Proc. Estonian Acad. Sci. Biol. Ecol., 1998, **47**, 1, 14–31
https://doi.org/10.3176/biol.ecol.1998.1.02

BUDGET COMPONENTS OF WATER, SALT, AND NUTRIENTS IN THE GULF OF RIGA IN 1993–95

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Received 30 July 1997, in revised form 2 December 1997

Abstract. Water, salt, and nutrient exchange of the Gulf of Riga with the surrounding water basins was studied. Intensive hydrographic and hydrochemical measurements were made in the Gulf of Riga within the framework of the Gulf of Riga Project in 1993–95. The initial data obtained in the Gulf of Riga within one month were interpolated into a grid covering the whole Gulf. Total amounts and mean concentrations as well as in- and outflow fluxes of salts and nutrients were estimated on a monthly basis. The outflow of all explored nutrients through the straits was found to be bigger than the inflow. This means that the Gulf of Riga acts as a source of nutrients (a polluter) for the rest of the Baltic Sea. Water exchange was found to be more active during the summer season and in winter with an ice cover (winters of 1993/94 and 1994/95 were compared). The transition zone between phosphorus limitation and nitrogen limitation calculated on the basis of the horizontal distribution of the N : P ratio divides the basin into two parts: the southeastern part is phosphorus-limited and the northwestern part nitrogen-limited. For the whole Gulf of Riga the nutrient limitation type (N or P) varied.

Key words: Gulf of Riga, water exchange, nutrient exchange, nutrient limitation.

INTRODUCTION

The Gulf of Riga is a semi-enclosed basin of the Baltic Sea with a total area of about 16 100 km^2 and volume of 401 km^3. The Gulf is connected with the Baltic Proper through the Väinameri area (sill depth about 5 m) and the Irbe Sound (25 m). A shallow region, which includes Pärnu Bay, covers the northern area of the Gulf of Riga where numerous islands and banks are located. The deepest part of the Gulf (Ruhnu Deep, depth 60 m) is located in its centre. The average depth of the Gulf of Riga is 25 m. The salinity of the water in the Gulf varied between 4 and 7 PSU during the investigation period. This makes an average of about 5.5 PSU, which is 1.5 PSU lower than in the surface layer of the Baltic Proper. The decrease of the salinity of the water in the Gulf of Riga compared to the Baltic Proper can be explained by its relative isolation from the open sea and the high freshwater input.

In autumn and winter the Gulf of Riga is well mixed and homohaline except the Irbe Sound and the mouths of the larger rivers. Sharp horizontal and vertical gradients are formed during the spring flood of fresh water and during the summer thermal stratification of the water body. A common pattern is that low saline water flows northwards along the eastern coast, while the saline water enters the Gulf and flows southwards along its western coast, increasing the salinity of the bottom layer in spring and summer. The long-term mean water exchange of the Gulf of Riga with other basins could be estimated at 130 km^3 per year.

The drainage basin of the Gulf of Riga is about 10 times as large as the area of the Gulf, covering 136 000 km^2 with a human population of about 4 million. Five rivers, Daugava, Lielupe, Pärnu, Gauja, and Salaca, give over 90% of the river input into the Gulf of Riga. The Daugava gives about 70% of the river input. All rivers are located to south or east of the Gulf. According to the long-term hydrological observations from the Latvian Hydrometeorological Agency, the annual freshwater runoff into the Gulf of Riga ranges between 17.1 and 55.1 km^3 (Yurkovskis et al., 1993). Because of its isolation and polluted drainage area, the Gulf of Riga is one of the most eutrophic systems in the Baltic Sea. The annual primary production was estimated at 4 million tonnes in 1989. This would make 290 g C m^{-2} $year^{-1}$, which is clearly higher than in the entire Baltic Proper, where it is 160 g C m^{-2} $year^{-1}$ (Yurkovskis et al., 1993).

1. MATERIALS

1.1 Measurements

Hydrographic and hydrochemical data were collected at a station network covering the whole Gulf of Riga (Fig. 1). Salinity, temperature, and nutrient (NO_2, NO_3, NH_4, PO_4, SiO_4, N_{tot}, P_{tot}) concentrations were measured. The measurements were performed in the northern part of the Gulf by the Estonian Marine Institute and in the southern part of the Gulf by the Institute of Aquatic Ecology of the Latvian University (or by the Latvian Hydrometeorological Agency) (Table 1).

Conductivity, temperature, and depth (CTD) measurements were performed with a Neil Brown Mark III probe. The quality of Neil Brown Mark III data was checked at the Estonian Marine Institute by means of analysing water samples with a salinometer AUTOSAL. The average salinity difference between CTD and AUTOSAL did not exceed 0.02 PSU.

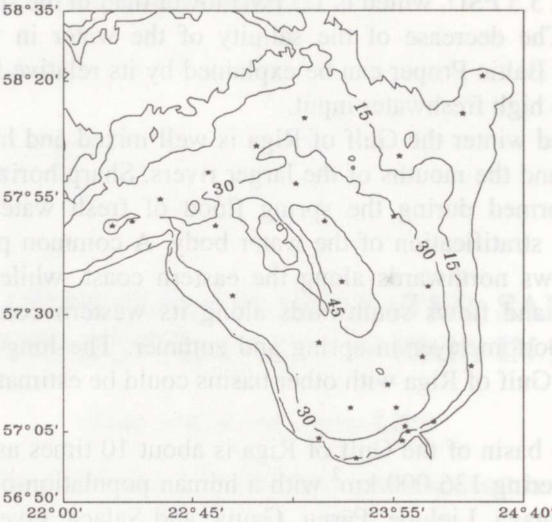

Fig. 1. The Gulf of Riga and the ordinary station network.

Table 1

Hydrophysical and hydrochemical measurements in 1993–95

Month, year	Ship	No. of stations	Month, year	Ship	No. of stations
Nov 1993	*Orbiit*	32	Oct 1994	*Kiir*	23
	Vejas	24		*Geofizik*	11
Apr 1994	*Aranda*	37	Nov 1994	*Tipton*	16
	Geofizik	13		*Geofizik*	15
May 1994	*Kiir*	24	March 1995	*Marina*	7
	Geofizik	14		*Antonia*	7
	Vejas	25	May 1995	*Marina*	9
	Livonia	2		*Antonia*	14
June 1994	*Kiir*	15	July 1995	*Kiir*	12
	Geofizik	15		*Antonia*	19
July 1994	*Kiir*	35	Aug 1995	*Marina*	7
	Geofizik	12		*Antonia*	29
	Muikku	2	Sep 1995	*Kiir*	12
Aug 1994	*Kiir*	29		*Antonia*	22
	Geofizik	23	Oct 1995	*Kiir*	12
Sep 1994	*Kiir*	24		*Antonia*	15
	Geofizik	24			

Water samples for the nutrient determination were collected with Nansen water samplers and stored frozen. Hydrochemical measurements were performed at the Marine Biological Station of the Estonian Marine Institute in Pärnu and at the Institute of Aquatic Ecology of the Latvian University. Measurements of nutrients were analysed applying the methods for seawater described by Grasshoff et al. (1983). Nitrite and nitrate analyses were performed on an AKEA autoanalyser using the method provided by DATEX. Phosphates and silicates were estimated manually with a HITACHI U-1100 spectrophotometer.

1.2 Freshwater inputs

Information on the total monthly river discharge to the Gulf of Riga was available for the time period from April 1993 to December 1994. For 1995 only data for the Daugava River were accessible (Fig. 2, E. Zakharchenko, pers. comm.). Since the Daugava gives about 70% of the total river input to the Gulf of Riga (Yurkovskis et al., 1993), the total monthly input for 1995 was calculated as the Daugava input divided by 0.7. The common pattern of the total river input for each year is a strong spring flood and a relatively low activity during the rest of the year although the maximums in each year were different. In 1993 and 1995 the spring flood in April was about twice smaller than in 1994. The long-term average of the annual freshwater input to the Gulf of Riga is 30 km^3, but in 1994 it was 41 km^3. The precipitation over the basin is assumed to be compensated with the evaporation (Falkenmark & Mikulski, 1974).

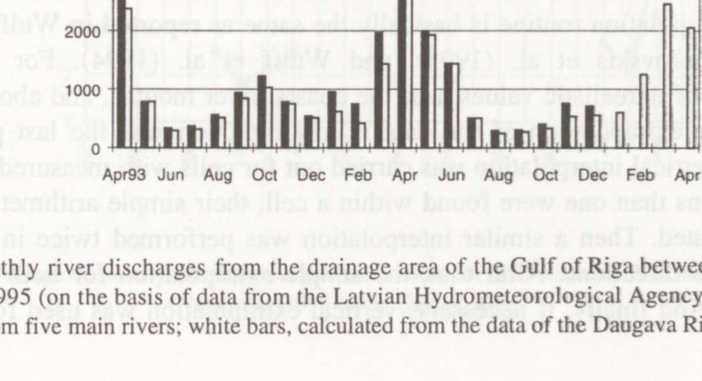

Fig. 2. Monthly river discharges from the drainage area of the Gulf of Riga between April 1993 and April 1995 (on the basis of data from the Latvian Hydrometeorological Agency). Black bars, data from five main rivers; white bars, calculated from the data of the Daugava River only.

1.3 Nutrient inputs from rivers and the atmosphere

Unfortunately, for the years described in this paper no information on nutrient concentration in rivers was available. In this work the net export/import and the changes in the basin were calculated only. Some conclusions for the annual river inputs and internal sinks and sources can be made using the data from previous years, but these estimates are highly approximate, since the freshwater input varies strongly in different years.

According to Granat (1990a), the Gulf of Riga is a region with a wet precipitation of nitrogen of 50–70 mmol m^{-2} $year^{-1}$. The dry precipitation of nitrogen was estimated by Lindfors et al. (1991) at 6 mmol m^{-2} $year^{-1}$. This means that the Gulf receives about 16 000 tonnes of nitrogen per year. The concentration of phosphorus in precipitation is presented in various studies (Granat, 1990b; Lindfors et al., 1991), ranging from 0.3 to 0.7 µM. According to Yurkovskis et al. (1993), the Gulf of Riga receives annually about 300 tonnes of PO_4, presuming that the amount of precipitation is 730 mm $year^{-1}$ and the concentration of PO_4 is 0.7 µM.

2. TOTAL AMOUNTS OF SALT AND NUTRIENTS

2.1 Methods

Total amounts of salt and nutrients were calculated from interpolated concentrations for November 1993 until November 1995. A grid of 2' × 4' in the latitude/longitude orientation covering the Gulf of Riga was used. The interpolation area was (22°00.0E–24°63.3E) × (56°90.0N–58°60.0N) × (0–55 m). Each column was divided into eight depth intervals in the following order: (1) 0–2.5 m, (2) 2.5–7.5 m, (3) 7.5–12.5 m, (4) 12.5–17.5 m, (5) 17.5–25.0 m, (6) 25.0–35.0 m, (7) 35.0–45.0 m, and (8) 45.0–55.0 m. A hypsographic database with a resolution of 1 km was used for the volume calculation of each cell in the grid.

The interpolation routine is basically the same as reported in Wulff & Rahm (1988), Yurkovskis et al. (1993), and Wulff et al. (1994). For maximum prevention of unrealistic values near the coasts, river mouths, and above the sea bottom, the extrapolation of the data in any direction was the last procedure. First, the vertical interpolation was carried out for cells with measured values. If more stations than one were found within a cell, their simple arithmetic average was calculated. Then a similar interpolation was performed twice in longitude and latitude directions. After that, the simple extrapolation for both directions was used. And finally, if necessary, vertical extrapolation was used for refining the data.

2.2 Results

The average salinity of the Gulf of Riga decreases during the first half of the year and increases during the second half. The salinity maximum, which ranged from 5.55 to 5.68 PSU, was observed in winter, and the minimum from 5.37 to 5.41 PSU in summer (Fig. 3).

The distributions of the inorganic nutrients (PO_4, NO_3, SiO_4) show an ordinary pattern: maximum concentrations were detected during the winter and early spring, minimum during the summer months (Figs. 3, 4). The distributions of total phosphorus and total nitrogen were more complicated. Although the

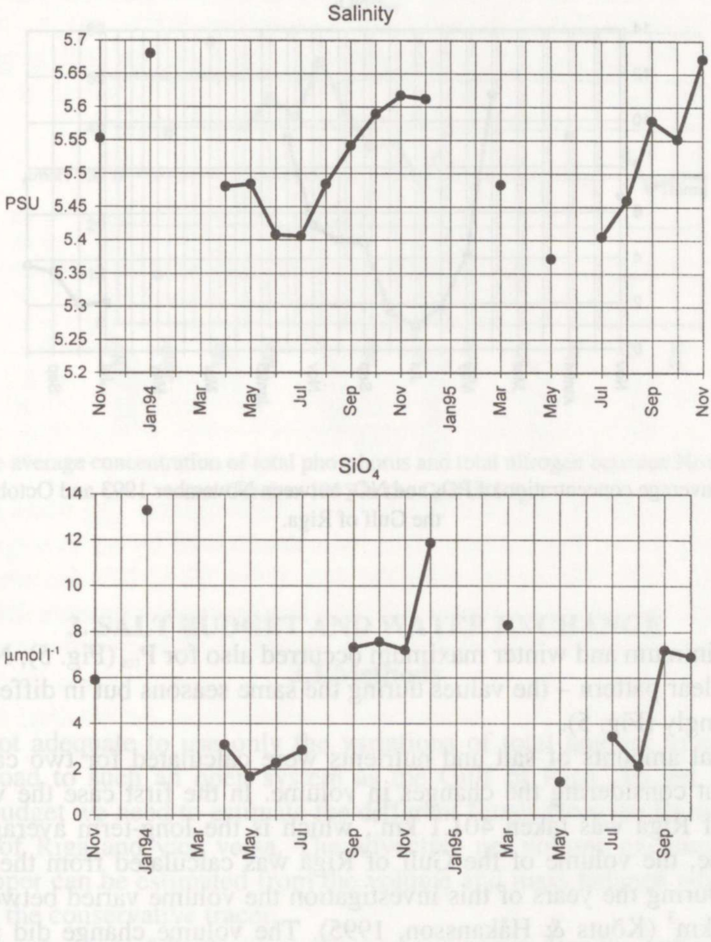

Fig. 3. The average of salinity and the average concentration of SiO_4 between November 1993 and November 1995 in the Gulf of Riga.

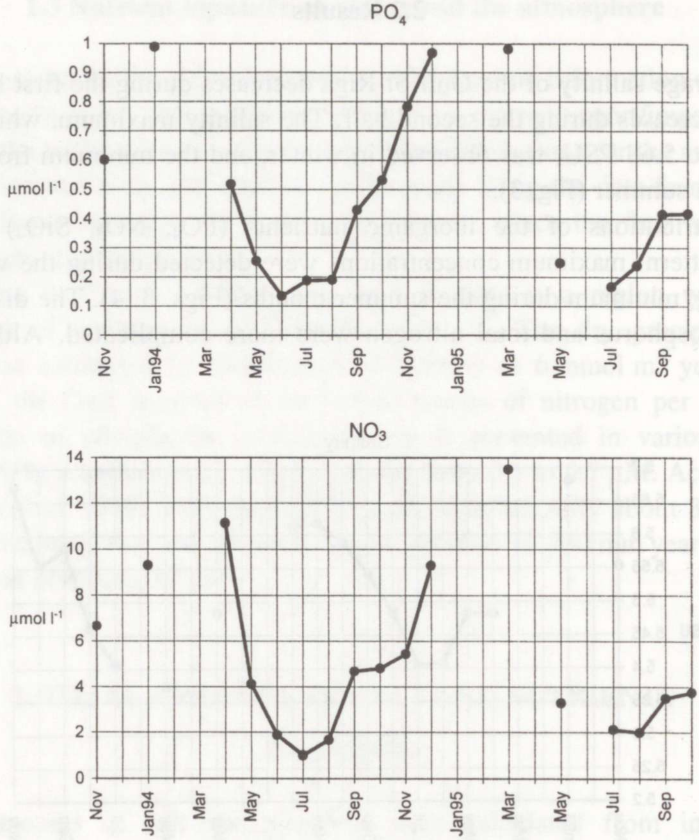

Fig. 4. The average concentration of PO_4 and NO_3 between November 1993 and October 1995 in the Gulf of Riga.

summer minimum and winter maximum occurred also for P_{tot} (Fig. 5), N_{tot} did not have any clear pattern – the values during the same seasons but in different years varied strongly (Fig. 5).

The total amounts of salt and nutrients were calculated for two cases: with and without considering the changes in volume. In the first case the volume of the Gulf of Riga was taken 401.1 km^3, which is the long-term average. In the second case, the volume of the Gulf of Riga was calculated from the sea-level changes. During the years of this investigation the volume varied between 393.2 and 409.2 km^3 (Kõuts & Håkansson, 1995). The volume change did not affect essentially the total amounts of salt and nutrients. The difference was about 2–3%.

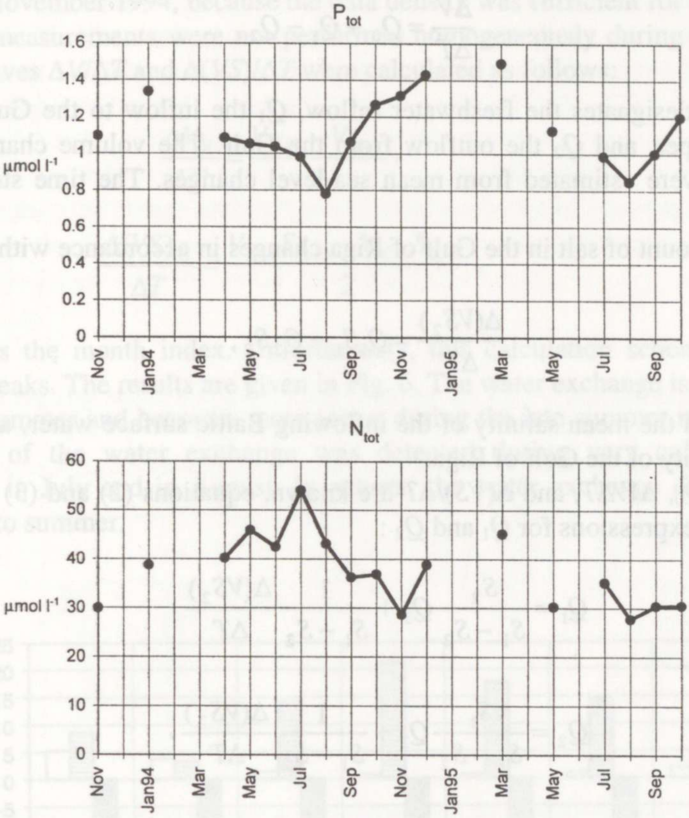

Fig. 5. The average concentration of total phosphorus and total nitrogen between November 1993 and October 1995 in the Gulf of Riga.

3. SALT BUDGET AND WATER EXCHANGE

3.1 Methods

It is not adequate to use only the variations of total amount to estimate the nutrient load to such an open system as the Gulf of Riga. To get a complete nutrient budget we need to estimate the different fluxes from the Baltic Proper to the Gulf of Riga and vice versa. The advective net volume exchange with the Baltic Proper can be estimated from the volume and mass balance where the salt is used as the conservative tracer.

Volume changes of the basin in time are represented as the balance between the inflows and the outflows as follows:

$$\frac{\Delta V}{\Delta T} = Q_0 + Q_1 - Q_2 , \tag{1}$$

where Q_0 designates the freshwater inflow, Q_1 the inflow to the Gulf from the Baltic Proper, and Q_2 the outflow from the Gulf. The volume changes in this equation were estimated from mean sea-level changes. The time step was one month.

The amount of salt in the Gulf of Riga changes in accordance with the in- and outflows:

$$\frac{\Delta(VS_2)}{\Delta T} = Q_1 S_1 - Q_2 S_2 , \tag{2}$$

where S_1 is the mean salinity of the inflowing Baltic surface water, and S_2 is the mean salinity of the Gulf of Riga.

Since Q_0, $\Delta V/\Delta T$, and $\Delta(VS)/\Delta T$ are known, equations (2) and (3) give us the following expressions for Q_1 and Q_2 :

$$Q_1 = \frac{S_2}{S_1 - S_2} Q_3 + \frac{1}{S_1 - S_2} \frac{\Delta(VS_2)}{\Delta T} \tag{3}$$

and

$$Q_2 = \frac{S_1}{S_1 - S_2} Q_3 + \frac{1}{S_1 - S_2} \frac{\Delta(VS_2)}{\Delta T} , \tag{4}$$

where

$$Q_3 = Q_0 - \frac{\Delta V}{\Delta T} . \tag{5}$$

The terms S_1 and S_2 may be estimated from observations. The mean salinity of the inflowing Baltic Sea surface water was determined by an average of three stations outside the Irbe Sound using the data above 30 m. It is assumed that the Gulf of Riga is connected with the Baltic Proper mainly through Irbe Sound, which covers about 80–85% of the total exchange. The co-ordinates of these stations are: (1) 57°20.0 N, 20°06.0 E; (2) 57°58.0 N, 21°33.0 E; and (3) 57°58.5 N, 20°32.0 E. The data for these stations were available from the seasonal monitoring cruises in March, May, August, and November. For other months, the simple linear interpolation was used.

3.2 Results

The water exchange was calculated for two cases like the total amounts, with and without considering the sea-level changes. Detailed calculations for the monthly water exchange were possible only for the time period between April

1994 and November 1994, because the data density was sufficient for this period. Since the measurements were not performed homogeneously during the month, the derivatives $\Delta V/\Delta T$ and $\Delta(VS)/\Delta T$ were calculated as follows:

$$\frac{\Delta V_X}{\Delta T} = \frac{V_{X+1} - V_{X-1}}{2}, \qquad (6)$$

$$\frac{\Delta(VS)_X}{\Delta T} = \frac{V_{X+1}S_{X+1} - V_{X-1}S_{X-1}}{2}, \qquad (7)$$

where X is the month index. Unfortunately, this calculation scheme will not show the peaks. The results are given in Fig. 6. The water exchange is low during the early summer and becomes more active during the late summer months. The maximum of the water exchange was detected during very calm weather conditions in July and in August. In autumn the water exchange decreased as compared to summer.

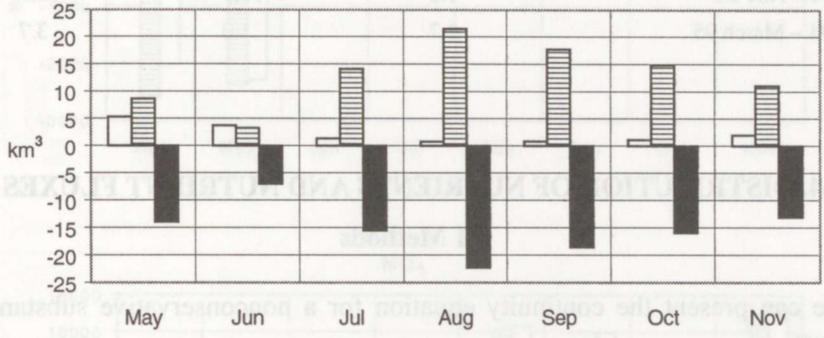

Fig. 6. Water fluxes, calculated without volume changes between May 1994 and November 1994. White bars, freshwater inflow; striped bars, inflow from the Baltic; black bars, outflow from the Gulf of Riga.

The water exchange analyses were made also for longer time periods, namely for November 1993 – April 1994, April 1994 – July 1994, July 1994 – November 1994, and November 1994 – March 1995. These periods were chosen considering the data density for the whole investigation period. The derivatives $\Delta V/\Delta T$ and $\Delta(VS)/\Delta T$ were calculated using the outermost data points. The results are presented in Table 2. The difference between the winters 1993/94 and 1994/95 may be caused by the different meteorological conditions during these winters. The winter 1993/94 was much colder than the winter 1994/95, and the Gulf of Riga was completely covered with ice, but in the winter 1994/95 ice was detected only in bays. Also the river input in early spring was 2–3 times higher in 1994 than in 1995 (Fig. 2). This could have been another cause for the more active average water exchange during the period Nov 93 – Apr 94. Generally, water exchange through the straits dominates over the freshwater input during the summer period while in the winter period the river input becomes comparable with the net export/import.

Table 2

Water fluxes in the Gulf of Riga during the whole investigation period (km^3 per month). Q_0, inflow from rivers; Q_1, inflow through the Irbe Sound; Q_2, outflow through the Irbe Sound

Time period	Q_0	Q_1	Q_2
Nov 93 – Apr 94	3.6	8.1	11.7
Apr 94 – July 94	5.8	12.6	18.4
July 94 – Nov 94	1.0	17.9	18.9
Nov 94 – March 95	2.7	1.0	3.7

4. DISTRIBUTION OF NUTRIENTS AND NUTRIENT FLUXES

4.1 Methods

We can present the continuity equation for a nonconservative substance as follows:

$$\frac{\Delta[VC_2]}{\Delta T} = C_0Q_0 + C_1Q_1 - C_2Q_2 + ATMOS + SEW + INT\ . \qquad (8)$$

In this equation, the term C_2 denotes the calculated mean concentration of the nonconservative substance in the Gulf of Riga. *ATMOS* is the nutrient load from the atmosphere, *SEW* is the sewage load from point sources, and *INT* is the internal source or sink.

4.2 Results

Two characteristics were calculated for the nutrient fluxes: first, the difference of the in- and outflows, and second, the nutrient change in the basin. The difference between these two values gives us the part of the budget which was not directly measured, that is nutrient sink and source, sewage load, and nutrient inputs from rivers and the atmosphere. Detailed calculations for each month could be made for the period April – November 1994. The results are presented in Figs. 7, 8, and 9.

A common pattern for the majority of nutrients is that the net export through the Irbe Sound gives a considerably smaller part of the nutrient budget in the Gulf of Riga than the other factors together. This means that most of the nutrients accumulate in the Gulf. It was detected also that the nutrient outflow from the Gulf is always bigger than the inflow from the Baltic Proper.

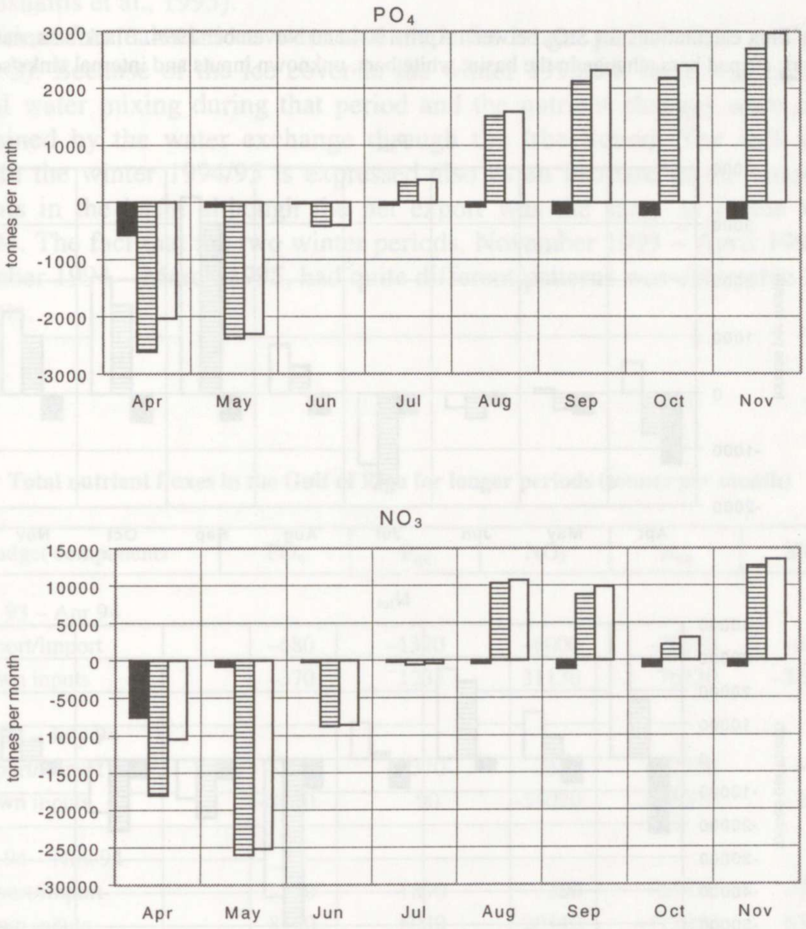

Fig. 7. Flux calculations for PO_4 and NO_3 between April 1994 and November 1994. Black bars, net export/import; striped bars, change in the basin; white bars, unknown inputs and internal sinks/sources.

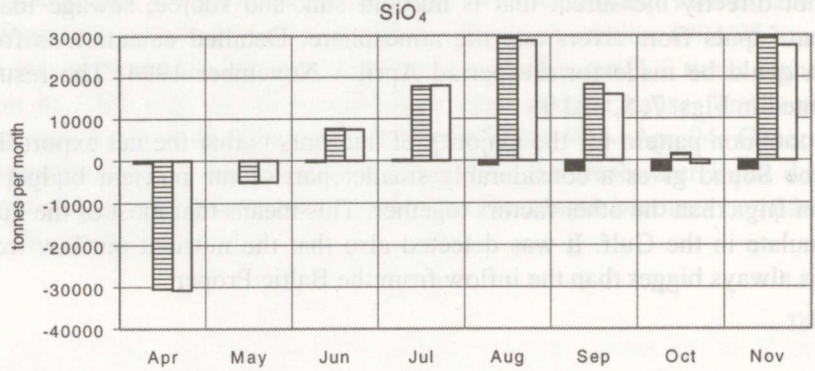

Fig. 8. Flux calculations for SiO_4 between April 1994 and November 1994. Black bars, net export/import; striped bars, change in the basin; white bars, unknown inputs and internal sinks/sources.

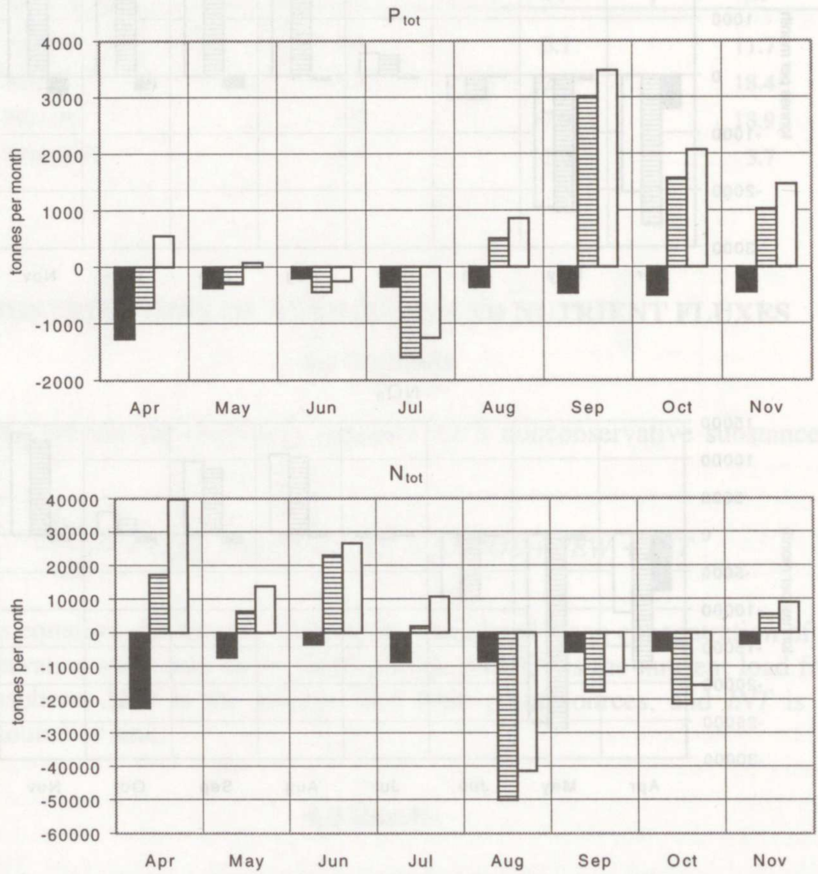

Fig. 9. Flux calculations for total phosphorus and total nitrogen between April 1994 and November 1994. Black bars, net export/import; striped bars, change in the basin; white bars, unknown inputs and internal sinks/sources.

For the inorganic nutrients (PO_4, NO_3), the change in the basin is negative during the spring bloom. In autumn, when the life activity is smaller and the water mixing reaches down to the sea bottom, the opposite process begins. The water motion brings nutrients back to the upper layers and the change in the basin turns positive (Fig. 7).

The flux calculations for the total phosphorus and total nitrogen show an interesting effect. While P_{tot} acts normally (decreases during spring and early summer and increases during autumn), then N_{tot} demonstrates the opposite patterns (Fig. 9). The positive balance for N_{tot} during spring and early summer may be caused by the bigger river load with the spring flood, because the amount of N_{tot} in the river water is about 40 times as big as the amount of P_{tot} (Andrushaitis et al., 1995).

Nutrient flux calculations were also made for longer periods than one month (Table 3). Because of the ice cover in the winter 1993/94, there was no active vertical water mixing during that period and the nutrient changes were mostly determined by the water exchange through the Irbe Sound. The lack of ice cover in the winter 1994/95 is expressed also as an increase in the amount of nutrients in the basin although the net export was the same as in the winter 1993/94. The fact that the two winter periods, November 1993 – April 1994 and November 1994 – March 1995, had quite different patterns was detectable for all nutrients.

Table 3

Total nutrient fluxes in the Gulf of Riga for longer periods (tonnes per month)

Budget components	PO_4	P_{tot}	NO_3	N_{tot}	SiO_4
Nov 93 – Apr 94					
Net export/import	–680	–1370	–6000	–20370	–3820
Unknown inputs	–370	1235	31130	76130	–32620
Apr 94 – July 94					
Net export/import	–270	–1370	–2850	–27350	–140
Unknown inputs	–3830	90	–54020	105070	–2680
July 94 – Nov 94					
Net export/import	–750	–1890	–3300	–27810	–7480
Unknown inputs	8150	6030	28140	–115050	63440
Nov 94 – March 95					
Net export/import	–360	–570	–1780	–6670	–3020
Unknown inputs	6980	2780	46960	99610	16960

Table 4 presents the fluxes for all nutrients during one year, from November 1993 to November 1994. Although the net export during the summer months was considerably smaller than the other budget components, the exchange through the straits per year is of the same order of magnitude as the changes in the Gulf and internal sinks/sources.

Table 4

Total nutrient fluxes between November 1993 and November 1994 (tonnes per year)

Budget components	PO_4	P_{tot}	NO_3	N_{tot}	SiO_4
Net export/import	–1700	–4650	–12140	–75530	–11440
Unknown inputs	3950	7370	5230	67950	28140

4.3 Nutrient limitation

The optimal N : P (molar) ratio for primary producers is known as the Redfield ratio. For the Gulf of Riga this ratio is supposed to be 16. An upward shift from the Redfield ratio indicates phosphorus limitation and a downward shift nitrogen limitation.

Our estimations show that the N : P ratio for the Gulf of Riga has decreased as compared to 1989. According to Yurkovskis et al. (1993), it varied from about 20 : 1 in winter to over 50 : 1 during the productive season. In this work, the N : P calculations for the whole water body show that the limitation type varies. The nutrient limitation depends on the river input, since the nitrogen concentration in the river water is about 40 times as high as the phosphorus concentration. More detailed calculations were performed for the upper water layer. Figure 10 shows that the line between nitrogen and phosphorus limitation (N : P = 16) divides the Gulf of Riga into two parts and that the location of the transition zone depends on the river input.

Long-term tendencies of the nutrient concentrations were observed by Suursaar (1995). The variation of the nutrient concentrations during the time period from 1975 to 1988 shows an increase in both PO_4 and NO_3. Since 1990, agricultural production has been decreasing and thus the anthropogenic nitrogen input has been decreasing too. This effect is indirectly detectable also through the decrease of the N : P ratio in recent years.

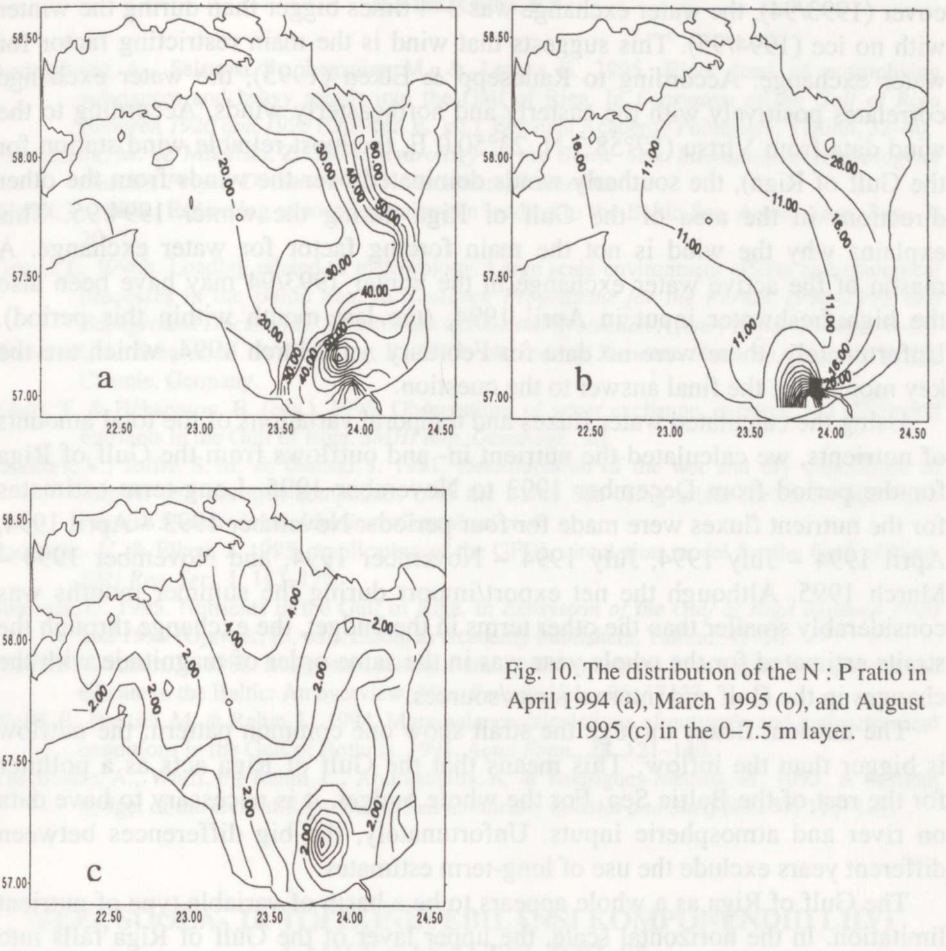

Fig. 10. The distribution of the N : P ratio in April 1994 (a), March 1995 (b), and August 1995 (c) in the 0–7.5 m layer.

5. DISCUSSION AND CONCLUSIONS

On the basis of the hydrographic and hydrochemical measurements in the Gulf of Riga in 1993–95, the concentrations and total amounts of salt and nutrients were calculated. To expand the data obtained from direct measurements over the whole Gulf, simple linear interpolation and extrapolation (in three directions) were performed.

The water exchange through the straits was estimated on the basis of the salt budget (salt conservation equations). It was observed that the water exchange through the straits was more active in the summer months, especially during the calm weather conditions. An analysis of quite different winters – 1993/94 and 1994/95 – revealed an interesting phenomenon. During the winter with an ice cover (1993/94), the water exchange was 3–4 times bigger than during the winter with no ice (1994/95). This suggests that wind is the main restricting factor for water exchange. According to Raudsepp & Elken (1995), the water exchange correlates positively with the easterly and northeasterly winds. According to the wind data from Virtsu (57°58.3 N, 23°50.0 E, the most reliable wind station for the Gulf of Riga), the southerly winds dominated over the winds from the other directions in the area of the Gulf of Riga during the winter 1994/95. This explains why the wind is not the main forcing factor for water exchange. A reason of the active water exchange in the winter 1993/94 may have been also the high freshwater input in April 1994, (the last month within this period). Unfortunately, there were no data for February and March 1994, which are the key months for the final answer to the question.

Using the calculated water fluxes and temporal variations of the total amounts of nutrients, we calculated the nutrient in- and outflows from the Gulf of Riga for the period from December 1993 to November 1995. Long-term estimates for the nutrient fluxes were made for four periods: November 1993 – April 1994, April 1994 – July 1994, July 1994 – November 1994, and November 1994 – March 1995. Although the net export/import during the summer months was considerably smaller than the other terms in the budget, the exchange through the straits estimated for the whole year was in the same order of magnitude with the changes in the Gulf and internal sinks/sources.

The nutrient fluxes through the strait show one common pattern: the outflow is bigger than the inflow. This means that the Gulf of Riga acts as a polluter for the rest of the Baltic Sea. For the whole budget, it is necessary to have data on river and atmospheric inputs. Unfortunately, the big differences between different years exclude the use of long-term estimates.

The Gulf of Riga as a whole appears to be a basin of variable type of nutrient limitation. In the horizontal scale, the upper layer of the Gulf of Riga falls into two parts: the southern part, where the influence of the polluted river water is stronger, is phosphorus-limited, and northern part, where the limiting nutrient is nitrogen. The location of the line between these two limitation types is affected by the magnitude of the river inflow.

ACKNOWLEDGEMENTS

Since the data used in this work were obtained from several scientific institutions, we want to express our special thanks to Tarmo Kõuts (previously from the Estonian Hydrometeorological Institute), to Yevgenij Zakharchenko from the Latvian Hydrometeorological Agency, and Aivars Yurkovskis from the Institute of Aquatic Ecology of the Latvian University. The measurements were performed within the Gulf of Riga Project, which is financed by the Nordic Council of Ministers.

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VEE-, SOOLA- JA TOITAINETEBILANSI KOMPONENDID LIIVI LAHES AASTATEL 1993–95

Laur MÄGI ja Urmas LIPS

On uuritud Liivi lahe ning seda ümbritsevate veekogude vee-, soolade- ja toitainetevahetust. Artikkel põhineb Liivi lahe projekti raames aastatel 1993–95 tehtud hüdrofüüsikalistel ja hüdrokeemilistel mõõtmistel. Saadud andmed interpoleeriti kogu lahte katvale regulaarsele võrgule varem kasutatud meetodite abil. Soolade ja toitainete koguhulka ja keskmist kontsentratsiooni ning nende sisse- ja väljavoolu hinnati kuude lõikes. Iga uuritud toitaine puhul oli väljavool Liivi lahest suurem kui sissevool. See tähendab, et Liivi laht on ülejäänud Läänemere jaoks toitainete allikaks. Leiti, et Liivi lahe veevahetus avamerega oli aktiivsem suvel ja jääkattega talvel (võrreldi kahte erinevat talve, 1993/94 ja 1994/95). Liivi lahes ei eksisteeri ühte kindlat vetikate kasvu piiravat toitainet, see võib olla nii lämmastik kui ka fosfor. Pinnakihis on Liivi laht jagatud kaheks – lahe lõunaosas on vetikate kasvu limiteerivaks toitaineks fosfor, põhjaosas lämmastik.