2.82	2.87
Varna Bay	av	7.19	1.02	7.30	7.56	1.87	1.45	229.38	33.28	123.06	14.47	8.27	2.84	2.15
	median	5.47	0.90	8.21	5.08	2.17	1.43	258.63	26.38	94.73	9.96	8.52	2.98	2.10
	stdev	4.25	0.77	4.31	6.72	0.94	0.81	84.97	23.65	143.66	10.89	3.81	0.38	0.29
	min	3.17	0.28	1.73	1.74	0.02	0.01	70.67	9.18	16.56	6.38	1.01	2.14	1.78
	max	14.90	2.59	12.43	18.27	3.14	2.63	313.17	62.71	453.09	39.13	14.15	3.25	2.68
C. Galata	av	2.16	0.18	1.64	1.59	3.20	2.72	334.43	9.25	5.09	168.65	10.04	2.18	1.51
	me	2.17	0.17	0.83	1.69	3.28	2.98	268.74	6.99	4.33	16.77	9.59	2.08	1.61
	stdev	1.07	0.13	1.81	0.90	0.43	0.84	252.96	9.66	5.45	314.51	3.92	0.44	0.53
	min	0.90	0.03	0.12	0.43	2.70	1.65	110.22	0.62	0.23	0.82	5.97	1.76	0.79
	max	3.78	0.41	4.59	2.47	3.88	3.64	690.01	22.42	11.47	640.24	15.70	2.79	2.04
C. Kaliakra	av	3.43	0.52	3.22	3.88	2.65	2.61	397.64	28.23	103.50	28.92	9.38	2.66	1.82
	me	3.09	0.32	1.21	1.91	2.77	2.59	283.36	4.97	6.40	22.88	10.95	2.45	1.54
	stdev	1.22	0.55	5.64	4.82	0.52	0.70	309.67	42.39	173.41	27.14	5.17	0.58	0.57
	min	2.16	0.08	0.01	1.09	1.93	1.72	161.35	2.56	0.40	5.31	2.33	2.22	1.45
	max	5.43	1.43	13.27	12.45	3.14	3.50	748.20	77.15	303.71	58.58	13.27	3.31	2.48

PC Analysis was applied in order to figure out and score the most relevant combination of parameters to discriminate between sites and select representative descriptors (pressure/state) of eutrophication.

Two PCA plots were produced, the first one to select representative variables among the coastal marine sites (Figure 2) and the second one based on the same parameters to test their relevance when applied in a system of proved gradient in the eutrophication level as suggested by historical data (Rozhdestvenskiy, 1986, 1992) and from the foregoing analysis. The matrices were based on all chemical and biological variables discussed above.

PCA analysis of the matrix based on parameters of the three marine sites (C. Kaliakra, C. Galata and Varna Bay) extracts 3 components to which ecological significance could be attached (PC1), (PC2) and (PC3) explaining 65.9% of the total variance. PC1(35%) discriminates the sites (Galata–Kaliakra–Varna Bay) by the decrease of nutrients molar ratios (N:P and Si:P) and zooplankton diversity index (Hb(z)) and the increase in the capacity of the system to produce and sustain organic matter (Chl a, PhBM, P), phytoplankton taxonomic dominance (Bac:Din biomass ratio) the trophic index (TRIX), and grazing pressure (Ph:ZB, Bac:Cop). According to the second principle component (PC2, explaining 20% of variance) the main discriminating variables are nitrogen and phytoplankton diversity indices (Ha and Hb). Both by PC1 and PC2 only Varna Bay sits clearly apart from the other two sites, which are projected at similar coordinates.

PCA analysis of the system Beloslav lake-Varna lake-Varna bay data set extracts first 3 components (PC1), (PC2) and (PC3) explaining 59.5% of the total variance. The PCA plot of the determinants scores displays a clear discrimination between Beloslav lake (cluster A), Varna lake (cluster B) and Varna Bay (cluster C) more apparent along PC1 axis. PC1 (a loading of 32% in the total variance) correlates positively with N, TRIX, Chl.a. The scores projected along the PC2 axis (16% loading) correspond to an increase in Shannon-Weaver diversity index Ha(ph), HB(ph) and Hb(z) and Si concentration and a decrease in the total phytoplankton abundance and biomass, Bac:Din ratio and grazing pressure (Phyto:Zoobiomass). In general PC2 discriminates clearly only between Cluster A and the

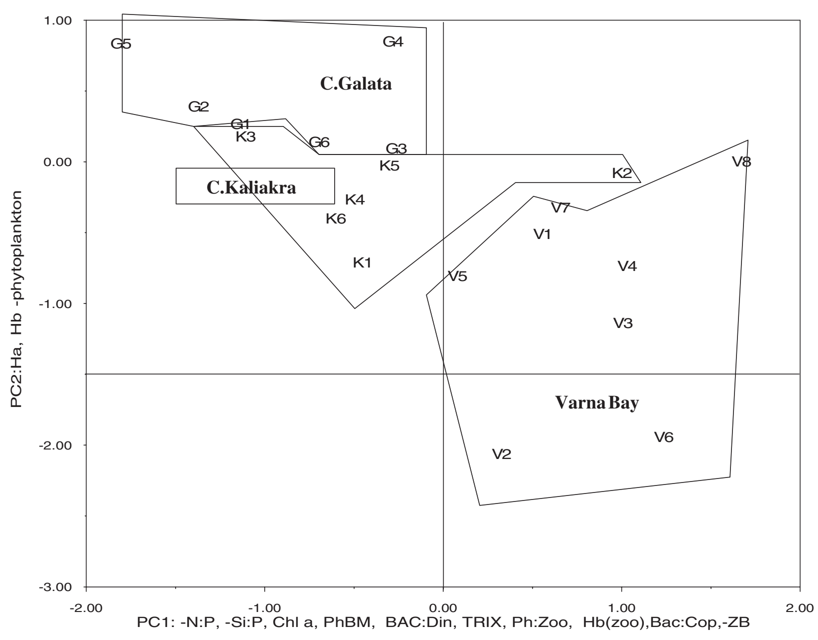

Figure 2 Plot of the PCA score for the marine sites stations

stations located in the transition zone Varna lake–Varna Bay (sub-cluster B1) and those in the periphery of the bay (sub-cluster C1) – Figure 3.

The PCA results distinguish the following variables as relevant descriptors for classification of the sites: nutrients (N, P, Si) and their molar ratios (N:P and Si:P), the capacity of the system to produce and sustain organic matter (Chl a, PhBM), phytoplankton taxonomic dominance (Bac:Din biomass ratio), grazing pressure (Ph:ZB, Bac:Cop), plankton diversity index (Hb and Ha) and the trophic state index (TRIX).

According to TRIX values the sites are ranked in a decreasing order from high to moderate eutrophic level: Beloslav lake (6.8), Varna lake (6), Varna bay (5.3), C. Kaliakra (4.6) and C. Galata (4).

In order to assess chemical quality in a more integrated way Water quality index (WQI) is estimated as a ratio of the measured values of nutrient and Chl a to the local regulation standards. Overall, WQI is expressed as an average of these ratios. The following scale for water quality is used: <0.25 – High, 0.25–0.75 – Good, 0.75–1.25 – Fair, 1.25–1.75 – Poor, and >1.75 – Bad. To test the relevance of TRIX a combination of the variables (indicators) suggested by PCA, WQI for the sites under a different anthropogenic pressure are compared in Table 3.

According to WQI the two lakes fall into the category "BAD", according to TRIX (>6) – very highly eutrophicated, biodiversity indices (H) lower than the critical 2, and PhB:ZB exceeding the classical ratio more than 9 times in Beloslav lake and a hundred times in

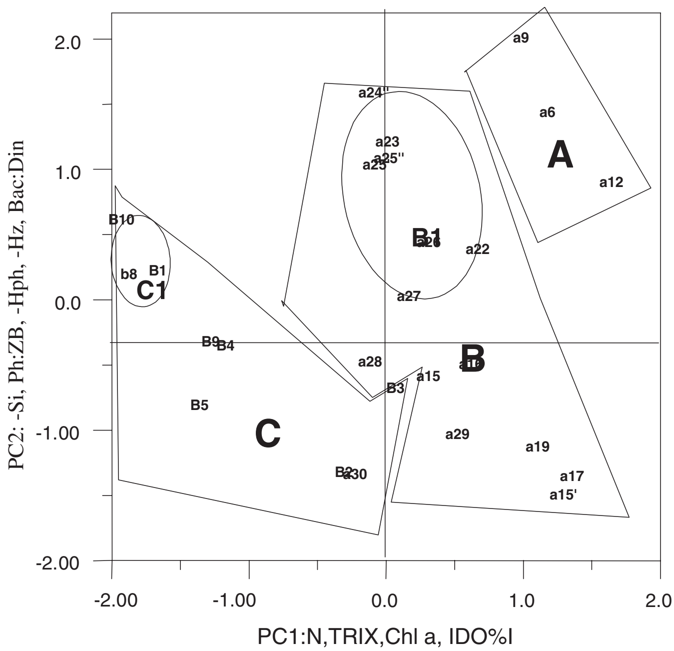

Figure 3 PCA plot of the scores of selected variables for Beloslav lake–Varna Lake–Varna Bay

Table 3 Table of selected descriptors and indicators

Site	WQI	TRIX	Ha (ph)	Hb (ph)	Ha (zoo)	Hb (zoo)	PhBM	Ph:ZB
Beloslav lake	Bad	6.8	1.09	0.97	1.9	1.6	80	90
Varna Lake	Bad	6	1.8	1.2	2.3	2.2	200	1100
Varna Bay	Poor	5.3	1.9	1.43	2.8.	2.15	7.6	33
Kalikra	Fair	4.6	2.6	2.6	2.7	1.8	3.9	28
Galata	Fair	4	3.2	2.7	2.1	1.5	1.6	9

Varna lake respectively. Utilisation efficiency coefficient (log ratio of (Chl. a*DO%)/(P*N) is low in the Beloslav lake due to over-enrichment with N, despite the high biomass (Figure 3). In some cases N concentration exceeds Critical Level Action. The lake receives riverine waters highly loaded (especially with N) from the largest Bulgarian Chemical Industrial Complex (including fertilizer production). The water quality category of the rivers, discharging into the lake according to the same scale is Bad due mainly to nitrogen. Highest is the Utilization efficiency coefficient in Varna Lake due both to the high nutrients and highest phytobiomass.

Varna Bay is scaled in Poor WQ category, highly eutrophicated (TRIX 5.3), with diversity indices below 2, and PH:ZB about 30.

In the system (lakes-Bay) correlation between aggregate components of TRIX log(N*P) and log (Chl. a*aDO%) is high indicating that changes of biomass and biomass activity are in regard to nutrients.

At the coastal sites no correlation is found (Galata r = 0.01) or it is low (Kaliakra, r = 0.42) due to more fluctuating nutrients:production ratio. Utilization efficiency coefficient is higher than in the lakes –Varna Bay system.

Galata, Kaliakra sites are of moderate trophic level (4, 4.8), higher diversity indices and are defined as of Fair WQI. Phyto:Zoobiomass ratio is about 28 for Galata and 9 for Kaliakra and Bac:Din 3.2, 1.6 respectively. Diversity indices are higher than 3.

The good correspondence of TRIX to other indicators of eutrophication such as a phyoplankton community and trophic structures,WQI and negative correlation with Shannon-Weaver (r = –0.7) diversity indices suggests relevance of TRIX for scaling eutrophic conditions.

Presumably no index is a perfect substitute of the original data e.g. the properties and the operational mechanisms of the system that the index represents. The more complex a system, the less it can be described by a few key parameters. The main arguments in favor of TRIX as a unified driver-state type indicator of ecosystem health assessment are that it: sets uniform bases for classification of marine coastal waters according to their trophic characteristics; conciliates considerations on spatial and temporal variability of trophic state over a wide range of environmental conditions and critical levels for "eutrophic/ecological risk"; provides Local Authorities with easy-to-manage information in decision-making and promoting of remedial actions.

Inclusion of additional parameters as biotic ones (grazing pressure, trophic interactions etc.) is an advantage in defining the eutrophic conditions (Moncheva *et al*., 2000).

Conclusions

The selected parameters readily discriminating among sites could be considered as indictors of ecological quality (EcoQ). EcoQ in the present paper is expressed as a complexity of indicators of impact (TRIX, nutrients) and basic ecosystem properties – productivity (Chl. a, PhBM, IDO%I), diversity (Ha, Hb), trophic structure (Ph:ZB, Din:Cop, Bac:Cop).

Although preliminary the results could contribute to further efforts for defining typology and mapping WQ based on harmonized unified descriptors and indicator categories.

Acknowledgements

The study was partly supported by NATO SfP Project – 971818 ODBMS Black Sea, NSF Project B-906/99 and CESUM-BS (Contract ICA1-CT-2000-70031).

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