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Trophic status of coastal and open areas of the south-eastern Baltic Sea based on nutrient and phytoplankton data from 1993 - 1997

by

Norbert Wasmund[1], Günther Nausch[1], Lutz Postel[1],
Zbigniew Witek[2], Mariusz Zalewski[2], Sławomira Gromisz[2],
Elżbieta Łysiak- Pastuszak[3], Irina Olenina[4], Rima Kavolyte[4], Aldona Jasinskaite[4]
Bärbel Müller-Karulis[5], Anda Ikauniece[5], Andris Andrushaitis[5]
Henn Ojaveer[6], Kalle Kallaste[6], Andres Jaanus[6]

[1]Baltic Sea Research Institute, Seestr. 15, D-18119 Warnemünde, Germany
[2]Sea Fisheries Institute, Kołłątaja 1, PL-81-332 Gdynia, Poland
[3]Institute of Meteorolgy and water Management, Maritime Branch, Waszyngtona 42, PL-81-342 Gdynia, Poland
[4]Centre of Marine Research, Taikos 26, LT-5802 Klaipeda, Lithuania
[5]Institute of Aquatic Ecology, University of Latvia, Miera 3, LV-2169 Salaspils, Latvia
[6]Estonian Marine Institute, Viljandi Rd. 18b, EE-11216 Tallinn, Estonia

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Summary

Despite of the high importance of coastal areas for the functioning of the whole Baltic ecosystem and the special socio-economical interest in these regions, an international coastal monitoring programme has been established by the Helsinki Commission (HELCOM) only recently. Data of coastal areas were ascertained, however, in national responsibilities for years. One of the major aims of our work was to compile the basic hydrochemical and phytoplankton (incl. chlorophyll and primary production) data and supply them as base-line data for future trend-analyses by the coastal monitoring programme in the HELCOM COMBINE.

Data were collected from the Pomeranian Bay, the Gulf of Gdańsk, the coastal area in front of Lithuania, and the Gulf of Riga in the years 1993-1997. As large rivers discharge into these areas, the plume waters were considered separately. The coastal data were compared with data from the open Baltic Sea (Arkona Sea, Bornholm Sea, Eastern Gotland Sea).

Nutrient concentrations and N:P ratios decreased from the plumes to the open sea. N:P ratios in the plumes were higher than 16 (with some exceptions in summer and autumn), indicating potential P-limitation of phytoplankton growth, whereas they were lower than 16 in the open Baltic Proper, indicating potential N-limitation. In the Gulf of Riga, a decrease in N:P ratios was noticed in the course of our investigations.

The highest chlorophyll *a* concentrations were found in the inner parts of the Pomeranian Bay (5-years-mean = 9.4 mg m^{-3}) and the Gulf of Gdańsk (5-years-mean = 11.2 mg m^{-3}). The mean chlorophyll *a* concentrations in central regions of the Baltic Proper were 2.4 – 2.6 mg m^{-3}.

Water transparency (Secchi depth) was inversely related to chlorophyll *a*. Secchi depth rarely exceeded 4 m in the plumes but was 5-15 m (annual means 8-10 m) in the open sea.

Primary production was in general higher in the plumes than in the open waters. Exceptions were found in very turbid plumes, where *in situ* primary production was sometimes lower than in the open waters because of light limitation.

Big differences in species composition exist between coastal and open waters, mainly due to salinity differences. Most of the dinoflagellates are marine species, whereas Chlorophyceae may serve as indicators for fresh-water influence.

Special attention was paid to the spring blooms - an important feature in temperate seas. The earliest spring blooms, mainly composed of diatoms, developed in coastal areas and the western Baltic Sea in February to April. In the Eastern Gotland Sea, the spring blooms (mainly dinoflagellates) grew only in April or May. The spring bloom starts after the stabilisation of the water column. This stabilisation, mainly due to thermal stratification, takes much more time in the deeper central regions than in shallow waters (temperature hypothesis). The different timing and species composition of the spring blooms can also be explained by the alternative "seeding hypothesis": Due to isolation of the deep water by the permanent halocline, a passive upwards transport of diatom cysts may only occur in shallow coastal areas. The central areas of the Baltic Sea have to be seeded by advective currents. Due to long distances to the central basins of the Baltic Sea, diatom blooms develop late or fail completely here. Dinoflagellates benefit from the loss of diatoms. In the 1990s, a long-term tendency of replacement of diatoms by dinoflagellates became obvious in the central Baltic Proper. Also this phenomenon can be explained by the temperature and seeding hypotheses.

On the basis of the phytoplankton primary production and biomass data the big plumes of the south-eastern Baltic Sea could be characterised as eutrophic while outer parts of the coastal waters and the open sea are mesotrophic.

1. Introduction

Coastal areas of the Baltic Sea are of special importance for the functioning of the whole marine ecosystem as well as for the human population which uses the resources. These regions are, however, heavily influenced by human activities especially if they are widely separated from the open sea and, additionally, fed by large rivers. The increase in the input of inorganic nutrients leads to higher primary production, which results in higher phytoplankton biomass, higher turbidity in the water and, possibly, changes in species composition and in the food web. This process is termed "eutrophication". According to NIXON (1995), eutrophication is the increase in the rate of supply of organic matter to an ecosystem. The Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) noted that eutrophication was "... one of the major causes of immediate concern in the marine environment" (GESAMP, 1990).

The Baltic Sea, as an intra-continental shelf sea, is especially subjected to eutrophication. To ascertain and to combat the eutrophication process, the riparian countries founded the Baltic Marine Environment Protection Commission (Helsinki Commission, HELCOM), which shelters the Baltic Monitoring Programme (BMP) since 1979. In contrast to the open Baltic Sea, where HELCOM activities resulted in well-published long-term data (e.g. HELCOM 1996), the data of national coastal research are frequently not well disseminated and hardly comparable due to different aims and consequently different strategies and methods. HELCOM (1993 a) tried to compile existing national data of coastal waters, which did, however, not emerge from harmonised monitoring activities.

For a comparison and assessment of the status of different coastal areas of the Baltic Sea, an international co-operation of scientists of all bordering countries, working in a co-ordinated programme with comparable methods, is needed. For this reason, an international research project of the European Community (EC), covered by scientists from Estonia, Germany, Latvia, Lithuania, Poland and Russia, was established. Three joint cruises were conducted in the different coastal waters of the south-eastern Baltic Sea from 1993 to 1996. To improve the limited data basis gathered from these three cruises, additional national data were collected. All accessible data of national monitoring or research programmes from different coastal areas in the south-eastern Baltic Sea were compiled. For instance, data from German and Polish projects in the Pomeranian Bay are included. These data are compared with those from the open Baltic Proper, gathered from the Baltic Monitoring Programme (BMP) of HELCOM.

HELCOM recognised the special importance of the coastal waters and has conducted the Coastal Monitoring Programme (CMP) for long-term trend monitoring of eutrophication or de-eutrophication phenomena since 1998. To increase the value of such time-series, older data should be involved, especially if the methods are comparable. One of our goals was to make the existing older data accessible to potential users. We concentrated on data from the years 1993 to 1997, i.e. data series preceding the newly established Coastal Monitoring Programme directly, without any interruption.

First evaluations of the combined data sets adduced interesting findings on the state of eutrophication in these presumably polluted coastal waters, namely the Pomeranian Bay, the Gulf of Gdańsk, the Lithuanian/Latvian west coast and the Gulf of Riga. Within each of these coastal waters, obviously fresh-water influenced stations were treated separately from stations of more marine characteristics. Differences between these different coastal waters are discussed also in comparison to the open sea.

2. Characterisation of the investigation area

The Baltic Sea is the world's largest brackish sea area, with a total surface, including the Kattegat, of 412,500 km^2. It is sub-divided into a number of different regions. In the open Baltic Proper (211,000 km^2) three regions were investigated (Figure 1): **Arkona Sea** (18,700 km^2; Stations BMP K4, BMP K5, BMP K7, all about 47 m depth), **Bornholm Sea** (39,000 km^2; Stations BY4, BMP K2, BY7, all about 92 m depth), and the **Eastern Gotland Sea** (Stations BMP K1, 90 m depth; BY9, 124 m depth; Stat. 260, 148 m depth; BMP J1, 249 m depth). The Darss Sill (sill depth 18 m) is the topographical and oceanographic borderline between the Baltic Proper and the Mecklenburg Bight, which belongs to the Belt Sea (western Baltic Sea). As the Baltic Sea is connected with the fully marine North Sea only by shallow and narrow straits in the west, the salinity of surface water decreases to the east and north. Tides do not occur.

The open Baltic Proper is permanently stratified. A pycnocline separates the low saline surface water (6 - 8 PSU) from the higher saline deep water (9 - 20 PSU) and excludes the deep water from vertical mixing. The depth of the pycnocline varies in general between 15 and 25 m in the Mecklenburg Bight, between 30 and 40 m in the Arkona Sea, between 50 and 60 m in the Bornholm Sea and between 60 and 80 m in the Gotland Sea. When the surface water warms in spring, a thermocline develops in 10 - 30 m depth and remains until autumn (for more details see Chapter 5.3.1).

The river Oder crosses Szczecin Lagoon before it pours forth its 18 km^3 water per year into the **Pomeranian Bay** (6000 km^2; MAJEWSKI, 1974) via three outlets (Swina, Peene Stream, Dziwna). Nutrient loads of river Oder of 62300 to 99400 t total nitrogen and 4900 to 7100 t total phosphorus (1993-1997) enter annually Szczecin Lagoon (CYBERSKA et al., 1998). The role of the Szczecin Lagoon in the transformation of nutrients has been assessed by GRELOWSKI et al. (in print). Westerly winds promote transport from the Pomeranian Bay into the Gulf of Gdańsk, but easterly winds lead to a transport into the Arkona Sea (SIEGEL et al., 1999). As the salinity of the central Arkona Sea (and mostly of the Bornholm Sea as well) does not fall below 7.3 PSU, a lower salinity in this region (as frequently found in the Pomeranian Bay) is indicating fresh-water influence. In the Swina, which is the main outlet, current velocity could reach 1 m s^{-1}, in stormy periods even 1.3 to 1.75 m s^{-1} (MAJEWSKI, 1974). The Pomeranian Bay is very shallow (average depth 14 m), therefore well mixed and not a deposition area.

In contrast, the **Gulf of Gdańsk** (5000 km^2) is permanently stratified by a halocline in about 60-70 m depth. The greatest depth is 109 m at Gdańsk Deep. In the western part, sandy sediments reach down to about 15 m depth and in the eastern part down to about 40 m. Below these isobaths, muddy sediments are deposited. Vistula river transports about 30 km^3 per year directly into the gulf (MAJEWSKI, 1994). The annual load of total nitrogen, discharged by the Vistula river into the Gulf of Gdańsk in 1993-97 ranged from 89000 to 131100 t and that of total phosphorus from 5600 to 7600 t (CYBERSKA et al., 1998). Up to 100 mmol m^{-3} nitrate may be found off the river mouth during discharge maxima in April. The Vistula river plume extends horizontally 9 to 27 km and vertically 5 to 10 m, if the 7 PSU isohaline is taken as the borderline (GRELOWSKI, WOJEWÓDZKI, 1996). Northerly winds concentrate the river plume in the inner gulf, southerly winds enhance outflow. Pockets of lower saline water are stable for some days (MATCIAK, NOWACKI, 1995; PASTUSZAK, 1995; NOWACKI, JAROSZ, 1998).

An additional source of nutrients in the eastern part of the Gulf of Gdańsk is the Vistula Lagoon. It discharges about 3.7 km^3/year (DUBRA, 1994) into the Baltic Sea at its northern end (near Baltisk, Russia). This tributary was not investigated. According to KWIATKOWSKI et al. (1997), 4.43 km^3 of fresh water, containing 16028 t total nitrogen and 2555 t total phosphorus, were discharged into the lagoon in 1994. Presumably the loads transported from this source to the Gulf of Gdańsk are lower due to retention and removal processes taking place in the lagoon.

The **coastal area off Lithuania** is influenced mainly by annual fresh-water input of about 23 km^3 (DUBRA, 1994) via Klaipeda Strait, which connects Curonian Lagoon with the open sea. The lagoon acts, like Szczecin Lagoon, as a pre-purification area for the riverine input (especially the large river Njeman). The mean load from 1985 to 1991 was 47600 t nitrogen and 2300 t phosphorus (DUBRA, 1993). In 1993, 29000 t nitrogen and 1450 t phosphorus reached the sea from Curonian Lagoon (DUBRA, DUBRA, 1994). As the coastal area off Lithuania is not a separated water, no definite area or volume can be given. The criterion we used was the possible extension of the river plume. The salinity of the Eastern Gotland Sea does not fall below 6.8 PSU. The area of lower salinity in the coastal region is, therefore, assumed to be influenced by fresh water. According to DUBRA (1994), the plume extends about 16 to 20 km from the shore during spring floods but only up to 5 km in summer; for about 290 days a year it flows into northerly direction. We noticed an extension of limnetic conditions up to the latitude of 56 °N (cf. Fig. 1). The current velocity of the plume is no more than 0.1 m s^{-1} in 65 % of the cases. The maximum speed can reach 1.0-1.5 m s^{-1} (DUBRA, DUBRA, 1994). The nutrient and phytoplankton situation in Curonian Lagoon was described by OLENINA (1998).

The **Gulf of Riga** (16 330 km^2, mean depth 26 m, HELCOM 1996) is connected to the Baltic Sea by the relatively narrow Irbe Strait in the northwest and the Muhu Sound in the north (BERZINSH, 1995). The gulf could be considered as relatively autonomous subsystem of the Baltic Sea (OJAVEER, ELKEN, 1997). Total fresh-water input is 36.2 km^3, with 2050 t phosphorus and 113200 t total nitrogen per year, of which 58 700 t are dissolved inorganic nitrogen (LAZNIK et al., 1999). The Daugava and Lielupe rivers discharging into the southern part of the gulf contribute approximately 73 % of the freshwater input, containing 68 % of the total phosphorus and 77 % of the total nitrogen load to the gulf. The gulf acts as a deposition area because of a sub-marine sill to the Baltic Sea and strong temperature stratification during summer, especially in its eastern part, whereas the water is mixed to the bottom in winter, as there is no permanent halocline in the gulf. Because of big differences in the total freshwater input to the basin, differences were anticipated in the parameters determined between the northern (Estonian) and southern (Latvian) parts. Therefore these regions were treated separately. In the northern Gulf of Riga we concentrated especially on the very shallow Pärnu Bay (max. depth 8 m) in the north-eastern edge of this region which receives relatively small input from rivers (2 km^3 annually on average).

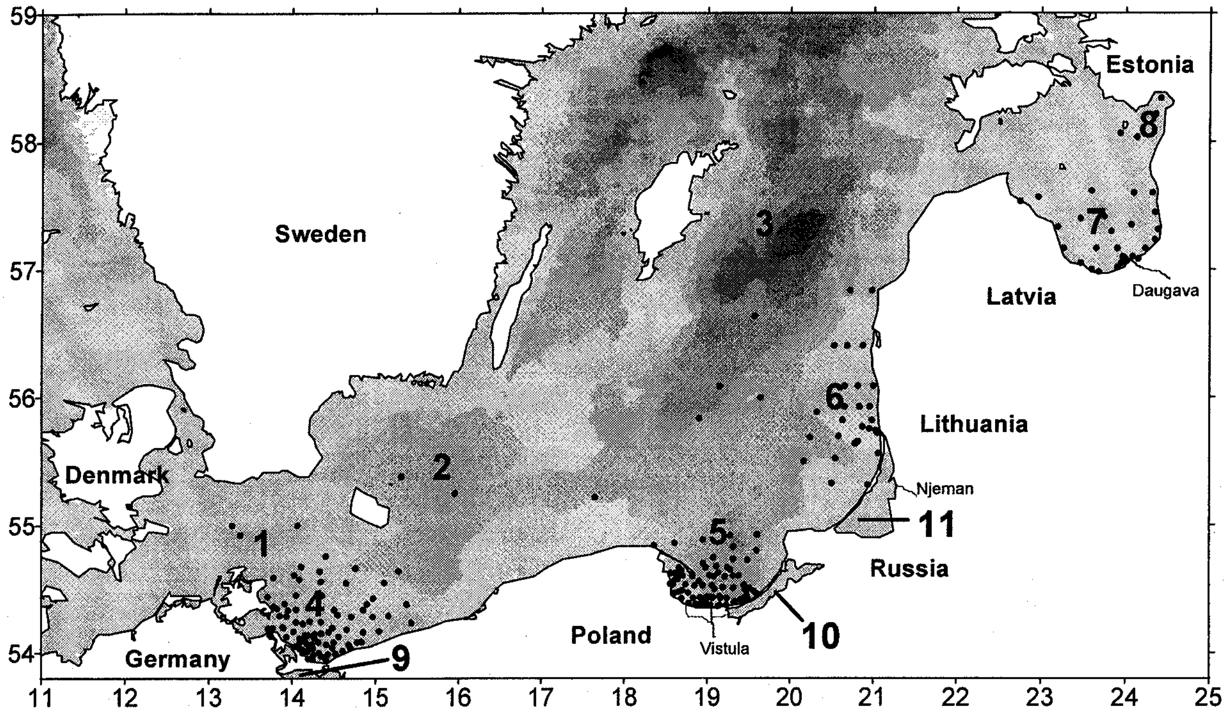

Fig. 1
Investigation area and sampling grid.
Basins of the Baltic Proper: 1 = Arkona Sea, 2 = Bornholm Sea, 3 = Eastern Gotland Sea.
Coastal areas: 4 = Pomeranian Bay, 5 = Gulf of Gdańsk, 6 = Lithuanian coast, 7 = southern Gulf of Riga, 8 = north-eastern Gulf of Riga. Lagoons: Szczecin Lagoon, Vistula Lagoon, Curonian Lagoon.

3. The investigation programme

Three cruises (July 1993, September 1995, April 1996) were carried out within the frame of the EC-project "Impact of Eutrophication on Trophic Relationships in Different Coastal Areas of the South-East Baltic" onboard r/v “Alexander v. Humboldt“, covering the Pomeranian Bay (Germany, Poland), the Gulf of Gdańsk (Poland), the Lithuanian coast and the Gulf of Riga (Latvia, Estonia). The Gulf of Riga could not be sampled in April 1996 because of the ice-cover after an exceptionally strong winter.

Most of the stations were situated relatively close to the shore and potentially within the sphere of riverine (plume) impact. For reference, at least one station per area was chosen outside that sphere (at least 50 km away from the river mouth. The relation of potential plume (coastal) stations and open sea ("marine") stations was approximately 6 : 1. The station grids were mostly adapted to those of the national monitoring programmes.

Measuring campaigns with up to three ships (r/v “Alexander v. Humboldt“, r/v “Professor Albrecht Penck“, r/v “Baltica“) were carried out in the frame of German and Polish projects in the Pomeranian Bay.

The national monitoring programmes were conducted by different countries in their coastal waters as well as in the open Baltic Proper at least once per ice-free season. This enabled us to calculate seasonal means. The seasons were defined according to HELCOM (1996); see chapter 5.

Table 1: Number of cruises in the different regions, separated for countries. The three international cruises mentioned above are not included in this table, as they covered all regions.

Year	Baltic Proper				Pomeranian Bay		Gulf of Gdansk	
	Int. EC-project BASYS	Germany	Poland (southern Baltic Proper)	Estonia (Eastern Gotland Sea)	Germany	Poland	Germany	Poland
1993	-	5	10	1	7	1	2	1
1994	-	10	10	4	6	-	-	3
1995	-	8	11	3	8	-	2	1
1996	1	6	8	1	7	2	1	2
1997	2	6	9	1	6	2	-	1

Year	Lithuanian coast	Southern Gulf of Riga (by Latvia)	North-eastern Gulf of Riga (by Estonia)
1993	4	22	11
1994	4	26	15
1995	4	16	17
1996	4	15	11
1997	4	16	15

The cruises were performed using various ships:

- Germany: A. v. Humboldt, Professor Albrecht Penck;
- Poland: Baltica, Arctowski, Heweliusz, Kopernik, Lubecki, Oceania;
- Lithuania: Vejas
- Latvia: Geofizik, Vejas, Antonija, KA 01, KA 09
- Estonia: Kiir, Koha, Livonia, Marina, Orbiit, Reet, Tripton
- EC-project BASYS, subgroup 2: A. v. Humboldt, Petr Kottzov.

4. Methods

To make use of the different data, they have to be based on comparable methods. We applied all methods according to HELCOM (1988), allowing only insignificant deviations. Only the data from the upper 10 m of the water column were considered (with the exception of shallow Pärnu Bay where the upper 5 m water column was sampled). However, for data of primary production per m^2, the whole euphotic layer was covered. The upper 10 m represent, roughly, the upper mixed layer. This layer comprises the biggest part of the total chlorophyll and almost the complete primary production (cf. OCHOCKI et al., 1995 a, b). If a strong pycnocline was situated in the upper 10 m of the water column, only data from above the pycnocline were used to avoid inclusion of deeper water in our considerations. This was especially necessary in some plumes of a thickness less than 10 m. The vertical salinity gradient between two samples (2.5 m distance) should be at least 0.5 PSU to define the lower border of the plume.

Samples were taken by a rosette sampler from 1, 2.5, 5, 7.5 and 10 m depth. Salinity and temperature measurements were performed at the same time by a CTD probe. Chlorophyll was determined from every sampling depth separately. Only the phytoplankton biomass and species composition was determined from an integrated sample that was produced by mixing equal amounts of water from every depth. Nutrient concentrations (PO_4^{3-}, NO_2^-, NO_3^-, NH_4^+, SiO_4) were determined only from 1 m, 5 m and 10 m depth.

Secchi depth (i.e. the maximal distance of the visibility of a white disk in the water) was determined as a proxy for water turbidity.

The determinations of nutrient concentrations were based on GRASSHOFF et al. (1983) and ROHDE and NEHRING (1979): reactive phosphate by molybdene blue method; ammonium by indophenol blue method; nitrate and nitrite by reaction to azo dye, whereby nitrate first is reduced to nitrite; silicate by the formation of a yellow silicomolybdic acid. For some purposes (e.g. calculation of N:P ratios), the concentration of dissolved inorganic nitrogen (DIN) was calculated as a sum of ammonia, nitrite and nitrate. The N:P ratios were calculated for each sample separately. The averages of N:P ratios presented in this paper are based on these original data and not on calculation from mean nutrient concentrations. They are always given on molar basis.

Chlorophyll *a* was extracted from Whatman GF/F filters by 90 % acetone and the absorbance of the extract measured in a spectrophotometer or fluorometer before and after acidification. Calculation was done according to LORENZEN (1967). The Estonian samples were measured and calculated according to JEFFREY and HUMPHREY (1975). Latvian chlorophyll *a* data is based on extraction from Whatman GF/C filters. Until 1996 90 % acetone and in 1997 96 % ethanol were used as extractants.

Primary production was measured *in situ*. For calculation of primary production in the water column, also samples from 15 and 20 m were included. Incubation time was different. If it lasted for half a day (sunrise to noon or noon to sunset, i.e. 4-8 hours depending on season; normally applied in the Baltic Proper experiments), daily production was calculated by simple multiplication by 2. If shorter incubation periods were used (preferably for 4 hours in the morning or around noon; normally in the Gulf of Gdańsk), parallel daily curves of light intensity were recorded as the basis for calculation of daily production, assuming linear correlation between light and primary production. Incubation was done in 100 cm^3 glass bottles with 74 kBq (= 2 μCi) $NaH^{14}CO_3$. After incubation, the contents of the bottles were filtered onto Whatman GF/F filters. Subsequently, filters were fumed by concentrated hydrochloric acid (HCl) and put into scintillation vials. Measurement of radioactivity was done in the institute by liquid scintillation counting. The dissolved inorganic carbon (DIC), required for the calculation of primary production, was determined on the basis of pH-measurements (for alkalinity), according to GRASSHOFF et al. (1983) Latvian data of primary production were based on oxygen method (cf. p.18).

The phytoplankton was counted in an inverted microscope while assigned to species and size classes. The cell volume was calculated from the size measurements by using the appropriate stereometric formula. It was converted to wet weight assuming that the density of the plasma is equal to that of water (~ 1 mg mm^{-3}).

5. Results and discussion

The basic results of the data compilation are summarized in Tables A1- A14 in the appendix of this paper. As the different stations in the coastal regions are more or less influenced by river water, two groups of stations (inner and outer stations) have been treated separately in separate tables. The inner ("coastal") stations are influenced by fresh-water (river plumes). The outer ("open water") stations are influenced by the open sea, even if situated close to the coast. The criterion for differentiation of the two groups of data was salinity. Salinity lower than 7.3 PSU, 7.0 PSU, 6.8 PSU and 5.0 PSU was an indicator for fresh-water influence in Pomeranian Bay, Gulf of Gdańsk, coastal area off Lithuania and Latvia and the southern part of the Gulf of Riga, respectively.

In the north-eastern Gulf of Riga, the northernmost station which is permanently under direct riverine influence was considered as "coastal".

The seasons were defined according to HELCOM (1996), Fig. 4.4.17:
Winter = January - February
Spring = March - May
Summer = June - September
Autumn = October – December

They were based on the natural phytoplankton succession: The spring season was characterised by the spring bloom, which can occur within the time range from March to May in the waters investigated. The summer blooms (incl. the cyanobacteria bloom) may extend up to the end of September. The autumn bloom (mainly diatoms) occurs in the period from October to December. We kept these distinct blooms apart by calculating "seasonal means" ("seasons" always defined acc. to the definition above). The calculation of mean annual values of phytoplankton composition is less meaningful.

The seasonal mean values for every year of investigation are presented in Tables A1-A13. Some examples of seasonal means (means of 1993 to 1997 for every region) are also shown in Figs. 12-14. In most cases, the data are evenly distributed over the year so that all periods are covered to more or less the same extent (cf. Figs. 2-11). If special measuring campaigns were included, the number of data was exceptionally high. To avoid an over-representation of such intensively sampled periods, monthly means were calculated first. From these monthly means, seasonal means were calculated (e.g. spring means from means of March, April and May). Therefore all months are represented to the same extent in the season's data. Also the number of samplings, the seasonal means are based on, is indicated in Tables A1-A13. One sampling includes several samples from different depths on one sampling occasion. Seasonal means for the Gulf of Riga dataset were calculated as time-weighted averages. First, samples were spatially aggregated into daily means, then each daily mean was weighted with the time interval between the previous and the following measurement.

As the specific regional patterns especially of nutrient and biomass data (Figs. 12-14) are reflected in all seasons, the calculation of an annual mean is useful. In Table A14, means of the entire 5 years (1993-1997) were calculated for every season. From these seasonal means, annual mean values were calculated. These representative annual data are presented in Figs. 15-17. As they are based on seasonal means (and seasonal means on monthly means), their data basis is homogenous. To present also an indicator of variability, confidence limits for $p = 0.05$ were calculated from the annual means of each year (1993-1997, therefore $n=5$).

The calculation of standard deviation of the total data basis or of the seasonal original data was not useful because every season covered a bloom, starting with very low biomass and peaking in extreme maxima. High standard deviation of biological parameters in the course of a bloom is, therefore, natural. To present an estimate of variability of the original data, box-an-whisker plots are shown for some parameters and some regions in Figures A1- A6 in the Annex. The plot divides the data into four areas of equal frequency. The box encloses the middle 50 percent. The median is indicated by the horizontal line in the box. If the median is not centered in the box, this is an indication of skewness. The "whiskers" are lines extending above and below the box. They show the extent of the rest of the sample (unless they are outliers). An outlier is a value that is more than 1.5 times the interquartile range away from the top or bottom of the box.

It has to be admitted that some data (especially those from the Lithuanian coast) are based on only one cruise per season. Therefore they do not reflect the high variability in weather conditions, river outflow and, consequently, the hydrological, chemical and biological components.

Winter data from the Pärnu Bay and partly from the southern Gulf of Riga are lacking due to ice coverage.

5.1 Seasonal course

This chapter may serve as a background for the interpretation of the data basis. In Figures 2-11, the sampling patterns in the different years are shown. Each data point is the mean of samples taken at more or less the same time in this region. If more than three days were between the samplings, they were shown as separate data points.

From the results in different years, a general picture of the seasonal development of phytoplankton in the Baltic Sea can be drawn. Similarly to other waters of the boreal region, it looks as follows:

The maximum nutrient concentrations but the lowest biomass are found in winter (January/February; in the Eastern Gotland Sea the winter situation is conserved until beginning of April). The warming-up of the water in spring leads to thermal stratification, i.e. a stabilisation of the water column. With the earliest onset of this stabilisation, the phytoplankton becomes trapped in the upper water layer, where light conditions are optimal for growth (WASMUND et al., 1998). These conditions (i.e. mixed depth < euphotic depth) appear in the shallow western Baltic Sea (Belt Sea) already in March but in the deep basins of the Baltic Proper only in April or May (cf. Table 1 in Chapter 5.3.1). The early spring blooms in the western Baltic Sea are mainly composed of diatoms (Bacillariophyceae). The late spring blooms in the Eastern Gotland Sea are made from dinoflagellates (Dinophyceae). The blooms consume the nutrients in the upper water layer. In the Baltic Proper, the nitrogen is used up first, whereas in the western Baltic Sea frequently the phosphorus disappears earlier than nitrogen. Also in coastal waters, phosphate is the limiting nutrient (cf. Chapter 5.2.1). For this reason, the annual phosphate minimum occurs in coastal waters already in spring but in the open sea only in summer (cf. TRZOSIŃSKA, ŁYSIAK-PASTUSZAK, 1996).

Phosphorus remaining in the water of the Baltic Proper after the spring bloom constitutes the basis for the growth of nitrogen-fixing cyanobacteria that are independent of chemically bound nitrogen. However, they form blooms only if the water temperature exceeds 16 °C (WASMUND, 1997). The summer blooms are less pronounced than the spring blooms. The peaks are found in July (Figs. 3 a and 4 a) or August (Figs. 2 a and 5 a). The relatively low biomass especially in the open waters in summer, as shown in Tables A1 to A13, for most years, is caused by stronger nutrient limitation. Despite the relatively low phytoplankton biomass, the primary production was high in summer, perhaps due to quick nutrient recycling. SAHLSTEN and SÖRENSSON (1989) demonstrated that the primary production is based to a great extent on regenerated forms of nitrogen, and that ammonia and urea play a key role in that process. Cyanobacteria accounted for 15-58 % of total phytoplankton wet weight in summer in the different years in the Baltic Proper (Table A1- A3). In the gulfs and bays, the percentage of cyanobacteria was much more variable, from zero (1993 in Tab. A12) to 96.1 % (1994 in Tab. A11).

Besides the cyanobacteria, also highly diverse flagellates occur in summer. They are principally able to migrate into deeper water layers where nutrients are still available. Some species (e.g. *Dinophysis norvegica*) concentrate at very specific depths. Also picoplankton has its maximum in summer. These very small cells are efficient in uptaking even the traces of nutrients.

When the thermocline disappears due to cooling down of the water in autumn, nutrient-rich deeper water can be transported into the surface layers. This gives rise to an autumn bloom of diatoms (mainly *Coscinodiscus granii* and *Actinocyclus octonarius*) in the Baltic Proper, but dinoflagellates (*Ceratium* spp.) in the western Baltic Sea. The diatom bloom occurs in October (Fig. 6 a+b) or November (Fig. 2 a+b, 3 b and 4 a), cf. also WITEK et al. (1993) and HELCOM (1996). Peak biomass up to about 3 g m^{-3} can be found. The big vacuole of the diatoms is included in these wet weight values, as explained below.

The blooms are more or less represented in the different years and areas (Figs. 2-6). In some cases the blooms were missed because of too low sampling frequency (e.g. Fig. 4 b). The peak of the bloom is rarely met. WASMUND et al. (1998) calculated a mean new production of a spring bloom to be 415, 374 and 322 mg C m^{-3} in the Arkona Sea, Bornholm Sea and southern Gotland Sea, respectively. This calculation was based on the decrease of nitrogen in the water during the bloom (1981-1993). These production data correspond to protoplasm wet weight of 3776, 3403 and 2930 mg m^{-3}, respectively. The biomass especially of diatoms is, however, much higher than the protoplasm weight due to the big vacuole, containing little carbon but belonging to biomass. Therefore, the extremely high value on 5 April 1993 (Fig. 2 a) may reflect the real peak of the bloom (dominated by *Chaetoceros* cf. *debilis*). Because of the big vacuole in diatoms, there is a discrepancy between wet weight and chlorophyll content. In the Eastern Gotland Sea, the spring blooms are dominated by dinoflagellates that contain no vacuole. Therefore, carbon content, wet weight and chlorophyll content are more closely related than in diatoms. The biomass maxima measured in 1993 (Fig. 2 c) and 1996 (Fig. 5 c) may be the realistic peaks of the blooms. The timing of the spring bloom is different from year to year. For example in the Arkona Sea, it occurred only in April in 1994 (Fig. 3 a) but already at the beginning of March in 1997 (Fig. 6 a).

In the diagrams of the Pomeranian Bay and the Gulf of Gdańsk (Figs. 7-11), phytoplankton biomass and primary production are omitted because of too few data (these data can be looked up in Tables A4-A7). Nutrients are shown instead. As mentioned above, the decrease in nutrient concentrations is an indication of phytoplankton growth. Therefore we conclude that the spring bloom starts in February or March in the coastal waters. The relationship between decline in nutrients and increase in chlorophyll *a* concentration can be seen from Figs. 7 d and 10 d.

Data on seasonal changes in phytoplankton composition in the Gulf of Gdańsk are presented by WITEK et al. (1993) for the year 1987, by BRALEWSKA (1992) for the years 1987 and 1988 and by PLIŃSKI (1995) for the years 1992 and 1993. In spring they found a diatom bloom, followed by a dinoflagellate bloom, in summer high biomass of cyanobacteria and small flagellates and in autumn a diatom bloom.

Yurkovskis et al. (1999) describe a similar pattern in the Gulf of Riga where the vernal phytoplankton bloom typically starts in the end of March – beginning of April. First arctic-boreal diatoms dominate the phytoplankton community, then – in a second phase – the proportion of autotrophic dinoflagellates increases. In summer cyanobacteria and small green algae, diatoms and dinoflagellates occur, with possible cyanobacteria blooms in July/August. After the thermocline weakens at the end of September, diatoms develop.

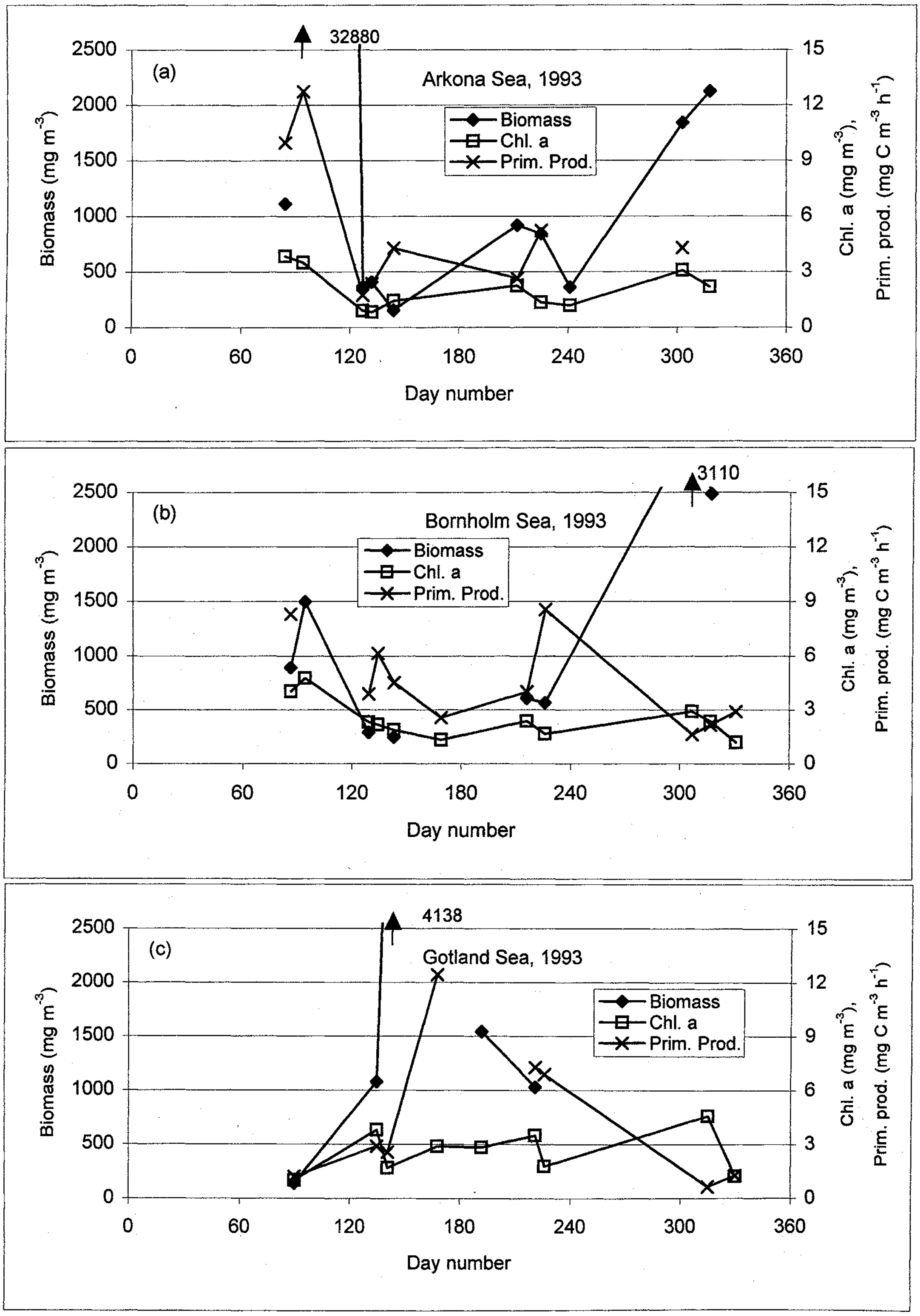

Fig. 2:
Seasonal cycle of phytoplankton biomass (wet weight), chlorophyll *a* and primary production (*in situ*) in (a) Arkona Sea, (b) Bornholm Sea and (c) Gotland Sea in 1993 (0-10 m depth).

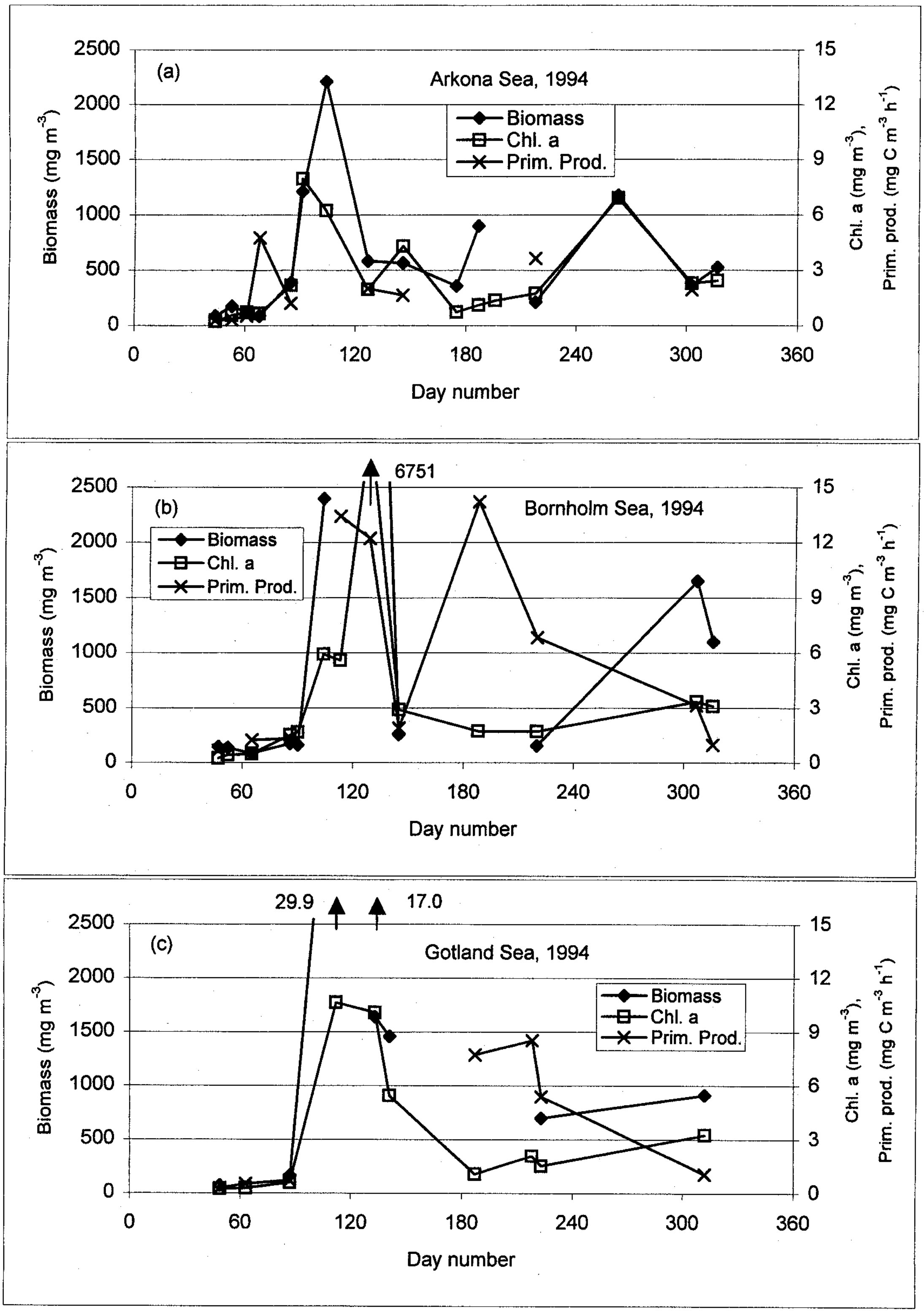

Fig. 3:
Seasonal cycle of phytoplankton biomass (wet weight), chlorophyll *a* and primary production (*in situ*) in (a) Arkona Sea, (b) Bornholm Sea and (c) Gotland Sea in 1994 (0-10 m depth).

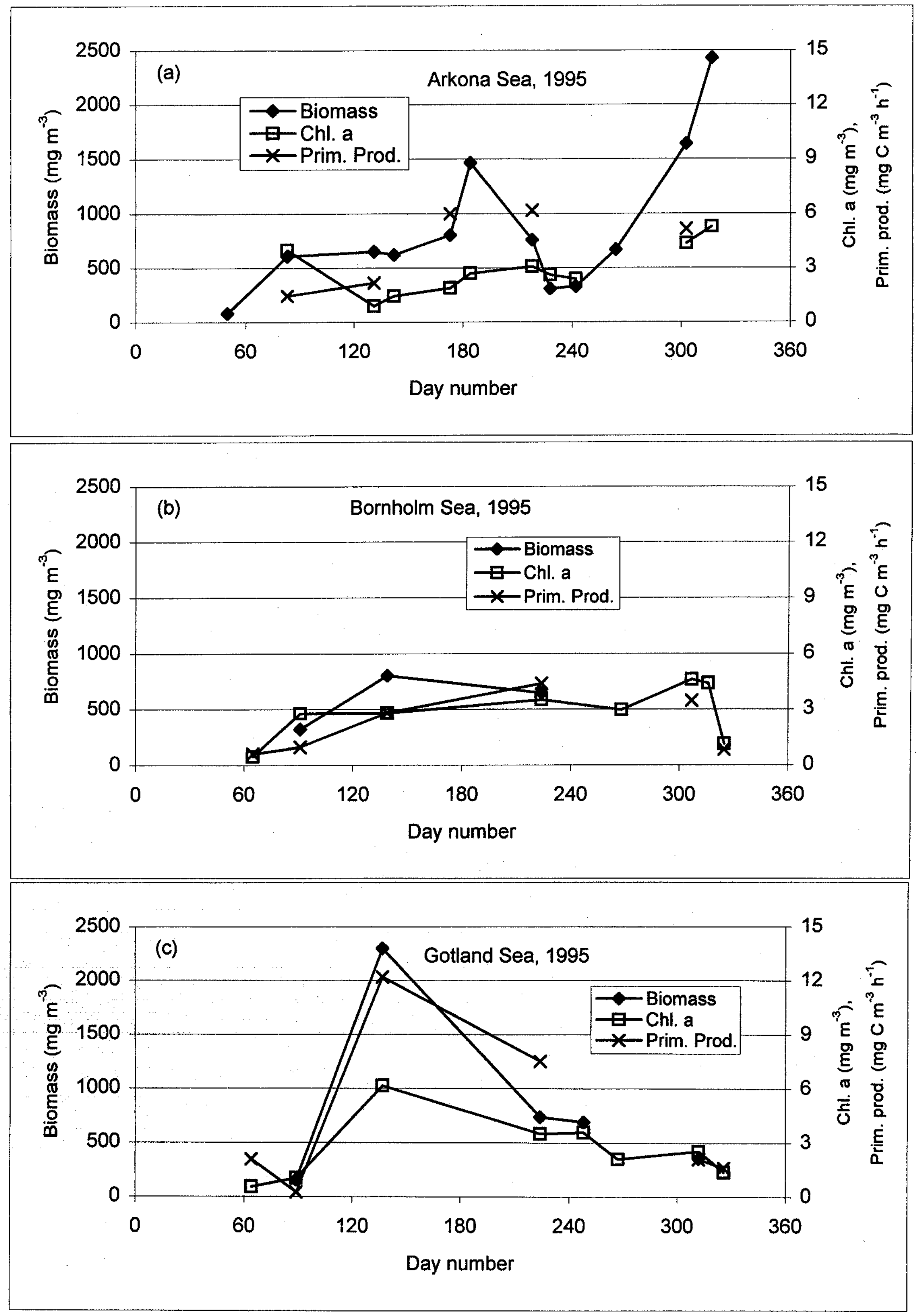

Fig. 4:
Seasonal cycle of phytoplankton biomass (wet weight), chlorophyll *a* and primary production (*in situ*) in (a) Arkona Sea, (b) Bornholm Sea and (c) Gotland Sea in 1995 (0-10 m depth).

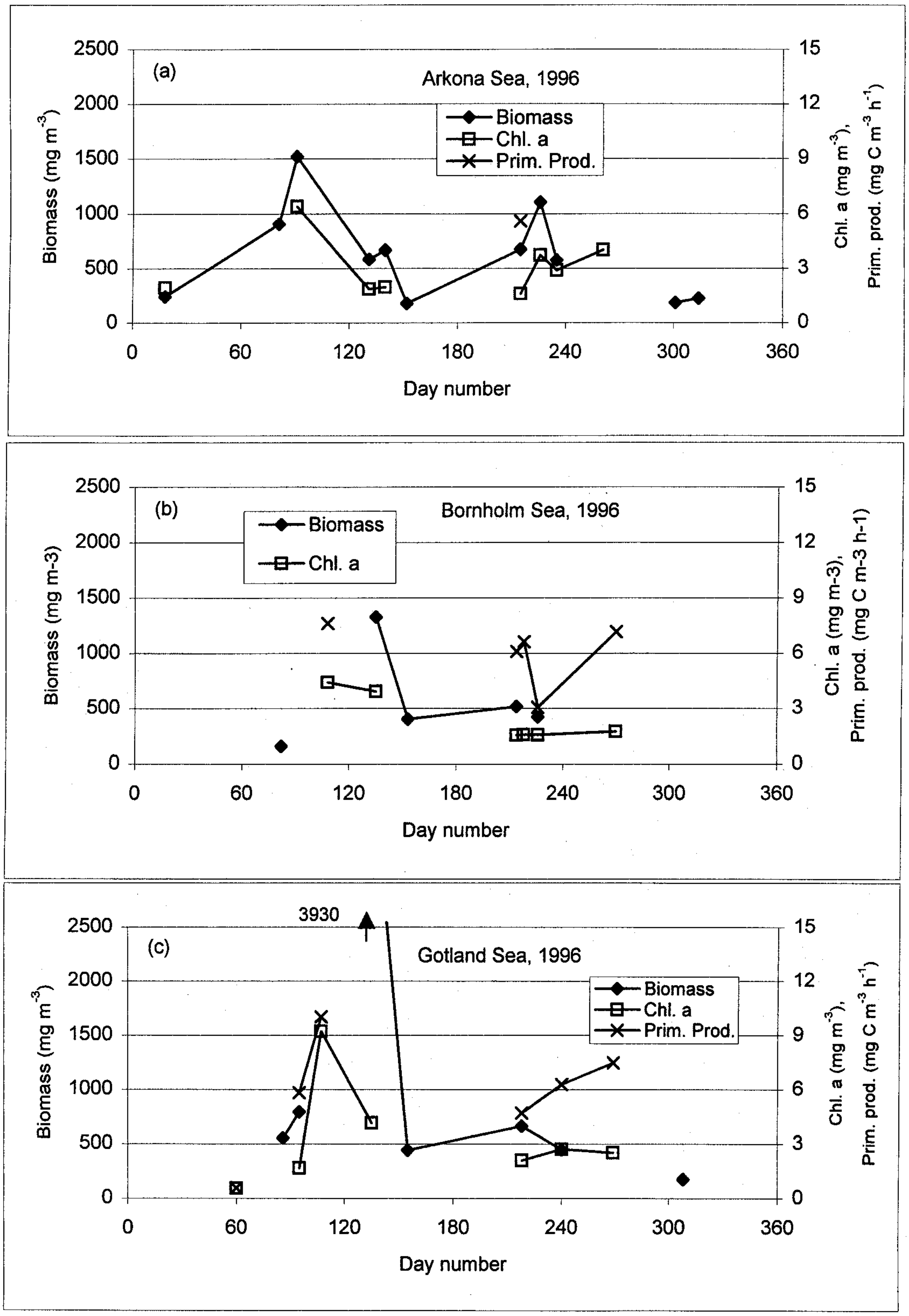

Fig. 5:
Seasonal cycle of phytoplankton biomass (wet weight), chlorophyll *a* and primary production (*in situ*) in (a) Arkona Sea, (b) Bornholm Sea and (c) Gotland Sea in 1996 (0-10 m depth).

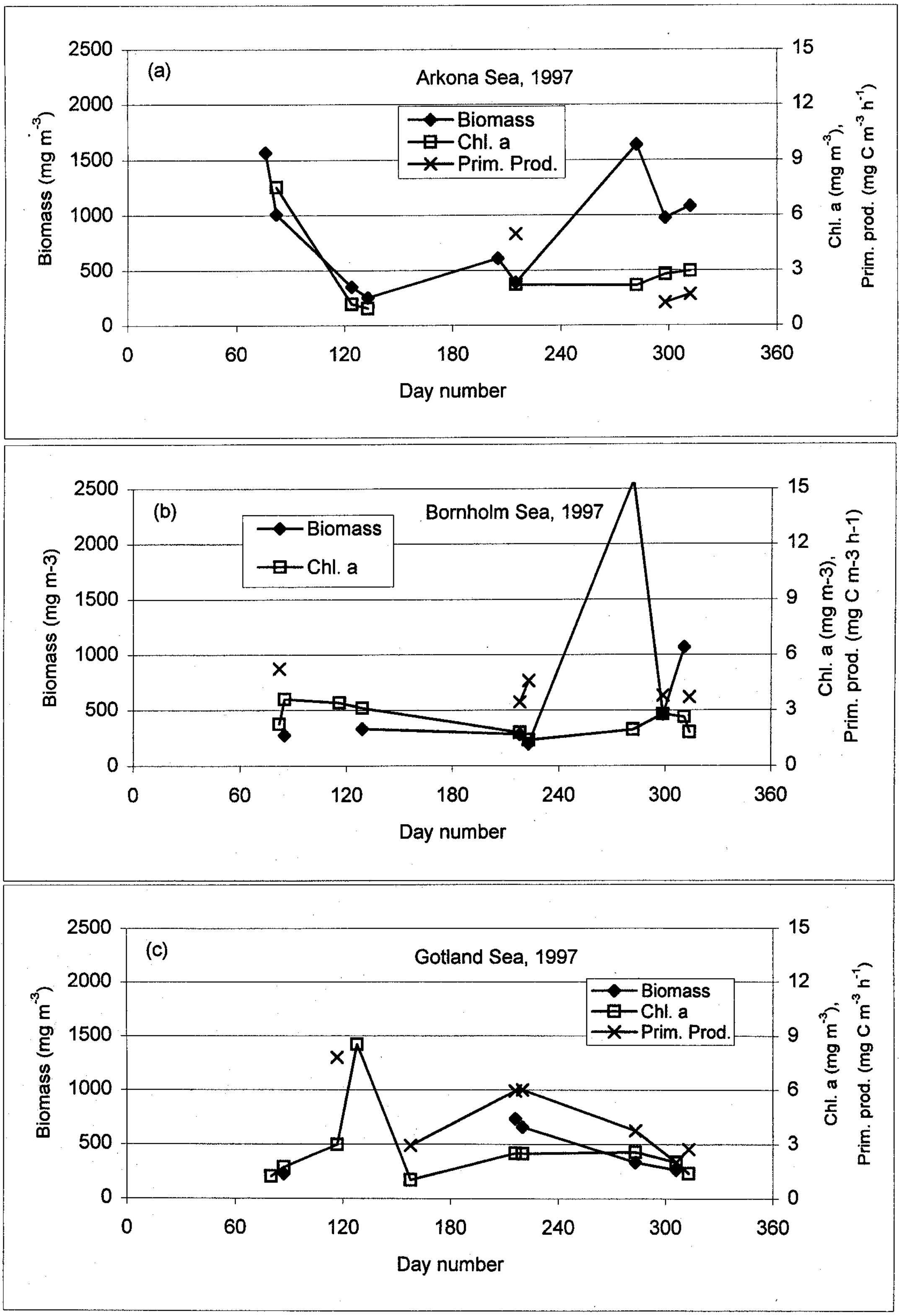

Fig. 6:
Seasonal cycle of phytoplankton biomass (wet weight), chlorophyll *a* and primary production (*in situ*) in (a) Arkona Sea, (b) Bornholm Sea and (c) Gotland Sea in 1997 (0-10 m depth).

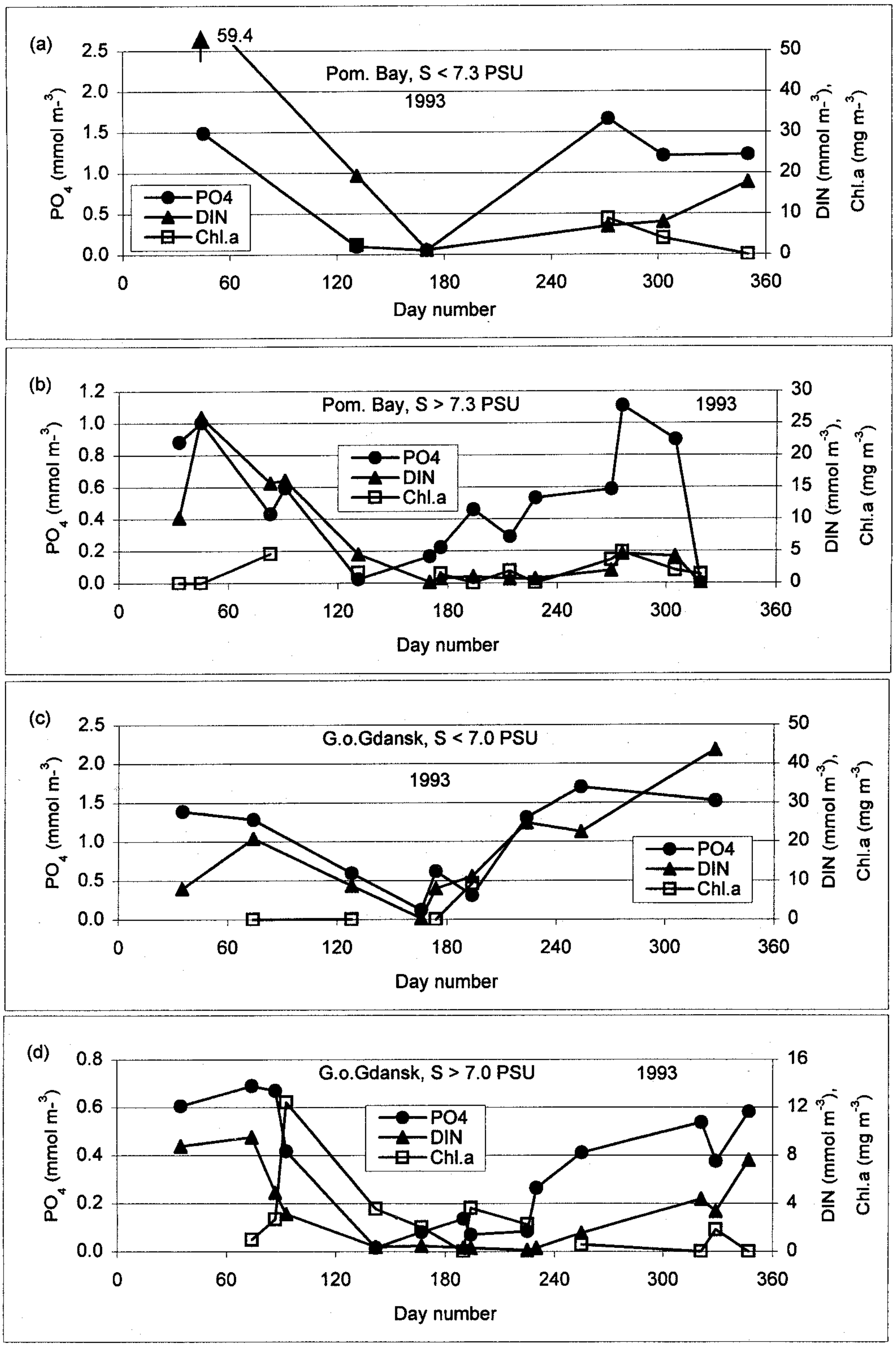

Fig. 7:

Seasonal cycle of phosphate, dissolved inorganic nitrogen (DIN) and chlorophyll *a* concentrations in (a) Pomeranian Bay (coastal), (b) Pomeranian Bay (marine), (c) Gulf of Gdańsk (coastal) and (d) Gulf of Gdańsk (marine) in 1993 (0-10 m depth).

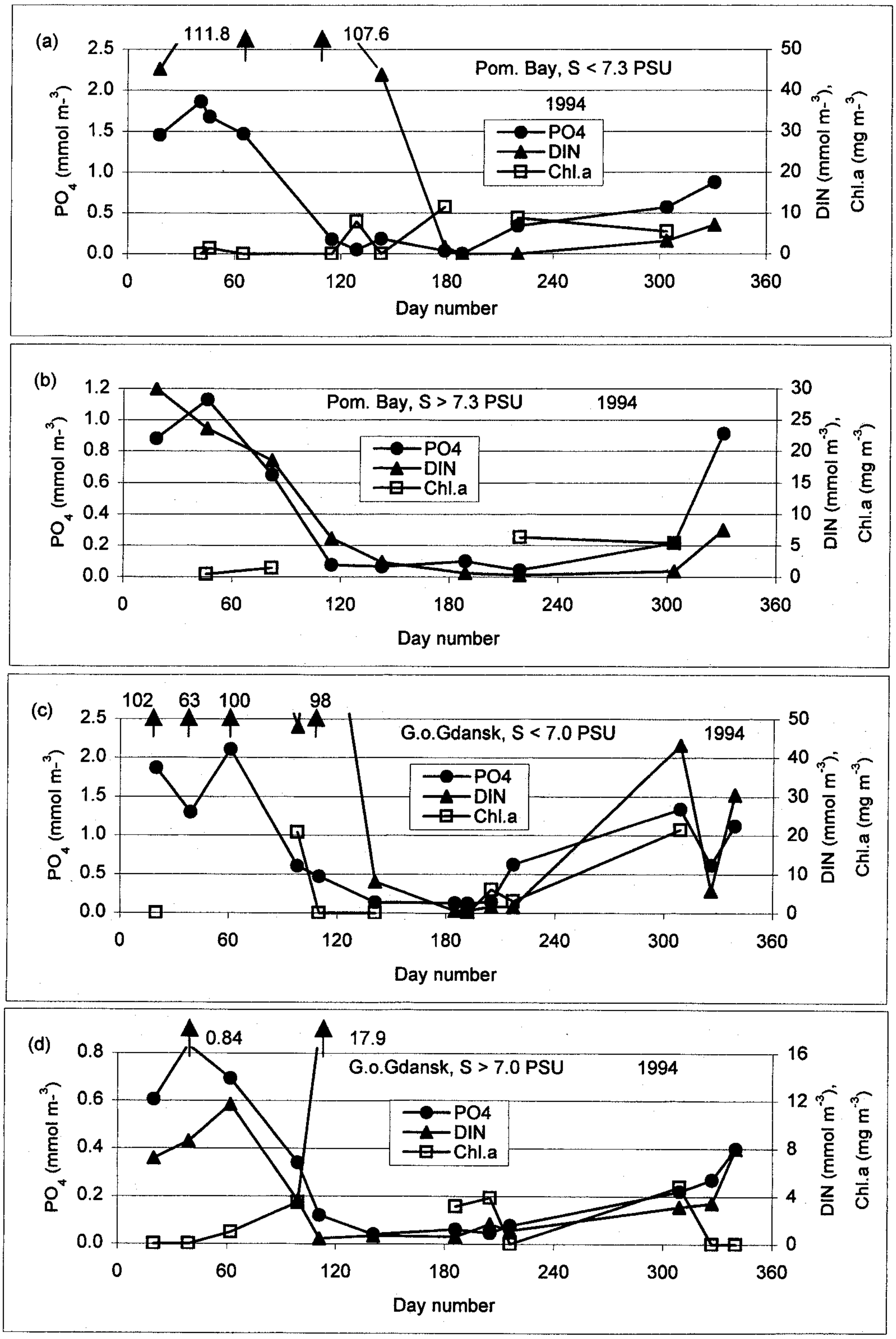

Fig. 8:
Seasonal cycle of phosphate, dissolved inorganic nitrogen (DIN) and chlorophyll *a* concentrations in (a) Pomeranian Bay (coastal), (b) Pomeranian Bay (marine), (c) Gulf of Gdańsk (coastal) and (d) Gulf of Gdańsk (marine) in 1994 (0-10 m depth).

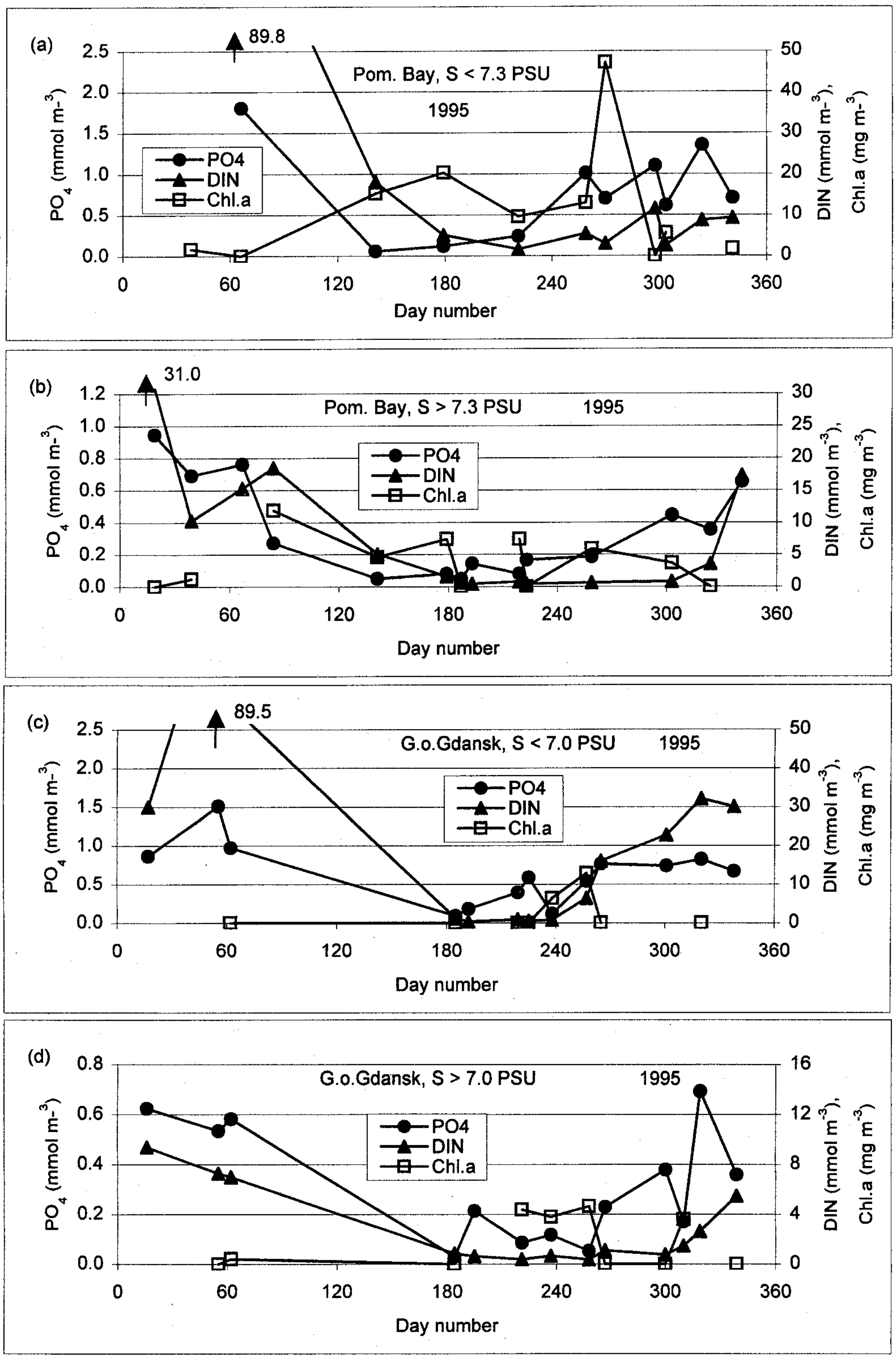

Fig. 9:
Seasonal cycle of phosphate, dissolved inorganic nitrogen (DIN) and chlorophyll *a* concentrations in (a) Pomeranian Bay (coastal), (b) Pomeranian Bay (marine), (c) Gulf of Gdańsk (coastal) and (d) Gulf of Gdańsk (marine) in 1995 (0-10 m depth).

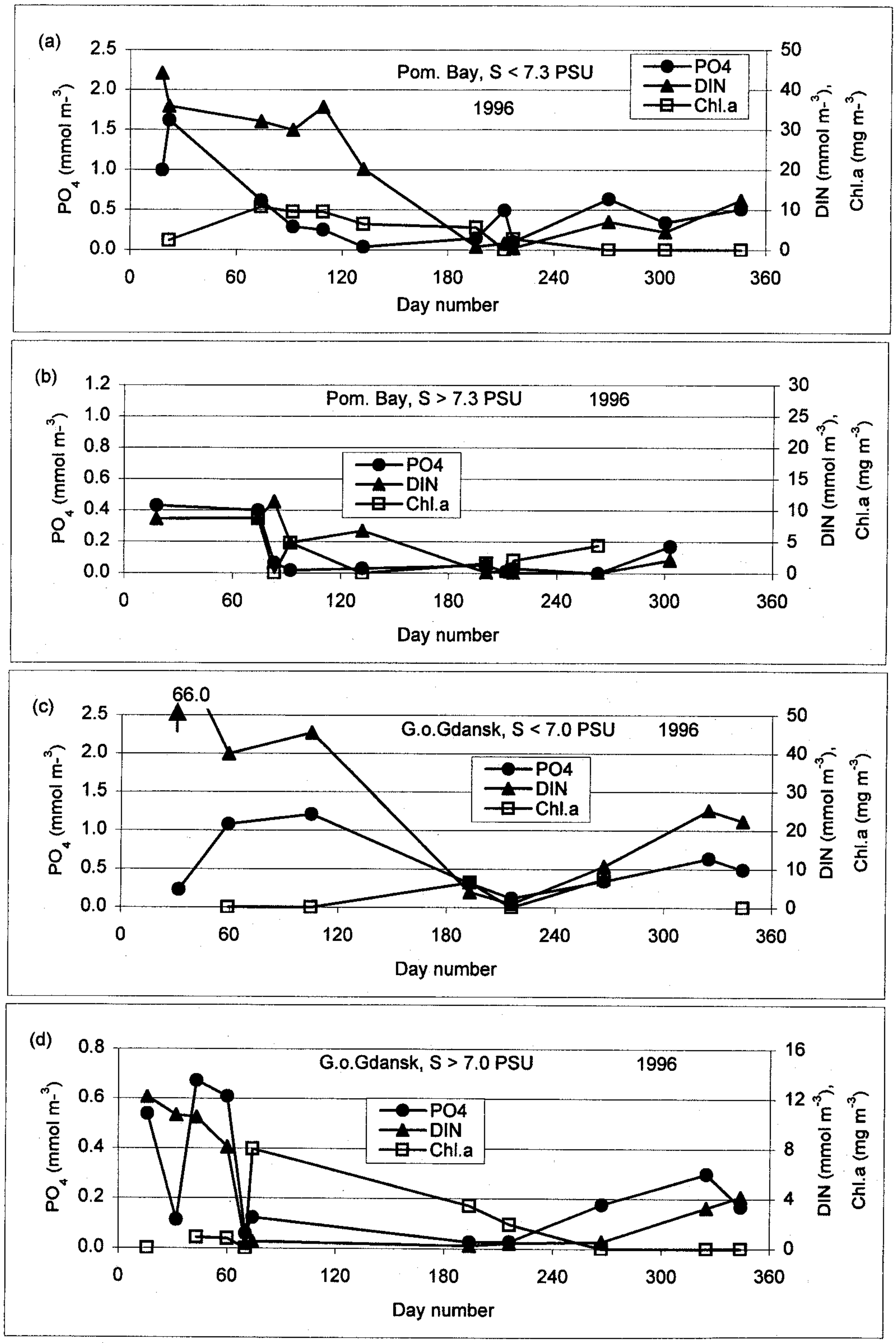

Fig. 10:
Seasonal cycle of phosphate, dissolved inorganic nitrogen (DIN) and chlorophyll *a* concentrations in (a) Pomeranian Bay (coastal), (b) Pomeranian Bay (marine), (c) Gulf of Gdańsk (coastal) and (d) Gulf of Gdańsk (marine) in 1996 (0-10 m depth).

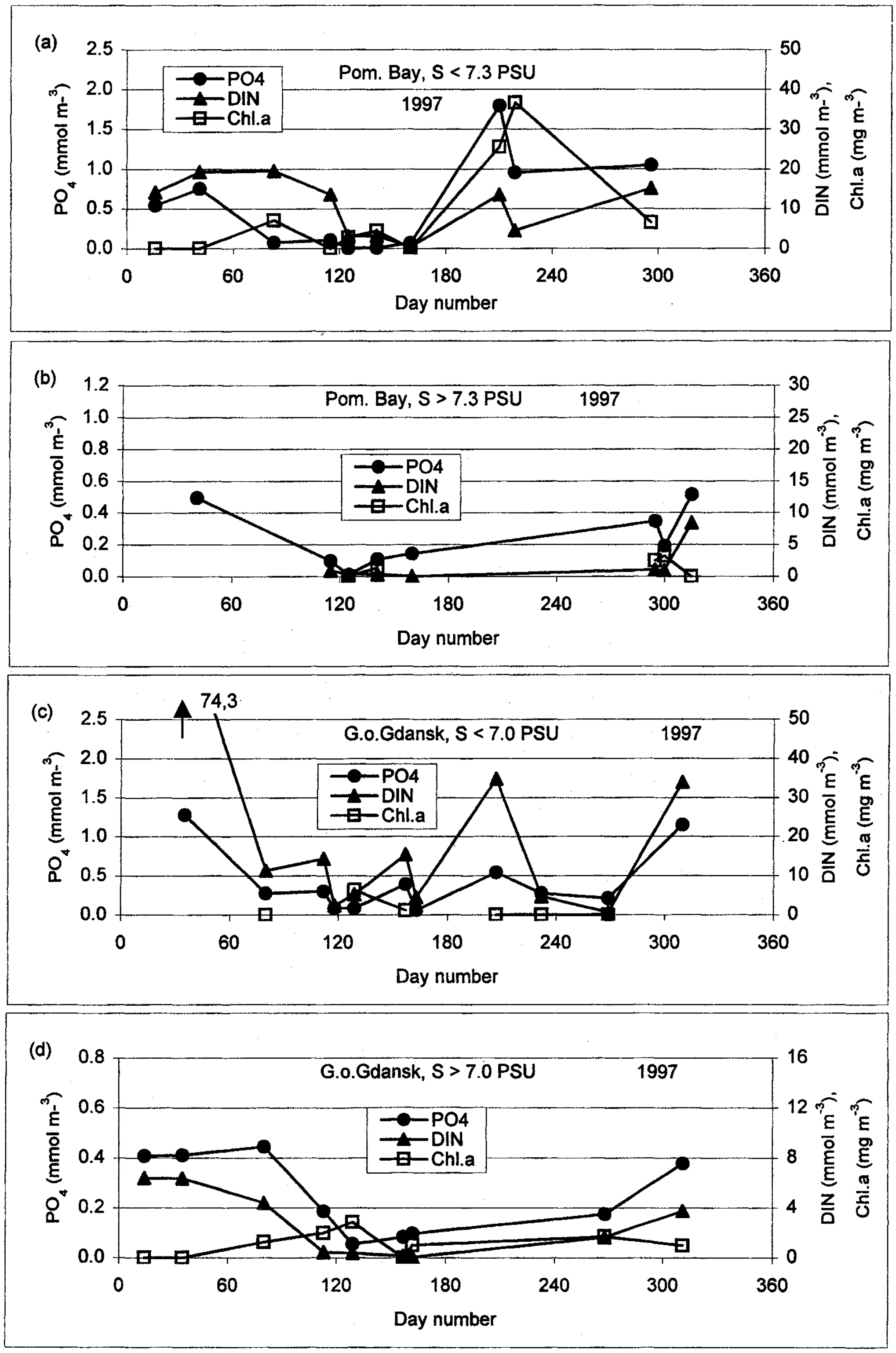

Fig. 11:
Seasonal cycle of phosphate, dissolved inorganic nitrogen (DIN) and chlorophyll *a* concentrations in (a) Pomeranian Bay (coastal), (b) Pomeranian Bay (marine), (c) Gulf of Gdańsk (coastal) and (d) Gulf of Gdańsk (marine) in 1997 (0-10 m depth).

5.2 Regional differences

The decrease in salinity from west to east in the Baltic Sea due to the increasing distance to the North Sea can be seen from Table A14. Of course, salinity increases from coastal waters (e.g. Lithuanian coast) to the open sea (e.g. Eastern Gotland Sea). Especially the plumes of the big rivers can be followed by the distribution patterns of salinity.

The seasonal means of water temperature, given in Tables A1-A11, reflect the typical seasonal pattern. They give also information about the sampling situation. Low spring temperatures, for instance, indicate that the sampling dates were relatively early. An example is the Gulf of Gdańsk in spring 1995 (Tab. A7), where temperature and nutrient concentrations are nearly the same as in winter, reflecting still winter conditions when spring samples were taken (cf. Fig. 9 c+d).

5.2.1 Nutrients

Nutrient concentrations decrease from the coast to the open sea (Figs. 12, 13, 15 a-c). The ratios of nutrient concentrations of coastal waters and the open sea become bigger from winter to summer (cf. Figs. 12 and 13), indicating a relatively low nutrient decrease in the inner coastal water (in comparison with the open sea) due to continuous nutrient input from rivers during the growing season. The confidence intervals of annual means (Fig. 15) in the open Baltic Proper and the plumes do not overlap, indicating that the differences are significant. Nitrogen concentrations are relatively low, but phosphate and silicate concentrations are relatively high in the open sea. Correspondingly, the N:P ratios (DIN:PO_4) decrease from the plume to the sea (Fig. 15 d). In the Gulf of Riga, the differences between inner (coastal) and outer (open) waters are less pronounced. It is remarkable that the silicate concentrations in the open Gulf of Riga are significantly lower than those of the open Baltic Proper.

The phytoplankton incorporates nitrogen and phosphorus in a molar ratio of 16:1 (REDFIELD et al., 1963). If the ratio of N:P supply is lower than 16, the phytoplankton growth is potentially limited by nitrogen; if it is higher than 16, it is potentially limited by phosphorus.

The N:P ratios were always calculated directly from the single original data. From these single N:P ratios, the means shown in Tables A1-A14 and Fig. 15 d were calculated. These directly calculated means of N:P ratios are more realistic but more extreme than those calculated simply from the mean values (e.g. seasonal means) of nitrogen and phosphorus. If phosphorus concentrations are nearly zero (sometimes in summer), the N:P ratios increase strongly. These extreme values are less reliable.

Of course, the N:P ratios change in the course of the year. In the Pomeranian Bay and the inner coastal waters of the Gulf of Gdańsk, the Lithuanian coast and the southern Gulf of Riga, the N:P ratios were higher than 16 at the beginning of the spring bloom (cf. Table A4-A14), indicating potential phosphorus limitation of algal growth. From winter to spring, the N:P ratio increased in these waters because of stronger consumption of the limiting phosphorus. The N:P ratios decreased, however, in summer, but normally not below 16. In the open waters of the southern Gulf of Riga the winter N:P ratio exceeded 16 only in 1993. P limitation during the spring bloom has been suggested to occur in the nitrogen rich coastal waters affected by the river Daugava spring runoff (Maestrini et al., 1997, Tamminen and Seppälä, 1999) whereas the open waters of the Gulf are today mainly nitrogen limited (Maestrini et al., 1997, Tamminen and Seppälä, 1999, Seppälä et al., 1999). The transition from the formerly P-limited basin (Yurkovskis et al., 1993) to a chiefly N-limited system was noted during the beginning of the 1990ies, when simultaneous shortages of N, P and Si at the end of the spring bloom were observed (HELCOM; 1996). This tendency is also reflected by our data from the north-eastern Gulf of Riga (Table A12-A13).

In the Baltic Proper, the N:P ratios are smaller than 16 at the beginning of the spring bloom (indicating potential nitrogen limitation, cf. GRANÉLI et al., 1990) and phosphorus is taken up in excess (cf. WASMUND et al., 1998). The N:P ratios increase in most of the years slightly during summer, but there is still an indication of nitrogen limitation. This may be a reason that nitrogen-fixing cyanobacteria blooms develop primarily in the open sea and not in the coastal areas. N-limitation is also found in the Gulf of Gdańsk after the spring bloom and during summer (cf. WITEK et al., 1993). It has to be stressed, however, that the inner coastal waters, influenced by fresh water inflow, are completely different from the open waters concerning nutrient concentrations and composition.

The mean values of the 5-years period (Fig. 15) show only slight differences between Pomeranian Bay and the Gulf of Gdańsk. In general, the Gulf of Gdańsk is more affected by the river than the Pomeranian Bay where the Szczecin Lagoon plays a role of a filter. Our nutrient data from the Pomeranian Bay and the Gulf of Gdańsk are in the general range given by FALKOWSKA et al. (1993), PASTUSZAK et al. (1996), TRZOSIŃSKA and ŁYSIAK-PASTUSZAK (1996) and CYBERSKA et al. (1998).

The coastal waters in front of the Lithuanian coast contain much less nutrients than those of the Pomeranian Bay and the Gulf of Gdańsk. But the open waters in front of the Lithuanian coast resemble that of the Gulf of Gdańsk. The N:P ratios are high.

In the Gulf of Riga, the highest nutrient concentrations are found in the plume of the Daugava and the inner Pärnu Bay (= coastal north-eastern Gulf of Riga). The silicate concentrations are lowest in the open Gulf of Riga. At the inner station of the north-eastern Gulf of Riga (= Pärnu Bay), the nitrogen and silicate concentrations are twice that of the open waters. Phosphate concentrations at the coastal station are only slightly higher than that of the open gulf stations.

An increase in phosphate and nitrate concentrations (means of February, 0-40 m depth) was found from 1974 to 1993 in the Gulf of Riga (HELCOM, 1996). However, from 1991 to 1993, there was a strong decrease in nitrate concentrations possibly due to the reduction in the use of fertilizers in agriculture since 1987. Silicate concentrations decreased. In the early 1990's there was a shift from phosphate limitation of the spring bloom to a limitation of both phosphate and nitrogen, sometimes even silicate. Indeed, we found N:P ratios close to the Redfield ratio in the open water of the southern Gulf of Riga (Table A11).

The differences in nutrient concentrations between Arkona Sea, Bornholm Sea and Southern Gotland Sea are not significant.

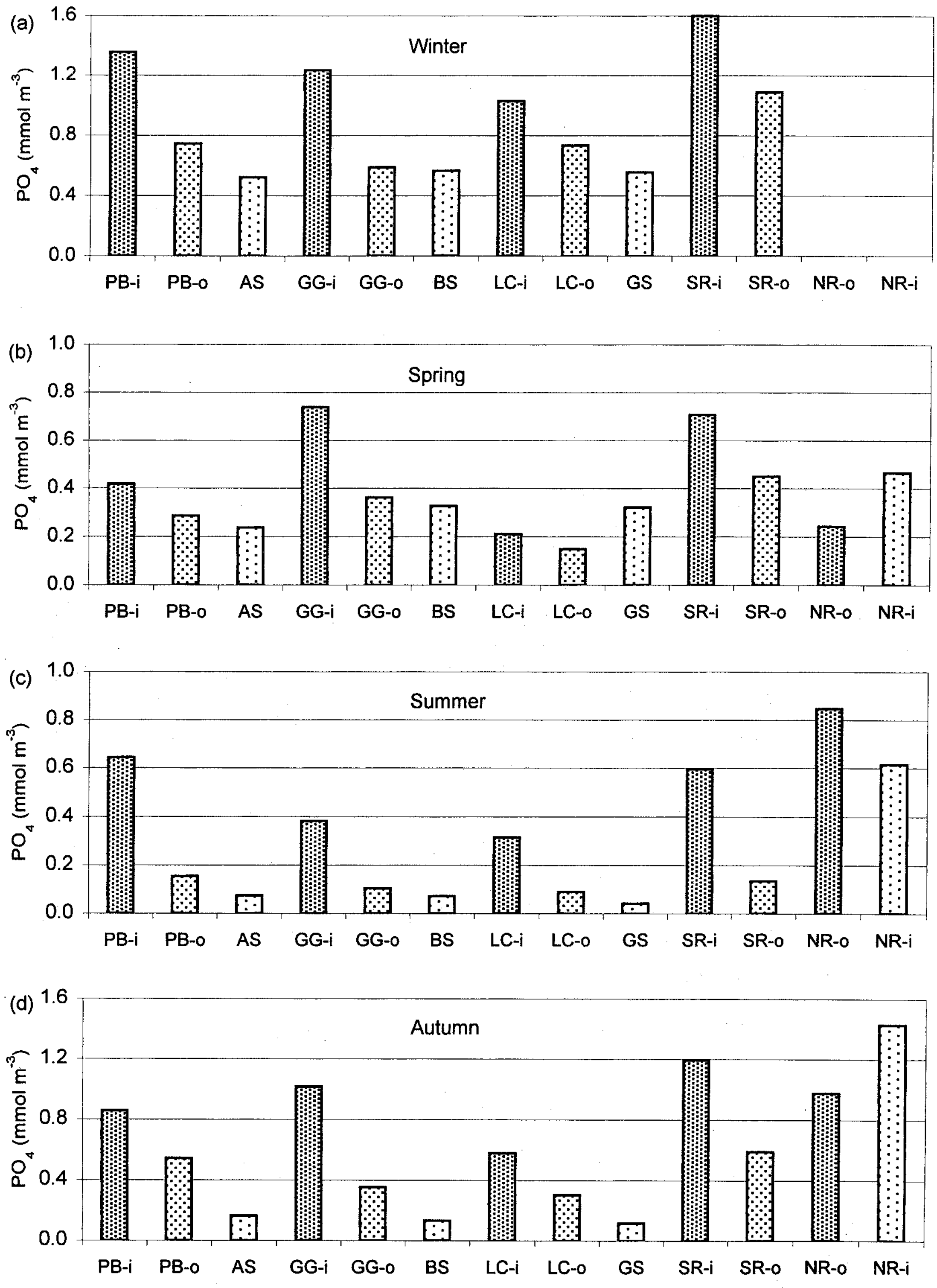

Fig. 12:
Seasonal mean (1993-1997) values of phosphate concentrations in the upper water layer (0-10 m) in different sea areas in (a) winter, (b) spring, (c) summer and (d) autumn. The columns are arranged to short transects from the inner coastal regions (= i, columns densely stippled) via the outer coastal regions (= o) to the open sea (AS = Arkona Sea, BS = Bornholm Sea, GS = Eastern Gotland Sea, columns sparsely stippled). PB = Pomeranian Bay, GG = Gulf of Gdańsk, LC = Lithuanian coast. In the Gulf of Riga, the transect is arranged from the southern part (SR) to the northern part (NR).

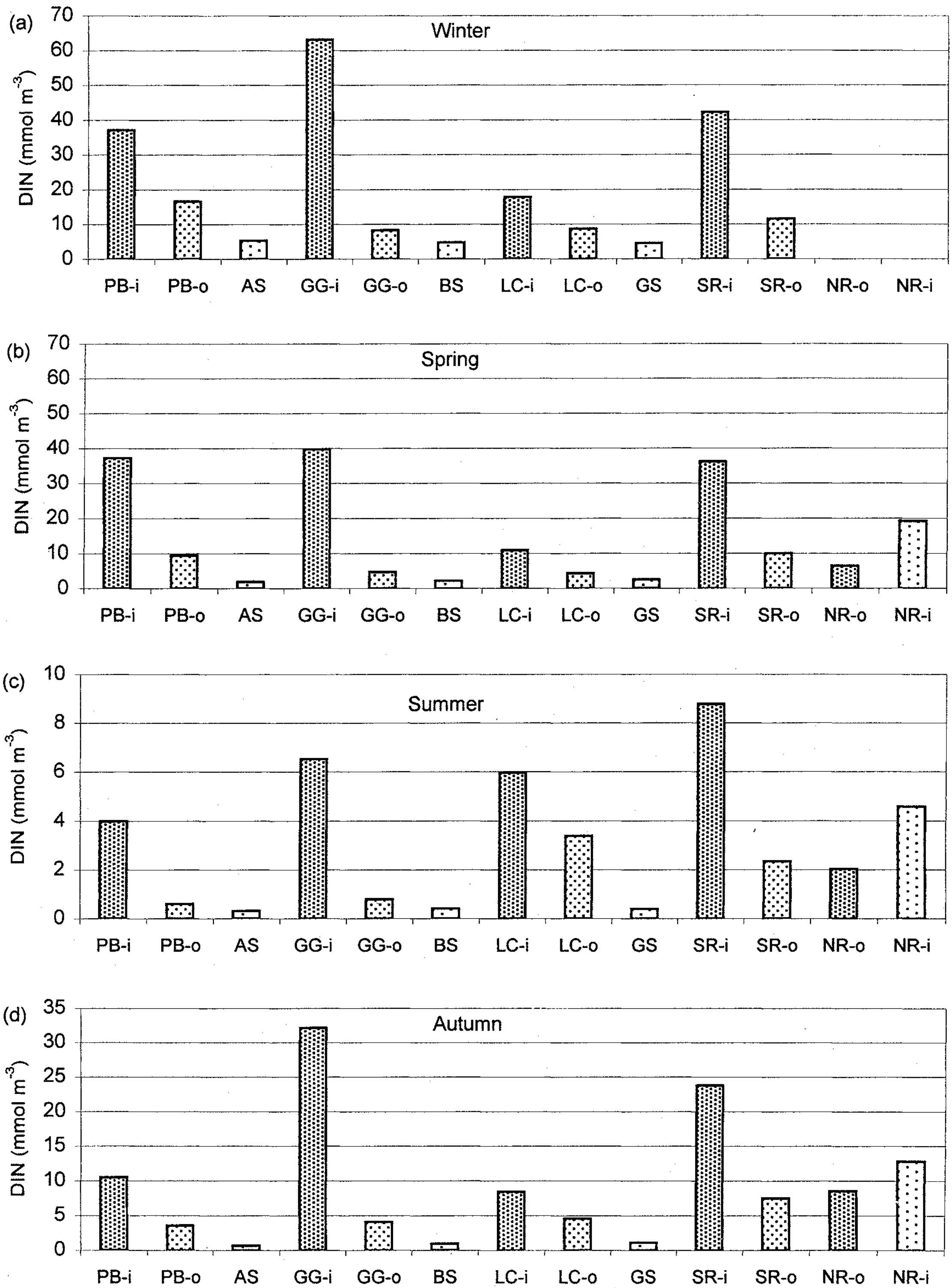

Fig. 13:
Seasonal mean (1993-1997) values of dissolved inorganic nitrogen concentrations in the upper water layer (0-10 m) in different sea areas in (a) winter, (b) spring, (c) summer and (d) autumn. The columns are arranged to short transects from the inner coastal regions (= i, columns densely stippled) via the outer coastal regions (= o) to the open sea (AS = Arkona Sea, BS = Bornholm Sea, GS = Eastern Gotland Sea, columns sparsely stippled). PB = Pomeranian Bay, GG = Gulf of Gdańsk, LC = Lithuanian coast. In the Gulf of Riga, the transect is arranged from the southern part (SR) to the northern part (NR).

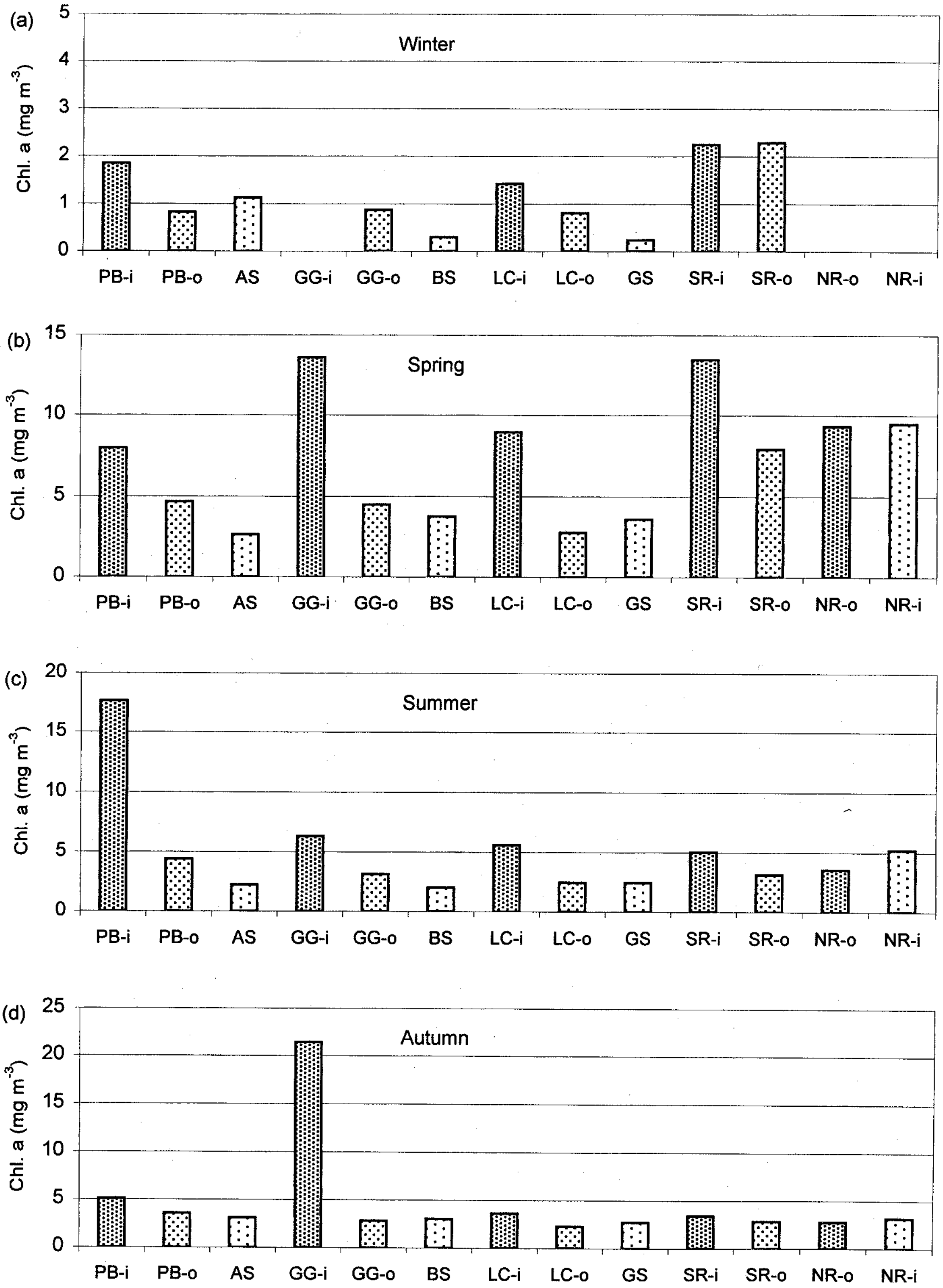

Fig. 14:
Seasonal mean (1993-1997) values of chlorophyll *a* concentrations in the upper water layer (0-10 m) in different sea areas in (a) winter, (b) spring, (c) summer and (d) autumn. The columns are arranged to short transects from the inner coastal regions (= i, columns densely stippled) via the outer coastal regions (= o) to the open sea (AS = Arkona Sea, BS = Bornholm Sea, GS = Eastern Gotland Sea, columns sparsely stippled). PB = Pomeranian Bay, GG = Gulf of Gdańsk, LC = Lithuanian coast. In the Gulf of Riga, the transect is arranged from the southern part (SR) to the northern part (NR).

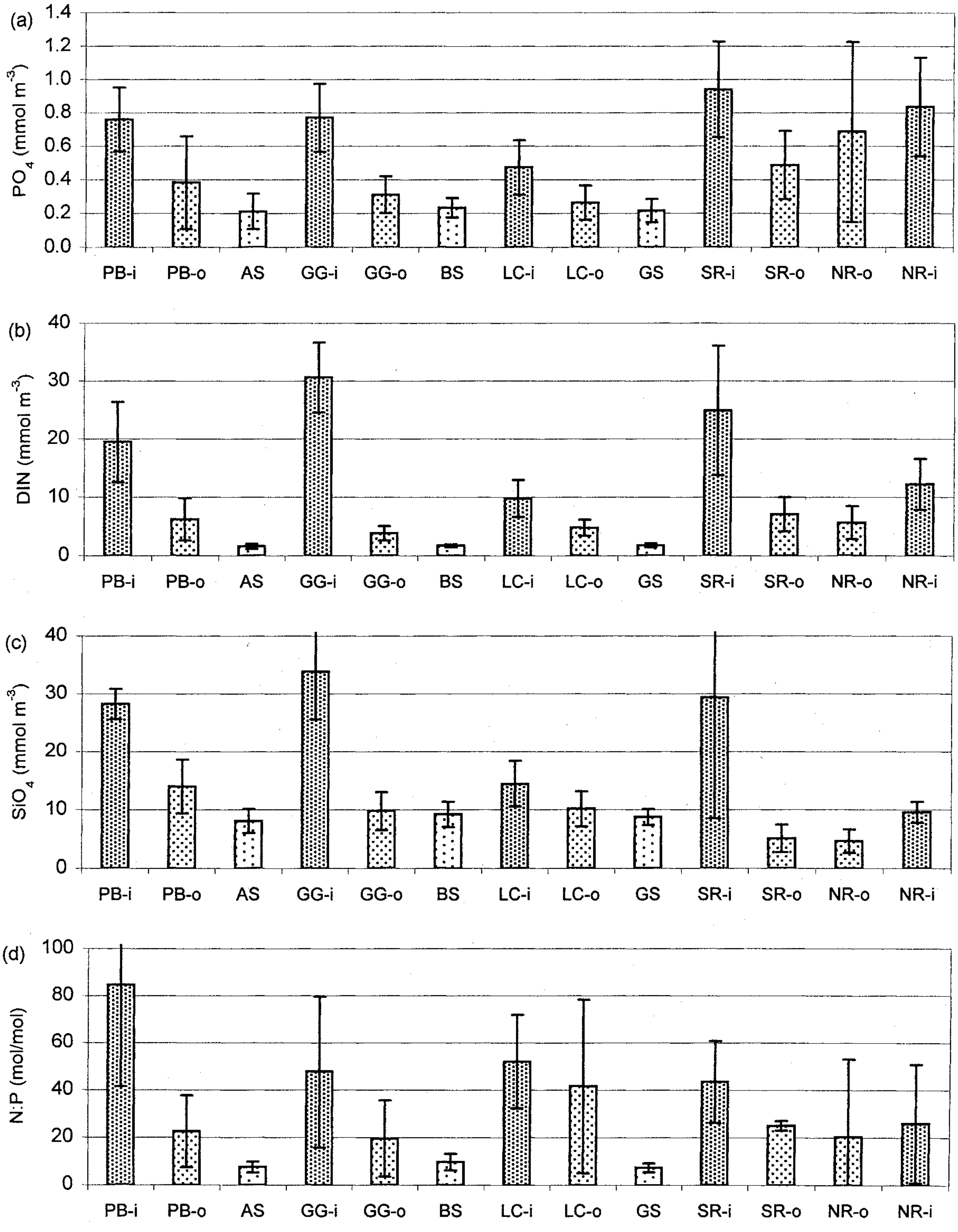

Fig. 15:
Annual mean (1993-1997) values of (a) phosphate concentrations, (b) dissolved inorganic nitrogen concentrations, (c) silicate concentrations and (d) N:P ratios in the upper water layer (0-10 m) in different sea areas. The columns are arranged to short transects from the inner coastal regions (= i, columns densely stippled) via the outer coastal regions (= o) to the open sea (AS = Arkona Sea, BS = Bornholm Sea, GS = Eastern Gotland Sea, columns sparsely stippled). PB = Pomeranian Bay, GG = Gulf of Gdańsk, LC = Lithuanian coast. In the Gulf of Riga, the transect is arranged from the southern part (SR) to the northern part (NR). The bars indicate confidence intervals ($p = 0.05$, $n = 5$).

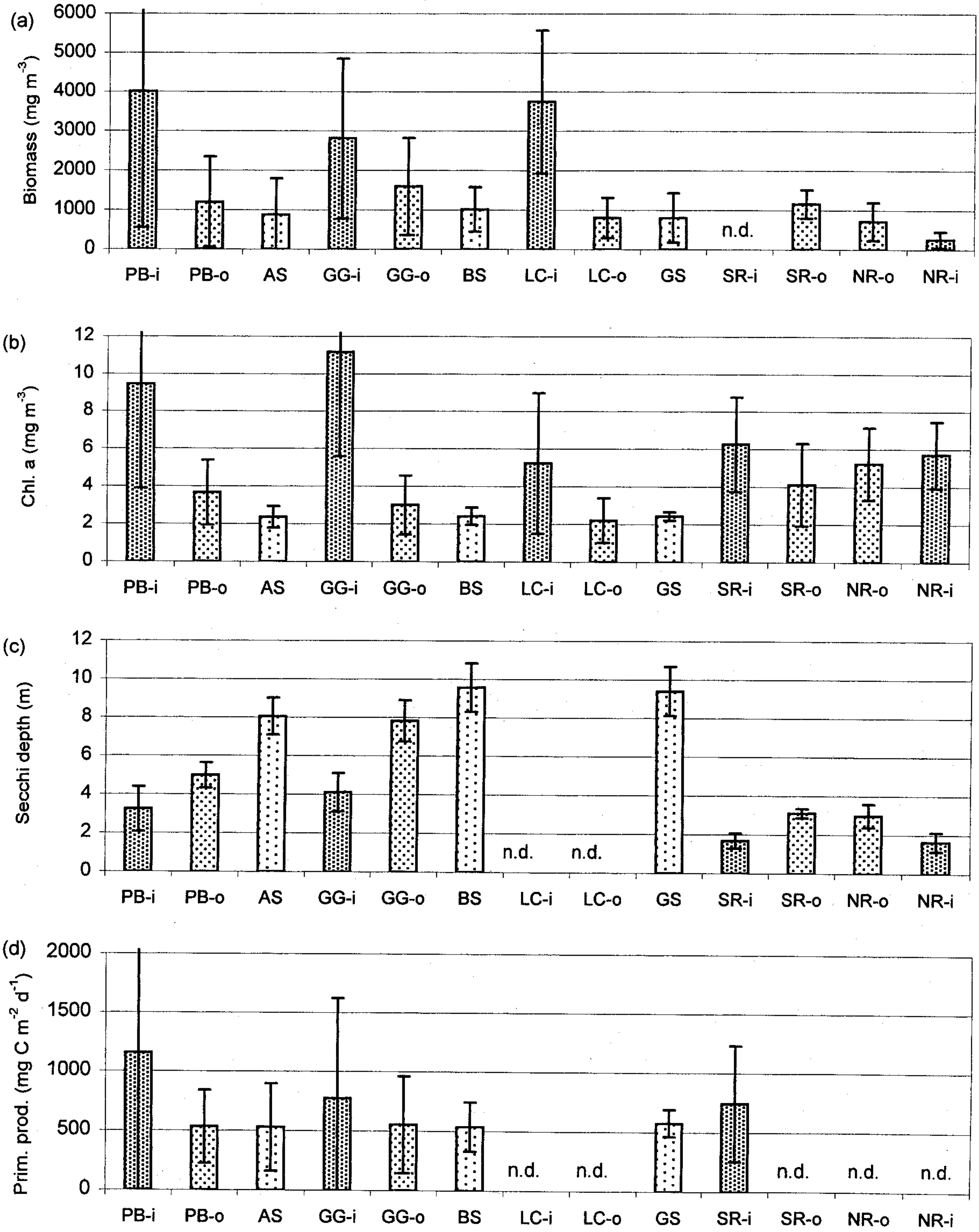

Fig. 16: Annual mean (1993-1997) values of (a) phytoplankton biomass (wet weight), (b) chlorophyll *a* concentrations, (c) Secchi depth and (d) *in situ* primary production in different sea areas. The columns are arranged to short transects from the inner coastal regions (= i, columns densely stippled) via the outer coastal regions (= o) to the open sea (AS = Arkona Sea, BS = Bornholm Sea, GS = Eastern Gotland Sea, columns sparsely stippled). PB = Pomeranian Bay, GG = Gulf of Gdańsk, LC = Lithuanian coast. In the Gulf of Riga, the transect is arranged from the southern part (SR) to the northern part (NR). The bars indicate confidence intervals ($p = 0.05$, $n = 5$). Primary production means from the Gulf of Riga include only the years 1994, 1995 and 1997.

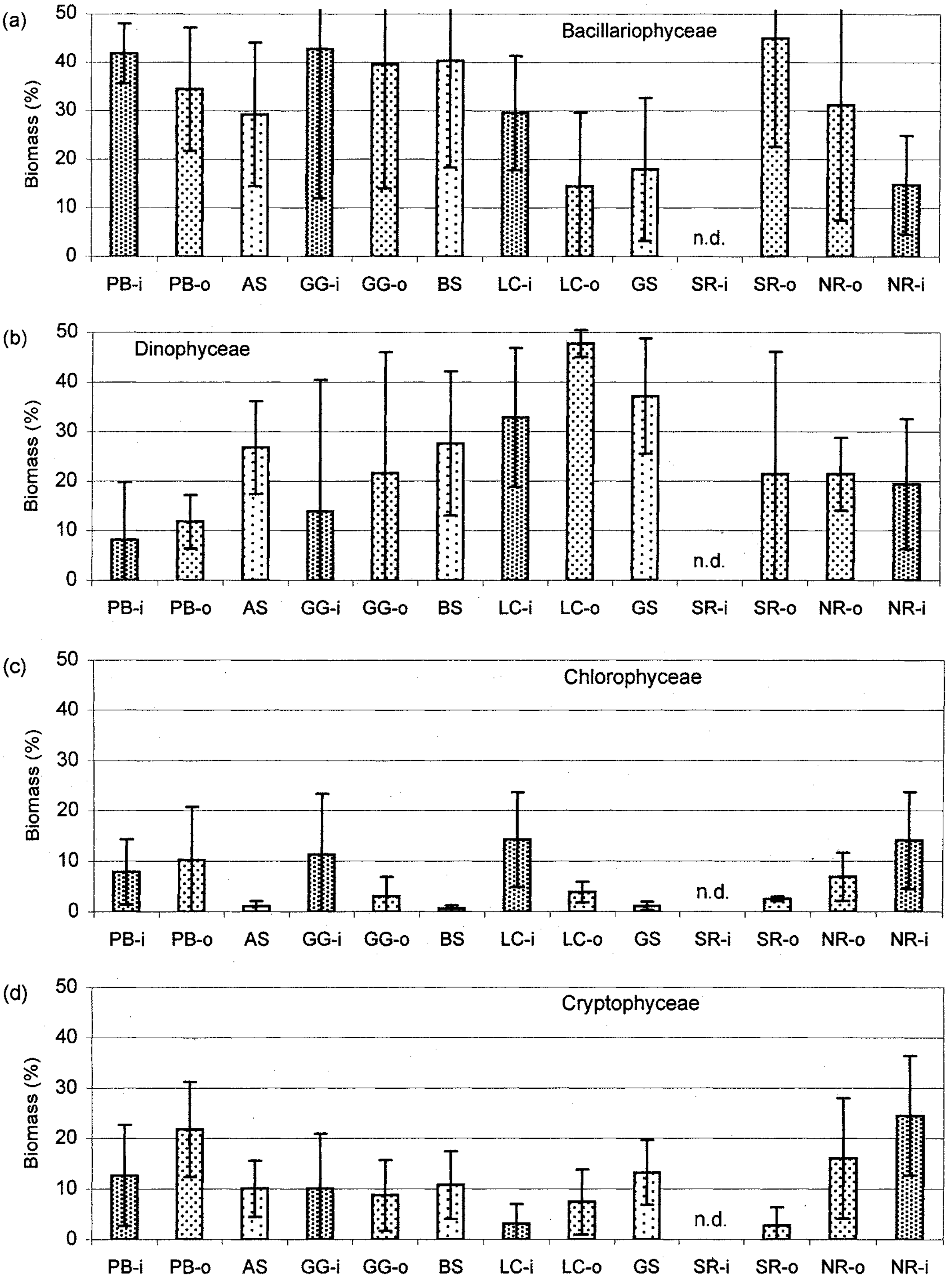

Fig. 17:
Annual mean (1993-1997) values of the contribution (%) of different phytoplankton groups in total phytoplankton biomass (wet weight): (a) diatoms (Bacillariophyceae), (b) dinoflagellates (Dinophyceae), (c) Chlorophyceae and (d) Cryptophyceae in the upper water layer (0-10 m) in different sea areas. The columns are arranged to short transects from the inner coastal regions (= i, columns densely stippled) via the outer coastal regions (= o) to the open sea (AS = Arkona Sea, BS = Bornholm Sea, GS = Eastern Gotland Sea, columns sparsely stippled). PB = Pomeranian Bay, GG = Gulf of Gdańsk, LC = Lithuanian coast. In the Gulf of Riga, the transect is arranged from the southern part (SR) to the northern part (NR). The bars indicate confidence intervals ($p = 0.05$, $n = 5$).

5.2.2 Phytoplankton biomass and chlorophyll

According to the differences in nutrient concentrations, also phytoplankton biomass (Fig. 16 a) and chlorophyll *a* concentrations (Fig. 16 b), as a proxy for phytoplankton biomass, are different in the sea areas. The variability of the seasonal data is shown in Figs. A4 and A5. The general tendency of decreasing chlorophyll *a* concentrations from the inner coastal waters to the open sea is obvious in Figs. 14 and 16 b. Especially in the inner coastal waters, extremely high values can be measured in big pulses of river outflow (e.g. the Oder flood in summer 1997). Low biomass values in the coastal region of the north-eastern Gulf of Riga (Fig. 16 a) might be due to dominance of small flagellates and chlorophytes with high chlorophyll content and high production potential.

The coastal waters investigated differed considerably in their mean phytoplankton biomass and chlorophyll *a* concentration. The maximal values (1993-1997) were found in the inner parts of the Pomeranian Bay and the Gulf of Gdańsk. In the other coastal regions, the plume data were lower but always higher than in the open waters. The outer part of the Lithuanian coastal region contained nearly the same chlorophyll *a* concentration as the Eastern Gotland Sea. The three regions investigated in the open Baltic Proper did not differ significantly in their phytoplankton and chlorophyll *a* concentrations.

The maximum chlorophyll *a* concentration (87 mg m^{-3}) was found in the mouth of the Peene Stream on 25 September 1995 (cf. Fig. A4 a). High concentrations (67 mg m^{-3}) were also found in the bay on 4 August 1997, during the exceptionally strong flood of the Oder river. In one patch of a surface bloom of *Microcystis aeruginosa*, transported from Szczecin Lagoon into the bay, even a chlorophyll *a* concentration of 300 mg m^{-3} was measured during this flood. This value was, however, excluded from our data basis because of special sampling conditions. These special events influence the calculation of the 5-years summer means given in Table A14 and Fig. 14 c.

The highest chlorophyll *a* concentration in the Gulf of Gdańsk (Fig. A4 c), with a peak value of 40 mg m^{-3}, was found on 7 November 1994 in the Vistula mouth (salinity only 0.4 PSU). This exceptionally high autumn value influences the seasonal and annual means, shown in Fig. 14 d. But even this peak value was low in comparison with that measured by LATAŁA (1993), who found a peak of 131 mg m^{-3} in April 1986 in front of the Vistula mouth. Especially the stations situated in the river plume are highly influenced by high estuarine biomass (cf. NAKONIECZNY et al., 1991). NAKONIECZNY et al. (1991) calculated chlorophyll *a* "summer" (June to October) means of 7.2 mg m^{-3} in 1981 to 1983 both in Pomeranian Bay and Gulf of Gdańsk.

In the Lithuanian coastal area, the peak chlorophyll *a* concentration (57 mg m^{-3}) was found on 15 May 1993 on front of the mouth of Klaipeda strait, representing a dinoflagellate bloom (Fig. A4 e).

In the north-eastern Gulf of Riga, we measured a chlorophyll *a* concentration of 29 mg m^{-3} in May 1993, but the real peaks of the spring blooms are missed, assumed to be higher than 50 mg m^{-3} chlorophyll a. For literature data on chlorophyll *a* in the Gulf of Riga see JANSONE (1995) and HELCOM (1996).

5.2.3 Secchi depth

As phytoplankton biomass causes turbidity, Secchi depth was especially low during phytoplankton blooms (compare Fig. 16 a,b with Fig. 16 c). The transparency of the water is not only reduced by phytoplankton but also other particulate matter and even by dissolved humic substances. These are of special importance in river plumes. Rivers with high contents of humic substances (e.g. Daugava) can be extremely turbid. Within the dataset, the mean annual Secchi depth in the Daugava plume was only 2.0 m. The coastal zone of the north-eastern Gulf of Riga (Pärnu Bay) had an extremely low Secchi depth (annual mean 1.6m), which is probably mostly related to other factors than directly to phytoplankton density. Certain increasing tendency in Secchi depth was evident during the years of 1995-1997 (Tab. A12). Also, TENSON (1995) reported on an increase in water transparency in Pärnu Bay since 1992. The annual mean of Secchi depth was 2.6 m (mean of only spring and summer) in the plume of Klaipeda Strait, 4.1 m in the Vistula plume and 3.0 m in the Oder plume (cf. Table A14). In the open waters of the gulfs and bays, Secchi depth is significantly higher than in the plumes. The maximal Secchi depth (single measurements) was found in winter 1994 in the open sea areas (Tab. A1 - A3), up to 15 m in the Bornholm Sea and Eastern Gotland Sea.

5.2.4 Primary production

In situ primary production data (Figs. 16 d and A6) are relatively rare because of the high effort for getting them. Therefore, and because of their high natural variability, they might not be very representative. In general, primary production is higher in the plumes than in the open waters. In very turbid plumes, primary production can even be lower than in the open waters because of light limitation. This was the case in summer 1995 in front of the Klaipeda Strait, where Secchi depth was only 1 m and primary production was 2.2 mg C m^{-3} h-1 (195 mg C m^{-2} d^{-1}) in contrast to the outer waters, where Secchi depth was 4.8 m and primary production was 4.6 mg C m^{-3} h^{-1} (589 mg C m^{-2} d^{-1}) (Tables A8 and A9). A similar situation was found in front of the Daugava mouth. Incubations at the open gulf and the plume stations were done under the same weather conditions, on two successive days in the same morning hours. Primary production was smaller in the plume than in the open Gulf of Riga despite of the higher chlorophyll concentration (compare Table A10 and A11).

Long-term means are 190 g C m^{-2} $year^{-1}$ in the Gulf of Gdańsk, 172 g C m^{-2} $year^{-1}$ in the Gdańsk Deep (Stat. 220) and 141 g C m^{-2} $year^{-1}$ in the southern part of the Eastern Gotland Sea (RENK, 1993). The distribution of primary production and chlorophyll *a* in the Gulf of Gdańsk in three seasons of 1994 is depicted by OCHOCKI et al. (1995 b) and those in the Pomeranian Bay in September/October 1993 by OCHOCKI et al. (1995 a) and POLLEHNE et al. (1995) and in 1996 and 1997 by OCHOCKI et al. (1999). Annual gross primary production in the Gulf of Gdańsk from 1993 to 1997 was estimated by WITEK et al. (in press) at 225 g C m^{-2}, which was about 20 % higher than the average value for the period from 1966 to 1995. This is similar to our data (multiply our daily data in Table A14 by 365). Our primary production data in the "outer part" of the Pomeranian Bay (Table A5) are comparable with those of Ochocki et al. (1999). They found maximum values in July 1997 (= 1239 mg C m^{-2} d^{-1}). Our plume data (Table A4) were especially high in summer

1994, 1995 and 1997 (in 1997 due to the flood of Oder river).

Measurements of the plankton primary productivity of the Gulf of Riga have not been performed regularly enough to analyse the interannual variability of this parameter. All of these data were collected using oxygen method with light bottles incubated *in situ* throughout the whole light period of a day except in 1991, when daily productivity was reconstructed according to data of 4-5 subsequent ^{14}C incorporation measurements, each incubated for 4 h *in situ.* Summarizing GPP values determined in different locations of the southern and central Gulf of Riga in 1991 – 1997, average daily plankton productivity may be estimated as 1814, 1270, 1353 and 385 mg C m^{-2} d^{-1} during April-May, June, July-August, and September-October, respectively. These rates correspond to annual production of 255 g C m^{-2} y^{-1}; 111 g C m^{-2} being produced during spring, 38 g C m^{-2} during early summer phytoplankton decline, 83 g C m^{-2} during summer and 23 g C m^{-2} during autumn. Noteworthy, only during the spring season the productive layer of the gulf appears as net-autotrophic system: throughout the rest of year plankton community respiration exceeds its primary production. Still, the evidence exists that the applied methodology of GPP determination may underestimate actual rates during periods of strong nutrient depletion (Olesen et al., 1999).

In Pärnu Bay, the highest primary production was measured already in early spring under the ice (in 1985-1987; TENSON, 1995). The "blooming" of diatoms begins in shallow water near the coast and extends stepwise towards the deeper open parts of the Gulf of Riga.

5.2.5 Species composition

The eight most important phytoplankton taxa (species or higher taxa, if not specified to species), with regard to their biomass, are presented in Tables A15-A24, with regard to regions, seasons and years. Their percentage in total phytoplankton biomass is roughly indicated by a rank number:

Biomass (percentage in total phytoplankton):	Rank:
76-100 %	5
50-75 %	4
26-50 %	3
11-25 %	2
1-10 %	1
< 1 %	0

Due to progress in taxonomy, a few species names changed at the end of 1993:

In 1993, *Rhodomonas minuta* (= *Rh. lacustris*, incl. var. *nannoplanctica*; acc. to PANKOW, 1990) was the most important Cryptophyceae. Since 1994, this species has been split into *Plagioselmis prolonga*, *Teleaulax amphioxeia*, *T. acuta* and *Hemiselmis* sp.

Small (< 3 µm) cyanobacteria cells in unspecific colonies were named *Microcystis reinboldii* (acc. to PANKOW, 1990) in 1993. Due to new taxonomic knowledge (meanwhile compiled by KOMAREK and ANAGNOSTIDIS, 1999) we used new species names (instead of *Microcystis reinboldii*) since 1994, like *Aphanocapsa delicatissima, A. elachista, A. incerta, Chroococcus microscopicus, Cyanodictyon reticulatum, C. planctonicum*. Because of splitting one species into a lot a new species, the separate species did not belong to the eight most important species yet.

In the southern Gulf of Riga, *Gomphosphaeria pusilla* (acc. to PANKOW, 1990) was determined, but in the other regions *Woronichinia* spp., *Snowella* spp. and *Coelomoron* spp. were distinguished (cf. KOMAREK , ANAGNOSTIDIS, 1999), instead of the collective species *Gomphosphaeria pusilla.*

The *Aphanizomenon* species of the open Baltic Sea has to be separated from the fresh-water species *Aphanizomenon flos-aquae*. The species of the open sea resembles *A. klebahnii* but is not described yet and has, therefore, to be named *Aphanizomenon* sp.

A comparison of Tables A15-A24 reveals that species composition does not vary greatly in the regions of the open Baltic Proper. One difference is the dominance of diatoms in the spring blooms in the Arkona Sea but the dominance of dinoflagellates in the spring blooms in the Bornholm Sea and Eastern Gotland Sea.

Big differences in species composition exist, however, between coastal and open waters. We think that the salinity is the main factor influencing the species distribution. In Figs. 18-19, data from the 3 cruises in the frame of the EC project (cf. Chapter 3) are shown for the distribution of selected species in the salinity gradient of coastal transects. Most of the Cyanobacteria originate from fresh-water and decrease with increasing salinity (*Planktothrix agardhii* and *Limnothrix redekei* in Fig. 18 a). *Nodularia spumigena* (Fig. 18 a) preferred a salinity of 7–7.5 PSU. Almost all Chlorophyceae (examples in Fig. 18 b) had an affinity to fresh-water. In diatoms both fresh-water and marine species have been found. In Fig. 19 a, species related to brackish or marine conditions are shown. Dinoflagellate species (Fig. 19 b) were adapted to brackish or marine water in most cases.

The same distribution patters become obvious also if all data are pooled for the different regions. In Fig. 17, the annual means of the phytoplankton composition in the different regions are shown. In general, there is a tendency of decrease in the percentage of diatoms and Chlorophyceae but an increase in dinoflagellates and Cryptophyceae from the coast to the open sea. Of course, there are deviations from this rule, depending on the concrete species composition, especially if both fresh-water and marine species are occurring in a taxonomic group (e.g. in the diatoms and Cryptophyceae). Most of the dinoflagellates are marine species. Chlorophyceae may serve as indicator for fresh-water influence.

Species lists of the Gulf of Gdańsk, Lithuanian coast and northern Gulf of Riga are presented by BRALEWSKA (1992), OLENINA (1996) and TENSON (1995), respectively.

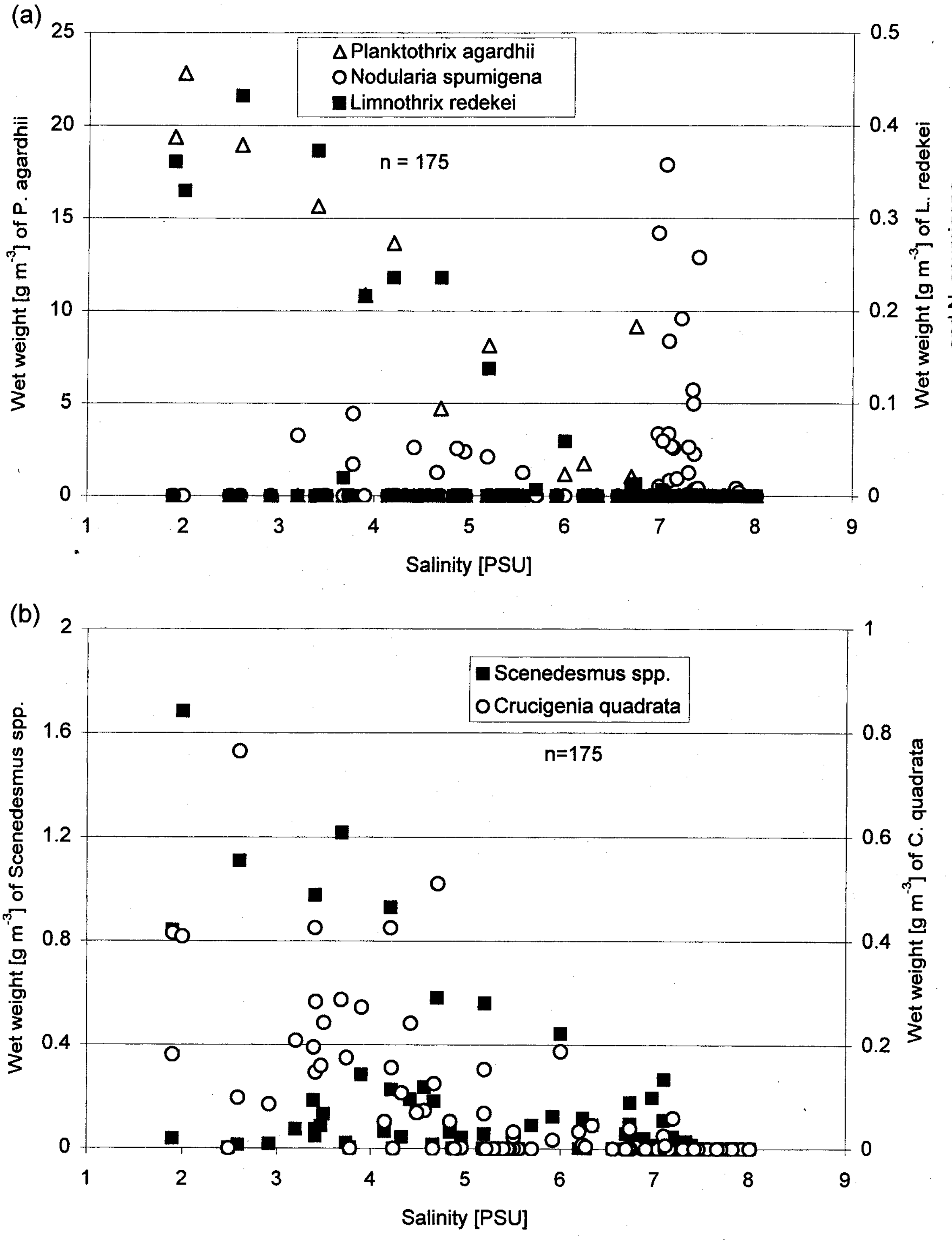

Fig. 18:
Distribution of biomass of selected species of (a) Cyanobacteria and (b) Chlorophyceae in salinity gradients during 3 cruises (in July 1993, September 1995, April 1996) in the Pomeranian Bay, Gulf of Gdańsk, coastal waters off the Lithuanian coast and the Gulf of Riga. (WASMUND et al., in press)

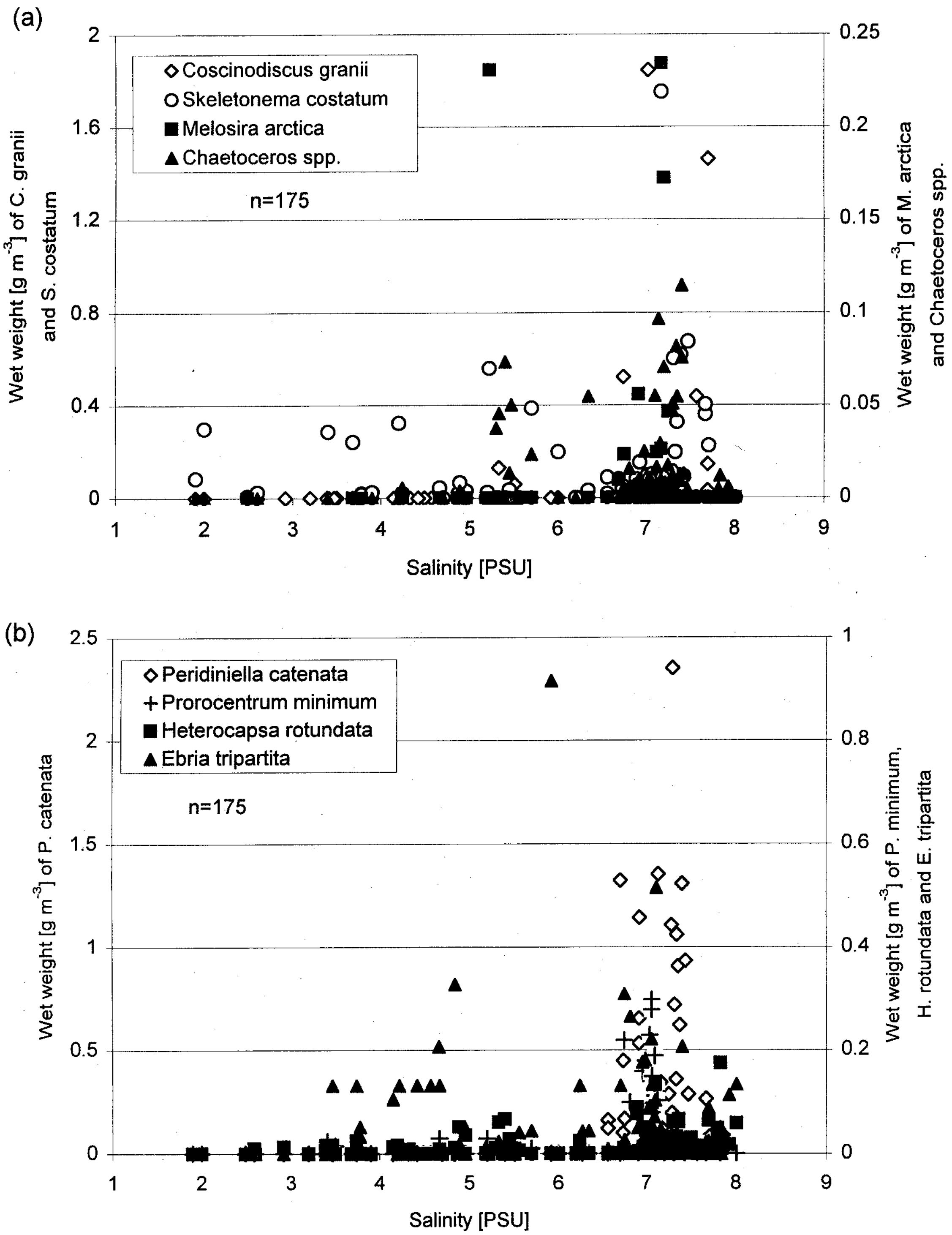

Fig. 19:
Distribution of biomass of selected species of (a) diatoms and (b) dinoflagellates in salinity gradients during 3 cruises (in July 1993, September 1995, April 1996) in the Pomeranian Bay, Gulf of Gdańsk, coastal waters off the Lithuanian coast and the Gulf of Riga.
(WASMUND et al., in press)

5.3 Phytoplankton spring blooms

5.3.1 Regional pattern of bloom initiation ("temperature hypothesis")

As shown in Chapter 5.1 and reported already by KAISER and SCHULZ (1978), the spring bloom develops in the eastern regions of the Baltic Proper later than in the western Baltic Sea (Table 1). This phenomenon is, however, mainly found after cold winters. A winter is "cold", if the minimum temperature of surface water falls below the temperature of maximum density of the water (2.3 to 2.4 °C in the southern Baltic Proper). After a cold winter, the warming-up of the water causes a circulation down to the permanent pycnocline. This mixing lasts until homogeneity in the water column (above the permanent pycnocline) is reached. After this, a continuation of warming-up leads to a stabilisation of the water column (i.e. the very beginning of thermocline formation), that is a precondition for the start of the bloom development. The duration of this process depends on the thickness of the water column above the halocline. Whereas the permanent halocline is situated in 20 m depth in Mecklenburg Bight (Belt Sea), it is as deep as about 60-80 m in the Eastern Gotland Sea (cf. Table 2). It takes much more time to warm up an 80 m deep water column (until stabilisation) than a 20 m deep water column. Therefore, the spring bloom occurs in the shallower areas (e.g. Arkona Sea) already in March (for instance in 1997, see Fig. 6 a) but in the deep areas (Eastern Gotland Sea, Gdańsk Deep) only in May (Fig. 6 c and 11 d). This "temperature hypothesis" (established already by WASMUND et al., 1998) could be supported by our coastal data because earliest blooms occurred in shallow coastal areas, where water warmed up most quickly.

Table 2: General period of spring bloom and depth of the permanent halocline in different sea areas.

Sea area	Period of the spring bloom	Depth of the halocline
Mecklenburg Bay	beginning of March - mid of April	15 - 25 m
Arkona Sea	mid of March - end of April	30 - 40 m
Bornholm Sea	end of March - beginning of May	50 - 60 m
Gulf of Gdańsk	beginning of March – beginning of May	60 - 70 m
Eastern Gotland Sea	mid of April - mid of May	60 - 80 m
Southern Gulf of Riga	end of March - beginning of June (Yurkovskis et al., 1999)	no permanent halocline, bottom depth < 60 m

In 1996, after a cold winter, the spring bloom (indicated by high chlorophyll concentrations and decrease of nutrient concentrations in the water) occurred in the open waters of the Pomeranian Bay and the Gulf of Gdańsk in March (Fig. 10 b + d) and in the Arkona Sea at the end of March (Fig. 5 a) but in the Eastern Gotland Sea in April (acc. to chlorophyll) or May (acc. to biomass, Fig. 5 c).

The bloom appeared so early in the central Gulf of Gdańsk because of a stabilisation of the water column already on 29 February 1996, indicated by a slight temperature and salinity gradient in 10-15 m depth. In this area, relatively near to a large river mouth, a plume of low-saline water can cause a shallow halocline. For the Gulf of Riga, STIPA et al. (1999) similarly suggest that spreading of the Daugava river plume during the spring flood is the main mechanism for the development of the spring pycnocline.

In a mild winter, the temperature of water does not fall below the temperature of maximum density. Therefore, the water column is still stable, with the warmest water at the surface. The warming-up of the water after a mild winter stabilises the stratification of the water, without preceding deep circulation. Hence, under the above conditions, the spring bloom starts in all regions of the southern Baltic Proper at more or less the same time, as soon as light intensity is sufficient. An example for this situation is the year 1993. In 1993, the spring bloom occurred at the beginning of April in the Arkona Sea (Fig. 2 a), Bornholm Sea (Fig. 2 b) and the central Gulf of Gdańsk (Fig. 7 d). In the Eastern Gotland Sea, situated more northerly than the other areas considered, no bloom developed at the beginning of April but only in May (Fig. 2 c).

The literature supports our finding of the earliest blooms in shallow coastal waters. WITEK et al. (1993), found the start of the spring bloom at the end of March 1987 in the Gulf of Gdańsk and at the beginning of April, i.e. 1-2 weeks later, in the open sea. Related with the photosynthesis of the blooms, the spring maximum in oxygen concentration is reached earliest in the bays and shallow-water coastal zones (March-April), but much later (April-May) in the Bornholm Sea and the southern part of the Eastern Gotland Sea (TRZOSIŃSKA, ŁYSIAK-PASTUSZAK, 1996). Also in Pärnu Bay, TENSON (1995) reported on the start of the bloom (primary production) in the near-shore regions, spreading to the open waters later.

5.3.2 Regional pattern of species composition ("seeding hypothesis")

The “temperature hypothesis“ alone cannot explain the different taxonomical composition of the spring blooms. Spring blooms are mainly formed by diatoms and/or dinoflagellates with diatoms dominating in the western Baltic Sea and dinoflagellates in the Baltic Proper nowadays. This phenomenon as well as the delay of the spring blooms in the Eastern Gotland Sea and the early spring blooms in the Gulf of Gdańsk (despite of its big depth) can also be explained by a “seeding hypothesis“.

A seed population is a decisive precondition for a bloom. Diatom cysts survive the winter in the sediment. As diatoms are not able to migrate actively they have to be transported upwards by vertical water currents into the upper water layers. Assuming that no spring-bloom forming diatoms remain in the water in winter, passive vertical transport is the only chance for the seed population to reach the upper water layers. Even the convective circulation of water in spring after a cold winter does not penetrate the permanent halocline. Only in coastal areas, shallower than the depth of the halocline, convective mixing reaches the bottom. Here, diatom blooms can usually develop (Fig. 20 b). These areas might be the source also for the phytoplankton blooms in the open waters. The seeds have to be transported there by lateral transport (advection).

An example to support our seeding hypothesis is the situation in the Pomeranian Bay in March

1996. In the shallow coastal regions, *Thalassiosira* sp. (accompanied by *Skeletonema costatum* and *Chaetoceros* spp.) developed. As these were not fresh-water species and river run-off was low during that time, we assume an autochthonous development of these species in the Bay. In contrast, dinoflagellates developed in the open sea (GROMISZ et al., 1999).

Assuming that all diatom blooms have to be seeded from coastal populations, the earliest blooms would occur in near-coast areas but the latest blooms far from the coast, as it really happens. The central stations of the Arkona Sea are 30 km away from the nearest coast, that of the central Bornholm Sea almost 60 km and that of the Eastern Gotland Sea about 80 km. The diatom seed population reaches the central Arkona Sea rather early but the Bornholm Sea later and only if currents come from the west, south or north. In the central part of the Eastern Gotland Sea mostly no diatom blooms occur in spring. The reason could be, according to our "seeding hypothesis", that this area is too far away from the coast to be reached by diatoms by means of water currents, especially because diatoms would sink down during the transport and therefore are lost from the surface water. The distance from the shore to the Gdańsk Deep is short (about 35 km), enabling an early bloom in the central Gulf of Gdańsk despite of the big depth of the gulf. As no permanent halocline occurs in the Gulf of Riga, it is mixed to the bottom in winter, just like coastal waters. Therefore, a seed population is permanently available, enabling an extremely early bloom (cf. Fig. 14 a). Also according to OCHOCKI et al. (1995 b) the spring bloom normally starts in the near-shore zone and propagates to the off-shore areas, but they think that it is seeded by riverine input. Of course, coastal blooms may come from the rivers, but they have no relevance for the open sea because of the relatively high salinity, that inhibits fresh-water species (compare Fig. 18 with Fig. 19).

In all regions, dinoflagellates develop in April or May. They do not need advective transport because they are able to migrate actively. If the nutrients have already been widely consumed at that time by the preceding diatom bloom, the dinoflagellate bloom is sparse. In the Eastern Gotland Sea, where normally no diatom spring bloom occurred, the dinoflagellates find a plenty of nutrients and form a strong bloom in May.

This "seeding hypothesis" has, however, also weak points. WASMUND et al. (1998) produced a diatom bloom in a tank, filled with surface water, in February 1996 in the Arkona Sea. They concluded, that seed algae are contained in surface water of the Arkona Sea already in winter. The winter 1995/96 was, however, a cold winter with advective circulation. The tank experiment should be repeated after a mild winter.

Also the occurrence of a bloom of *Coscinodiscus granii* in the central Baltic Proper can not be explained by this hypothesis. The assumption, that diatoms are not able to migrate upwards through the permanent halocline may be not true. WAITE and HARRISON (1992) reported on buoyant post-auxospore cells of *Ditylum brightwellii*. Also diurnal migrations of *Rhizosolenia* spp. (MOORE, VILLAREAL 1996; VILLAREAL et al., 1996) and *Ditylum brightwellii* (FISHER, HARRISON, 1996) were described.

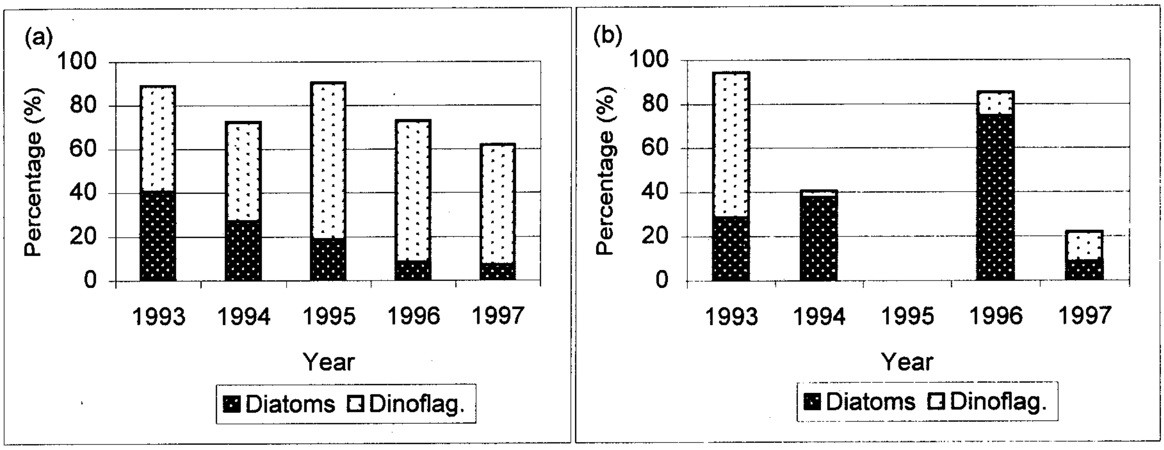

Fig. 20
Contribution (%) of diatoms and dinoflagellates in total phytoplankton wet weight during spring from 1993 to 1997 in (a) the open Bornholm Sea and (b) the inner part of the Pomeranian Bay.

5.3.3 Long-term trend in species composition

It is known from the monitoring in the open Baltic Sea, that the percentage of diatoms in the spring blooms decreases from the western Baltic Sea towards the Eastern Gotland Sea with a long-term tendency of replacing the diatoms by dinoflagellates. WASMUND et al. (1998) noticed, that the diatom growth decreased drastically since 1989 in the southern part of the Gotland Sea and the Bornholm Sea, to a lesser extent also in the Arkona Sea. They explained this with a series of mild winters in the 1990s. According to their "temperature hypothesis" (see Chapter 5.3.1), after a mild winter no deep convective circulation of the water column occurred, disabling the diatom cysts from upwards transport. Even if the silicate concentrations show a decreasing tendency (Tables A1-A3), the winter silicate pool should be high enough for diatom growth.

We were able to extend the time series of WASMUND et al. (1998) by the year 1997. The winter at the beginning of 1997 was a "mild winter" in the Bornholm Sea and Eastern Gotland Sea. The decreasing tendency of the percentage of diatoms in the spring bloom continued in the Bornholm Sea (Fig. 20 a). This tendency did not stop in the cold winters 1994 and 1996. Perhaps, the seed populations need more than only one single cold winter to recover after a series of five mild winters (1989-1993). However, in coastal waters, the percentage of diatoms was especially high after cold winters, which supports our temperature and seeding hypotheses: convective mixing of the water reaching the bottom in shallow waters (Fig. 20b). Diatom blooms were found, for example, in the year 1994 in the Pomeranian Bay (Tab. A4) and the Gulf of Gdańsk (Tab. A6), in contrast to the Gotland Sea (Tab. A3). TRZOSIŃSKA and ŁYSIAK-PASTUSZAK (1996) found in the period 1989-1993 a strong reduction of the silicate pool during spring in the Pomeranian Bay and the inner Gulf of Gdańsk, pointing to diatom blooms in these waters. They reported that the phosphate maximum in the Gulf of Gdańsk was found in the first half of March during the period 1979-1988, but already in February in the period 1989-1993. This supports our findings, that after mild winters (1989-1993), the spring bloom starts earlier, leading to a consumption of the nutrients already in February.

PLIŃSKI and JÓŹWIAK (1993) reported on an enormous increase of dinoflagellates (especially *Peridiniella catenata*) in April (after the diatom bloom) in 1992 and 1993 in the Gulf of Gdańsk.

Also in the relatively shallow Gulf of Riga, the percentage of the dinoflagellates - mainly *Peridiniella catenata* increased in the spring blooms at the end of the 1980's and the beginning of the 1990's, during the period of mild winters. Yurkovskis et al. (1999) explain these changes with climatic factors and changes in the nutrient pools in the Gulf. Mild winters followed by relatively warm spring periods promote the dominance of the more eurythermal dinoflagellate *Peridiniella catenata* over the arctic-boreal diatoms in the second phase of the spring bloom. Since the 1990ies, decreasing nitrate concentrations might also have led to the replacement of diatoms with high nutrient requirements to less demanding species. In summer, dinoflagellates and cyanobacteria increased, and diatoms in autumn (HELCOM, 1996).

5.4 Assessment of the trophic status

Eutrophication is the increase in the rate of supply of organic matter to an ecosystem (NIXON, 1995). The rate of organic carbon supply can be very different in different waters. NIXON (1995) proposed the following scheme for trophic classification of estuarine and coastal marine ecosystems:

	Organic carbon supply ($g\ C\ m^{-2}\ y^{-1}$):
oligotrophic	< 100
mesotrophic	100-300
eutrophic	301-500
hypertrophic	>500

The source of organic carbon may be fixation by primary producers within the system of concern (autochthonous carbon) or an input of organic matter from outside the system (allochthonous carbon).
In the waters considered, the allochthonous input of organic carbon is very low in comparison with the autochthonous production. For instance, we calculated an input of 383 000 t organic carbon into the southern Gulf of Riga from the biological oxygen demand (BOD) of the 4 largest Latvian rivers (ANDRUSHAITIS et al., 1995), using the formula of HELCOM (1993 b),. If this organic load spreads over the whole Gulf of Riga, a mean organic input of 23 $g\ C\ m^{-2}$ would result. This is low in comparison with primary production. The phytobenthos contributes little to the total primary production. Even in a very shallow lagoon of the southern Baltic Sea, the total micro- and macrophytobenthos accounted for only 7 % of total primary production (WASMUND, 1986). For

our assessment of the trophic status, only the primary production of the phytoplankton is considered (Tab. A14, Fig. 16 d). We are aware, that perhaps 10-20 % have to be added to the phytoplankton primary production for other sources of organic carbon. According to the scheme of NIXON (1995), the open waters of the Pomeranian Bay, Gulf of Gdańsk and the open Baltic Proper proved to be mesotrophic, whereas the plumes of Oder and Vistula river have a eutrophic status. It has to be admitted, that primary production especially in the plumes is highly variable. As regards the Lithuanian coast and the Gulf of Riga, not enough primary production data are available to calculate representative data. The phytoplankton biomass and chlorophyll data in these areas are, however, comparable with the data of the Gulf of Gdańsk. Therefore, we conclude, that also in the Lithuanian coastal waters and the Gulf of Riga the plumes are eutrophic and the open waters are mesotrophic. HEINONEN (1980) defined the border between the mesotrophic and eutrophic status in Finnish lakes at phytoplankton biomass of 2500 mg m^{-3}. This agrees with our statements (cf. Fig. 16 a).

That means that the plumes (inner coastal waters) are different from the outer coastal waters and the open waters of the Baltic Sea in physical, chemical and biological parameters, that are related to the trophic status (especially Secchi depth, nutrient concentrations, phytoplankton biomass and composition, chlorophyll *a* concentration and primary production). The plumes have to be treated separately in assessments (e.g. budget calculations, trend analyses, food web structure analyses, pollution estimations) of the whole Baltic Sea.

For budget calculations, knowledge on the extensions of the plumes would be necessary. They were not analysed because they are too variable in time and space. The main tributaries considered are comparable in their discharge, reaching from 18 km^3/year (Oder river) to 30 km^3/year (Vistula river, cf. Chapter 2). According to SIEGEL et al. (1999), a stable plume of the Oder river is 6-18 km long and 6-10 km wide, whereas that of the Vistula river is 9-27 km long (GRELOWSKI, WOJEWÓDZKI, 1996) and that of Klaipeda strait is up to 16-20 km long (DUBRA, 1994). In the Daugava plume, the 4 PSU isohaline was found at 7 km distance from the river mouth at the end of the spring high-runoff period (Müller-Karulis, in press).

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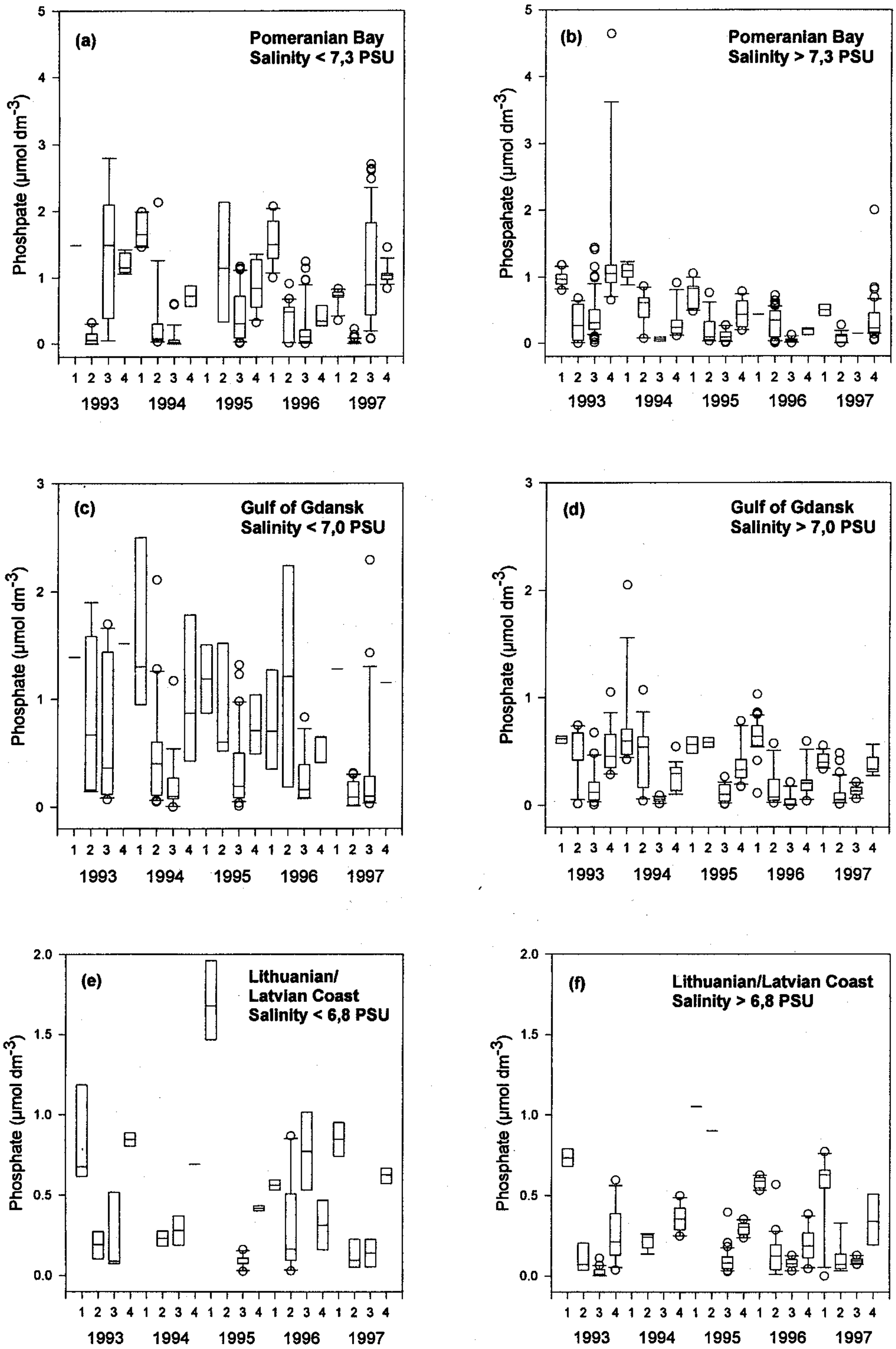

Fig. A1:
Box-and-Whisker plots of phosphate concentration in the coastal (plume) and the open parts of Pomeranian Bay, Gulf of Gdańsk and the region in front of the Lithuanian/Latvian coast. Explanation to Box-and-Whisker plots see page 11.

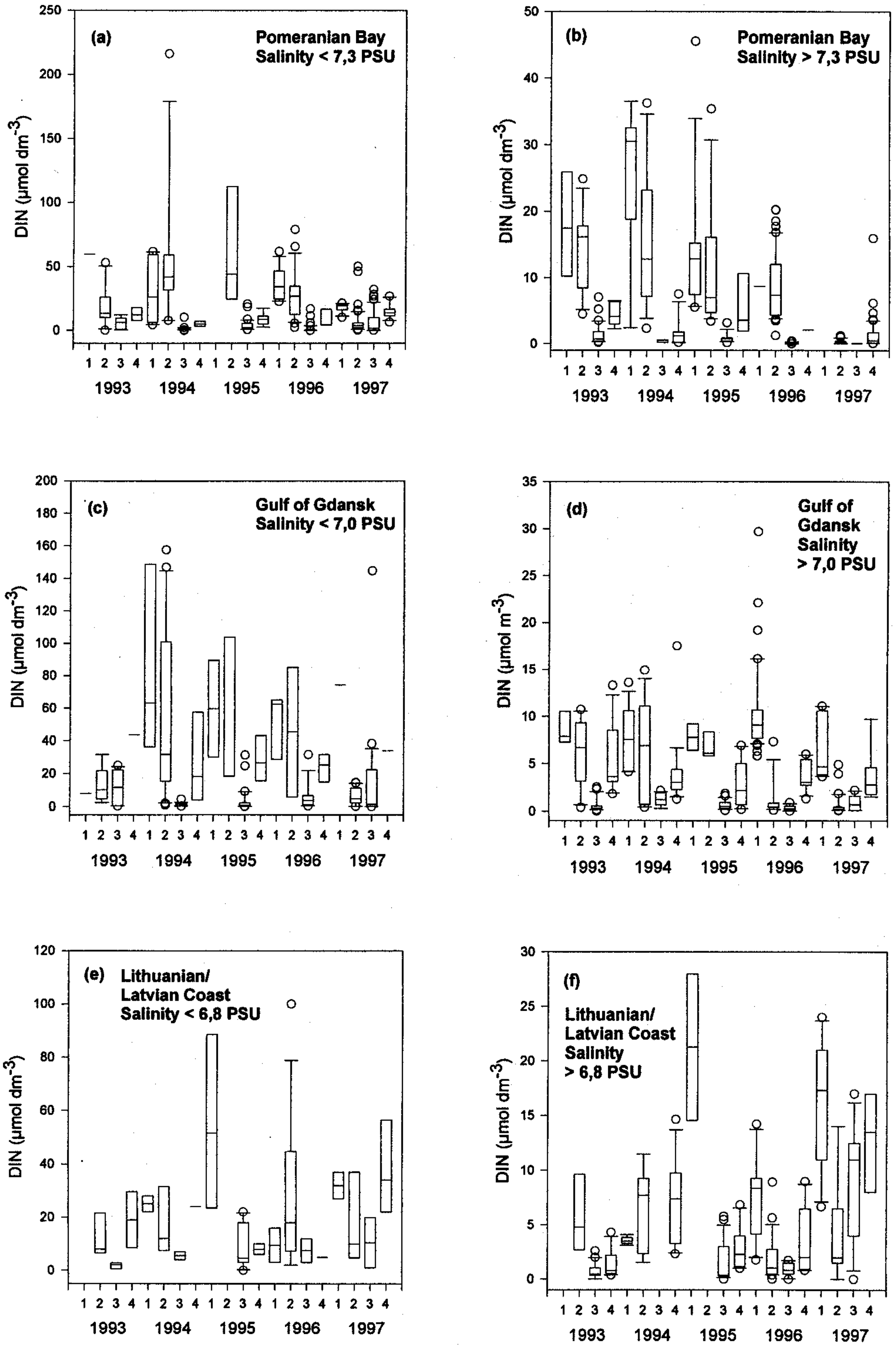

Fig. A2:
Box-and-Whisker plots of dissolved inorganic nitrogen ($NO_3 + NO_2 + NH_4$) concentration in the coastal (plume) and the open parts of the Pomeranian Bay, Gulf of Gdańsk and the region in front of the Lithuanian/Latvian coast. Explanation to Box-and-Whisker plots see page 11.

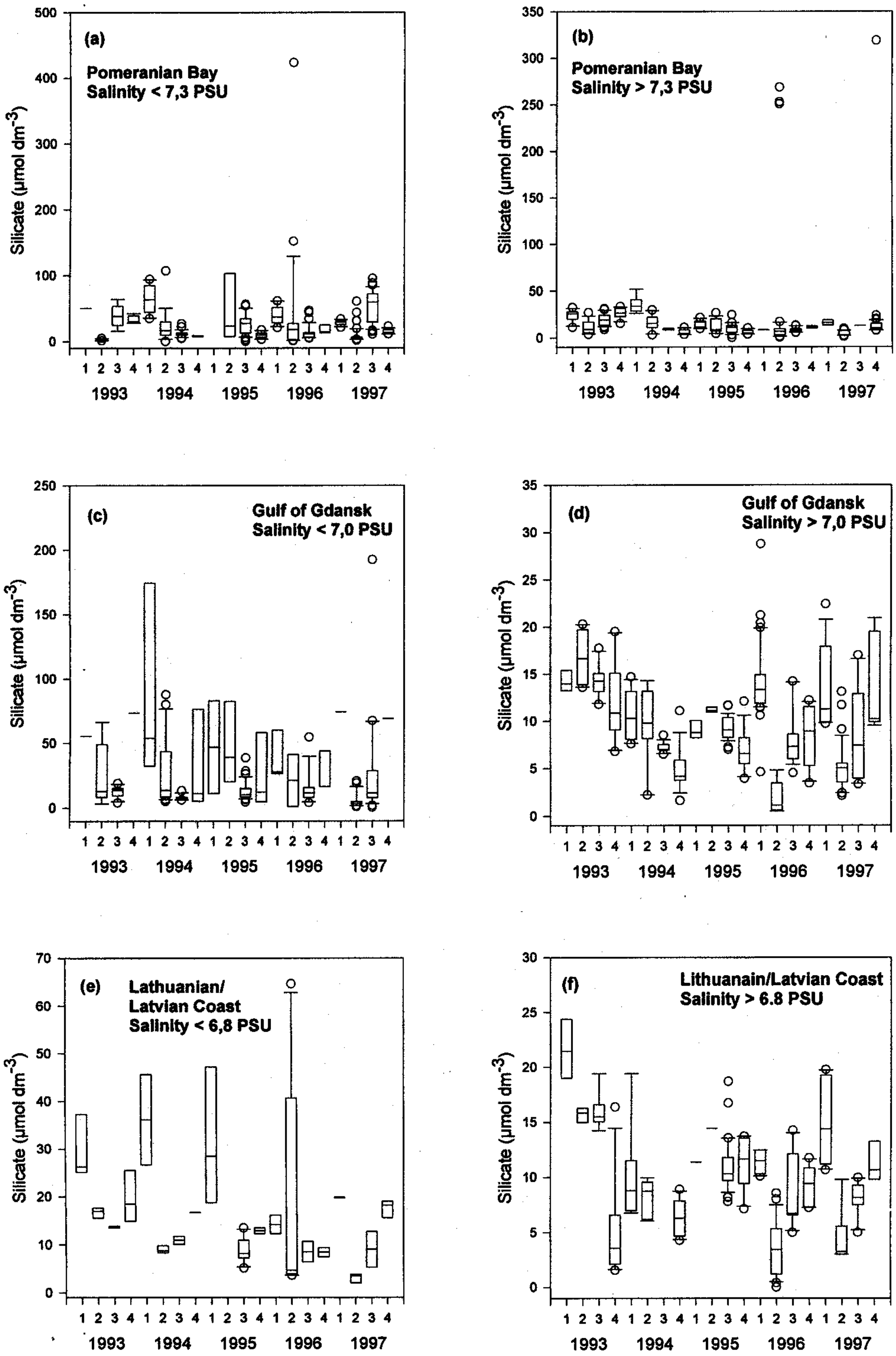

Fig. A3:
Box-and-Whisker plots of silicate concentration in the coastal (plume) and the open parts of Pomeranian Bay, Gulf of Gdańsk and the region in front of the Lithuanian/Latvian coast. Explanation to Box-and-Whisker plots see page 11.

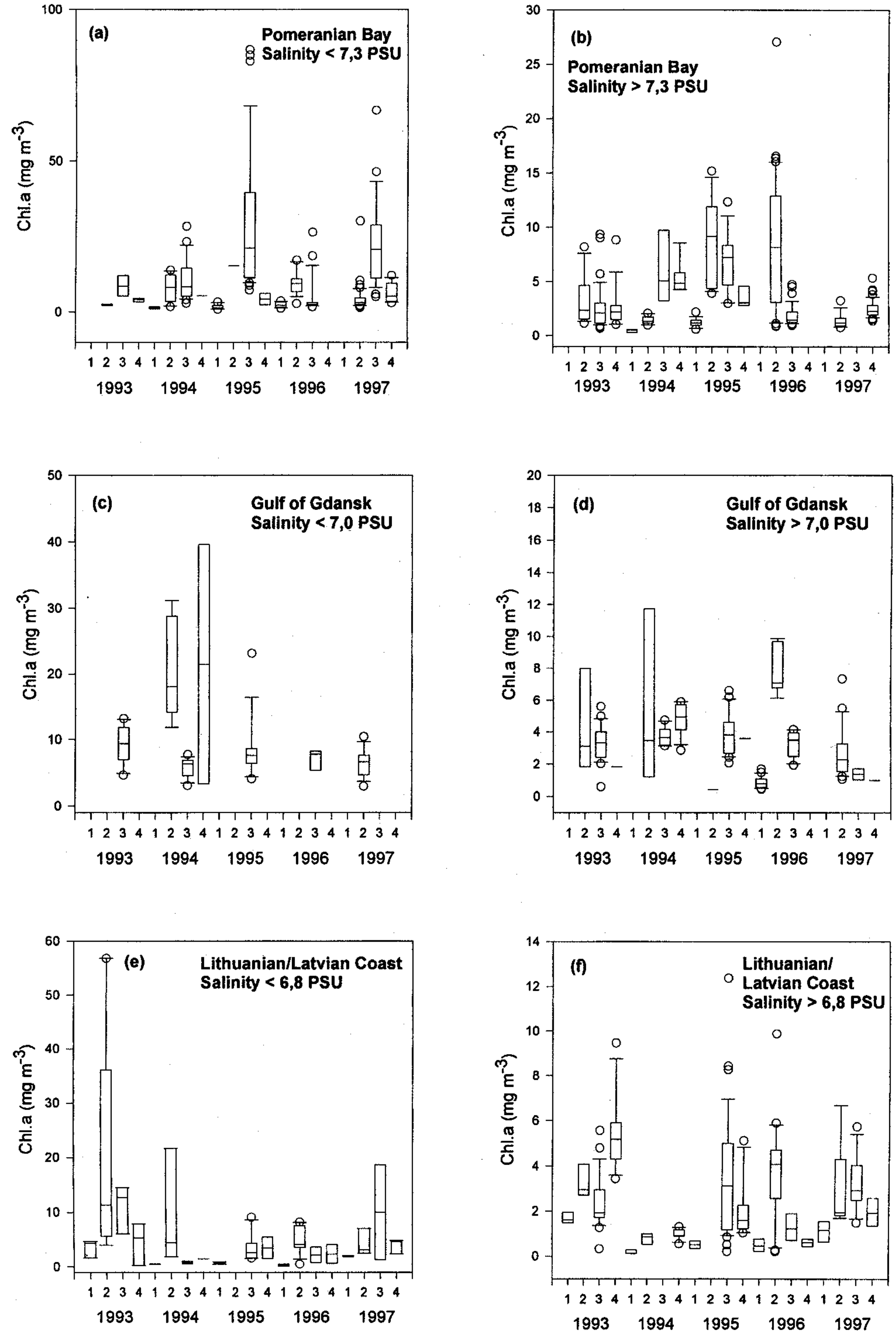

Fig. A4:
Box-and-Whisker plots of the concentration of chlorophyll a in the coastal (plume) and the open parts of the Pomeranian Bay, Gulf of Gdańsk and the region in front of the Lithuanian/Latvian coast. Explanation to Box-and-Whisker plots see page 11.

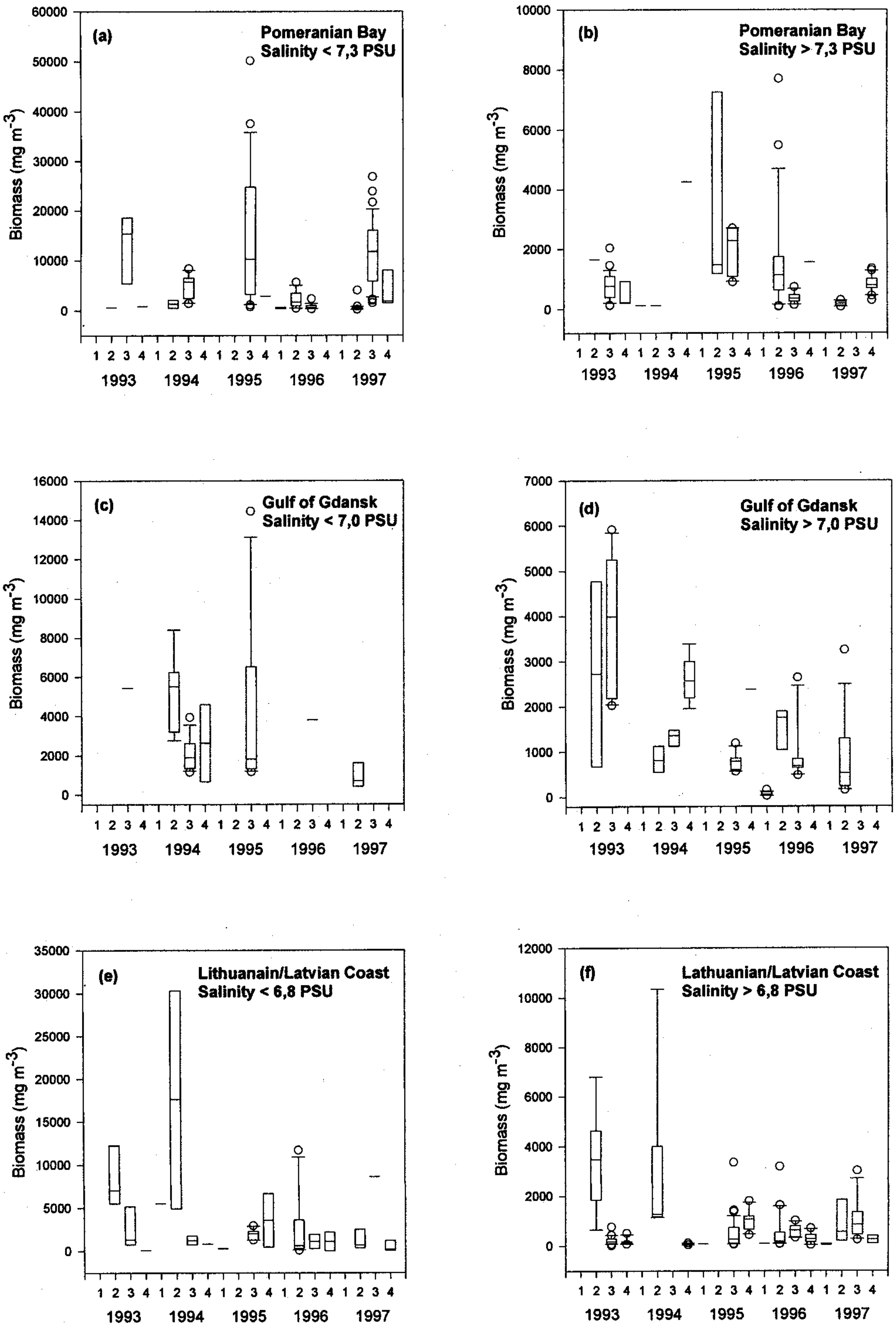

Fig. A5:
Box-and-Whisker plots of the phytoplankton biomass (wet weight) in the coastal (plume) and the open parts of the Pomeranian Bay, Gulf of Gdańsk and the region in front of the Lithuanian/Latvian coast. Explanation to Box-and-Whisker plots see page 11.

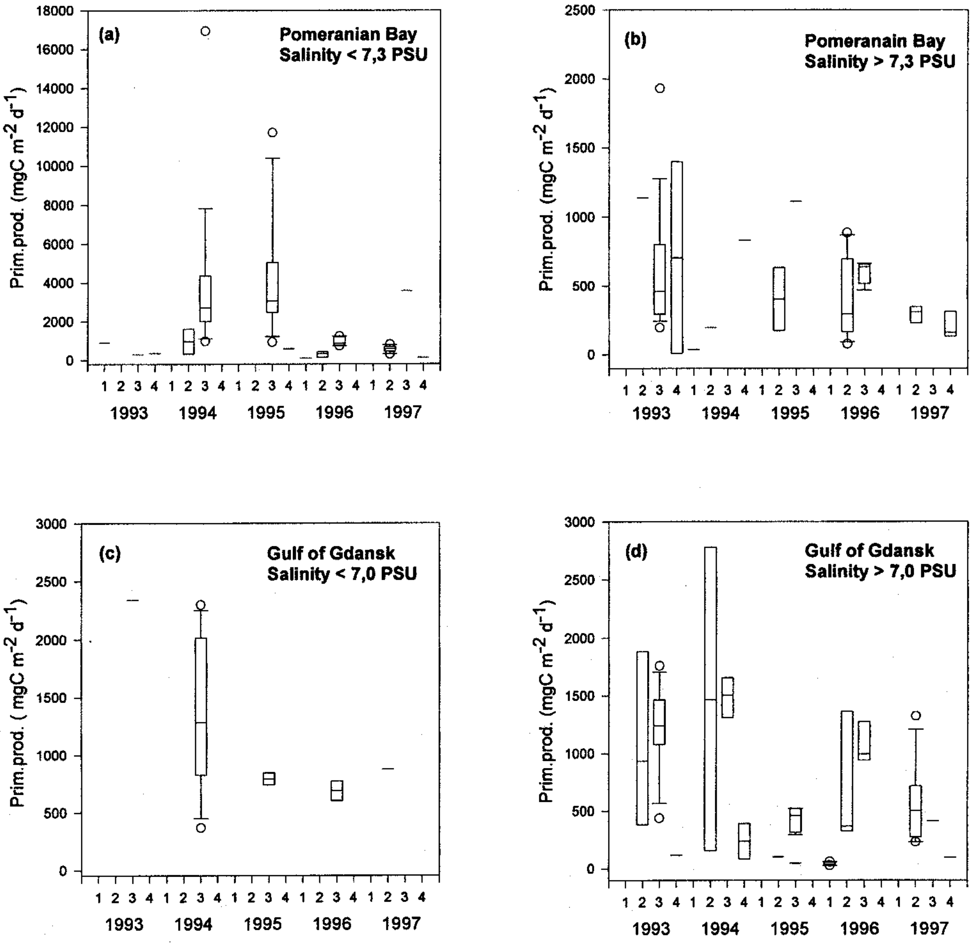

Fig. A6:
Box-and-Whisker plots of the primary production of phytoplankton in the coastal (plume) and the open parts of the Pomeranian Bay and the Gulf of Gdańsk. Explanation to Box-and-Whisker plots see page 11.

Table A1 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the Arkona Sea. Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Arkona Sea

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m ($mgC*m^{-3}*h^{-1}$)	Prim.prod. water column ($mgC*m^{-2}*d^{-1}$)	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	3	0	0	0	0	3,62	8,09	0,71	4,97	0,38	15,61	7,4										
2	6	17	13	5	9	5,05	8,11	0,35	1,03	0,22	12,53	2,8	2,26	8,4	6,21	1087	4208	2,4	36,0	54,5	0,2	3,3
3	3	7	5	2	7	18,38	7,44	0,24	0,10	0,22	7,49	4,5	1,66	6,0	3,94	719	668	32,2	10,6	39,3	3,8	6,6
4	3	4	2	1	4	9,74	7,64	0,25	0,44	0,36	8,81	3,0	2,86	8,0	4,28	399	1912	0,2	78,5	12,4	0,0	5,6
1994																						
1	3	3	2	2	3	2,63	7,87	0,54	4,91	0,24	10,17	9,3	0,33	12,0	0,32	37	115	0,0	46,2	14,4	8,0	28,3
2	6	17	17	9	12	4,78	7,80	0,27	2,83	0,42	9,43	12,2	2,55	9,0	1,83	160	755	0,2	44,2	27,5	0,1	10,0
3	3	7	5	1	6	21,36	7,45	0,04	0,11	0,23	5,34	5,6	2,18	7,5	3,64	743	511	15,6	16,8	24,9	0,7	13,2
4	3	4	3	1	4	10,15	8,22	0,16	0,62	0,56	9,33	6,1	2,33	9,0	1,94	219	405	3,4	58,2	12,3	0,0	15,9
1995																						
1	3	0	1	0	1	3,01	8,76	0,48	4,99	0,39	8,87	11,0		7,0			83	10,8	0,5	7,5	0,0	24,1
2	6	9	7	2	7	5,46	8,28	0,25	2,29	0,24	8,19	6,9	2,10	9,9	1,82	251	622	0,2	26,4	44,9	0,0	4,1
3	5	8	7	2	9	17,32	7,81	0,06	0,14	0,22	10,28	14,4	2,57	6,4	6,59	1217	724	24,3	12,7	22,7	0,3	6,1
4	3	4	4	1	4	12,30	7,95	0,15	0,23	0,17	4,25	2,1	4,58	7,0	5,16	582	1838	0,3	83,6	4,2	0,0	3,4
1996																						
1	3	1	1	0	2	-0,01	7,72	0,52	5,77	0,44	8,13	11,7	1,93	9,0			241	0,4	7,3	28,2	0,2	13,3
2	7	4	0	0	8	2,49	7,56	0,21	1,31	0,29	5,05	6,5	3,02				908	0,2	28,1	59,0	0,1	1,8
3	3	6	3	1	6	16,82	7,37	0,02	0,02	0,23	5,71	8,5	2,57	6,8	5,60	1100	646	45,8	3,9	19,0	1,7	7,9
4	3	0	0	0	4	11,09	7,39	0,12	0,24	0,37	8,58	4,0					195	17,8	9,5	19,2	1,5	15,7
1997																						
1	3	0	0	0	0	1,88	8,09	0,36	4,11	0,18	10,63	11,7										
2	6	3	3	0	4	4,47	7,81	0,10	0,36	0,41	5,66	8,3	3,21	9,5			796	0,9	39,5	37,4	0,2	4,2
3	3	1	1	1	2	18,80	7,42	0,02	0,07	0,25	5,08	14,5	2,22	7,0	5,00	925	499	39,6	18,4	14,3	0,6	8,7
4	3	6	4	2	4	10,99	8,05	0,15	0,17	0,18	9,39	1,6	2,65	7,0	1,47	165	1334	0,3	37,8	48,2	0,3	7,6

Table A2 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the Bornholm Sea. Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Bornholm Sea

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	3	0	0	0	0	3,47	7,79	0,76	5,04	0,20	18,14	6,9										
2	7	14	9	4	5	5,54	7,58	0,40	1,37	0,18	15,97	3,5	3,15	8,6	5,71	1046	885	4,3	40,5	48,5	0,6	2,0
3	5	7	6	4	2	15,32	7,36	0,08	0,10	0,17	12,04	11,0	1,91	5,8	5,92	776	586	31,0	18,6	30,5	0,3	15,0
4	4	5	4	3	2	8,57	7,26	0,12	0,91	0,44	3,36	33,3	2,46	9,5	2,23	126	2799	0,0	98,2	1,1	0,1	0,6
1994																						
1	3	4	3	1	2	2,75	7,45	0,54	4,30	0,19	12,89	8,0	0,30	15,2	0,67	93	140	0,3	60,8	12,1	0,7	22,4
2	8	17	13	8	9	4,12	7,34	0,31	2,30	0,43	10,36	9,5	6,00	10,3	4,23	557	1861	0,8	27,0	45,4	0,5	10,6
3	5	5	5	3	1	19,35	7,20	0,05	0,09	0,58	6,70	16,5	1,70	6,4	9,30	1240	154	23,4	10,4	2,6	1,3	35,7
4	3	4	2	2	2	9,37	7,35	0,09	0,65	0,45	5,93	9,4	3,29	10,8	2,06	199	1376	0,1	93,2	2,6	0,0	1,2
1995																						
1	3	0	0	0	0	3,31	7,81	0,50	4,48	0,14	9,45	9,2										
2	7	8	6	3	2	3,59	7,61	0,39	2,58	0,35	11,82	6,2	2,49	11,7	1,45	190	561	0,1	18,7	71,7	0,0	1,1
3	6	6	5	2	2	18,05	7,28	0,10	0,16	0,30	10,10	10,3	3,27	5,1	6,42	975	647	33,9	1,5	42,8	0,5	12,7
4	4	8	5	2	3	10,11	7,41	0,21	0,91	0,12	2,79	4,8	4,09	9,1	2,15	195	4037	0,1	95,6	1,9	0,1	0,6
1996																						
1	3	0	0	0	0	1,69	7,47	0,50	4,48	0,44	8,63	9,2										
2	7	4	1	1	4	2,58	7,39	0,25	1,68	0,31	8,03	8,4	4,05	11,0	7,62	975	1035	0,2	8,3	64,6	0,3	2,9
3	5	6	5	4	3	15,50	7,06	0,06	0,04	0,38	7,76	5,9	1,59	6,1	5,74	796	448	28,3	8,5	23,2	2,7	6,9
4	3	0	0	0	0	11,38	7,14	0,07	0,15	0,55	7,47	10,1										
1997																						
1	3	0	0	0	0	2,67	7,39	0,52	4,01		11,77	7,8										
2	8	5	4	2	3	3,65	7,50	0,29	1,50	0,29	11,14	5,5	3,09	10,8	7,80	740	311	5,4	7,0	54,9	0,3	4,8
3	4	3	2	3	2	16,90	7,41	0,08	0,09	0,19	6,26	10,1	1,64	7,3	3,83	631	240	16,7	15,9	35,8	0,4	10,0
4	4	5	4	2	4	10,90	7,42	0,18	0,47	0,15	9,38	3,8	2,21	8,9	3,75	303	1671	0,3	55,4	31,7	0,4	6,8

Table A3 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the Eastern Gotland Sea. Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Eastern Gotland Sea

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	3	0	0	0	0	3,47	7,33	0,75	5,11	0,15	15,81	7,5										
2	8	16	11	4	6	6,35	7,36	0,40	2,65	0,41	14,26	4,5	2,10	9,0	1,96	300	1786	1,8	5,0	67,5	0,3	3,1
3	7	9	7	4	6	15,46	7,18	0,03	0,09	0,18	10,44	11,6	2,81	5,1	8,46	1356	1153	62,3	6,4	15,0	0,4	7,6
4	4	6	3	2	3	8,11	7,27	0,06	0,36	0,72	1,38	9,3	3,77	13,1	0,95	38	2575	0,1	97,6	1,4	0,1	0,3
1994																						
1	3	3	2	1	2	1,79	7,29	0,51	3,92	0,05	10,74	7,7	0,24	13,8	0,29	39	72	0,0	31,5	24,2	0,0	38,1
2	6	13	8	4	7	4,17	7,22	0,22	1,43	0,23	9,89	6,5	5,17	10,4	13,64	1412	824	1,3	3,6	73,7	0,2	14,2
3	5	7	6	4	3	20,44	7,05	0,03	0,07	0,64	7,11	10,8	1,73	6,3	6,51	1026	524	18,7	22,4	30,7	1,7	22,9
4	3	5	4	1	3	7,96	6,91	0,09	1,05	0,51	6,97	13,0	2,97	10,9	1,06	98	668	10,4	34,5	35,6	1,5	7,9
1995																						
1	3	0	0	0	0	3,20	7,30	0,58	4,51	0,11	10,40	7,8										
2	7	11	7	4	6	3,82	7,24	0,45	3,19	0,36	12,70	5,4	3,43	12,4	3,83	569	936	2,0	9,4	68,1	0,4	8,0
3	7	8	7	2	4	16,51	7,09	0,07	0,06	0,25	8,91	7,1	3,08	5,3	7,50	925	880	51,5	4,2	18,2	1,1	4,5
4	4	6	4	2	3	8,45	7,09	0,21	0,75	0,66	7,76	5,3	2,03	8,5	1,84	162	283	34,2	28,9	15,0	2,7	8,5
1996																						
1	3	0	0	0	0	2,00	7,26	0,47	4,22	0,46	10,40	9,3										
2	8	6	4	3	6	2,51	7,26	0,27	2,05	0,42	8,44	6,6	3,63	9,4	5,48	639	1665	6,6	25,2	57,9	0,0	1,7
3	5	14	11	10	9	18,02	6,90	0,05	0,02	0,29	6,64	3,0	2,35	5,7	6,08	857	502	36,5	4,6	28,2	3,2	6,3
4	3	0	0	0	1	9,67	6,98	0,08	0,24	0,41	6,57	5,2					177	41,2	1,3	31,1	0,7	10,7
1997																						
1	4	0	0	0	0	2,50	7,27	0,46	3,79	0,17	10,35	8,4										
2	7	5	3	1	3	3,05	7,29	0,27	1,77	0,11	10,23	5,1	4,59	9,5	7,80	1011	2351	0,8	5,9	82,2	0,0	1,9
3	5	9	3	5	7	18,55	6,99	0,04	0,09	0,27	5,12	7,5	2,36	5,8	5,35	830	679	40,6	4,8	32,6	2,6	8,1
4	4	7	6	5	6	9,94	6,97	0,15	0,57	0,30	7,32	4,8	2,23	8,4	3,20	371	310	13,8	3,9	48,1	1,8	15,8

Table A4 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the coastal waters of Pomeranian Bay (S < 7.3 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Pomeranian Bay, S < 7.3 PSU

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m ($mgC*m^{-3}*h^{-1}$)	Prim.prod. water column ($mgC*m^{-2}*d^{-1}$)	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	1	0	0	0	0	1,87	6,64	1,49	41,22	18,23	50,32	39,9										
2	6	3	5	1	1	11,32	6,19	0,10	18,37	0,96	4,01	185,4	2,39	3,8	5,50	899	627	0,4	28,4	65,8	3,3	1,2
3	5	4	1	2	3	13,43	6,71	1,34	3,93	1,87	38,88	10,9	8,79	4,0	4,71	288	12423	84,0	5,3	1,6	5,8	1,4
4	5	3	2	1	1	5,92	6,74	1,22	8,25	4,91	33,16	10,5	3,99	4,1	4,05	357	900	0,9	76,1	7,4	9,3	2,8
1994																						
1	6	2	3	0	0	1,02	6,05	1,70	26,19	8,95	64,18	17,8	1,44	2,3								
2	14	7	11	2	2	8,46	5,68	0,39	59,33	4,85	24,75	465,0	7,92	2,9	6,08	975	1333	0,2	37,4	3,2	7,6	9,9
3	24	23	11	13	7	18,45	6,40	0,09	0,71	0,88	12,11	92,4	11,01	1,9	25,78	3959	4925	14,6	36,4	6,5	27,1	8,2
4	2	1	0	0	0	7,59	7,13	0,73	3,66	3,06	8,33	6,7	5,48									
1995																						
1	0	7	6	0	0	1,78	6,15						1,72	2,7								
2	3	1	1	0	0	6,00	5,85	1,22	59,87	6,04	51,92	131,9	15,35	4,0								
3	34	34	7	7	18	16,44	5,65	0,44	1,28	2,73	27,11	45,9	29,02	1,9	27,31	4406	14448	57,3	9,8	1,8	16,5	5,8
4	7	3	2	2	2	9,45	6,78	0,87	5,25	3,94	9,92	9,6	4,33	3,5	6,39	592	2917	2,9	87,2	0,4	0,2	1,1
1996																						
1	8	9	2	1	2	-0,06	6,04	1,54	19,94	15,67	39,41	24,2	2,37	4,4	1,30	104	512	1,7	27,9	1,7	3,6	34,7
2	17	13	4	4	8	3,03	6,71	0,35	21,23	8,96	46,24	302,9	9,68	4,9	5,13	289	2288	0,1	74,3	10,8	0,6	5,9
3	40	24	13	6	12	15,92	6,53	0,23	0,95	0,45	13,37	6,4	5,44	4,3	13,28	945	774	11,9	28,0	5,8	6,9	22,1
4	4	0	0	0	0	7,24	6,77	0,42	6,00	2,52	18,96	19,2										
1997																						
1	7	0	0	0	0	0,18	6,93	0,69	16,98	1,41	28,37	25,9										
2	47	38	8	8	19	8,73	6,67	0,03	5,97	0,48	8,97	245,0	4,50	3,3	8,04	566	578	2,2	8,3	13,6	11,7	41,4
3	41	25	1	1	29	20,67	4,64	1,12	6,03	1,08	52,51	4,0	34,02	1,4	36,00	3580	11476	11,1	56,7	4,3	18,1	2,3
4	10	8	1	1	3	10,39	4,93	1,05	12,68	2,45	14,89	14,1	6,50	2,8	8,71	123	4416	0,8	62,3	0,8	0,9	3,4

Table A5 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the open waters of Pomeranian Bay (S > 7.3 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Pomeranian Bay, S > 7.3 PSU

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m ($mgC*m^{-3}*h^{-1}$)	Prim.prod. water column ($mgC*m^{-2}*d^{-1}$)	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	8	0	0	0	0	2,14	7,93	0,97	13,45	3,12	23,78	17,3										
2	12	11	10	1	1	5,65	7,95	0,31	8,27	0,91	11,35	35,2	3,51	4,2	8,80	1140	1654	0,0	93,8	1,0	0,9	2,6
3	50	42	33	12	25	14,36	7,72	0,41	0,56	0,73	19,33	5,0	2,53	6,0	9,09	625	796	3,3	7,5	32,6	1,8	21,3
4	8	10	2	2	3	10,91	7,54	1,45	2,61	2,50	26,07	4,2	2,67	5,4	6,44	705	533	2,4	38,1	20,5	1,7	24,8
1994																						
1	5	4	2	1	1	0,71	7,63	1,08	23,34	4,13	35,43	23,4	0,45	3,3	0,40	37	119	0,0	11,8	10,9	29,4	42,9
2	9	6	4	1	1	3,85	8,04	0,52	15,10	0,82	15,71	35,2	1,41	6,0	1,45	198	122	0,0	24,6	8,2	0,0	39,3
3	4	3	2	0	0	20,42	7,42	0,06	0,08	0,54	9,09	10,6	6,32	3,3								
4	7	5	4	1	1	8,54	7,70	0,32	1,19	2,36	6,27	4,5	5,39	7,1	9,70	834	4251	0,4	89,9	3,4	1,8	1,1
1995																						
1	9	15	6	0	0	1,82	8,00	0,75	13,23	5,06	15,31	18,4	1,20	3,8								
2	14	11	5	2	3	6,42	8,07	0,21	12,27	0,71	12,18	93,7	8,58	3,7	4,28	404	3915	0,1	15,9	17,1	38,7	8,4
3	16	9	10	1	6	18,07	7,52	0,11	0,31	0,62	10,07	28,5	6,94	3,5	13,00	1113	1995	9,7	30,2	8,3	8,2	13,5
4	8	4	2	0	0	9,20	7,65	0,45	2,13	3,72	5,82	12,5	3,69	6,5								
1996																						
1	1	0	0	0	0	0,83	7,51	0,43	6,65	2,03	8,13	20,2										
2	47	37	15	8	20	0,48	7,59	0,31	8,01	0,78	22,80	51,8	8,39	4,7	7,49	409	1703	0,3	73,3	14,2	0,0	5,9
3	33	34	12	5	14	15,61	7,38	0,05	0,06	0,08	8,34	6,3	1,85	5,8	6,35	592	380	23,5	2,4	7,2	9,0	30,9
4	4	0	0	0	1	10,65	7,73	0,17	0,87	0,97	10,93	53,0					1571	9,7	72,6	2,7	2,6	2,6
1997																						
1	2	0	0	0	0	0,61	7,62	0,50	8,26		15,85											
2	23	15	8	3	7	7,53	7,52	0,08	0,18	0,24	5,79	23,8	1,41	5,7	2,43	291	180	5,7	5,8	15,5	14,5	38,2
3	1	0	1	0	0	10,55	7,47	0,14	0,06	0,00	12,73	0,4		7,0								
4	53	41	16	4	16	10,27	8,18	0,34	1,02	0,50	17,52	3,6	2,48	4,7	4,79	216	837	0,3	77,2	3,5	1,2	13,8

Table A6 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the coastal waters of the Gulf of Gdansk (S > 7.0 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Gulf of Gdansk, S < 7 PSU

Season	n1	n2	n3	n4	n5	emp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	1	0	1	0	0	1,76	4,80	1,39	66,06	7,3	55,42	5,7		3,0								
2	5	0	1	0	0	7,42	5,48	0,87	33,83	2,27	27,23	24,7		2,0								
3	13	6	4	1	1	15,40	6,20	0,70	2,30	3,02	12,62	19,0	9,22	2,6	56,33	2339	5438	47,5	15,2	11,4	15,9	3,8
4	1	0	0	0	0	2,25	5,76	1,52	27,44	16,2	73,55	28,7										
1994																						
1	3	0	1	0	0	2,25	5,07	1,51	46,27	13,12	73,65	33,4		1,5								
2	16	5	6	0	5	6,67	5,04	0,51	51,96	2,52	26,49	240,0	20,81	3,7			5106	0,4	61,4	30,1	3,7	0,4
3	13	9	7	6	8	19,51	6,67	0,22	0,10	1,30	8,21	62,2	5,67	3,0	16,12	1540	2095	40,2	4,1	12,9	23,9	6,4
4	4	2	1	1	2	7,36	5,02	1,11	26,90	3,71	40,84	18,6	21,44	7,0	6,12	369	2617	0,8	82,1	0,6	12,4	1,5
1995																						
1	2	0	1	0	0	3,30	5,27	1,19	54,50	5,23	47,05	46,8		5,0								
2	3	0	0	0	0	3,72	5,14	0,97	53,95	2,31	49,94	46,1										
3	29	14	12	2	7	18,27	6,35	0,35	2,54	1,01	12,73	11,9	8,69	3,4	9,76	792	4360	38,1	9,2	6,4	29,1	2,5
4	4	0	0	0	0	8,32	5,41	0,76	24,23	5,01	31,46	34,0										
1996																						
1	3	0	1	0	0	0,15	5,42	0,80	37,02	11,59	41,56	118,1		5,0								
2	2	0	2	0	0	4,86	4,41	1,21	37,51	7,95	21,21	36,0		2,0								
3	9	4	4	2	1	14,40	6,44	0,28	5,08	1,19	15,69	19,4	6,74	2,6	14,44	688	3808	2,6	65,7	2,2	2,8	23,2
4	3	0	1	0	0	6,63	6,48	0,54	19,20	4,13	31,66	40,4		8,0								
1997																						
1	1	0	0	0	0	0,71	5,69	1,28	41,51	32,8	74,49	58,0										
2	17	13	4	1	4	6,15	6,49	0,12	5,79	0,52	5,47	79,0	6,38	3,3	9,84	874	1002	2,7	16,4	55,4	9,0	6,5
3	18	1	8	0	0	17,81	5,36	0,36	15,25	0,81	29,81	39,4	1,16	2,8								
4	1	0	0	0	0	6,66	4,57	1,15	29,39	4,55	69,08	29,5										

Table A7 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the open waters of the Gulf of Gdansk (S > 7.0 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Gulf of Gdansk, S > 7 PSU

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	3	0	1	0	0	3,26	7,55	0,61	7,41	1,36	14,30	14,5		8,0								
2	6	4	5	3	2	4,44	7,36	0,53	7,09	0,81	16,81	13,7	4,91	8,3	10,58	1109	2722	0,4	8,2	50,2	0,6	0,6
3	22	19	16	7	6	15,10	7,23	0,17	0,10	0,49	14,33	9,6	3,31	4,8	9,06	1213	3894	45,1	4,0	19,1	5,4	11,7
4	11	1	5	1	0	4,66	7,43	0,51	3,77	1,79	12,24	10,2	1,83	13,6	7,80	113						
1994																						
1	9	0	1	0	0	2,92	7,38	0,73	7,20	0,86	10,84	12,1		7,0								
2	10	4	4	2	4	2,93	7,26	0,44	5,89	0,83	9,48	14,5	6,45	8,3	13,22	1465	835	2,1	34,3	45,6	0,4	1,8
3	11	6	5	3	4	17,73	7,11	0,06	0,11	1,17	7,20	37,2	3,75	4,8	12,01	1485	1299	57,9	0,7	4,8	12,0	4,0
4	15	8	2	2	5	8,29	7,18	0,27	2,93	1,25	4,96	14,9	4,79	8,5	5,00	236	2611	0,1	95,6	0,5	0,8	1,4
1995																						
1	4	0	3	0	0	3,18	7,41	0,56	6,99	0,79	9,12	14,0		12,3								
2	3	1	1	1	0	3,16	7,56	0,58	6,66	0,31	11,19	12,3	0,41	12,0	1,08	99						
3	25	18	13	5	7	17,39	7,08	0,12	0,11	0,58	9,27	12,2	3,94	4,8	5,07	421	784	47,8	11,3	10,2	3,4	7,2
4	10	1	2	0	1	9,34	7,19	0,38	2,12	0,86	7,01	8,4	3,59	8,0			2384	0,4	94,0	3,9	0,1	0,7
1996																						
1	37	21	7	7	15	0,77	7,26	0,64	7,57	2,93	14,08	20,0	0,87	8,4	0,71	42	70	3,7	37,8	23,0	0,9	20,6
2	8	5	4	3	4	1,99	7,34	0,16	0,96	0,38	1,94	12,0	7,95	7,0	6,09	790	1468	0,2	73,9	20,6	0,0	0,6
3	15	8	6	4	6	14,77	7,17	0,05	0,23	0,14	7,98	52,4	3,24	5,0	10,61	1105	992	11,4	3,8	40,3	4,8	29,3
4	7	0	2	0	0	7,22	7,11	0,22	3,09	0,83	8,58	79,7		9,5								
1997																						
1	10	0	6	0	0	1,96	7,24	0,41	5,41	0,96	13,57	15,1		9,2								
2	29	20	18	7	11	5,39	7,25	0,10	0,48	0,19	5,17	8,2	2,73	6,8	5,45	577	908	2,0	10,8	58,9	9,2	7,8
3	6	2	5	1	0	12,88	7,18	0,13	0,20	0,84	8,65	5,7	1,37	6,6	2,68	411						
4	5	1	2	1	0	9,25	7,22	0,38	2,35	1,39	13,93	10,8	0,98	10,0	1,37	95						

Table A8 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in coastal waters off the Lithuanian/Latvian coast (S < 6.8 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec. n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Lithuanian coast, S < 6.8 PSU

Sea-son	n1	n2	n3	n4	n5	emp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	SiO_4 (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	ryp. (%)
1993																						
1	3	3	0	0	0	1.93	6.28	0.88		3.69	30.68		3.56									
2	5	5	0	0	5	9.80	6.41	0.17	3.74	3.15	16.60	92.2	17.27				8479	0.7	1.0	83.1	9.8	0.1
3	3	3	1	0	3	17.44	5.65	0.27	0.60	2.45	13.71	15.1	11.09	1.5			4476	16.2	20.8	18.7	38.8	0.8
4	2	2	0	0	1	8.47	5.84	0.85	3.29	5.16	16.11	22.5	6.64				115	0.0	96.0	0.0	4.0	0.0
1994																						
1	3	3	0	0	1	0.83	6.06		23.79	0.99	33.40		0.44				5516	5.3	37.7	48.6	7.8	0.5
2	3	3	0	0	2	7.95	6.38	0.23	6.47	2.80	9.02	82.1	9.35				17635	0.0	0.3	99.3	0.1	0.2
3	2	2	0	0	2	15.68	6.68	0.28	1.73	3.93	10.92	23.7	0.84				1273	35.5	10.9	32.5	15.2	0.7
4	1	1	0	0	1	7.81	5.98	0.69	5.93	4.21	16.73	36.0	1.51				850	11.4	87.2	0.4	1.0	0.0
1995																						
1	4	4	0	0	1	2.05	5.81	1.72	18.47	2.89	33.02	33.0	0.68				297	19.2	33.0	28.7	7.2	10.0
3	6	6	1	1	6	13.93	6.06	0.10	1.26	5.65	8.86	92.7	3.67	1.0	2.20	195	3948	40.5	12.1	33.7	8.4	1.4
4	2	2	0	0	2	11.18	6.53	0.42	3.28	2.64	12.90	20.2	3.51				3584	26.4	9.7	48.4	11.6	3.8
1996																						
1	2	2	0	0	0	-0.49	6.63	0.57	7.78	1.24	14.24	16.9	0.33									
2	8	9	6	2	9	4.13	5.82	0.31	12.88	5.26	20.88	83.0	5.01	3.9	6.83	591	6655	0.3	76.4	12.7	6.0	1.2
3	2	2	0	0	2	17.77	5.95	0.77	1.86	3.98	8.54	13.2	2.24				1110	40.7	8.9	17.2	19.3	8.4
4	2	2	0	0	2	9.74	6.26	0.32	1.61	3.35	8.45	23.0	2.39				1115	17.8	31.3	30.0	20.4	0.3
1997																						
1	1	1	0	0	0	0.75	6.60	0.95	12.11	2.25	19.94	28.6	2.11									
2	3	3	0	0	3	7.75	5.65	0.14	6.76	2.44	3.02	159.3	4.24				1373	9.2	43.5	10.7	30.5	5.9
3	2	2	0	0	1	18.18	5.05	0.14	1.17	7.23	9.08	57.8	10.04				8624	38.5	2.4	28.1	30.5	0.2
4	4	3	0	0	4	9.10	6.45	0.62	5.10	7.62	17.35	61.2	3.98				641	24.3	23.3	18.0	15.3	16.5

Table A9 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the open waters off the Lithuanian/Latvian coast (S > 6.8 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec. n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Lithuanian coast, S > 6.8 PSU

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	SiO_4 (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	4	3	0	0	0	2.63	7.24	0.74		1.86	21.69		1.70									
2	4	3	0	0	3	9.65	7.12	0.12	2.18	2.78	15.63	144.3	3.34				3235	0.1	0.2	98.9	0.0	0.1
3	25	25	19	3	25	15.67	7.07	0.02	0.31	0.83	16.08	103.2	2.53	5.7	5.62	755	1317	27.2	7.7	39.5	2.1	5.3
4	6	6	0	0	6	9.70	7.20	0.30	0.63	1.86	3.78	5.9	5.68				114	8.2	69.7	1.3	10.5	0.8
1994																						
1	5	3	0	0	0	1.85	7.37		7.12	0.57	10.18		0.21									
2	5	4	0	0	5	6.17	7.21	0.22	4.55	1.38	8.08	30.4	0.77				3170	0.2	15.6	83.8	0.1	0.1
3	6	6	0	0	6	18.14	6.96	0.17	0.87	2.64	11.90	17.8	1.08				493	37.9	6.5	37.0	2.2	1.5
4	7	7	0	0	7	8.88	7.20	0.36	2.14	3.43	6.31	21.6	0.98				75	4.8	77.5	12.8	0.7	3.2
1995																						
1	2	2	0	0	2	2.49	7.03	0.98	6.73	3.09	12.90	22.4	0.52				81	8.0	7.6	49.7	9.0	22.5
3	27	27	15	1	1	15.24	7.06	0.08	0.46	1.70	10.75	19.4	3.92	4.8	4.61	589	1281	31.5	6.8	35.6	1.4	4.3
4	6	6	0	0	6	11.35	7.13	0.30	1.66	1.86	11.18	10.6	2.14				1041	30.6	3.6	51.0	5.0	8.8
1996																						
1	6	3	0	0	1	0.51	7.20	0.58	5.41	1.36	11.38	13.4	0.50				93	0.1	2.8	69.0	3.7	23.2
2	21	17	15	3	20	3.13	7.23	0.14	1.00	1.18	3.51	28.8	3.81	9.2	5.77	474	1445	0.2	32.0	53.6	0.1	3.2
3	6	4	0	0	6	15.83	7.04	0.08	1.10	0.96	8.55	15.5	1.31				619	48.3	1.0	34.9	6.4	6.6
4	6	4	0	0	6	9.54	7.05	0.20	1.36	2.18	9.34	15.6	0.60				315	33.0	5.0	23.0	6.9	15.3
1997																						
1	6	4	0	0	2	1.94	7.09	0.63	8.54	1.87	14.93	25.1	1.10				61	23.0	8.5	42.1	1.7	23.0
2	5	5	0	0	4	6.47	7.00	0.11	1.58	2.76	4.65	45.8	3.14				1026	5.6	4.7	75.1	5.9	7.4
3	6	6	0	0	6	16.20	6.98	0.10	1.58	6.54	7.99	112.5	3.43				1207	31.4	1.9	57.6	5.1	1.4
4	4	4	0	0	3	10.85	7.03	0.35	2.61	5.04	11.51	42.4	1.97				260	36.4	13.9	25.5	6.8	5.0

Table A10 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth and primary production in the upper 10 m (primary production also for the total water column) in the coastal waters of the southern Gulf of Riga (S < 5.0 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec.
n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Southern Gulf of Riga, S < 5 PSU

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	SiO_4 (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m ($mgC*m^{-3}*h^{-1}$)	Prim.prod. water column ($mgC*m^{-2}*d^{-1}$)	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	3	2	0	0	0	0.43	4.55	1.22	31.38	1.53	18.49	28.10	2.55									
2	35	23	3	0	0	5.03	3.86	0.74	30.13	1.98	19.20	45.23	8.57	2.28								
3	27	14	9	0	0	15.55	4.60	0.35	4.06	1.84	9.39	32.80	4.94	2.52								
4	7	7	0	0	0	4.20	4.36	0.92	13.84	2.71	26.98	18.23	3.19									
1994																						
1	8	0	0	0	0	0.34	2.60	1.89	26.86	9.12	69.22	19.00										
2	52	10	27	0	0	4.47	2.93	0.97	17.15	6.11	23.92	40.86	13.58	1.16								
3	74	26	44	15	0	16.48	3.92	0.54	5.74	1.84	11.56	19.21	5.06	2.97		931						
4	29	4	8	3	0	5.66	3.63	1.24	16.60	2.96	22.75	15.17	3.58	2.74		194						
1995																						
1	4	0	0	0	0	0.50	2.62	1.61	27.54	7.68	48.27	21.34										
2	30	13	13	9	0	4.50	3.00	0.77	39.22	1.93	34.76	51.25	14.34	1.58		906						
3	33	17	14	9	0	16.29	3.79	0.49	7.18	1.51	11.18	17.72	6.20	1.88		1038						
4	9	3	1	9	0	5.24	3.27	1.31	19.99	3.04	31.03	17.27	2.27	2.00		269						
1996																						
1	0	0	0	0	0																	
2	19	5	5	12	0	5.91	4.06	0.19	26.67	0.51	11.21	287.47	18.61	2.00		1900						
3	30	17	14	0	0	14.65	4.06	0.51	3.74	1.59	9.24	20.34	6.09	1.83								
4	5	1	1	0	0	8.07	3.62	1.24	16.54	4.14	18.46	16.53	3.60	2.10								
1997																						
1	1	0	0	0	0	0.32	1.69	1.68	58.53		94.17		1.94									
2	24	19	8	3	0	4.44	2.30	0.86	54.49	2.80	48.83	106.20	12.21	1.55		2134						
3	34	26	13	4	0	17.56	3.06	1.09	14.17	2.22	34.74	32.24	2.80	1.74		526						
4	7	0	2	3	0	5.91	2.38	1.26	34.97	3.93	57.06	32.50	4.37	1.65		208						

Table A11 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the open waters of the southern Gulf of Riga (S > 5.0 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec. n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

Southern Gulf of Riga, S > 5 PSU

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	SiO_4 (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
1	7	2	4	0	1	1.52	5.44	1.08	17.90	1.40	7.22	24.05	3.64	3.09			929	0.0	97.2	2.4	0.4	0.0
2	72	53	43	0	11	3.10	5.43	0.62	11.80	0.69	2.23	43.44	5.34	3.67			1930	0.3	32.6	66.6	0.4	0.1
3	55	37	36	1	3	14.98	5.25	0.18	1.41	2.31	4.68	20.87	2.68	3.14	5.11	732	893	74.6	1.6	16.1	7.3	0.5
4	28	18	4	0	4	4.93	5.51	0.68	8.28	0.48	6.71	13.23	3.70	3.64			1833	2.1	93.6	3.2	0.9	0.2
1994																						
1	11	2	11	0	1	1.17	5.62	1.13	7.08	1.15	11.17	7.04	1.04	3.32			1102	4.6	91.8	0.9	2.5	0.2
2	20	1	13	0	0	2.81	5.57	0.39	9.54	0.56	2.19	46.27	4.39	2.03								
3	39	13	28	0	1	13.98	5.19	0.15	1.08	1.83	2.97	22.94	2.81	3.59			1511	96.1	0.0	1.0	2.7	0.2
4	48	13	34	0	0	6.80	5.44	0.83	7.62	0.47	9.88	10.48	2.01	3.64								
1995																						
1	9	0	4	0	0	1.02	5.62	1.14	9.76	0.38	11.47	8.91		3.21								
2	20	6	17	0	2	2.64	5.51	0.69	9.98	0.54	2.37	15.42	8.31	2.69			1659	0.9	13.1	82.0	2.9	1.1
3	52	23	37	1	2	14.17	5.22	0.12	1.29	0.46	3.23	12.70	3.91	2.69	0.65	73	419	68.2	2.8	15.4	3.8	9.8
4	27	11	16	0	2	7.06	5.40	0.41	7.09	0.48	3.99	18.76	2.23	3.20			557	2.4	93.7	2.8	0.6	0.5
1996																						
1	0	0	0	0	0																	
2	22	6	19	0	2	3.61	5.35	0.09	9.05	0.27	1.39	114.48	14.60	2.28			3578	0.1	71.0	26.2	2.4	0.2
3	58	27	51	0	2	13.22	5.28	0.09	0.39	0.56	1.66	22.44	4.08	3.13			273	61.8	14.5	6.0	4.9	12.6
4	15	7	15	0	2	8.55	5.66	0.47	4.54	0.76	4.13	11.48	3.36	3.23			347	44.1	46.9	4.9	2.0	2.1
1997																						
1	6	2	5	0	0	0.47	5.76	1.01	8.50	0.03	9.42	10.60	2.18	2.39								
2	33	19	32	0	4	2.36	5.54	0.46	7.04	0.30	4.33	28.93	6.94	3.25			1384	7.4	3.9	83.5	4.8	0.4
3	66	56	65	0	4	13.80	5.39	0.14	1.47	0.94	4.98	26.42	2.21	3.20			237	25.7	13.1	22.2	1.1	12.8
4	15	0	11	0	0	7.34	5.58	0.56	7.17	0.65	9.55	14.19		3.63								

Table A12 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary production also for the total water column) in the coastal waters of the north-eastern Gulf of Riga (S > 5.0 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec. n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

North-eastern Gulf of Riga, coastal station

Season	n1	n2	n3	n4	n5	emp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	SiO4 (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m ($mgC{*}m^{-3}{*}h^{-1}$)	Prim.prod. water column ($mgC{*}m^{-2}{*}d^{-1}$)	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
2	0	0	0	0	0																	
3	0	1	1	0	1	17,9	5,26						3,50	1,0			30	0,0	25,0	13,3	41,7	1,7
4	0	0	0	0	1	3,6	4,42										190	17,9	0,0	4,2	1,0	72,1
1994																						
2	2	2	2	0	0			0,26	15,10	2,16	7,57	66,4	16,09	1,8								
3	4	4	3	0	0			0,77	0,72	1,81	6,62	3,3	5,19	1,4								
4	2	2	0	0	1	4,5	4,98	1,94	12,60	2,22	12,37	7,6	2,70				30	26,7	10,0	30,0	0,0	20,0
1995																						
2	2	2	0	0	1	10,9	2,58	0,26	32,47	3,07	10,16	136,7	6,48				470	4,5	19,6	24,9	24,9	7,0
3	5	5	3	0	1	19,9	4,93	0,36	3,45	2,46	12,86	16,4	7,03	1,3			810	62,7	5,8	0,7	9,3	21,5
4	4	4	2	0	1			0,88	7,84	0,79	11,84	9,8	2,99	1,1			80	12,5	58,8	7,5	1,2	23,8
1996																						
2	2	2	2	0	1	11,1	4,37	0,68	7,84	2,75	5,57	15,6	7,81	1,4			240	0,0	0,0	51,2	16,3	20,0
3	5	5	3	0	1	18,8	5,01	0,74	1,00	2,62	9,89	4,9	4,05	1,4			80	1,3	15,0	12,5	11,3	53,7
4	1	1	2	0	0			1,64	19,37	0,36	12,80	12,0	2,08	1,5								
1997																						
2	3	3	2	0	2			0,66	10,06	3,57	4,17	20,7	7,55	2,0			275	13,0	11,0	26,4	23,4	4,8
3	7	7	3	7	9	15,9	4,99	0,59	2,86	3,40	7,77	10,6	5,00	2,0	69,3	333,0	321	11,6	13,2	20,4	13,1	13,8
4	2	2	2	1	2	4,7	5,49	1,25	5,23	2,89	13,21	6,5	4,87	2,4	70,1	157,0	155	6,4	7,7	7,8	5,6	45,6

Table A13 Seasonal means of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (primary prod. also for the total water column) in the open waters of the north-eastern Gulf of Riga (S > 5.0 PSU). Seasons: 1=Jan-Feb, 2=Mar-May, 3=June-Sep, 4=Oct-Dec. n1-n5 = number of sampling occasions: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass.

North-eastern Gulf of Riga, open-water stations

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	SiO4 (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m mgC*m^{-3}*h^{-1})	Prim.prod. water column mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
1993																						
2	0	0	0	0	2	10,9	5										3165	9,3	0,4	66,4	16,5	6,5
3	2	2	0	0	5	16,86	5,47	0,01	0,16	0,43		74,0	3,03				323,8	31,2	15,6	6,9	10,2	23,6
4	0	0	0	0	2	5	5,38										95	17,9	0,0	2,8	3,4	63,9
1994																						
2	4	4	4	0	0			0,16	6,18	1,29	1,04	46,7	15,80									
3	9	9	8	0	0			0,28	0,58	1,56	4,23	7,6	3,14	3,0								
4	4	4	0	0	2	5,9	5,29	1,02	3,08	1,85	6,66	4,8	2,53	2,9			180	24,4	55,3	13,2	0,3	7,7
1995																						
2	4	4	0	0	4	4,3	4,56	0,11	2,83	2,51	1,14	48,5	6,15				1690	4,0	37,0	38,7	3,4	2,7
3	12	12	6	0	4	17,13	5,49	2,86	0,92	0,18	0,97	2,1	5,32	2,7			687,3	40,9	8,4	6,6	5,1	19,9
4	7	7	4	0	2	4,75	5,52	0,68	4,50	2,59	6,15	10,4	3,22	1,5			105	8,7	73,8	0,0	4,3	15,7
1996																						
2	4	4	4	0	2	9	4,93	0,33	4,71	1,95	1,05	20,2	9,95	3,4			635	1,7	31,3	42,6	8,8	12,3
3	9	9	6	0	2	18,4	5,36	0,58	0,63	1,76	5,61	4,1	3,57	3,0			405	16,7	61,6	8,3	5,6	5,9
4	1	1	4	0	0			1,21	14,35	0,21	9,89	12,0	1,75	2,8								
1997																						
2	6	6	4	0	4			0,37	3,29	3,03	2,25	17,1	5,43	3,6			890	16,7	10,3	49,5	12,5	2,8
3	13	13	6	14	18	14,1	5,36	0,51	1,04	2,92	6,18	7,8	2,77	3,3	42,4	114,0	267	21,8	31,2	17,0	8,1	10,8
4	4	4	4	2	4	5,18	5,52	0,99	4,88	2,75	10,89	7,7	3,62	2,6	39,8	108,0	125	16,3	48,9	4,8	4,0	20,9

Table A14 Average 1993-1997 of the seasonal means (see Table A1-A13) of water temperature, salinity, nutrient and chlorophyll *a* concentrations, Secchi depth, primary production, phytoplankton wet weight and relative taxonomic composition (Cyanobacteria, Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae) in the upper 10 m (prim. prod. also for the total water column) in the different sea areas. n1- n5 = sum of samples: n1 for nutrients, n2 for Chl.a, n3 for Secchi depth, n4 for primary production, n5 for phytoplankton biomass. Seasons: 1=Jan-Feb, 2=Mar-May, 3= June-Sep, 4= Oct-Dec. From the seasonal means, annual means were calculated, taking the different length of the seasons into account (except for the north-eastern Gulf of Riga, where winter data are missing). For missing winter data in the Gulf of Gdansk, the data from Pomeranian Bay plume were taken (for the calculation of annual means).

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
Arkona Sea																						
1	15	4	4	2	6	2.23	8.11	0.52	4.95	0.32	10.68	10.2	1.13	9.3	0.32	37	146	3.7	18.0	16.7	2.7	21.9
2	31	50	40	16	40	4.45	7.91	0.24	1.56	0.31	8.17	7.3	2.63	9.2	3.29	499	1458	0.7	34.8	44.6	0.1	4.7
3	17	29	21	7	30	18.54	7.50	0.07	0.09	0.23	6.78	9.5	2.24	6.7	4.95	941	609	31.5	12.5	24.0	1.4	8.5
4	15	18	13	5	20	10.85	7.85	0.16	0.34	0.33	8.07	3.3	3.10	7.8	3.21	341	1137	4.4	53.5	19.2	0.4	9.6
Mean						10.38	7.79	0.21	1.33	0.29	8.10	7.5	2.37	8.0	3.33	530	876	12.4	29.3	26.8	1.1	10.1
Bornholm Sea																						
1	15	4	3	1	2	2.78	7.58	0.57	4.46	0.24	12.18	8.2	0.30	15.2	0.67	93	140	0.3	60.8	12.1	0.7	22.4
2	37	48	33	18	23	3.89	7.48	0.33	1.89	0.31	11.46	6.6	3.75	10.5	5.36	702	930	2.2	20.3	57.0	0.3	4.3
3	25	27	23	16	10	17.02	7.26	0.07	0.09	0.32	8.57	10.8	2.02	6.1	6.24	884	415	26.7	11.0	27.0	1.1	16.1
4	18	22	15	9	11	10.07	7.32	0.13	0.62	0.34	5.79	12.3	3.01	9.6	2.55	206	2471	0.1	85.6	9.3	0.1	2.3
Mean						9.63	7.38	0.23	1.40	0.31	9.20	9.7	2.42	9.6	4.17	537	1012	9.5	40.3	27.6	0.6	10.7
Eastern Gotland Sea																						
1	16	3	2	1	2	2.59	7.29	0.55	4.31	0.19	11.54	8.2	0.24	13.8	0.29	39	72	0.0	31.5	24.2	0.0	38.1
2	36	47	29	14	23	3.98	7.27	0.32	2.22	0.31	11.10	5.6	4.00	10.3	7.19	786	1666	1.0	11.6	71.6	0.1	3.0
3	29	42	30	24	24	17.80	7.04	0.04	0.07	0.33	7.64	8.0	2.52	5.7	6.92	999	769	39.3	5.6	29.3	1.5	9.7
4	18	21	17	10	13	8.83	7.04	0.12	0.59	0.52	6.00	7.5	2.92	10.2	1.76	167	903	16.0	38.8	23.6	0.8	8.0
Mean						9.57	7.14	0.22	1.44	0.35	8.75	7.3	2.61	9.3	4.59	578	911	17.4	19.7	37.6	0.7	12.3
Pomeranian Bay, S < 7.3 PSU																						
1	22	18	11	1	2	0.96	6.36	1.36	26.08	11.07	45.57	26.9	1.84	3.1	1.30	104	512	1.7	27.9	1.7	3.6	34.7
2	87	62	29	15	30	7.51	6.22	0.42	32.95	4.26	27.18	266.0	7.97	3.8	6.19	682	1206	0.7	37.1	23.3	5.8	14.6
3	144	110	33	29	69	16.98	5.99	0.64	2.58	1.40	28.80	32.0	17.65	2.7	21.42	2636	8809	35.8	27.2	4.0	14.9	8.0
4	28	15	5	4	6	8.12	6.47	0.86	7.17	3.37	17.05	12.0	5.07	3.5	6.38	357	2744	1.5	75.2	2.9	3.5	2.4
Mean						9.73	6.23	0.76	15.24	4.22	28.25	84.7	9.45	3.2	10.50	1156	4009	12.8	41.8	8.2	7.9	12.7

Table A14 (continued):

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
Pomeranian Bay, S > 7.3 PSU																						
1	25	19	8	1	1	1.22	7.74	0.75	12.99	3.58	19.70	19.8	0.83	3.5	0.40	37	119	0.0	11.8	10.9	29.4	42.9
2	105	80	42	15	32	4.79	7.83	0.29	8.77	0.69	13.56	48.0	4.66	4.9	4.89	489	1515	1.2	42.7	11.2	10.8	18.9
3	104	88	58	18	45	15.80	7.50	0.15	0.21	0.39	11.91	10.1	4.41	5.1	9.48	776	1057	12.1	13.4	16.0	6.4	21.9
4	80	60	24	7	21	9.91	7.76	0.54	1.56	2.01	13.32	15.6	3.56	5.9	6.97	585	1798	3.2	69.5	7.5	1.8	10.6
Mean						9.15	7.69	0.38	4.82	1.40	13.97	22.6	3.66	5.0	6.19	533	1200	5.2	34.5	11.8	10.2	21.8
Gulf of Gdansk, S < 7.0 PSU																						
1	10	0	4	0	0	1.63	5.25	1.23	49.07	14.01	58.43	52.4		3.6								
2	43	18	13	1	9	5.77	5.31	0.74	36.61	3.11	26.07	85.2	13.59	2.7	9.84	874	3054	1.5	38.9	42.8	6.4	3.4
3	82	34	35	11	17	17.08	6.20	0.38	5.05	1.47	15.81	30.4	6.30	2.9	24.16	1340	3925	32.1	23.6	8.2	17.9	9.0
4	13	2	2	1	2	6.24	5.45	1.02	25.43	6.72	49.32	30.2	21.44	7.5	6.12	369	2617	0.8	82.1	0.6	12.4	1.5
Mean						8.97	5.63	0.77	25.37	5.28	33.86	47.7	11.16	4.1	12.26	775	2811	11.6	42.7	13.9	11.3	10.0
Gulf of Gdansk, S > 7.0 PSU																						
1	63	21	18	7	15	2.42	7.37	0.59	6.92	1.38	12.38	15.1	0.87	9.0	0.71	42	70	3.7	37.8	23.0	0.9	20.6
2	56	34	32	16	21	3.58	7.36	0.36	4.22	0.50	8.92	12.2	4.49	8.5	7.28	808	1483	1.2	31.8	43.8	2.6	2.7
3	79	53	45	20	23	15.57	7.16	0.10	0.15	0.65	9.49	23.4	3.12	5.2	7.88	927	1742	40.5	5.0	18.6	6.4	13.1
4	48	11	13	4	6	7.75	7.23	0.35	2.85	1.22	9.34	24.8	2.80	9.9	4.72	148	2498	0.3	94.8	2.2	0.4	1.0
Mean						8.43	7.26	0.31	2.97	0.88	9.79	19.6	3.01	7.8	5.75	555	1588	14.5	39.6	21.5	3.0	8.7
Lithuanian coast, S < 6.8 PSU																						
1	13	13	0	0	2	1.01	6.28	1.03	15.54	2.21	26.25	26.2	1.42				2906	12.3	35.4	38.6	7.5	5.3
2	19	20	6	2	19	7.41	6.06	0.21	7.46	3.41	12.38	104.2	8.97	3.9	6.83	591	7591	2.6	30.3	51.4	11.6	1.8
3	15	15	2	1	14	16.60	5.88	0.31	1.32	4.65	10.22	40.5	5.58	1.3	2.20	195	3157	34.3	11.0	26.0	22.4	2.3
4	11	10	0	0	10	9.26	6.21	0.58	3.84	4.60	14.31	32.6	3.61				1261	16.0	49.5	19.4	10.5	4.1
Mean						9.87	6.07	0.47	5.86	3.92	14.46	52.0	5.24	2.6	4.52	393	3750	18.1	29.5	32.8	14.2	3.1
Lithuanian coast, S > 6.8 PSU																						
1	23	15	0	0	5	1.88	7.19	0.73	6.95	1.75	14.22	20.3	0.81				79	10.4	6.3	53.6	4.8	22.9
2	35	29	15	3	32	6.35	7.14	0.15	2.33	2.03	7.97	62.3	2.76	9.2	5.77	474	1970	1.5	13.1	77.9	1.5	2.7
3	70	68	34	4	44	16.22	7.02	0.09	0.86	2.53	11.05	53.7	2.45	5.3	5.12	672	616	35.2	4.8	40.9	3.4	3.8
4	29	27	0	0	28	10.07	7.12	0.30	1.68	2.87	8.43	19.2	2.27				361	22.6	33.9	22.8	6.0	6.6
Mean						9.83	7.11	0.27	2.45	2.36	10.15	41.7	2.21	7.2	5.44	573	801	19.5	14.4	47.7	3.8	7.4

Table A14 (continued):

Season	n1	n2	n3	n4	n5	Temp. (°C)	Sal. (PSU)	PO_4 (mmol m^{-3})	NO_{2+3} (mmol m^{-3})	NH_4 (mmol m^{-3})	Si (mmol m^{-3})	N/P	Chl.a (mg m^{-3})	Secchi depth (m)	Prim.prod. 0-10 m (mgC*m^{-3}*h^{-1})	Prim.prod. water column (mgC*m^{-2}*d^{-1})	Phyto. total (mg m^{-3})	Cya. (%)	Bac. (%)	Din. (%)	Chl. (%)	Cryp. (%)
Southern Gulf of Riga, stations with Sal < 5.0 PSU																						
1	13	2	0	0	0	0.40	2.87	1.60	36.08	6.11	57.54	22.8	2.25									
2	107	52	56	24	0	4.87	3.23	0.71	33.53	2.67	27.58	106.2	13.46	1.7		1647						
3	126	78	94	28	0	16.11	3.89	0.60	6.98	1.80	15.22	24.5	5.02	2.2		832						
4	38	9	12	15	0	5.82	3.45	1.19	20.39	3.36	31.26	19.9	3.40	2.1		224						
Mean						8.11	3.44	0.94	21.82	3.12	32.90	43.4	6.03	2.0		745						
Southern Gulf of Riga, stations with Sal > 5.0 PSU																						
1	18	5	24	0	2	1.05	5.61	1.09	10.81	0.74	9.82	12.7	2.29	3.0			1016	2.3	94.5	1.7	1.4	0.1
2	44	20	125	0	19	2.90	5.48	0.45	9.48	0.47	2.50	49.7	7.92	2.8			2138	2.2	30.2	64.6	2.6	0.4
3	124	99	217	0	12	14.03	5.27	0.14	1.13	1.22	3.50	21.1	3.14	3.2			667	65.3	6.4	12.2	4.0	7.2
4	64	26	80	0	8	6.94	5.52	0.59	6.94	0.57	6.85	13.6	2.83	3.5			912	16.2	78.0	3.6	1.2	0.9
Mean						7.31	5.44	0.49	6.28	0.79	5.14	25.0	4.11	3.1			1154	26.7	44.9	21.4	2.5	2.8
North-eastern Gulf of Riga, coastal station																						
2	9	9	6	0	4			0.47	16.37	2.89	6.87	59.8	9.48	1.7			328	5.8	10.2	34.2	21.5	10.6
3	21	21	12	0	13			0.62	2.01	2.57	9.29	8.8	5.32	1.5			310	18.9	14.8	11.7	18.9	22.7
4	9	9	6	0	5			1.43	11.26	1.57	12.56	9.0	3.16	1.7			114	15.9	19.1	12.4	2.0	40.4
Mean								0.84	9.88	2.34	9.57	25.9	5.99	1.6			251	13.5	14.7	19.4	14.1	24.5
North-eastern Gulf of Riga, open water stations																						
2	18	18	12	0	12			0.24	4.25	2.20	1.37	33.1	9.33	3.5			1595	7.9	19.8	49.3	10.3	6.1
3	45	45	26	0	29	17.00	5.48	0.85	0.66	1.37	4.25	19.1	3.57	3.0			421	27.7	29.2	9.7	7.3	15.1
4	16	16	12	0	10			0.98	6.70	1.85	8.40	8.7	2.78	2.5			126	16.8	44.5	5.2	3.0	27.1
Mean								0.69	3.87	1.80	4.67	20.3	5.23	3.0			714	17.5	31.1	21.4	6.9	16.1

Table A15: The 8 most important phytoplankton species (by biomass) in the different seasons and years in the Arkona Sea. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
1993					
Chaetoceros cf. debilis	4	Aphanizomenon sp.	3	Prorocentrum minimum	2
Skeletonema costatum	2	Gymnodinium cf. lohmannii	2	Actinocyclus octonarius	2
Gymnodinium cf. lohmannii	1	Gymnodinium cf. arcticum	2	Rhodomonas minuta	2
Gymnodinium cf. arcticum	1	Nodularia spumigena	1	Heterocapsa rotundata	1
Peridiniella catenata	1	Rhodomonas minuta	1	Coscinodiscus granii	1
Thalassiosira levanderi	1	Microcystis reinboldii	1	Pyramimonas sp.	1
Thalassiosira baltica	1	Heterocapsa rotundata	1	Gymnodinium cf. arcticum	1
Heterocapsa rotundata	1	Protoperidinium sp.	1	Ceratium tripos	1
1994					
Thalassiosira levanderi	2	Prorocentrum minimum	3	Coscinodiscus granii	4
Thalassiosira baltica	2	Dactyliosolen fragilissimus	2	Teleaulax amphioxeia	1
Skeletonema costatum	2	Phacus sp.	2	Eutreptiella sp.	1
Peridiniella catenata	1	Eutreptiella sp.	2	Plagioselmis prolonga	1
Gymnodinium cf. lohmannii	1	Aphanizomenon sp.	1	Gymnodinium cf. lohmannii	1
Protoperidinium sp.	1	Plagioselmis prolonga	1	Prorocentrum minimum	1
Pyramimonas sp.	1	Teleaulax amphioxeia	1	Actinocyclus octonarius	1
Actinocyclus octonarius	1	Gymnodinium albulum	1	Aphanizomenon sp.	1
1995					
Skeletonema costatum	4	Aphanizomenon sp.	2	Coscinodiscus granii	5
Phacus sp.	1	Phacus sp.	2	Ceratium tripos	1
Thalassiosira baltica	1	Gymnodinium cf. lohmannii	2	Eutreptiella sp.	1
Gymnodinium cf. lohmannii	1	Coscinodiscus granii	1	Teleaulax amphioxeia	1
Thalassiosira levanderi	1	Nodularia spumigena	1	Gymnodinium cf. lohmannii	1
Scrippsiella hangoei	1	Eutreptiella sp.	1	Pyramimonas sp.	0
Peridiniella catenata	1	Pyramimonas sp.	1	Plagioselmis prolonga	0
Heterocapsa rotundata	1	Plagioselmis prolonga	1	Phacus sp.	0
1996					
Gymnodinium cf. lohmannii	2	Nodularia spumigena	3	Nodularia spumigena	2
Thalassiosira levanderi	2	Aphanizomenon sp.	2	Teleaulax amphioxeia	1
Peridiniella catenata	2	Eutreptiella sp.	1	Eutreptiella sp.	1
Melosira nummuloides	1	Plagioselmis prolonga	1	Aphanizomenon sp.	1
Skeletonema costatum	1	Phacus sp.	1	Pyramimonas sp.	1
Gymnodinium sp.	1	Protoperidinium sp.	1	Gymnodinium cf. lohmannii	1
Scrippsiella hangoei	1	Teleaulax amphioxeia	1	Plagioselmis prolonga	1
Thalassiosira baltica	1	Anabaena sp.	1	Phacus sp.	1
1997					
Thalassiosira levanderi	2	Aphanizomenon sp.	2	Gymnodinium cf. lohmannii	4
Achnanthes taeniata	2	Gymnodinium cf. lohmannii	2	Coscinodiscus granii	3
Gymnodinium cf. lohmannii	2	Ceratium tripos	1	Pyramimonas sp.	1
Peridiniella catenata	1	Gymnodinium sp.	1	Plagioselmis prolonga	1
Phacus sp.	1	Phacus sp.	1	Teleaulax amphioxeia	1
Skeletonema costatum	1	Prorocentrum minimum	1	Ceratium tripos	0
Teleaulax amphioxeia	1	Plagioselmis prolonga	1	Eutreptiella sp.	0
Heterocapsa rotundata	1	Eutreptiella sp.	1	Ebria tripartita	0

Table A16: The 8 most important phytoplankton species (by biomass) in the different seasons and years in the Bornholm Sea. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
1993					
Coscinodiscus sp.	3	Rhodomonas minuta	2	Actinocyclus octonarius	3
Chaetoceros cf. debilis	3	Gymnodinium cf. arcticum	2	Coscinodiscus granii	3
Skeletonema costatum	1	Aphanizomenon sp.	2	Rhodomonas minuta	1
Gymnodinium cf. lohmannii	1	Gymnodinium cf. lohmannii	1	Prorocentrum minimum	1
Gymnodinium cf. arcticum	1	Microcystis reinboldii	1	Gymnodinium cf. arcticum	1
Peridiniella catenata	1	Nodularia spumigena	1	Thalassiosira baltica	1
Thalassiosira levanderi	1	Pyramimonas sp.	1	Heterocapsa rotundata	0
Thalassiosira baltica	1	Eutreptiella sp.	1	Pyramimonas sp.	0
1994					
Peridiniella catenata	5	Plagioselmis prolonga	3	Coscinodiscus granii	5
Gymnodinium cf. lohmannii	1	Aphanizomenon sp.	2	Gymnodinium cf. lohmannii	1
Protoperidinium sp.	1	Pyramimonas sp.	2	Eutreptiella sp.	1
Skeletonema costatum	1	Actinocyclus octonarius	1	Actinocyclus octonarius	1
Thalassiosira levanderi	0	Teleaulax amphioxeia	1	Teleaulax amphioxeia	1
Actinocyclus octonarius	0	Thalassiosira levanderi	1	Plagioselmis prolonga	0
Dinophysis norvegica	0	Gymnodinium albulum	1	Prorocentrum minimum	0
Thalassiosira baltica	0	Amphidinium sp.	1	Dinophysis norvegica	0
1995					
Gymnodinium cf. lohmannii	3	Gymnodinium sp.	3	Coscinodiscus granii	5
Peridiniella catenata	2	Aphanizomenon sp.	3	Gymnodinium cf. lohmannii	1
Protoperidinium sp.	1	Gymnodinium cf. lohmannii	1	Actinocyclus octonarius	0
Thalassiosira levanderi	1	Plagioselmis prolonga	1	Eutreptiella sp.	0
Dinophysis norvegica	1	Teleaulax amphioxeia	1	Teleaulax amphioxeia	0
Phacus sp.	1	Eutreptiella sp.	1	Plagioselmis prolonga	0
Skeletonema costatum	1	Nodularia spumigena	1	Phacus sp.	0
Gymnodinium westificii	1	Dinophysis norvegica	1	Gymnodinium cf. arcticum	0
1996					
Peridiniella catenata	5	Aphanizomenon sp.	2		
Gymnodinium cf. lohmannii	1	Nodularia spumigena	2		
Glenodinium sp.	1	Gymnodinium cf. lohmannii	1		
Thalassiosira baltica	1	Pyramimonas sp.	1		
Scrippsiella hangoei	0	Thalassiosira baltica	1		
Gymnodinium albulum	0	Protoperidinium sp.	1		
Heterocapsa rotundata	0	Eutreptiella sp.	1		
Teleaulax amphioxeia	0	Plagioselmis prolonga	1		
1997					
Peridiniella catenata	3	Gymnodinium sp.	2	Gymnodinium cf. lohmannii	4
Gymnodinium cf. lohmannii	2	Chaetoceros danicus	2	Coscinodiscus granii	2
Heterocapsa rotundata	1	Gymnodinium cf. lohmannii	1	Teleaulax acuta	1
Scrippsiella hangoei	1	Aphanizomenon sp.	1	Prorocentrum minimum	1
Teleaulax amphioxeia	1	Nodularia spumigena	1	Plagioselmis prolonga	1
Aphanizomenon sp.	1	Phacus sp.	1	Pyramimonas sp.	1
Thalassiosira levanderi	1	Plagioselmis prolonga	1	Eutreptiella sp.	1
Glenodinium sp.	1	Pyramimonas sp.	1	Teleaulax amphioxeia	0

Table A17: The 8 most important phytoplankton species (by biomass) in the different seasons and years in the Eastern Gotland Sea. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
1993					
Peridiniella catenata	2	Microcystis reinboldii	2	Coscinodiscus granii	5
Gymnodinium cf. arcticum	1	Aphanizomenon sp.	2	Gymnodinium cf. lohmannii	1
Gymnodinium cf. lohmannii	1	Gymnodinium cf. arcticum	2	Gymnodinium cf. arcticum	1
Pyraminonas sp.	1	Nodularia spumigena	1	Actinocyclus octonarius	1
Heterocapsa rotundata	1	Rhodomonas minuta	1	Rhodomonas minuta	1
Protoperidinium longispinum	1	Gymnodinium cf. lohmannii	1	Eutreptiella sp.	1
Protoperidinium sp.	1	Pyraminonas sp.	1	Dinophysis norvegica	1
Dinophysis baltica	1	Coelosphaerium kuetzingianum	1	Nodularia spumigena	0
1994					
Peridiniella catenata	4	Nodularia spumigena	3	Coscinodiscus granii	5
Protoperidinium sp.	1	Gymnodinium sp.	3	Dinophysis norvegica	1
Gymnodinium cf. lohmannii	1	Plagioselmis prolonga	2	Gymnodinium cf. lohmannii	1
Glenodinium sp.	1	Pyramimonas sp.	1	Teleaulax amphioxeia	1
Dinophysis norvegica	1	Teleaulax amphioxeia	1	Aphanizomenon sp.	1
Dinophysis acuminata	0	Aphanizomenon sp.	1	Pyramimonas sp.	1
Actinocyclus octonarius	0	Amphora coffeaeformis	1	Eutreptiella sp.	1
Phacus sp.	0	Thalassiosira levanderi	0	Plagioselmis prolonga	0
1995					
Peridiniella catenata	4	Aphanizomenon sp.	2	Coscinodiscus granii	3
Gymnodinium cf. lohmannii	2	Phacus sp.	2	Woronichinia compacta	1
Glenodinium sp.	1	Gymnodinium cf. lohmannii	2	Gymnodinium cf. lohmannii	1
Scrippsiella hangoei	1	Protoperidinium sp.	1	Eutreptiella sp.	1
Protoperidinium sp.	1	Pyraminonas sp.	1	Teleaulax amphioxeia	1
Eutreptiella sp.	0	Thalassiosira levanderi	1	Aphanizomenon sp.	1
Dinophysis norvegica	0	Nodularia spumigena	1	Woronichinia naegeliana	1
Thalassiosira baltica	0	Gymnodinium albulum	1	Actinocyclus octonarius	1
1996					
Peridiniella catenata	4	Nodularia spumigena	2	Aphanizomenon sp.	2
Gymnodinium cf. lohmannii	2	Gymnodinium cf. lohmannii	2	Nodularia spumigena	2
Glenodinium sp.	1	Aphanizomenon sp.	1	Plagioselmis prolonga	1
Thalassiosira levanderi	1	Protoperidinium sp.	1	Gymnodinium westificii	1
Thalassiosira baltica	1	Phacus sp.	1	Teleaulax amphioxeia	1
Scrippsiella hangoei	1	Eutreptiella sp.	1	Heterocapsa rotundata	1
Heterocapsa rotundata	0	Plagioselmis prolonga	1	Protoperidinium sp.	1
Skeletonema costatum	0	Thalassiosira levanderi	1	Pyraminonas sp.	1
1997					
Peridiniella catenata	4	Aphanizomenon sp.	2	Gymnodinium cf. lohmannii	2
Gymnodinium cf. lohmannii	2	Nodularia spumigena	2	Prorocentrum minimum	2
Gymnodinium sp.	1	Gymnodinium cf. lohmannii	2	Aphanizomenon sp.	2
Thalassiosira baltica	1	Protoperidinium sp.	1	Pyramimonas sp.	1
Scrippsiella hangoei	1	Plagioselmis prolonga	1	Teleaulax acuta	1
Dinophysis norvegica	0	Gymnodinium albulum	1	Dinophysis norvegica	1
Glenodinium sp.	0	Thalassiosira levanderi	1	Teleaulax amphioxeia	1
Phacus sp.	0	Pyramimonas sp.	1	Ebria tripartita	1

Table A18: The 8 most important phytoplankton species (by biomass) in the different seasons and years in the coastal area (S< 7.3 PSU) of Pomeranian Bay. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
1993					
Gymnodinium cf. lohmannii	2			Rhodomonas minuta	3
Chaetoceros wighamii	2			Oscillatoria sp.	2
Gymnodinium albulum	2			Prorocentrum minimum	2
Protoperidinium longispinum	2			Anabaena sp.	2
Ebria tripartita	1			Dinophysis norvegica	1
Heterocapsa rotundata	1			Pediastrum boryanum	1
Rhodomonas minuta	1			Coscinodiscus granii	1
Pediastrum boryanum	0			Dinophysis cf. arctica	1
1994					
Diatoma elongatum	3				
Skeletonema costatum	2				
Pediastrum spp.	2				
Thalassiosira baltica	1				
Actinocyclus octonarius	1				
Leptocylindrus danicus	1				
Coelastrum microporum	1				
Scenedesmus spp.	1				
1995					
		Planktothrix agardhii	3	Coscinodiscus granii	3
		Coscinodiscus granii	2	Planktothrix agardhii	2
		Pseudanabaena limnetica	2	Pediastrum boryanum	1
		Plagioselmis prolonga	1	Eutreptiella sp.	1
		Monoraphidium sp.	1	Planktolyngbya subtilis	1
		Gymnodinium cf. lohmannii	1	Woronichinia compacta	1
		Teleaulax amphioxeia	1	Anabaena sp.	1
		Distephanus speculum	1	Scenedesmus spp.	1
1996					
Diatoma elongatum	3	Cryptophyceae	2		
Thalassiosira sp.	2	Coscinodiscus granii + C. sp.	2		
Skeletonema costatum	2	Cylindrotheca closterium	1		
Ebria tripartita	2	Actinocyclus octonarius + "other centrales"	1		
Dinobryon sp. + "other flagellates"	1	Pyramimonas spp.	1		
Melosira arctica	1	Nodularia spumigena	1		
Chaetoceros spp. (5-15 µm)	1	Aphanizomenon sp.	1		
Myrionecta rubra	1	Heterocapsa rotundata	1		
1997					
Cryptophyceae	3			Actinocyclus octonarius	4
Heterocapsa rotundata	2			Coscinodiscus granii + C. sp.	2
Pyramimonas sp.	1			Cryptophyceae	1
Skeletonema costatum	1			Myrionecta rubra	1
Nodularia spumigena	1			Heterocapsa rotundata	0
Myrionecta rubra	1			Prorocentrum minimum	0
Asterionella formosa + Diatoma tenuis	1			Eutreptiella gymnastica	0
Actinocyclus octonarius + "other centrales"	1				

Table A19: **The 8 most important phytoplankton species (by biomass) in the different seasons and years in open Pomeranian Bay (S > 7.3 PSU). The number behind the species indicates the biomass rank, explained on page 34.**

Spring		Summer		Autumn	
1993					
Skeletonema costatum	3	Cryptophyceae	2	Prorocentrum minimum	3
Thalassiosira levanderi	3	Eutreptiella sp.	2	Cryptophyceae	2
Melosira arctica	1	Pyramimonas sp.	1	Coscinodiscus granii + Actinocyclus octonarius	2
Thalassiosira baltica	1	Heterocapsa rotundata	1	Snowella spp.	1
Rhodomonas minuta	1	Gymnodinium sp.	1	Heterocapsa rotundata	1
Melosira nummuloides	1	Ebria tripartita	1	Pyramimonas spp.	1
Pediastrum boryanum	1	Aphanizomenon sp.	1	Myrionecta rubra	1
Heterocapsa rotundata	0	Peridiniella catenata	1	Skeletonema subsalsum	1
1994					
Cryptophyceae	3	Glenodinium sp.	3	Coscinodiscus granii	5
Thalassiosira levanderi	2	Thalassiosira levanderi	2	Gymnodinium cf. lohmannii	1
Thalassiosira baltica	1	Microcystis sp.	1	Pediastrum boryanum	1
Protoperidinium sp.	1	Anabaena sp.	1	Eutreptiella sp.	1
Skeletonema costatum	1	Plagioselmis prolonga	1	Phacus sp.	0
Heterocapsa rotundata	1	Pyramimonas sp.	1	Teleaulax amphioxeia	0
Nitzschia delicatissima	0	Protoperidinium sp.	1	Woronichinia compacta	0
		Eutreptiella sp.	1	Skeletonema subsalsum	0
1995					
Pediastrum kawraiskyi	3	Coscinodiscus granii	3		
Phacus sp.	2	Phacus sp.	2		
Skeletonema costatum	2	Eutreptiella sp.	2		
Heterocapsa rotundata	2	Plagioselmis prolonga	2		
Teleaulax amphioxeia	1	Teleaulax amphioxeia	1		
Synedra sp.	1	Woronichinia compacta	1		
Pyramimonas sp.	1	Monoraphidium sp.	1		
Diatoma elongatum	1	Scrippsiella hangoei	1		
1996					
Thalassiosira sp.	3	Cryptophyceae	3		
Skeletonema costatum	2	Aphanizomenon sp.	2		
Cryptophyceae	1	Pyramimonas spp.	1		
Myrionecta rubra	1	Nodularia spumigena	1		
Dinophysis norvegica	1	Coscinodiscus granii + C. sp.	1		
Melosira arctica	1	Heterocapsa rotundata	1		
Peridiniella catenata	1	Eutreptiella gymnastica	1		
Rhizosolenia hebetata	1	Dinophysis norvegica	0		
1997					
Cryptophyceae	3			Coscinodiscus granii + C. sp.	5
Pyramimonas spp.	1			Cryptophyceae	2
Heterocapsa rotundata	1			Ceratium tripos	1
Coscinodiscus granii + C. sp.	1			Myrionecta rubra	1
Aphanizomenon sp.	1			Pyramimonas sp.	1
Myrionecta rubra	1			Prorocentrum minimum	0
Dinophysis acuminata	1			Eutreptiella gymnastica	0
Dinophysis norvegica	1			Actinocyclus octonarius	0

Table A20: The 8 most important phytoplankton species (by biomass) in the different seasons and years in coastal waters (S < 7.0 PSU) of the Gulf of Gdansk. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
		1993			
		Aphanizomenon sp.	3		
		Heterocapsa triquetra	2		
		Cyclotella sp.	1		
		Microcystis reinboldii	1		
		Rhodomonas minuta	1		
		Coelastrum microporum	1		
		Dinophysis norvegica	1		
		Nodularia spumigena	1		
		1994			
Centrales	3	Oocystis sp.	2	Coscinodiscus granii	3
Peridiniella catenata	3	Heterocapsa triquetra	2	other centrales	2
Myrionecta rubra	2	Aphanothecoideae	2	Oocystis sp.	2
Asterionella sp.	1	Aphanizomenon sp.	1	Dictyosphaerium sp.	1
Gymnodiniales	1	Nodularia spumigena	1	Pediastrum sp.	1
Aulacoseira granulata	1	Anabaena sp.	1	other Chlorophyceae	1
Eutreptiella gymnastica	1	Skeletonema costatum	1	Cryptophyceae	1
Scenedesmus quadricauda	0	Coscinodiscus granii	1	Scenedesmus spp.	1
		1995			
		Aphanizomenon sp.	2		
		Snowella septentrionalis	2		
		Dictyosphaerium sp.	2		
		Nodularia spumigena	1		
		Ebria tripartita	1		
		Coelastrum microporum	1		
		Eutreptiella sp.	1		
		Prorocentrum minimum	1		
		1996			
		Thalassiosira spp. + Actinocyclus octonarius	4		
		Aulacoseira granulata	1		
		Skeletonema costatum	1		
		Dinophysis norvegica	1		
		Scenedesmus acutus + S. acuminatus	1		
		other Scenedesmus spp.	1		
		other Chlorophyceae	1		
		Cryptophyceae	1		
		1997			
Peridiniella catenata	3				
Myrionecta rubra	2				
Centrales 5-20 µm	1				
Pyramimonas spp.	1				
Cryptophyceae	1				
other Dinophyceae	1				
Dinophysis acuminata	1				
Heterocapsa rotundata	1				

Table A21: **The 8 most important phytoplankton species (by biomass) in the different seasons and years in open Gulf of Gdansk (S > 7.0 PSU). The number behind the species indicates the biomass rank, explained on page 34.**

Spring		Summer		Autumn	
1993					
Peridiniella catenata	2	Microcystis reinboldii	2	Coscinodiscus granii	4
Gymnodinium cf. lohmannii	1	Gymnodinium cf. arcticum	2	Prorocentrum minimum	2
Protoperidinium sp.	1	Aphanizomenon sp.	2	Gymnodinium cf. lohmannii	1
Gymnodinium cf. arcticum	1	Rhodomonas minuta	2	Rhodomonas minuta	1
Skeletonema costatum	1	Gymnodinium cf. lohmannii	1	Gymnodinium cf. arcticum	1
Heterocapsa rotundata	1	Coelosphaerium kuetzingianum	1	Pyramimonas sp.	0
Dinophysis acuta	0	Thalassiosira levanderi	1	Eutreptiella sp.	0
Aphanizomenon sp.	0	Nodularia spumigena	1	Heterocapsa rotundata	0
1994					
Peridiniella catenata	4	Aphanothecoideae	2	Coscinodiscus granii	5
Myrionecta rubra	2	Nodularia spumigena	2	Teleaulax amphioxeia	1
Chaetoceros spp. 5-10 µm	2	Aphanizomenon sp.	1	Eutreptiella sp.	0
other Centrales	2	Oocystis sp.	1	Dinophysis norvegica	0
Skeletonema costatum	1	Anabaena sp.	1	Plagioselmis prolonga	0
Cryptophyceae	1	Cryptophyceae	1	Protoperidinium sp.	0
"Scrippsiella sp."	1	Heterocapsa triquetra	1	Chaetoceros danicus	0
Melosira arctica	1	Pyramimonas sp.	1	Actinocyclus octonarius	0
1995					
		Aphanizomenon sp.	3	Coscinodiscus granii	5
		Plagioselmis prolonga	2	Gymnodinium cf. lohmannii	1
		Thalassiosira levanderi	1	Prorocentrum minimum	0
		Woronichinia compacta	1	Actinocyclus octonarius	0
		Teleaulax amphioxeia	1	Eutreptiella sp.	0
		Gymnodinium albulum	1	Teleaulax amphioxeia	0
		Prorocentrum minimum	1	Dinophysis norvegica	0
		Woronichinia naegeliana	1	Woronichinia compacta	0
1996					
Peridiniella catenata	3	Nodularia spumigena	2		
Skeletonema costatum	2	Thalassiosira levanderi	2		
Gyrodinium sp.	0	Aphanizomenon sp.	1		
Ebria tripartita	0	Dinophysis norvegica	1		
Plagioselmis prolonga	0	Plagioselmis prolonga	1		
Gymnodinium sp.	0	Teleaulax amphioxeia	1		
Aphanizomenon sp.	0	Eutreptiella sp.	1		
Gymnodinium albulum	0	Coelosphaerium kuetzingianum	1		
1997					
Peridiniella catenata	3	Glenodinium sp.	2		
Myrionecta rubra	2	Nodularia spumigena	2		
Cryptophyceae	1	Dictyosphaerium sp.	1		
Heterocapsa rotundata	1	Thalassiosira levanderi	1		
Asterionella formosa + Diatoma tenuis	1	Aphanizomenon sp.	1		
Fragilaria crotonensis	1	Phacus sp.	1		
Heterocapsa rotundata	1	Pediastrum sp.	1		
Pyramimonas sp.	1	Pseudolyngbya limnetica	1		

Table A22: The 8 most important phytoplankton species (by biomass) in the different seasons and years in coastal waters (S < 6.8 PSU) off the Lithuanian coast. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
1993					
Peridiniella catenata	5	Planktonema lauterbornii	3	Stephanodiscus hantzschii	3
Protoperidinium brevipes	1	Pediastrum boryanum	2	Stephanodiscus rotula + S. neoastraea	2
Stephanodiscus hantzschii	1	Snowella lacustris	1	Pediastrum boryanum	2
Melosira sp.	0	Microcystis aeruginosa	1	Planktonema lauterbornii	1
Pediastrum boryanum	0	Coelosphaerium kuetzingianum	1	Thalassiosira baltica	1
Thalassiosira baltica	0	Zygabikodinium lenticulatum	1	Skeletonema subsalsum	1
Diatoma tenuis	0	Thalassiosira spp. d=12 µm	1	Microcystis aeruginosa	1
Stephanodiscus rotula	0	Actinocyclus normanii f. subsalsa	1	Aphanizomenon sp.	1
1994					
Peridiniella catenata	5	Aphanizomenon sp.	2	Stephanodiscus hantzschii	4
Stephanodiscus hantzschii	1	Nodularia spumigena	2	Aphanizomenon sp.	2
Flagellata gen. spp.	0	Dinophysis norvegica	2	Stephanodiscus rotula + S. neoastraea	1
Zygabikodinium lenticulatum	0	Pediastrum duplex	1	Coscinodiscus granii	1
Stephanodiscus rotula	0	Coscinodiscus granii	1	Cyclostephanos dubius	0
Protoperidinium brevipes	0	Snowella lacustris	1	Pediastrum boryanum	0
Pediastrum boryanum	0	Dinophysis acuminata	1	Actinocyclus octonarius	0
Snowella lacustris	0	Heterocapsa triquetra	1	Scenedesmus quadricauda	0
1995					
		Heterocapsa triquetra	3	Prorocentrum minimum	3
		Aphanizomenon sp.	2	Aphanizomenon sp.	3
		Flagellata gen. spp.	1	Actinocyclus normanii f. subsalsa	1
		Zygabikodinium lenticulatum	1	Dictyosphaerium pulchellum	1
		Snowella lacustris	1	Stephanodiscus rotula	1
		Oocystis lacustris	1	Coelomoron pusillum	1
		Microcystis aeruginosa	1	Snowella lacustris	1
		Aphanocapsa spp.	1	Stephanodiscus hantzschii	1
1996					
Stephanodiscus hantzschii	4	Aphanizomenon sp.	3	Skeletonema costatum	3
Dictyosphaerium pulchellum	2	Anabaena spiroides	2	Stephanodiscus hantzschii	2
Peridiniella catenata	1	Nodularia spumigena	1	Dictyosphaerium pulchellum	1
Diatoma tenuis	1	Heterocapsa triquetra	1	Dictyosphaerium elegans	1
Zygabikodinium lenticulatum	1	Pediastrum boryanum	1	Pediastrum boryanum	1
Gymnodinium sp.	1	Zygabikodinium lenticulatum	1	Aphanizomenon sp.	1
Aphanizomenon sp.	0	Pediastrum duplex	1	Woronichinia compacta	1
Heterocapsa rotundata	0	Stephanodiscus binderanus	1	Diatoma tenuis	1
1997					
Dictyosphaerium pulchellum	2	Dictyosphaerium pulchellum	3	Aphanizomenon sp.	4
Gyrodinium sp.	2	Hetrocapsa triquetra	3	Skeletonema subsalsum	1
Diatoma tenuis	1	Aphanizomenon sp.	2	Stephanodiscus rotula	1
Peridiniella catenata	1	Planktothrix agardhii	1	Dictyosphaerium pulchellum	1
Chaetoceros wighamii	1	Anabaena flos-aquae	1	Stephanodiscus hantzschii	1
Pediastrum boryanum	1	Woronichinia compacta	1	Oocystis borgei	1
Zygabikodinium lenticulatum	1	? Scrippsiella hangoei	1	Oocystis lacustris	1
Stephanodiscus rotula + S. neoastraea	1	Snowella lacustris	1	Pediastrum boryanum	1

Table A23: **The 8 most important phytoplankton species (by biomass) in the different seasons and years in open waters (S > 6.8 PSU) off the Lithuanian coast. The number behind the species indicates the biomass rank, explained on page 34.**

Spring		Summer		Autumn	
1993					
Peridiniella catenata	5	Coelosphaerium kuetzingianum	2	Coscinodiscus granii	4
Protoperidinium brevipes	2	Nodularia spumigena	2	Coelosphaerium kuetzingianum	2
Zygabikodinium lenticulatum	1	Aphanizomenon sp.	2	Actinocyclus normanii f. subsalsa	1
Dinophysis acuminata	1	Coelomoron pusillum	2	Eutreptiella spp.	1
Gonyaulax verior	0	Cyclotella ? choctawhatcheana	1	Pediastrum boryanum	1
Snowella lacustris	0	Thalassiosira spp. d=12	1	Planktonema lauterbornii	1
Heterocapsa triquetra	0	Oocystis lacustris	1	Stephanodiscus hantzschii	1
Gymnodinium simplex	0	Eutreptiella spp.	1	Snowella lacustris	1
1994					
Peridiniella catenata	5	Aphanizomenon sp.	3	Coscinodiscus granii	5
Chaetoceros wighamii	1	Nodularia spumigena	2	Dinophysis norvegica	1
Zygabikodinium lenticulatum	1	Heterocapsa triquetra	1	Dinophysis acuminata	1
Skeletonema costatum	0	Dinophysis norvegica	1	Protoperidinium pellucidum	1
Flagellata gen. spp.	0	Flagellata gen. spp.	1	Cryptomonadales	1
Stephanodiscus hantzschii	0	Eutreptiella spp.	1	Zygabikodinium lenticulatum	1
Protoperidinium brevipes	0	Protoperidinium brevipes	1	Snowella lacustris	1
Gonyaulax verior	0	Zygabikodinium lenticulatum	1	Teleaulax spp.	1
1995					
		Heterocapsa triquetra	2	Prorocentrum minimum	3
		Flagellata gen. spp.	2	Coelomoron pusillum	2
		Aphanizomenon sp.	2	Teleaulax spp.	1
		Zygabikodinium lenticulatum	1	Flagellata gen. spp.	1
		Coelomoron pusillum	1	Gyrodinium ? spirale	1
		Snowella lacustris	1	Oocystis lacustris	1
		Nodularia spumigena	1	Cryptomonadales	1
		Cryptomonadales	1	Snowella lacustris	1
1996					
Peridiniella catenata	3	Heterocapsa triquetra	3	Aphanizomenon sp.	3
Stephanodiscus hantzschii	2	Aphanizomenon sp	2	Gyrodinium ? spirale	2
Gyrodinium ? spirale	2	Nodularia spumigena	1	Snowella lacustris	1
Protoperidinium brevipes	1	Flagellata gen. spp.	1	Teleaulax spp.	1
Dinobryon balticum	1	Cryptomonadales	1	Dinophysis acuta	1
Zygabikodinium lenticulatum	1	Zygabikodinium lenticulatum	1	Coelomoron pusillum	1
Teleaulax spp.	0	Chrysochromulina spp.	1	Coelosphaerium kuetzingianum	1
Dictyosphaerium pulchellum	0	Teleaulax spp.	1	Oocystis lacustris	1
1997					
Peridiniella catenata	5	Heterocapsa triquetra	3	Aphanizomenon sp.	3
Gonyaulax verior	1	Nodularia spumigena	3	Heterocapsa triquetra	2
? Scrippsiella hangoei	1	Aphanizomenon sp.	1	Teleaulax spp.	1
Protoperidinium brevipes	0	Planktothrix agardhii	1	Prorocentrum minimum	1
Katodinium rotundatum	0	Zygabikodinium lenticulatum	1	Eutreptiella spp.	1
Dinophysis acuminata	0	Gyrodinium ? spirale	1	Snowella lacustris	1
Prorocentrum balticum	0	? Scrippsiella hangoei	1	Coelosphaerium kuetzingianum	1
Aphanizomenon flos-aquae	0	Snowella lacustris	1	Cryptomonadales	1

Table A24: The 8 most important phytoplankton species (by biomass) in the different seasons and years in open waters (S > 5.0 PSU) of the southern Gulf of Riga. The number behind the species indicates the biomass rank, explained on page 34.

Spring		Summer		Autumn	
1993					
Peridiniella catenata	4	Nodularia spumigena	4	Coscinodiscus granii	5
Thalassiosira baltica	3	Aphanizomenon flos-aquae	3	Thalassiosira baltica	1
Coscinodiscus granii	1	Dinophysis acuminata	2	Chaetoceros danicus	1
Melosira nummuloides	1	Oocystis lacustris	1	Ebria tripartita	1
Ebria tripartita	1	Ebria tripartita	1	Aphanizomenon flos-aquae	1
Actinocyclus octonarius	1	Oocystis submarina	0	Dinophysis acuminata	1
Dinophysis acuminata	0	Gomphosphaeria pusilla	0	Actinocyclus octonarius	1
Chaetoceros danicus	0	Gymnodinium sp.	0	Oocystis lacustris	0
1994					
		Nodularia spumigena	5		
		Aphanizomenon flos-aquae	2		
		Oocystis lacustris	1		
		Dinophysis acuminata	0		
		Gomphosphaeria pusilla	0		
		Cryptophyceae	0		
		Thalassiosira baltica	0		
1995					
Peridiniella catenata	5	Aphanizomenon flos-aquae	3	Actinocyclus octonarius	3
Thalassiosira baltica	2	"other flagellata"	2	Thalassiosira baltica	3
Pyramimonas sp.	1	Nodularia spumigena	1	Coscinodiscus granii	1
Cryptophyceae	1	Dinophysis acuminata	1	Chaetoceros danicus	1
Heterocapsa rotundata	0	Cryptophyceae	1	Gomphosphaeria pusilla	1
Ebria tripartita	0	Pyramimonas sp.	1	Dinophysis acuminata	1
Dinophysis acuminata	0	Ebria tripartita	1	Ebria tripartita	0
Gomphosphaeria pusilla	0	Actinocyclus octonarius	1	Cryptophyceae	0
1996					
Peridiniella catenata	3	Aphanizomenon flos-aquae	4	Aphanizomenon flos-aquae	3
Chaetoceros wighamii	2	Actinocyclus octonarius	2	Actinocyclus octonarius	3
Achnanthes taeniata	2	Cryptophyceae	2	Coscinodiscus granii	1
Thalassiosira baltica	2	"other flagellata"	1	Dinophysis acuminata	1
Chaetoceros holsaticus	1	Pyramimonas sp.	1	Protoperidinium granii	1
Pyramimonas sp.	1	Dinophysis acuminata	1	Cryptophyceae	1
Melosira nummuloides	0	Ebria tripartita	0	Oocystis solitaria	0
Diatoma elongatum	0	Gomphosphaeria pusilla	0	Gomphosphaeria pusilla	0
1997					
Peridiniella catenata	5	Dinophysis acuminata	2		
Aphanizomenon flos-aquae	1	Nodularia spumigena	2		
Pyramimonas sp.	1	Aphanizomenon flos-aquae	2		
Achnanthes taeniata	1	Chrysochromulina sp.	2		
Ebria tripartita	1	Cryptophyceae	2		
Chaetoceros wighamii	0	Actinocyclus octonarius	1		
Bodo sp.	0	Pyramimonas sp.	1		
Heterocapsa rotundata	0	Ebria tripartita	1		

Table A25: **The 8 most important phytoplankton species (by biomass) in the different seasons and years in the coastal area of the north-eastern Gulf of Riga. The number behind the species indicates the biomass rank, explained on page 34.**

Spring		Summer		Autumn	
1993					
		Monoraphidium convolutum	4	Teleaulax acuta	3
		Eutreptiella sp.	1	Aphanizomenon sp.	2
		Koliella sp.	1	Teleaulax amphioxeia	2
				Plagioselmis prolonga	2
				Heterocapsa rotundata	1
				Eutreptiella sp.	1
				Snowella sp.	1
				Pyramimonas spp.	1
1994					
				Woronichinia sp.	2
				Teleaulax amphioxeia	2
				Eutreptiella sp.	2
				Heterocapsa rotundata	1
				Thalassiosira baltica	1
				Aphanizomenon sp.	1
				Plagioselmis prolonga	1
				Teleaulax acuta	1
1995					
Monoraphidium contortum	2	Aphanizomenon sp.	4	Actinocyclus octonarius	3
Peridiniella catenata	2	Plagioselmis prolonga	1	Teleaulax acuta	2
Eutreptiella sp.	1	Snowella sp.	1	Teleaulax amphioxeia	2
Thalassiosira baltica	1	Pyramimonas spp.	1	Snowella sp.	1
Snowella sp.	1	Monoraphidium convolutum	1	Woronichinia sp.	1
Melosira nummuloides	1	Heterocapsa rotundata	1	Dinophysis acuminata	1
Teleaulax amphioxeia	1	Actinocyclus octonarius	1	Fragilaria sp.	1
Protoperidinium granii	1	Nodularia spumigena	1	Heterocapsa rotundata	1
1996					
Scrippsiella hangoei	3	Actinocyclus octonarius	3		
Gymnodinium sp.	2	Aphanizomenon sp.	2		
Monoraphidium contortum	2	Snowella sp.	1		
Teleaulax acuta	2	Dinophysis acuminata	1		
Protoperidinium pellucidum	1	Pyramimonas spp.	1		
Teleaulax amphioxeia	1	Hemiselmis virescens	1		
Katablepharis sp.	1	Teleaulax acuta	1		
Plagioselmis prolonga	1	Oocystis lacustris	1		
1997					
Peridiniella catenata	3	Actinocyclus octonarius	2	Teleaulax amphioxeia	3
Aphanizomenon sp.	2	Aphanizomenon sp.	2	Eutreptiella sp.	1
Achnanthes taeniata	2	Protoperidinium pellucidum	1	Actinocyclus octonarius	1
Monoraphidium contortum	2	Dinophysis acuminata	1	Plagioselmis prolonga	1
Gymnodinium sp.	1	Myrionecta rubra	1	Teleaulax acuta	1
Myrionecta rubra	1	Amylax triacantha	1	Heterocapsa rotundata	1
Teleaulax amphoxeia	1	Heterocapsa rotundata	1	Gymnodinium sp.	1
Chlorococcales sp.	1	Chlorococcales sp.	1	Aphanizomenon sp.	1

Table A26: **The 8 most important phytoplankton species (by biomass) in the different seasons and years in the open north-eastern Gulf of Riga. The number behind the species indicates the biomass rank, explained on page 34.**

Spring		Summer		Autumn	
		1993			
Peridiniella catenata	5	Actinocyclus octonarius	3	Teleaulax acuta	3
Monoraphidium contortum	1	Aphanizomenon sp.	2	Aphanizomenon sp.	2
Scrippsiella hangoei	1	Dinophysis acuminata	1	Plagioselmis prolonga	2
Chroococcales sp.	1	Teleaulax acuta	1	Teleaulax amphioxeia	1
Teleaulax acuta	1	Plagioselmis prolonga	1	Eutreptiella sp.	1
Heterocapsa rotundata	1	Snowella sp.	1	Snowella sp.	1
Plagioselmis prolonga	1	Monoraphidium convolutum	1	Heterocapsa rotundata	1
Snowella sp.	1	Oocystis lacustris	1	Nodularia spumigena	1
		1994			
				Thalassiosira baltica	3
				Woronichinia sp.	2
				Coscinodiscus granii	2
				Aphanizomenon sp.	1
				Teleaulax amphioxeia	1
				Scrippsiella hangoei	1
				Dinophysis acuminata	1
				Heterocapsa rotundata	1
		1995			
Thalassiosira baltica	4	Aphanizomenon sp.	4	Actinocyclus octonarius	5
Peridiniella catenata	2	Plagioselmis prolonga	1	Teleaulax acuta	1
Protoperidinium granii	1	Snowella sp.	1	Snowella sp.	1
Heterocapsa rotundata	1	Heterocapsa rotundata	1	Eutreptiella sp.	1
Achnanthes taeniata	1	Pyramimonas sp.	1	Monoraphidium contortum	1
Monoraphidium contortum	1	Teleaulax acuta	1	Oocystis lacustris	1
Chaetoceros wighamii	1	Monoraphidium convolutum	1		
Snowella sp.	1	Monoraphidium contortum	1		
		1996			
Scrippsiella hangoei	2	Actinocyclus octonarius	4		
Achnanthes taeniata	2	Aphanizomenon sp.	2		
Peridiniella catenata	2	Dinophysis acuminata	1		
Gymnodinium sp.	1	Snowella sp.	1		
Monoraphidium contortum	1	Pyramimonas sp.	1		
Teleaulax acuta	1	Hemiselmis virescens	1		
Teleaulax amphioxeia	1	Oocystis lacustris	1		
Thalassiosira baltica	1	Ebria tripartita	1		
		1997			
Peridiniella catenata	4	Actinocyclus octonarius	3	Actinocyclus octonarius	2
Aphanizomenon sp.	1	Aphanizomenon sp.	2	Teleaulax amphioxeia	2
Achnanthes taeniata	1	Dinophysis acuminata	1	Aphanizomenon sp.	1
Scrippsiella hangoei	1	Myrionecta rubra	1	Plagioselmis prolonga	1
Monoraphidium contortum	1	Protoperidinium granii	1	Teleaulax acuta	1
Protoperidinium granii	1	Teleaulax amphioxeia	1	Monoraphidium contortum	1
Thalassiosira baltica	1	Hemiselmis virescens	1	Heterocapsa rotundata	1
Teleaulax amphioxeia	1	Gymnodinium sp.	1	Scrippsiella hangoei	1

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