Baltic Coastal Zone
No. 5

(17-34)
2001

Institute of Biology and Environmental Protection
Pomeranian Pedagogical University
Słupsk

SELECTED CHEMICAL INDICATORS OF WATER QUALITY IN THE NEAR BOTTOM LAYER OF THE POMERANIAN BAY CLOSE TO THE MOUTH OF THE CHANNEL ŚWINA BETWEEN 1991-1994

Gorzysław Poleszczuk[1], Stanisław Sitek[2], Norbert Wolnomiejski[2]

[1]University of Szczecin, Felczaka St. 3A, 71-412 Szczecin, POLAND
[2]Sea Fisheries Institute in Gdynia, Research Station in Świnoujście, Pl. Słowiański 11, 72-600 Świnoujście, POLAND

Abstract

Between 1991-1994 a study was conducted on the chemical composition of near bottom water of the Pomeranian Bay liable to back flow in the water-way to the Szczecin Lagoon. The aim of this study was to investigate the quality of water in the vicinity of the river Świna mouth (water depth ≥10 m) in respect to the following parameters: chlorinity, concentrations of sulphate, bicarbonate as well as calcium and magnesium ions, temperature, pH, redox conditions indicators – Eh, O_{2diss}, COD-Mn and BOD_5, and indicators of the trophic status, i.e. the concentrations of nitrate, nitrite, total nitrogen, dissolved phosphate, total phosphorus and dissolved silicate. The collected results of measurements, if compared with data on riverine outflow form the Odra river, can be used in mass balance calculations of substances inflowing into the Szczecin Lagoon. Further on, the balance calculations can indicate the biogeochemical processes influencing the chemical composition of water in the estuary of the river Odra.

Key words: water composition, near bottom water, Świna mouth, Pomeranian Bay, Baltic Sea

INTRODUCTION

The exchange of water between the Szczecin Lagoon and the Pomeranian Bay is accomplished in a way typical for estuaries. Normally, water from the Szczecin Lagoon is flowing into the Pomeranian Bay, but under specific meteorological conditions water from the Pomeranian Bay can reverse and be pushed into the Szczecin Lagoon. Since there is no tidal movement in the estuary of the river Odra, the exchange of water is regulated by the intensity of the river flow and, the already mentioned, meteorological conditions, especially barotropic gradients facilitating the backflows into the Lagoon (Siegel et al. 1994). Hence, the direction of the flow alternates or the flow can proceed simultaneously in both directions: fresh – riverine water flowing downward the estuary on the surface, while in the near bottom layer more saline marine water moves upwards, mainly in the trough of the water-way Świnoujście-Szczecin. Water exchange processes, beside the biotic ones, are the basic factor influencing the chemical composition of water in the estuary of the river Odra (Majewski 1980, Jasińska 1981, Poleszczuk 1997, 1998).

The prognosis or modelling of the changes in the chemical composition of water in the estuary can be conducted on the basis of mixing coefficients (e.g. Poleszczuk 1997) and these can be determined from the data on chemical composition of riverine and marine waters mixing in the estuary. Further on, the comparison of these „modelled" data with the results of field measurements in the estuary should be helpful in determining the biogeochemical processes responsible for the environmental conditions in the Odra estuary. The relevant studies have been conducted by the authors between 1991-1994, and the results concerning the chemical composition of water in the Szczecin Lagoon have been already published (Poleszczuk et al. 1995, Poleszczuk 1997, 1998).

Chemical composition of water in the Szczecin Lagoon, especially with regard to salinity, was subject to earlier studies: Majewski 1957, 1972, 1974, Wiktor and Wiktor *1961*, Jaworski *1965*, Trzosińska *1970*, *1978*, Kiermut *1976*, Renk et al. *1976*, Ringer 1976, Tadajewski and Kubiak 1976, Wiktor 1976, Tadajewski 1977, Andrulewicz 1978, Kubiak 1983, Baltic 1987, Trzosińska et al. 1988, Jasińska et al. 1989, Tadajewski et al. 1989, Jasińska 1991, Robakiewicz 1993, Poleszczuk 1994, Kowalewska 1995, Poleszczuk and Sitek 1995, Mutko et al. 1995, Trzosińska and Łysiak-Pastuszak 1995). Only scarce publications presented results of a greater number of chemical indicators of water quality Wiktor and Wiktor 1961, Trzosińska 1970, Majewski 1974, Tadajewski and Kubiak 1976, Wiktor 1976, Tadajewski 1977, Kubiak 1983, Trzosińska et. al. 1988, Mutko et al. 1995, Poleszczuk and Sitek 1995, Trzosińska and Łysiak-Pastuszak 1996), but in turn, the studied area in these publications was usually the central Pomeranian Bay. The articles regarding the area near the mouth of the river Świna are still fewer: Wiktor and Wiktor (1961), Wiktor (1976), Majewski (1974), Mutko et al. (1995), Poleszczuk and Sitek (1995). However, often the results on chemical composition of water in the Pomeranian Bay, presented in publications (Majewski and Lauer 1994, Cyberska et al. 1999, Łysiak-Pastuszak and Drgas 2000), were collected at station located at a greater distance to the Świna mouth than in our investigations. Hence, the authors hope the data published in this article can bring additional information on the chemistry of water in the Pomeranian Bay.

MATERIAL AND METHODS

The study of chemical composition of near bottom water in the Pomeranian Bay was conducted between 1991-1994 using the boats: m/s "Stynka", owned by the Sea Fisheries Institute in Gdynia, and SNB-US of the Szczecin University.

Water samples were collected at 6 measurement stations located in the Pomeranian Bay (Fig. 1) from the depth of 10-12 m when the bay water was free of ice. Water samples were collected with Patalas samplers (PN/C-04632) from the near bottom layer, usually ca. 0.5 m above the bottom. Altogether 159 water samples were collected and analysed.

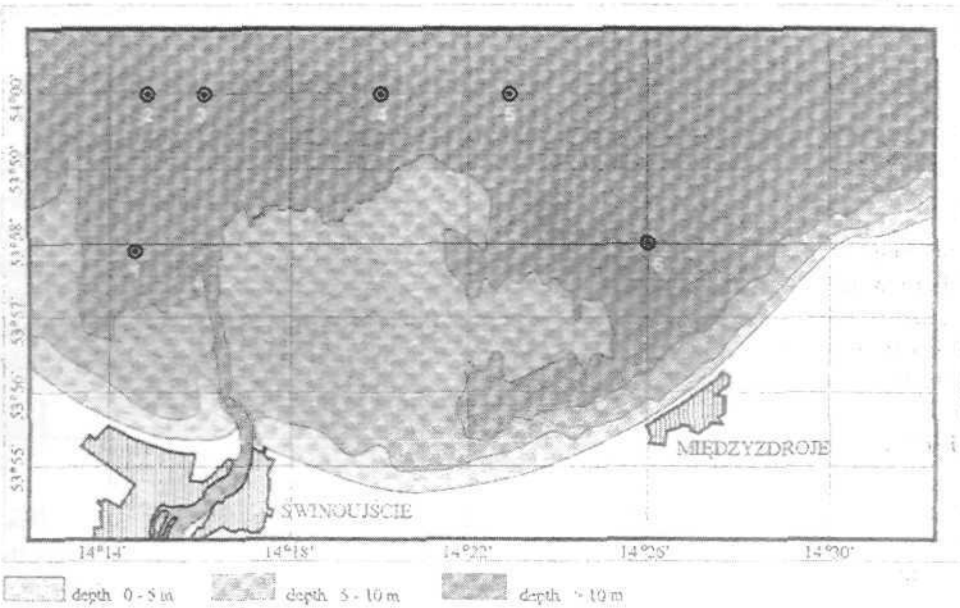

Fig.1. Location of measurment stations in the Pomeranian Bay

The following parameters were measured while sampling: water temperature (by reversing thermometers), pH – by a pH-meter (PN/C-4540.03) using pH standard solutions for calibration (PN/C-06504), Eh - by potentiometric method (Kölling 1986) where the measurement cell was calibrated with ZoBell (1946) standards, and hydrocarbonate as total alkalinity – by acidimetric method (PN/C-04540.03).

The other analyses were conducted in the land laboratory in less than 24 h. The following water quality indicators were determined in the analysed samples: the concentration of chloride ions – as chlorinity, using an argentometric method with normal Copenhagen water as a standard (Grasshoff 1976), sulphate concentration – by gravimetric method (PN/C-04566.09), total concentration of calcium and magnesium ions by complexometric method (PN/C-04551.01, PN/C-04562.01). The concentration of dissolved oxygen was determined by the classical Winkler method with azide modification according to Alsterberg (PN/C-04545.03), COD-Mn – by a method modified from the working procedure for the fresh water (PN/C-04578.02) with addition of 10-15 g of $HgCl_2$ to the analysed sample to bind chloride ions in stable complexes, and BOD_5 according to the Polish Standard PN/C-04576.07. The concentrations of nutrients were determined according to the Polish standards for fresh water analyses; nitrate – PN/C-04576.07, nitrite – PN/C-04576.06, ammonia – PN/C-04576.01, total nitrogen after sample digestion – PN/C-04576.14, dissolved reactive phosphate – PN/C-04576.02, total phosphorus – PN/C-04576.09 and dissolved silicate – PN/C-04562.01).

Statistical evaluation of the data, especially the calculations of mean values (x), standard deviations (SD) and relative standard deviations (CV %) as well as the regression equations between the concentrations of macro-components and chlorinity and box-whiskers diagrams were done using „Statgraphics" software.

RESULTS

Considering the spatial differentiation of water quality indicators at a given date of measurements, the results of analyses showed considerable uniformity of parameters in the near bottom water at a given time of measurement. The results of the analysed parameters did not differ more than 5% between the stations, hence it was assumed there was no statistically significant spatial differences. However, the analysed parameters differed significantly in time. For this reason, the mean values from six measurement stations were analysed with regard to temporal changes as a single measurement value (Fig. 2-4, Tab. 1-3).

Indicators of water mineralisation

The chlorinity of water in the studied area varied between 3.85 and 4.50‰, the concentrations of sulphate - between 0.530 and 0.590 g SO_4^{2-} dm^{-3}, hydrocarbonate - between 0.120 and 0.145 g HCO_3^- dm^{-3} and calcium and magnesium (total forms), respectively – between 0.105 and 0.115 g Ca dm^{-3} and 0.260 and 0.300 g Mg dm^{-3}.

All analysed ionic macro-components of near bottom water of the Pomeranian Bay showed specific seasonal variability accounting to three quasi-seasons, namely May – July, August – October and November – April. Between May and July the maximal concentrations appeared of the following ions chloride, calcium and magnesium and sulphate and a minimum in carbonate concentrations was detected. Between August and October the chemical composition of near bottom water was close to the annual mean values, while the lowest salinity and the lowest concentrations of SO_4^{2-} , Ca^{2+} and Mg^{2+} and were found between November and April, hydrocarbonate concentrations reaching than maximal values.

A strong positive correlation was found between sulphate concentrations and chlorinity of the analysed water ($r > 0.98$) and similar relations were detected for calcium ($r \cong 0.80$) and magnesium ($r > 0.98$) ions. A reverse and not that strong correlation appeared between carbonate and chloride ion concentrations ($r \cong -0.67$).

Water temperature and factors indicating acid-base and redox status of water

Water temperature in the near bottom layer of the studied area showed a sharp maximum on the turn of July and August in both presented here measurement periods in 1992 and 1993. Between May and July water temperature increased from about 8°C to the maximum and from August to October it decreased from the maximum to 8°C.

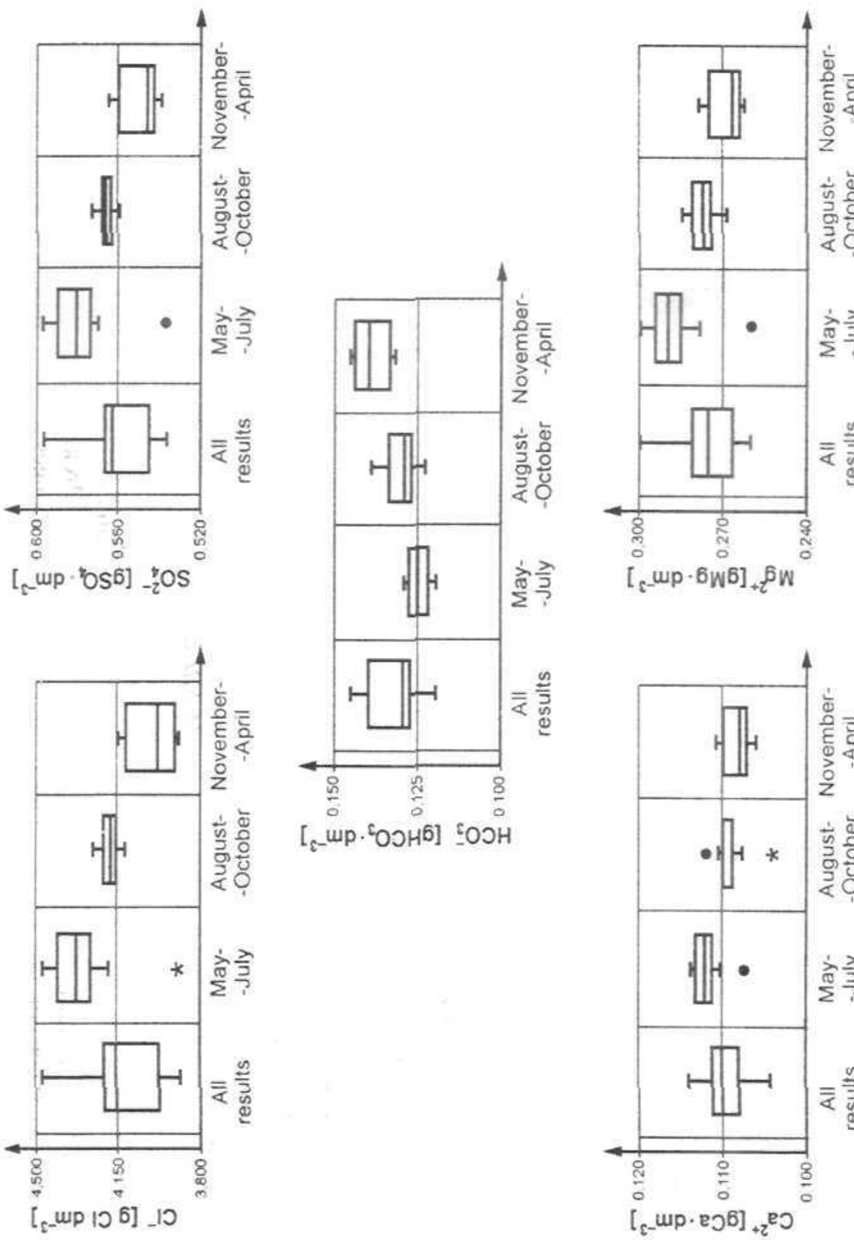

Fig. 2. Box-whiskers diagrams of ionic macro-components concentrations in near bottom water of the Pomeranian Bay (depth > 10 m), close to the mouth of the river Świna, in the period 1991-1994

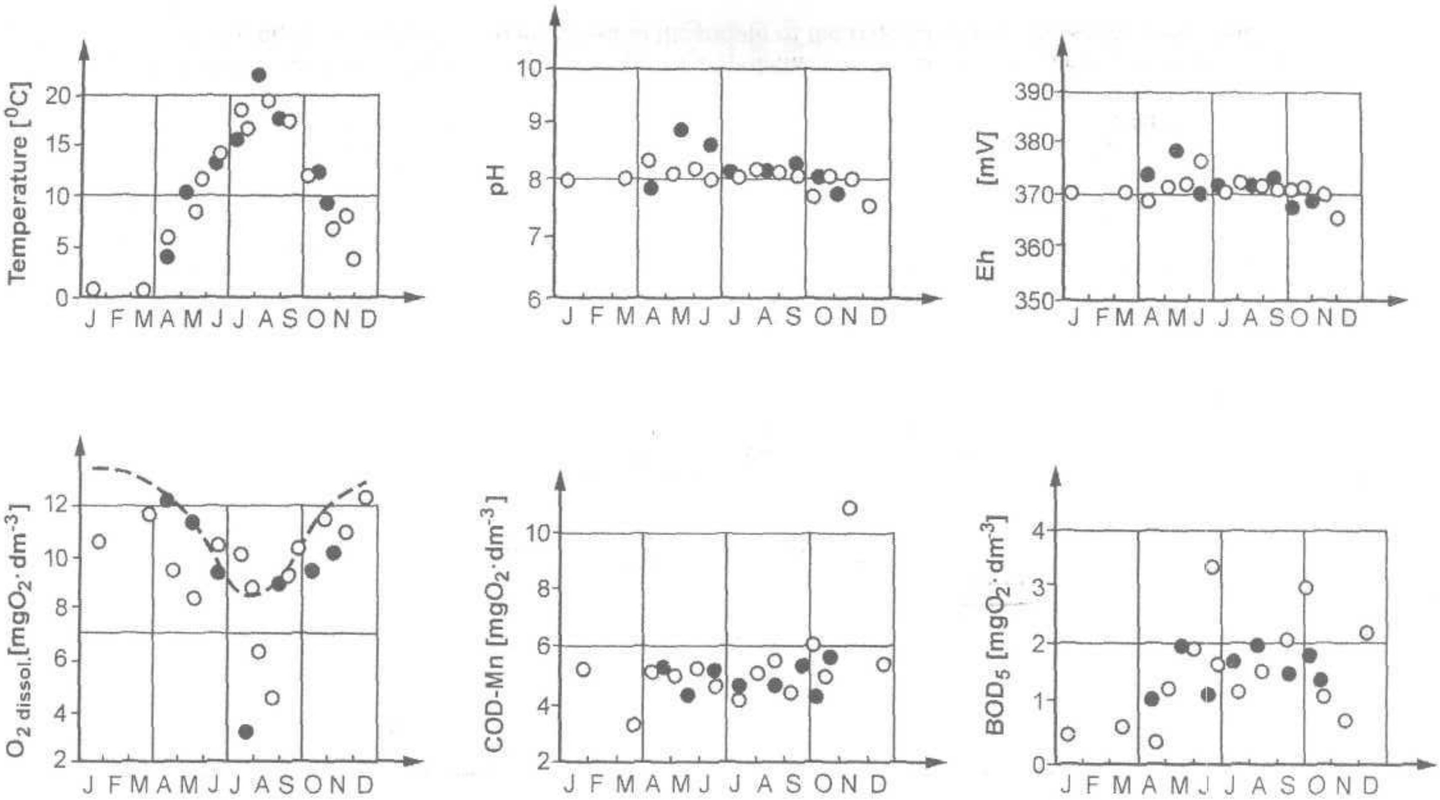

Fig. 3. Water quality indicators in near bottom water of the Pomeranian Bay (depth >10 m), close to the mouth of the river Świna; pH and redox conditions indices; data from: (o)1992 i (•) 1993. Broken line in the diagram illustrating changes in dissolved oxygen concentration during the year represents the changes in water saturation with oxygen (%).

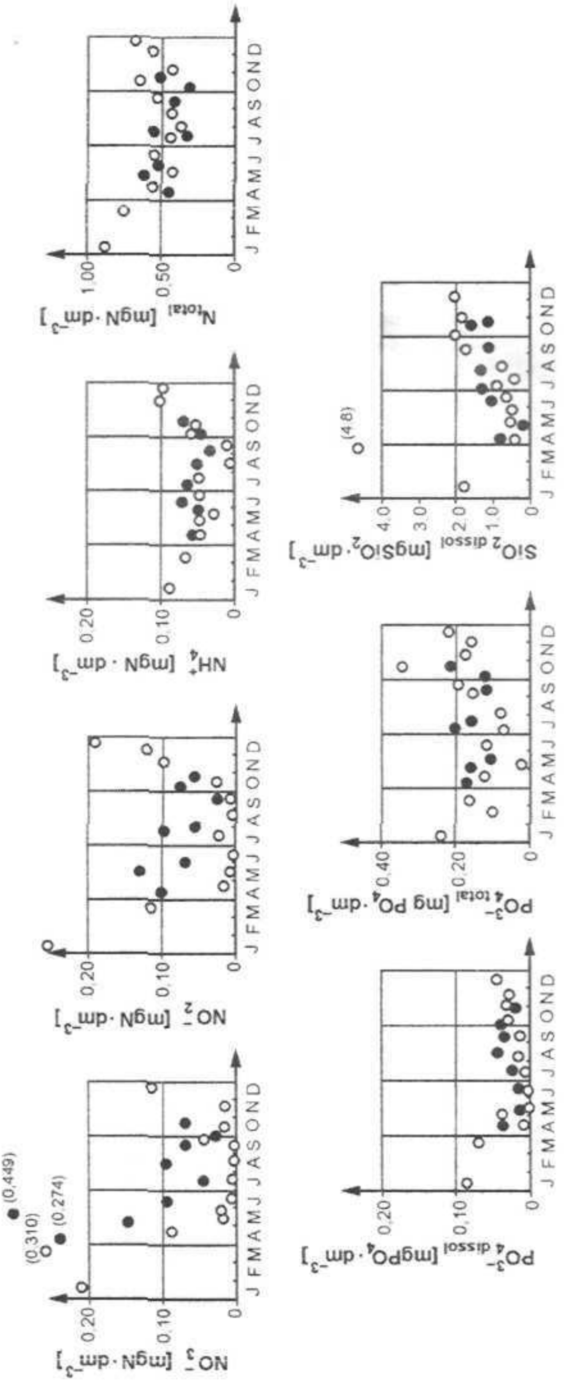

Fig. 4. Water quality indicators in near bottom water of the Pomeranian Bay (depth >10 m), close to the mouth of the river Świna; trophic status indices; data from: (o) 1992 i (●)1993

Table 1

Concentrations (in g/1000g) of selected ions versus chlorinity (Cl $^0/_{00}$) in bottom water of the Szczecin Lagoon, the Pomeranian Bay near Świnoujście and in the Southern Baltic waters

No	Ion	Region	Coefficients in equation: ion concentration = A (Cl $^0/_{00}$) + B		Corelation coefficient r	Chlorinity range (‰)	Period of investigations	Data from
			A	B				
1	2	3	4	5	6	7	8	9
1	SO_4^{2-}	Szczecin	0.1230	0.0599	0.970	0.10 ÷ 2.50	1970 year	Młodzińska 1980
		Lagoon	0.1000	0.0730	0.935	0.08 ÷ 2.90	March-November 1992	Poleszczuk 1998
		Pomeranian Bay near Świnoujście – bottom waters	0.994	0.1499	0.994	3.85 ÷ 4.50	1991-1994 year	this work
		Southern Baltic	0.1359	0.0220	-	4.00 ÷ 4.50	into 1970 year	Trzosińska 1970
2	HCO_3^- *	Szczecin	0.0023	0.1435	0.090	0.10 ÷ 2.50	1970 year	Młodzińska 1980
		Lagoon	0.0260	0.1240	0.311	0.08 ÷ 2.90	March-November 1992	Poleszczuk 1998
		Pomeranian Bay near Świnoujście – bottom waters	-0.0310	0.2615	-0.673	3.85 ÷ 4.50	1991-1994 year	this work
		Southern Baltic	0.0063	0.0660	-	4.00 ÷ 4.50	into 1970 year	Trzosińska 1970
3	Ca^{2+}	Szczecin	0.0161	0.0646	0.780	0.10 ÷ 2.50	1970 year	Młodzińska 1980
		Lagoon	0.0010	0.0860	0.053	0.08 ÷ 2.90	March-November 1992	Poleszczuk 1998
		Pomeranian Bay near Świnoujście – bottom waters	0.0120	0.0598	0.805	3.85 ÷ 4.50	1991-1994 year	this work
		Southern Baltic	0.0180	0.0350	-	4.00 ÷ 4.50	into 1970 year	Trzosińska 1970
4	Mg^{2+}	Szczecin	0.0693	0.0056	0.980	0.10 ÷ 2.50	1970 year	Młodzińska 1980
		Lagoon	0.0600	0.0080	0.933	0.08 ÷ 2.90	March-November 1992	Poleszczuk 1998
		Pomeranian Bay near Świnoujście – bottom waters	0.0619	0.0211	0.982	3.85 ÷ 4.50	1991-1994 year	this work
		Southern Baltic	0.070	0.0020	-	4.00 ÷ 4.50	into 1970 year	Trzosińska 1970

* total alkalinity as HCO_3^- concentration in g HCO_3 dm^{-3}

Table 2

Statistical evaluation of selected quality indices in the near bottom water of the Pomeranian Bay in 1991-1994; general indices and pH and redox status indices

Statistical characteristics	Indices values			
	All results	In seasons		
		May - July	August - October	November-April
pH				
Min.	7.40	8.05	7.80	7.40
Average	8.06	8.20	8.09	7.91
Median	8.05	8.20	8.05	8.00
Max.	8.50	8.40	8.50	8.40
SD	0.27	0.13	0.25	0.34
CV (%)	3.37	1.55	3.13	4.26
Eh (mV)				
Min.	327	354	327	348
Average	370	390	350	365
Median	368	383	338	370
Max.	415	415	387	389
SD	63	68	57	62
CV (%)	39.70	38.60	26.70	41.70
$O_{2\ dissolved}$ ($mgO_2 \cdot dm^{-3}$)				
Min.	4.50	8.90	4.50	9.30
Average	9.42	9.50	7.53	11.25
Median	9.30	9.20	8.50	11.40
Max.	12.50	10.50	10.20	12.50
SD	2.23	0.72	2.43	1.13
CV (%)	23.66	7.55	32.30	10.06
COD-Mn ($mgO_2 \cdot dm^{-3}$)				
Min.	3.40	4.00	4.10	3.40
Average	5.40	4.88	5.41	5.81
Median	5.10	5.00	5.60	5.25
Max.	11.00	5.50	6.20	11.00
SD	1.61	0.55	0.80	2.64
CV (%)	29.94	11.35	14.70	45.51
BOD_5 ($mgO_2 \cdot dm^{-3}$)				
Min.	1.00	1.63	1.08	1.00
Average	1.97	3.15	1.50	1.47
Median	1.60	3.12	1.41	1.38
Max.	4.68	4.68	2.12	2.01
SD	1.00	1.11	0.35	0.41
CV (%)	33.59	15.76	23.12	28.17

Table 3

Statistical evaluation of selected quality indices in the near bottom water of the Pomeranian Bay in 1991-1994 years; trophic status indices

Statistical characteristics	Indices values			
	All results	In seasons		
		May - July	August - October	November-April
NO_3^- ($mgN \cdot dm^{-3}$)				
Min	< 0.01	< 0.01	< 0.01	0.06
Average	0.06	0.01	0.02	0.15
Median	0.02	0.01	0.01	0.10
Max	0.31	0.02	0.08	0.31
SD	0.09	0.01	0.03	0.10
CV (%)	139.4	90.6	144.8	66.1
NO_2^- ($mgN \cdot dm^{-3}$)				
Min	0.001	0.001	0.002	0.009
Average	0.008	0.003	0.006	0.014
Median	0.006	0.001	0.005	0.012
Max	0.026	0.004	0.010	0.026
SD	0.006	0.001	0.003	0.006
CV (%)	80.1	46.6	52.7	44.4
NH_4^+ ($mgN \cdot dm^{-3}$)				
Min	< 0.01	< 0.01	< 0.01	0.05
Average	0.04	0.02	0.01	0.08
Median	0.04	0.02	0.01	0.08
Max	0.10	0.04	0.05	0.10
SD	0.03	0.02	0.02	0.02
CV (%)	85.2	65.9	131.5	26.1
N_{tot} ($mgN \cdot dm^{-3}$)				
Min	0.04	0.39	0.44	0.04
Average	0.49	0.43	0.48	0.56
Median	0.45	0.41	0.45	0.60
Max	0.83	0.52	0.58	0.83
SD	0.17	0.05	0.05	0.28
CV (%)	34.2	12.3	11.3	49.5
$PO_{4\,dissolved}$ ($mgPO_4 \cdot dm^{-3}$)				
Min	0.01	0.01	0.03	0.03
Average	0.05	0.01	0.06	0.08
Median	0.04	0.01	0.05	0.05
Max	0.20	0.02	0.10	0.20
SD	0.05	0.01	0.03	0.06
CV (%)	94.0	69.6	50.9	76.6
P_{tot} ($mgPO_4 \cdot dm^{-3}$)				
Min	0.01	0.01	0.15	0.11
Average	0.16	0.09	0.20	0.18
Median	0.17	0.06	0.18	0.17
Max	0.37	0.16	0.37	0.24
SD	0.08	0.06	0.08	0.05
CV (%)	49.7	71.5	38.8	27.4
$SiO_{2\,dissolved}$ ($mgSiO_2 \cdot dm^{-3}$)				
Min	0.26	0.39	0.75	0.26
Average	1.39	0.56	1.28	2.20
Median	1.01	0.48	1.02	1.97
Max	5.14	1.01	2.14	5.14
SD	1.18	0.26	0.58	1.59
CV (%)	84.7	46.1	45.8	72.5

The period of stable chemical composition of water, between November and April, coincided with water temperature < 8°C. Oxygen concentration corresponded to 100% saturation in most measurement series, however, in June and July certain over-saturation with oxygen was noticeable. Simultaneously about 30% of results of oxygen determinations in near bottom water from the vicinity of Świna mouth indicated considerable oxygen deficit.

pH and Eh were extremely stable in the entire measurement period, with the mean values of 8.06 and 370 mV, respectively.

COD-Mn behaved very much alike Eh; varying between 5.0-5.5 mg $O_2 \cdot dm^{-3}$ while BOD_5 showed greater changeability, with the maximum in the period May-July ($BOD_5 \cong 3.00$ mgO_2 dm^{-3}) and lower values (around 1.50 mgO_2 dm^{-3}) in summer and early autumn.

Trophic status indicators

Nitrate concentrations showed clearly marked seasonal variability with maximal values in early spring and the general range between 0.10-0.30 mg $N\text{-}NO_3$ dm^{-3}. Nitrite concentrations changed also according to the season, showing minimal values in summer and early autumn while the maximal concentrations were found in early spring and late autumn (0.026 mg $N\text{-}NO_2$ dm^{-3}). Ammonia content in the analysed samples was rather stable, around 0.04 mg $N\text{-}NH_4$ dm^{-3}, but it increased in autumn even up to 0.10 mg $N\text{-}NH_4$ dm^{-3}. Total nitrogen concentrations were rather stable throughout the year around 0.50 mg N/dm^3 and a minimum of about 0.40 mg N dm^{-3} appeared in autumn and winter months.

The mean concentration of dissolved phosphate reached 0.06 mg $P\text{-}PO_4$ dm^{-3}, with a minimum (0.01 mg $P\text{-}PO_4$ dm^{-3}) in the period May-July. The mean concentration of total phosphorus was ca. 0.16 mg PO_4 dm^{-3} with minimum (0.09 mg PO_4 dm^{-3}) in May-July and a maximum up to 0.20 mg PO_4 dm^{-3} in the autumn and winter.

Silicate concentrations varied strongly with the season; with low (0.47 mg SiO_2 dm^{-3} on average) values in spring, a level close to the annual mean (1.30 mg SiO_2 dm^{-3}) in summer and higher concentrations (up to 2.00 mg SiO_2 dm^{-3}) when the water temperature dropped <8°C.

This specific seasonal variability was characteristic also for other water quality indicators as illustrated in diagrams in Figs.3 and 4. In general, seasonal variability in near bottom water of the Pomeranian Bay was detected in the following parameters: oxygen concentration and saturation, BOD_5, nitrogen salts: nitrate, nitrite, ammonia and total nitrogen concentrations, phosphate and total phosphorus contents and concentration of dissolved silicate.

DISCUSSION

The results obtained in this study on water quality indicators in the near bottom water of the Pomeranian Bay (> 10 m) close to the mouth of the river Świna, indicated the lack of spatial differentiation of water quality in a given series of measurements.

Simultaneously they revealed that the chemical composition of the examined waters considerably changed depending on the period of measurement and the changes underwent annual cycles. The differences in chemical composition of the examined waters can be characterized in three quasi-seasons: early summer (May-July) with water temperature changing from > 8°C to the annual maximum on the turn of July and August, late summer/autumn (August-October), when water temperature decreased from the annual maximum to ca. 8°C, and late autumn/winter/early spring season (November-April), when water temperature dropped below 8°C.

Between May and July the highest degree of mineralisation was observed in the analysed waters (chlorinity > 4.2‰), which was accompanied by good oxygen situation or weak oxygen deficits appearing occasionally (80-100%), stable pH (≅ 8.0) and redox potential (≅ 370 mV). At the same time the waters contained low amounts of organic matter of reducing character (COD-Mn ≅ 4.90 mg O_2 dm^{-3}) and showed low intensity of biochemical degradation processes (BOD_5 ≅ 3.15 mg O_2 dm^{-3}). Simultaneously the concentrations of mineral nitrogen compounds and total nitrogen content were lower than in other seasons. The concentrations of dissolved phosphate and total phosphorus showed parallel changes.

The observed water quality indicators point to the fact that in this period chemical composition of the near bottom water was mainly influenced by the more intensive – due to spring storms – inflow of saline water from the Pomeranian Bay, this being particularly in evidence when taking into account the concentrations of total nitrogen and total phosphorus.

Between August-October when water temperature rather quickly declined from the annual maximum to 8°C, the studied waters showed different chemical composition. The mineralisation indicators were of similar magnitude as in spring, this being the evidence of fresh water excess from the Szczecin Lagoon. Water saturation with oxygen varied greatly from over saturation to deficit levels amounting to 20-40%, while pH remained unchanged around 8. The latter observation being indicative also of the inflow of fresh water from the Szczecin Lagoon, rich in HCO_3^-, and an increase in bicarbonate concentrations due to release from organic matter mineralisation processes, both enhancing the buffer capacity of the water in the Pomeranian Bay. The redox potential values changes in this period in a narrow range (Eh ≅ 370-375 mV) probably because of considerable stability of the COD-Mn and BOD_5 indicators. As regards nutrients, ammonia usually showed minimal concentrations in this period, what can be explained by increased assimilation activity of phytoplankton during phytoplankton blooms. The blooms are always accompanied by an increase in dissolved phosphate concentration, observed also in this study. The concentrations of total forms of phosphorus and nitrogen increased during this period, this was attributed to the inflow of fresh water from the Szczecin Lagoon which contained more organic compounds of phosphorus (Poleszczuk 1998).

During the final period, between November-April, when water temperature dropped < 8°C, the mineralisation of near bottom water in the Pomeranian Bay showed the lowest values, what can be related to the increased inflow of fresh water from the Szczecin Lagoon and the homogenising effect of storms mixing the fresh water in the surface layer and more saline near bottom water. Oxygen saturation values were usually 90-100%. The deficits in oxygen concentrations can be explained by the predominance of the dissimilation processes over assimilation ones. The observation is supported by clear, though not large, decline in Eh values and increase in COD-Mn and total alkalinity.

The obtained results seem to justify the characterisation of water quality changes in the near bottom layer of the Pomeranian Bay into three seasons. Chemical composition of water in this region is undoubtedly influenced by the fresh water inflow from the Szczecin Lagoon but this is more evident in the surface water layer than near the bottom, because chemical stratification of water in this region is quite strong particularly in autumn-winter-spring periods. This is relevant particularly in the case of oxygen depletion to 20-40% saturation value, caused by degradation of allochthonous organic matter and brought in by fresh water from the Szczecin Lagoon (Wiktor and Wiktor 1961) and accompanied by the increase in total phosphorus and total nitrogen concentrations.

The collceted data can form a basis for mass balance calculations of the turnover of material in the Szczecin Lagoon.

CONCLUSIONS

1. Near bottom water (depth > 10 m) in the Pomeranian Bay, close to the mouth of the river Świna, was examined between 1991-1994 and showed little spatial differentiation as regards chemical composition, though considerable temporal variability depending on the season was detected.
2. The obtained results were classified in three quasi-seasons of water quality:
   - late spring/summer: between May and July, characterised by water temperature in the range from 8°C to the annual maximum on the turn of July and August and by the maximal water salinity,
   - summer/early autumn: between August and October with water temperature declining from the annual maximum to ca. 8°C and salinity around the annual mean,
   - late autumn/winter/early spring: between November and April, with water temperature below 8°C and salinity below the annual mean.

ACKNOWLEDGEMENT

The results of the study were collected within the statutory activities of the Sea Fisheries Institute Research Station in Świnoujście – project No. 1 „Determination of principles and rational exploitation of fish stocks in the Polish sector of the Baltic Sea", under the supervision of dr Anna Garbacik-Wesołowska and a project of the State Committee for Scientific Research No. 5F311 006 05 "Benthic fauna as an indicator of environmental conditions in water of the Szczecin Lagoon and Pomeranian Bay" under the supervision of doc. dr hab. Norbert Wolnomiejski.
The authors express their deep gratitude to dr Anna Garbacik-Wesołowska from the Sea Fisheries Institute Research Station in Świnoujście, to prof. dr hab. Zbigniew

Piesik from the Department of Biological Oceanography of the Szczecin University as well as to the skipper of the vessel SNB - US for their invaluable assistance during the study in the years 1991-1994.

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STAN JAKOŚCIOWY WODY BAŁTYCKIEJ W STREFIE PRZYBRZEŻNEJ POMIĘDZY DARŁOWEM I ŁEBĄ

Streszczenie

W latach 1991-1994 badano chemizm wód naddennych Zatoki Pomorskiej w miejscu 6 stacji pomiarowych w pobliżu ujścia Świny. Oznaczano wybrane wskaźniki mineralizacji (Cl^-, SO_4^{2-}, HCO_3^-, Ca^{2+}, Mg^{2+}) temperaturę, pH, i wskaźniki stanu redoksowego wód ($O_{2\,rozp}$, COD-Mn, BOD_5), a także wskaźniki trofii (stężenia NO_3^-, NO_2^-, NH_4^+, N_{og}, PO_{4rozp}^{3-}, $PO_{4og.}$, $SiO_{2\,rozp}$). Wykazano brak zróżnicowania przestrzennego wód naddennych na badanym akwenie i równocześnie występowanie zmienności sezonowej ich składu chemicznego. Wyróżniono trzy quasi - sezony (maj-lipiec, sierpień-październik, listopad-kwiecień), kiedy chemizm wód jest względnie ustabilizowany i różny od chemizmu wód w różnych okresach. W związku z tym, że wody naddenne Zatoki Pomorskiej mogą napływać i napływają rynną toru wodnego Świnoujście – Szczecin w górę estuarium Odry, zebrane dane mogą być przydatne przy wykonywaniu bilansów dopływu różnych substancji do Zalewu Szczecińskiego.