Baltic Sea Environment Proceedings No. 128

Fifth Baltic Sea Pollution Load Compilation (PLC-5)

Helsinki Commission

Baltic Marine Environment Protection Commission

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Content

List of abbreviations

AOX	Adsorbable organically bound halogens
ARC	Archipelago Sea
BAP	Baltic Proper
BOB	Bothnian Bay
BOS	Bothnian Sea
BOD	Biological oxygen demand
BSAP	Baltic Sea Action Plan
Cd	Cadmium
COD_{Cr}	Chemical oxygen demand
Cr	Chromium
Cu	Copper
DE	Germany
DK	Denmark
EE	Estonia
EPER	European Pollutant Emissions Register
EU	European Union
FI	Finland
GIS	Geographic information system
GUF	Gulf of Finland
GUR	Gulf of Riga
Hg	Mercury
IACS	Integrated Administration and Control System
K	Potassium
KAT	The Kattegat
LI	Lithuania
LOAD	HELCOM Expert Group on follow up of national progrwss towards reaching BSAP nutrient reduction targets
LOD	Limit of detection
LOQ	Limit of quantification
LV	Latvia
MWWTP	Municipal wastewater treatment plants
NH4-N	Ammonium
NO_3-N	Nitrate
NO_2-N	Nitrite
N	Nitrogen
Ni	Nickel
P	Phosphorus
Pb	Lead
PE	Population equivalent
PO4-P	Orthophosphate
PL	Poland
PLC	Pollution load compilation
P_2O_5	Phosphorus pentoxide
RU	Russia
SE	Sweden
SOU	The Sound
TOC	Total organic carbon
WEB	Western Baltic
Zn	Zinc

Preface

To achieve the objectives of the Helsinki Convention, the Helsinki Commission needs reliable data on inputs into the Baltic Sea from land-based sources, as well as information about the significance of different pollution sources. Data on waterborne inputs to the Baltic Sea and the development in these inputs have been even more important after the agreement on the HELCOM Baltic Sea Action Plan (BSAP) in 2007 (HELCOM 2007a). The BSAP recognizes the need to reduce nutrient (nitrogen and phosphorus) inputs to a maximum allowable level and corresponding country-wise nutrient reduction requirements for nitrogen and phosphorus in order to achieve a Baltic Sea in good environmental status by 2021. In the BSAP it is acknowledged that the Fifth Pollution Load Compilation (PLC-5) should be taken into account when the figures related to the provisional reduction targets and maximum allowable nutrient inputs should be reviewed and revised. Information on inputs to the Baltic Sea is also required to assess the effectiveness of measures taken to reduce pollution in the Baltic Sea catchment area and to support the development of HELCOM's environmental policy. Further, it is required to interpret and evaluate the environmental status and related changes in the open sea and coastal waters.

To satisfy earlier needs to quantify waterborne inputs to the Baltic Sea, waterborne Pollution Load Compilations (PLCs) were carried out in 1987 (PLC-1), 1990 (PLC-2), 1995 (PLC-3) and 2000 (PLC-4). The Commission adopted HELCOM Recommendation 26/2 in March 2005, which recommended that the quantified waterborne discharges from point sources and losses from non-point sources of pollution as well as the quantified natural background losses into surface waters in the catchment area of the Baltic Sea located within the borders of the Contracting Parties should be reported every six years, as specified in the guidelines, with 2006 as the most recent reporting year. The PLC-5 therefore concerns monitoring of waterborne pollution loads from 1 January 2006 to 31 December 2006, and covers both point and non-point sources of pollution. Furthermore, it includes quantified annual waterborne total loads (which includes inputs from rivers, unmonitored and coastal areas, as well as direct point and diffuse sources discharging directly into the Baltic Sea) from 1994 to 2008 and analyses of trends.

The Fifth Pollution Load Compilation (PLC-5) is a further step forward in quantifying discharges and losses from both point and non-point sources within the Contracting Parties' catchment area of the Baltic Sea. Information on total waterborne inputs is the most frequently reported, but still with some deficiencies concerning completeness and lack of use of fully comparable methodologies. PLC-5 includes two different approaches to quantifying all pollution inputs into the Baltic Sea:

1. **Source-oriented approach:** This approach was introduced in PLC-4 to quantify the discharges from point sources and losses from diffuse sources into inland surface waters within the Baltic Sea catchment area. No common methodology is described in the PLC-5 guidelines, as the Contracting Parties use national methods.
2. **Load-oriented approach:** This approach was used to quantify total loads of nutrients, organic matter and heavy metals from rivers, unmonitored coastal areas and point sources discharging directly into the Baltic Sea and was also used in previous PLCs. The PLC-5 guidelines describe common methodologies that should be followed by the Contracting Parties.

This report includes the main results from the PLC-5. It includes quantified annual waterborne total loads (from rivers, unmonitored and coastal areas as well as direct point and diffuse sources discharging directly to the Baltic Sea) from 1994 to 2008 to provide a basis for evaluating any decreasing (or increasing) trends in the total waterborne inputs to the Baltic Sea. **Chapter 1** contains the objectives of PLC and the framework on classification of inputs and sources. **Chapter 2** includes a short description of the Baltic Sea catchment area, while the methods for quantification and analysis together with quality assurance topics are briefly introduced in **Chapter 3**. More detailed information on methodologies is presented in the PLC-5 guidelines (HELCOM 2006). **Chapter 4** reports the total inputs to the Baltic Sea of nutrients and selected heavy metals. Furthermore, the results of the quantification of discharges and losses of nitrogen and phosphorus from point and diffuse sources into inland surface waters within the Baltic Sea catchment area (source-oriented approach or gross loads) as well as the total load to the maritime area (load-oriented approach or net loads) in 2006 are shown. Typically, results are presented by country and by main Baltic Sea sub-region. In **Chapter 5**, flow normalization is introduced and the results of trend analyses on 1994-2008 time series data on total waterborne loads of nitrogen and phosphorus are given together with a first evaluation of progress in obtaining the provisional reduction targets by country and by main Baltic Sea sub-region. **Chapter 6** includes discussion of some of the main conclusions and advice for future PLCs. The annexes contain the flow-normalized annual load data and figures and tables with results from the PLC-5.

The PLC-5 clearly emphasizes that in 2006 losses from diffuse sources are the main origin of the excessive inputs of both nitrogen and phosphorus entering the Baltic Sea, as was the case also in PLC-3 and PLC-4. Riverine loads are much higher than direct loads from point and diffuse sources to the Baltic Sea. The large catchment areas with major rivers such as the Neva, Vistula, Oder, Nemunas and Daugava are also the main sources of nutrient inputs into the Baltic Sea. The area-specific load of nitrogen into the Baltic Sea is typically greatest in sub-regions with intensive agricultural activity and high population density, such as the southwestern part of the Baltic Sea catchment area. Correspondingly, the largest area-specific phosphorus losses were found in catchment areas with high population density, many industries and heavy agricultural activity. The report shows that even though PLC-5 provides the most complete compilation of total waterborne inputs to the Baltic Sea, some data are still missing and the methodologies applied are not fully comparable. To evaluate progress toward the fulfilment of the provisional reduction targets set in the BSAP, the importance of a common flow normalization and trend analysis methodology, and complete, comparable and quality-assured time series and datasets must be underlined. Owing to incomplete datasets and different methodologies, it is difficult to give an overall evaluation of the development in total loads of nutrients to the Baltic Sea, while for heavy metals the dataset is very incomplete. Nonetheless, trend analyses show that total waterborne nitrogen loads to the Baltic Sea were significantly reduced during the period 1994-2008, for Denmark, Germany and Sweden, and increased significantly for Estonia, while no significant trends were noted for the remaining countries. Furthermore, the total waterborne phosphorus loads from Denmark, Germany, Poland and Sweden were significantly decreasing and for Latvia significantly increasing during 1994-2008. In order to assess the effectiveness of reduction measures, losses from diffuse sources should be quantified using more accurate and comparable methodologies and they should include all catchment areas.

The Fifth Baltic Sea Pollution Load Compilation (PLC-5) has been carried out as a project with Mr. Seppo Knuutila, Finnish Environment Institute, as Project Manager assisted by a PLC-5 Core Group which, in addition to the project manager, consisted of Håkan Staaf, Swedish Environmental Protection Agency, Sweden; Susanne Boutrup and MONAS Vice-Chair Lars M. Svendsen, National Environmental Research Institute, Aarhus University, Denmark; data consultant Pekka Kotilainen, Finnish Environment Institute, Finland; Mikhail Durkin and Minna Pyhälä, HELCOM Secretariat. The Core Group has assisted the project manager in writing the report and scrutinizing the data underlying the report.

We wish to express sincere thanks to the representatives of all the Contracting Parties as a part of the project team who have contributed to the success of the work not only during the expert meetings but also in the collection, compilation, presentation and submission of national data and the checking of results and commenting on drafts of the report: Ms. Jytte Erfurt and Mr. Lars M. Svendsen, National Environmental Research Institute, Aarhus University, Denmark; Ms. Ülle Leisk, Tallinn University of Technology, Estonia; Mr. Antti Räike, Finnish Environment Institute, Finland; Mr. Dietmar Koch, Federal Environment Protection Agency, Germany; Mr. Juris Kalvans and Mr. Lauris Sinics, Latvian Environment, Geology and Meteorology Agency, Latvia; Mr. Svajunas Plunge and Ms. Dangira Bareikiene, Environment Protection Agency, Lithuania; Ms. Malgorzata Marciniewicz-Mykieta, Chief Inspectorate for Environmental Protection, Poland; Ms. Larisa Makarova, St. Petersburg Public Organisation "Ecology & Business", Russia, Mr. Håkan Staaf and Ms. Malin Kanth, Swedish Environmental Protection Agency, Sweden.

Special thanks go to our Consultant for Data Management Mr. Pekka Kotilainen, Finnish Environment Institute, without whom it would not have been possible to finalize the report.

The PLC-5 work was possible only with the close cooperation of all the Contracting Parties: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden, who carried out the measurements both in the rivers as well as at diffuse and point sources, performed source apportionment and reported the information to the data consultants.

Finally, our special thanks go to the HELCOM Secretariat for its efficient technical and financial assistance and hosting of expert meetings throughout the project. In particular, we wish to thank Mr. Mikhail Durkin, Ms. Minna Pyhälä and Ms. Maria Laamanen.

Project Manager
Seppo Knuutilla

Summary

This report presents the main results from the PLC-5 project. These include quantified annual waterborne total loads of nitrogen and phosphorus during the period 1994 to 2008 to provide a basis for evaluating any trends in the total flow-normalized waterborne inputs to the Baltic Sea. The contributions from different point and diffuse sources, including the natural background load, are also estimated and described. An estimate of total inputs of some heavy metals is also included. Furthermore, the report includes assessments of the major remaining gaps to reach the HELCOM Baltic Sea Action Plan (BSAP) nutrient reduction target as well the need for further measures. Finally, the lessons learned during the project and future prospects are discussed.

Based on the PLC-5 data, it is estimated that waterborne inputs in 2006 amounted to 638,000 tonnes of nitrogen and 28,400 tonnes of phosphorus. About 5% of the nitrogen load originated from point sources discharging directly into the Baltic Sea, while the rest was transported via rivers. For phosphorus the contribution from these sources was higher, about 8%. The Baltic Proper and the Gulf of Finland received the largest amounts of nutrients, and the main countries contributing to the nitrogen input were Poland (24%), Sweden (19%), and Russia (17%). The largest loads of phosphorus originated from Poland (36%), Russia (14%), and Sweden (13%). These figures include waterborne inputs from all anthropogenic sources as well as the natural background load. The area-specific load of nitrogen into the Baltic Sea was typically largest in sub-regions with intensive agricultural activity and high population density, such as the southwestern part of the Baltic Sea catchment area. Correspondingly, the greatest area-specific phosphorus losses were found in catchment areas with high population density, many industries and high agricultural activity.

For comparison, atmospheric deposition supplied the Baltic Sea with 196,000 tonnes of nitrogen in 2006. The atmospheric deposition of phosphorus directly to the Baltic Sea could not be quantified but is considered low. Atmospheric deposition is not discussed further in this report.

The results of riverine load apportionment for 2006 indicate that the largest share, at least 45% of the total inputs to the sea, of both phosphorus and nitrogen into the Baltic Sea originated from diffuse sources. Point sources contributed to the total load by 12% for nitrogen and about 20% for phosphorus. The proportion of natural background load varied considerably among countries, but it constituted on average 16% of the total phosphorus load and somewhat higher for nitrogen. Sweden reported the highest share of background loads (about 50%), followed by Finland and Poland. A considerable part of the unspecified and transboundary loads probably also originated from diffuse sources. The source apportionment methodology has not been fully and properly applied in all countries which resulted in some uncertainties when evaluating the importance of the different sources, with major uncertainties regarding diffuse sources.

An apportionment of anthropogenic diffuse sources performed for selected countries indicates that agriculture contributed with from approximately 70% to over 90% of the anthropogenic diffuse riverine nitrogen load and 60-80% of the corresponding phosphorus load. Agriculture thus contributed on average 60-90% of the reported total diffuse inputs to the sea. In some countries, scattered dwellings, storm water, and atmospheric nitrogen deposition were also significant sources, although much smaller than agriculture. The second largest anthropogenic source of nutrients originated from point sources, with municipalities as the main source (90%). Unspecified riverine load relates mainly to Russia, which did not perform any riverine load apportionment. Taking into account the large share of forests, wetlands and inland waters in the catchment area of the Baltic Sea in Russia, it can be assumed that the proportion of natural background load is relatively high.

Based on reported heavy metal data, the Gulf of Finland received the largest cadmium, lead, copper and nickel inputs, while mercury inputs were highest for the Baltic Proper. However, it should be noted that the mercury input from Russia seems to be unreliably low. A few major rivers accounted for very large proportions of the reported total riverine heavy metal inputs. The dataset for heavy metals is very incomplete, with data completely missing from some countries, and the results are considered uncertain.

During the period 1994 to 2008, discharges from coastal point sources to the Baltic Sea decreased significantly for both nitrogen and phosphorus, with an average annual reduction of 1,170 tonnes of nitrogen (33%) and 78 tonnes of phosphorus (27%). Direct nitrogen inputs decreased significantly for Germany, Denmark, Finland, Lithuania and Sweden, but significantly increased for Latvia. For direct coastal inputs of phosphorus, there was a significant decrease from Germany, Denmark, Finland, Lithuania and Sweden. Estonia and Latvia had a non-significant increase in these inputs. The direct coastal inputs of nitrogen decreased significantly to all main sub-basins except the Gulf of Riga, where it increased significantly. For phosphorus the same tendency was found, except for the Gulf of Finland, where the decrease was not significant.

When comparing riverine inputs into the Baltic Sea from different years, the controlling influence of the runoff, namely climate, should be taken into account because there is a close correlation between runoff and nutrient loads. During years with heavy precipitation and associated high runoff, more nitrogen and phosphorus are leached and eroded from cultivated areas, and most probably also from natural background areas, resulting in higher riverine nutrient inputs to the Baltic Sea than in dry years. Thus, flow-normalized annual riverine nitrogen loads during 1994-2008 had a large effect on the results, and only Denmark showed significant decreasing loads, with an annual decrease in nitrogen input of 1,520 tonnes (31%). Five HELCOM countries displayed no significant decrease of flow-normalized nitrogen loads, while two Contracting Parties (Estonia and Finland) showed statistically significant increasing riverine loads and Russia had a non-statistically significant increase in nitrogen load. The total flow-normalized nitrogen load to the whole Baltic Sea decreased, but not significantly, during 1994-2008. Two sub-regions, Kattegat and the Danish Straits, had significant decreases in flow-normalized riverine nitrogen loads, while in the Bothnian Bay there was a significant increase. Denmark, Germany, Poland and Sweden had a significant decrease in flow-normalized riverine loads of phosphorus and Latvia a significant increase. Four sub-regions had a significant decrease in flow-normalized phosphorus loads (Danish Straits, Baltic Proper, Bothnian Sea and Bothnian Bay) and one a significant increase (Gulf of Riga).

Finally, when analysing the flow-normalized riverine loads plus the direct coastal loads, i.e., the total waterborne loads, Germany (4%), Denmark (34%) and Sweden (12%) showed a significant decrease of nitrogen input during 1994-2008, while there was a significant increase from Estonia (47%). Furthermore, for Finland, Latvia and Russia the total nitrogen load increased, but not significantly. The waterborne nitrogen load to the whole Baltic Sea decreased, but not statistically significantly, during 1994-2008. The corresponding phosphorus loads showed a significant decrease for Germany (31%), Denmark (31%), Poland (18%), Sweden (28%) and for the whole Baltic Sea (13%), but a significant increase for Latvia. A statistically non-significant increase was seen for Estonia, and Lithuania. Total waterborne loads of nitrogen to the Kattegat (26%), Danish Straits (35%) and Baltic Proper (16%) significantly decreased during 1994-2008, but increased significantly for the Bothnian Bay (12%). Regarding phosphorus, a statistically significant decrease was observed for all main sub-regions except for the Gulf of Riga, which had a significant increase (67%), and the Gulf of Finland, which had a non-significant decrease.

An analysis based on non-flow-normalized data showed that the total load of nitrogen was approximately 69,000 tonnes lower (i.e., 9%) during 2000-2006 when compared with the period 1997-2003. For phosphorus, the corresponding reduction was nearly 3,000 tonnes (8%). However, when comparing the same periods using the flow-normalized data, as well as including updated load information from several countries, a decrease of only 10,000 tonnes of nitrogen (1%) and an increase of 300 tonnes of phosphorus (1%) was seen. This emphasizes the importance of flow-normalization when assessing the temporal development and the progress towards the nutrient reduction targets of the HELCOM BSAP.

When comparing the most recent period of available data (2006-2008) with the 1997-2003 reference period, more countries showed a decrease in total flow-normalized waterborne phosphorus loads (eight compared with six), although the trends were not always statistically significant. For nitrogen on the other hand, fewer countries showed a decrease in total waterborne loads (four compared with five). Flow-normalized waterborne nitrogen loads for the whole Baltic Sea were nearly 13,000 tonnes higher (2%) in 2006-2008 compared with 1997-2003 and the corresponding figure for phosphorus was 2,000 tonnes lower (6%). Thus, when considering this period for the whole Baltic Sea, the gap to the maximum allowable input has increased for nitrogen loads. However, the situation differs between the sub-basins and for nitrogen a positive development was seen for the Kattegat, Danish Straits and Baltic Proper. For phosphorus, the development was positive for the Danish Straits, Baltic Proper, Bothnian Sea and Bothnian Bay, although only the Baltic Proper has a reduction requirement according to the BSAP.

By comparing the flow-normalized load of nitrogen and phosphorus for 2006-2008 with the maximum allowable load defined in the BSAP, the remaining reduction requirement can be estimated. It amounts to about 108,000 tonnes per year of nitrogen and 9,500 tonnes per year of phosphorus for the whole Baltic Sea. This assessment does not take into account the specific situations in individual sub-basins and should thus be considered a rough estimate. If wastewater treatment levels required by HELCOM Recommendation 28E/5 are fulfilled by 2021, an annual reduction of roughly 17,000 tonnes of nitrogen and 6,400 tonnes of phosphorus would take place (HELCOM 2007e). Minor reductions could be achieved by measures to improve unconnected households, forestry operations and storm water constructions, but most of the remaining part would fall on agriculture, as well as on sectors causing large amounts of atmospheric deposition onto the Baltic Sea, such as shipping, traffic and combustion in industries. For the agricultural sector the reduction requirements would be about 90,000 tonnes of nitrogen per year and 2,100 tonnes of phosphorus per year. Because the efficiency of measures implemented in the agricultural sector has been fairly low, this will evidently be a very difficult task. The future common agriculture policy within the European union (EU) will be of vital importance in this process.

During the compilation of the PLC-5 report, significant gaps in the reported data were identified. Some of these are so serious that they complicate the interpretation of, for example, the trend analysis and the relative importance of different sources. In the future, it will be important to focus on data completeness and to improve the comparability of applied methodologies between countries. The new HELCOM Expert Group on follow-up of national progress towards reaching BSAP nutrient reduction targets (HELCOM LOAD), which will focus on methodologies for load assessments, should be a useful tool in this work. In addition, several approaches should be considered to improve the situation.

1 Introduction

1.1 Pollution of the Baltic Sea

Eutrophication is a major problem in the Baltic Sea. Since the beginning of the 20th century, the Baltic Sea has changed from an oligotrophic clear-water sea into a highly eutrophic marine environment (Larsson 1985). The deterioration of the Baltic Sea is considered alarming in many of its sub-regions since they have become overloaded with nutrients.

Nitrogen and phosphorus do not of themselves pose any direct hazard to marine organisms or people, but excessive nutrient inputs may disturb the balance of the ecosystem. High concentrations of nitrogen and phosphorus have resulted in intense primary production and led to the proliferation of algal blooms, especially of blue-green algae. The abundance of toxic algae populations has also increased, adding to the problem.

Nutrient concentrations in the Baltic Sea increased until the 1980s. In all areas except for the Gulf of Finland, phosphorus concentrations have declined during the past two decades but good environmental quality has not yet been re-established. Nitrogen concentrations have declined in the Gulf of Riga, Baltic Proper and Danish Straits (HELCOM 2009). These declines are partly caused by lower nutrient loads from land-based sources, but changing volumes of hypoxia in the Baltic Proper significantly alter nutrient concentrations in bottom waters and, through subsequent mixing, also surface waters.

Environmental problems in the Baltic Sea have also been aggravated by the presence of heavy metals such as mercury and cadmium, which have been shown to have harmful effects on aquatic life when accumulated over a period of time. The fate of such heavy metals when they ultimately come into contact with seafloor sediments, which are a habitat for many animals and plants, is another cause for concern.

1.2 Objectives of the PLC

Background

In implementing the objectives of the Convention and to follow progress in fulfilling the provisional reduction targets agreed in the Baltic Sea Action Plan, the Helsinki Commission needs reliable data on inputs to the Baltic Sea from land-based sources. These data can also be used to assess the effectiveness of measures taken to abate the discharge of harmful substances into surface waters and emissions to air, and for evaluation of the state of the open sea and coastal waters.

HELCOM regularly produces a Pollution Load Compilation which assesses the data collected by the Contracting Parties on total waterborne inputs of nutrients and some hazardous substances to the Baltic Sea. This is the Fifth Pollution Load Compilation, termed PLC-5, and is based on data collected in the year 2006 but also includes time series from 1994 to 2008. This report is directed at scientists, administrators and the general public.

This main objective of the PLC-5 report is:

- to quantify and describe the waterborne discharges from point sources and losses from non-point pollution sources as well as to quantify natural background losses into inland surface waters (source-oriented approach) within the catchment area of the Baltic Sea;
- to quantify and describe the loads (from rivers, unmonitored and coastal areas as well as point sources) discharging directly to the Baltic Sea (load-oriented approach);
- to evaluate changes in the pollution load since 1994;
- to explain the extent to which changes are caused by human activities or natural variations; and

to overall evaluate the significance of various water protection measures applied in the Baltic Sea catchment area to reduce the pollution load from land-based sources.

1.3 Main focus of the report

This report includes the main results from the most recent HELCOM waterborne pollution load compilation and refers to the year 2006. The data have been collected and compiled under the Fifth Baltic Sea Pollution Load Compilation Project (PLC-5). The main focus is on nutrients (nitrogen and phosphorus) together with selected data for some heavy metals (lead, cadmium and mercury).

This report describes the main waterborne inputs of nutrients from point and diffuse sources to the Baltic Sea as well as to inland surface waters within the catchment area. Trends in nutrient loads during the period 1994-2008 are also presented. A popular report will be published at a later stage in which waterborne loads will be combined with airborne loads to yield an estimate of total inputs of nitrogen and phosphorus to the Baltic Sea.

1.4 Classification of inputs

The PLC-5 compilation includes inputs and discharges to inland surfaces waters and to the Baltic Sea from point and diffuse sources in the catchment areas of the Baltic Sea (**Figure 1-1**). Point sources include municipal wastewater treatment plants, industries and fish farms. Diffuse sources include natural background losses, losses from agriculture and forestry, atmospheric deposition on inland surface waters and discharges from scattered dwellings and storm water constructions and overflows. During transportation from the source to the sea, retention of nutrients occurs in soil, groundwater, lakes, and watercourses which reduces the amounts entering into the sea. Further classification of different sources is given in the PLC-5 guidelines "Guidelines for the compilation of waterborne pollution load to the Baltic Sea" (HELCOM 2006).

The various sources to the sea are illustrated in **Figure 1-2**. Atmospheric deposition directly onto the sea, internal loading in the sea and net inflow/outflow to the Baltic Sea of nutrients are not included in this report.

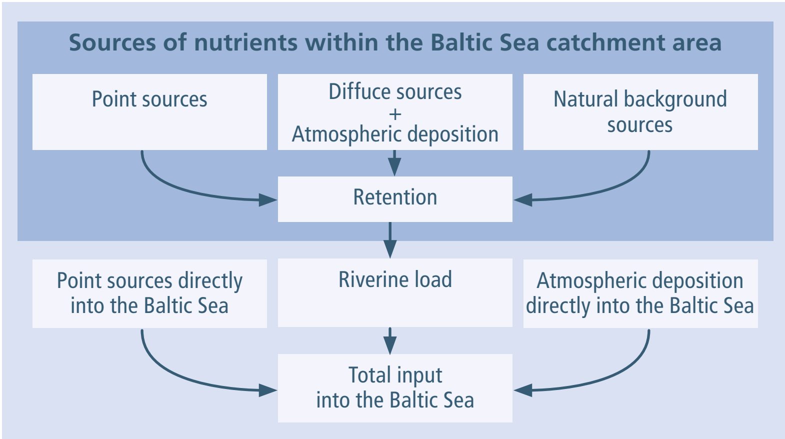


Figure 1-1 Conceptual model of sources of inputs to inland surface waters and to the Baltic Sea.

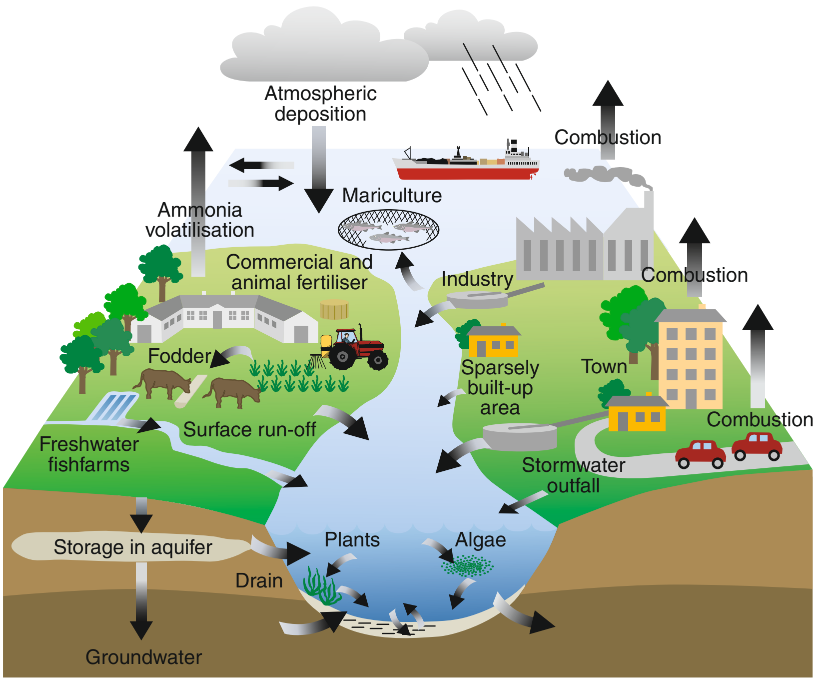


Figure 1-2 Different sources of nutrients to the sea and examples of nitrogen and phosphorus cycles (Source: Ærtebjerg et al. 2003).

1.5 History of the PLC

Pollution load compilations have been performed on a regular basis since the late 1980s.

The *First Pollution Load Compilation (PLC-1)* was published in 1987 as a first attempt to compile the various types of data concerning inputs of nutrients and organic matter previously submitted to the Commission (HELCOM 1987). The information came from various sources and no common guidelines had been developed. There were several shortcomings as data were often preliminary, background information or rough estimates, different methodologies had been used and there were many data gaps. Accordingly, it was recommended that PLC-1 results be used very carefully.

The *Second Pollution Load Compilation (PLC-2)* was published in 1993 (HELCOM 1993). It was implemented as a pilot programme for the survey year 1990. It was intended to provide basic information for all major aspects of pollution. To improve the quality of this compilation, a special set of guidelines for PLC-2 were developed. It also provided a unified methodology for measurements, calculations and reporting.

The PLC-2 report contained data characterizing major pollution sources and loads of nutrients for nine sub-basins of the Baltic Sea and for the Baltic Sea as a whole. The results of PLC-2 did not include all riverine and direct inputs and there were many uncertainties, but it represented a step forward in providing a first, more reliable estimate of total loads in the Baltic Sea, and was based on more detailed data from most of the Contracting Parties.

The *Third Pollution Load Compilation (PLC-3)* was published in 1998, based on data from 1995 (HELCOM 1998). A set of guidelines was prepared, including reporting requirements, and a quality assurance system was established and an interlaboratory comparison test performed. By this, some of the major uncertainties and weaknesses of PLC-2 were avoided, but there were still some shortcomings, missing data and uncertainties in the amount of total inputs.

In addition to the overall pollution load via rivers and direct input sources, apportionment of riverine loads (source apportionment of load) was introduced to distinguish between natural and anthropogenic contributions of nitrogen and phosphorus.

The *Fourth Pollution Load Compilation (PLC-4)* was published in 2004, based on data from the year 2000 (HELCOM 2004). The PLC-4 guidelines were largely based on the PLC-3 guidelines, and also reflected the experience gained during PLC-3. They were to some extent also harmonized with OSPAR's "Harmonised Systems and Procedures for Nutrients" (HARP). They included quantification of major sources of nitrogen and phosphorus using two approaches:

- Source-oriented approach, whereby inputs and losses are quantified to determine the inputs/losses from different point and diffuse sources into surface waters. Contracting Parties could use their own methodology to quantify the diffuse sources.
- Load-oriented approach, whereby the measured loads are apportioned into point and diffuse sources.

PLC-4 represented another step forward in terms of quality, as it included a first quantification of point and non-point sources of pollution in the catchment area of the Baltic Sea located within the borders of the Contracting Parties as well as a more comprehensive load apportionment. A time series with total inputs of nitrogen and phosphorus during the period of 1994 to 2000 was also included.

The estimate of total inputs to the Baltic Sea was the most extensive so far, but still with some missing data and some problems with the methodologies applied for part of the catchment area. In addition, the source apportionment (especially the source-oriented approach) was incomplete and not fully comparable between countries. Due to incomplete reporting, inputs of heavy metals to the Baltic Sea could not be quantified in PLC-4.

For further details on the PLC history, see Chapter 1.2 in the PLC-4 report (HELCOM 2004).

For the *Fifth Pollution Load Compilation (PLC-5)*, new guidelines for the compilation of waterborne pollution load to the Baltic Sea (PLC-Water) (HELCOM 2006) were developed. These guidelines comprise a revised version of the PLC-4 guidelines, with updated methodology and specifications concerning which information should be reported in the reporting formats.

2 Description of the Baltic Sea catchment area

The total Baltic Sea catchment area comprises 1,720,270 km^2, of which nearly 93% belongs to the HELCOM Contracting Parties and 7% lies within the territories of Non-Contracting Parties.

2.1 Division of the Baltic Sea catchment area

The division of each of the sub-basins of the catchment area between Contracting Parties and Non-Contracting Parties is presented in **Table 2-1** and illustrated in **Figure 2-1.**

The sub-basin catchment areas of the Baltic Proper and the Gulf of Finland are the largest, covering 575,000 km^2 and 410,000 km^2, respectively. The Archipelago Sea and the Sound have the smallest catchment areas. Sweden possesses the largest portion of the Baltic Sea catchment area, 440,000 km^2. The next largest national catchment areas are those of Poland, Russia and Finland, all of which are larger than 300,000 km^2.

Figure 2-1 Division of the Baltic Sea catchment area.

Germany has the smallest proportion of the catchment area of all the Contracting Parties, at 28,600 km^2. The total catchment area outside the borders of the Contracting Parties is 117,520 km^2, mostly within Belarus.

A more detailed description of the Baltic Sea catchment area and its specific sub-catchments can be found in Chapter 2 "Description of the Baltic Sea catchment area" of the Fourth Baltic Sea Pollution Load Compilation (HELCOM 2004).

Table 2-1 Division of the Baltic Sea catchment area between Contracting Parties and Non-Contracting Parties for each sub-basin, in km^2.

Sub-basins/ country	Gulf of Bothnia (GUB)			Gulf of Finland	Gulf of Riga	Baltic Proper	Belt Sea and Kattegat			Total
	Bothnian Bay (BOB)	Bothnian Sea (BOS)	Archipelago Sea (ARC)	(GUF)	(GUR)	(BAP)	Western Baltic (WEB)	The Sound (SOU)	The Kattegat (KAT)	
Contracting Parties										
Finland	146,000	39,300	9,000	107,000	-	-	-	-	-	301,300
Russia	-	-	-	276,100	23,700	15,000	-	-	-	314,800
Estonia	-	-	-	26,400	17,600	1,100	-	-	-	45,100
Latvia	-	-	-	3,600	49,600	11,400	-	-	-	64,600
Lithuania	-	-	-		11,140	54,160	-	-	-	65,300
Poland	-	-	-	-	-	311,900	-	-	-	311,900
Germany	-	-	-	-	-	18,200	10,400	-	-	28,600
Denmark	-	-	-	-	-	1,200	12,340	1,740	15,830	31,110
Sweden	113,620	176,610	-	-	-	83,225	-	2,885	63,700	440,040
Total	**259,620**	**215,910**	**9,000**	**413,100**	**102,040**	**496,185**	**22,740**	**4,625**	**79,530**	**1,602,750**
Non-Contracting Parties										
Belarus					33,300	58,050				91,350
Ukraine						11,170				11,170
Czech Republic						7,190				7,190
Slovakia						1,950				1,950
Norway	1,055	4,855							7,450	13,360
Total Baltic Sea catchment areas including Contracting Parties and Non-Contracting Parties										
Total	**260,675**	**220,765**	**9,000**	**413,100**	**135,340**	**574,545**	**22,740**	**4,625**	**86,980**	**1,727,770**

The total long-term mean flow rate via all rivers discharging into the Baltic Sea is about 15,200 m^3/s (480 km^3/y or 8,8 l/s km^{-2}), of which nearly half drains into the Baltic Sea via the seven largest rivers, namely the Neva, the Vistula, the Daugava, the Nemunas, the Kemijoki, the Oder and the Göta Älv. The long-term mean flow rates of these rivers and the division of the river catchment areas among the different countries are presented in **Table 2-2**.

Table 2-2 Division of river catchment areas among Contracting and Non-Contracting Parties for the seven largest rivers discharging into the Baltic Sea.

Rivers/States	Neva	Vistula	Nemunas	Daugava	Oder	Göta Älv	Kemijoki	Total
Long-term mean flows and measurement periods for the seven largest rivers discharging into the Baltic Sea								
in m^3/s	2,278	1,081	496	1,036	574	643	562	6,670
period	1943-2006	1951-1990	1956-2008	1906-2000	1951-1990	1985-2004	1970-2000	-
Length of the seven largest rivers								
in km	74[1]	1,047	937	1,020	854	90[2]	600	-
Catchment areas in Contracting Parties in km^2								
Finland	56,200						4 9470	105,670
Russia	215,600		3,170	27,000			1660	247,430
Estonia				2,360				2,360
Latvia			90	23,700				23,790
Lithuania			46,700	170				46,870
Poland		168,700	2,510		106,060			277,270
Germany					5,590			5,590
Denmark								
Sweden						42,470		42,470
Catchment area in Non-Contracting Parties in km^2								
Belarus		12,600	45,450	33,300				91,350
Ukraine		11,170						11,170
Czech Republic					7,190			7,190
Slovakia		1,950						1,950
Norway						7,760		7,760
Total	**271,800**	**194,420[3]**	**97,920**	**86,530**	**118,840**	**50,230**	**51,130**	**870,870**

[1] length of the Neva to Lake Ladoga
[2] length of the Göta Älv – Klarälven River
[3] without delta

2.2 Land use in the Baltic Sea catchment area

To support understanding and interpretation of the inputs, discharges and loads originating in different sub-basins, general information is included about population density (**Figure 2-2** and **Table 2-3**) and land use (**Figure 2-3** and **Table 2-6**) in the Baltic Sea catchment area. Large parts (60-70%) of the German, Danish and Polish sectors of the catchment area consist of agricultural land. For a more detailed description of the different sub-catchment areas, see Chapter 2 of the PLC-4 report (HELCOM 2004).

Figure 2-2 Estimated average population density in the Baltic Sea catchment area in 2010.

Population density has an effect on the magnitude of pollution loads. Cities with large human populations and a lot of industrial activity are generally considered as major point sources of pollution, but effective wastewater treatment can significantly reduce pollution loads and a major part of the nutrient loads from built-up areas. Humans that live in rural areas, with poor or no treatment of sewage discharges, can also have a significant impact on the load of nutrients entering the Baltic Sea.

The removal rate of municipal wastewater treatment plants varies considerably between cities and countries around the Baltic Sea region. Although efficient techniques to remove phosphorus from wastewater have been used for many years in several countries, there are several wastewater treatment facilities that require upgrading. Wastewater treatment in the Baltic Sea coastal countries has improved considerably during recent years. As can be seen in **Table 2-4**, there has been a steady increase in the percentage of the population connected to secondary and tertiary wastewater treatment systems since the early 2000s. The total number of municipal wastewater plants in HELCOM Contracting Parties and Belarus is presented in **Table 2-5**.

Primary (mechanical) treatment removes coarse debris and part of the suspended solids, while secondary (biological) treatment uses aerobic or anaerobic microorganisms to decompose most of the organic matter (up to 90%) and retain some of the nutrients (around 20-30%). Tertiary (advanced) treatment removes the organic matter even more efficiently (more than 80% of phosphorus and 50-90% of nitrogen). It generally includes chemical precipitation of phosphorus and in some cases extended nitrogen removal.

Table 2-3 Population size, population density and urbanization for the parts of countries within the Baltic Sea catchment area. The total country areas, including parts outside the catchment, are also given for comparison. (Data sources: UNEP 2005; FAOSTAT 2011; Federal Statistical Service of Russia 2009; National Statistical Committee of the Republic of Belarus 2010)

Country	Country area (km²)	Watershaded area (km²)	Population in catchment	Population density (km²)	Rural population (%)
Contracting Parties					
Poland	312,700	311,900	38,100,000	122	39
Russia	17,100,000	314,800	9,200,000	29	15
Sweden	450,000	440,000	9,100,000	21	16
Finland	338,200	301,300	5,300,000	18	37
Denmark	43,100	31,100	4,900,000	158	13
Lithuania	65,200	65,200	3,400,000	52	33
Germany	357,000	28,600	3,100,000	108	27
Latvia	64,600	64,600	2,300,000	36	32
Estonia	45,100	45,100	1,300,000	29	31
Non-Contracting Parties					
Belarus	207,600	83,850	4,000,000	48	27
Ukraine	603,700	11,200	1,800,000	161	n.i.[1]
Czech Republic	78,900	7,200	1,600,000	222	n.i.[1]
Slovakia	49,000	2,000	200,000	100	n.i.[1]
Norway	323,900	13,400	n.i.[1]	n.i.[1]	n.i.[1]
TOTAL	**20,039,000**	**1,720,250**	**84,300,000**	**42**	**29**

[1] n.i. = no information

Table 2-4 Percentage of population connected to urban wastewater collection and treatment systems. (Data sources: 2004: DK data from 1998. FI data from 2001. LV, LT data from 2003 – Eurostat. RU data from 2006 (PLC-5); 2007: DK data from 1998. FI data from 2001 – Eurostat. RU data from 2006 (PLC-5); 2009: FI data from 2001; DE, LV, LT, SE data from 2007 - Eurostat. RU estimate from the draft Baltic Sea Action Plan National Implementation Programme)

Country	2004				2007				2009			
	collection	primary	secondary	tertiary	collection	primary	secondary	tertiary	collection	primary	secondary	tertiary
Denmark	89	2	87	84	89	2	87	84	90	0,4	90	88
Estonia	73	1	71	46	74	1	74	61	81	1	80	61
Finland	81	0	81	81	81	0	81	81	81	0	81	81
Germany	95	0	94	90	96	0	95	93	96	0	95	93
Latvia	70	2	68	33	71	2	63	38	71	2	63	38
Lithuania	59	32	28	21	62	8	61	36	62	8	61	36
Poland	58	2	57	34	60	1	62	41	62	0	64	49
Russia	60	40	60	0	60	40	60	0	71	29	71	55
Sweden	86	0	86	81	86	0	86	81	86	0	86	81
Average	**75**	**9**	**70**	**52**	**75**	**6**	**74**	**57**	**78**	**5**	**77**	**65**

Table 2-5 Municipal wastewater treatment plants of different size categories and their total connected loads expressed in population equivalent (PE). (Data sources: EU Member States – reporting on implementation of the Urban Waste Water Treatment Directive as of 31.12.2007; Russia – information in the draft National Implementation Programme for the HELCOM BSAP and the RusNIP Project (SEPA 2010); Belarus – information on WWTPs in the Baltic Sea catchment provided to HELCOM in 2008. Danish data from 2009 and additionally the MWWTPs there are 1% of PE as private wastewater treatment plants. Swedish data from 2008: Statistics Sweden 2010)

Country	≤2,000 PE[1]		2,001-10,000 PE		10,001-100,000 PE		> 100,001 PE		Total	
	No. Plants	Load	No. Plants	Load	No. Plants	Load	No. Plants	Load	No. Plants	Load
Denmark	404	166,600	230	597,100	149	2,417,500	37	3,786,700	820	6,960,000
Estonia	7	6,200	16	35,128	14	180,403	7	1,006,528	44	1,228,248
Finland	1	1,400	100	449,100	95	2,506,100	14	3,170,900	210	6,127,500
Germany	3	6,300	150	623,273	103	2,798,035	13	2,627,000	269	6,054,558
Latvia	64	33,400	31	42,322	31	407,543	6	955,815	132	1,439,105
Lithuania	17	15,000	30	66,300	36	512,700	9	1,691,000	92	2,285,00
Poland	118	151,500	668	3,387,893	494	15,199,018	84	22,427,336	1364	41,165,752
Sweden	n.i.[2]	n.i.[2]	278	785,600	170	3,211,300	19	4,270,400	467	8,267,400
Russia	n.i.[2]	n.i.[2]	n.i.[2]	n.i.[2]	n.i.[2]	n.i.[2]	n.i.[2]	n.i.[2]	361	n.i.[2]
Belarus	n.i.[2]	n.i.[2]	45	242,522	25	615,513	6	1,383,586	76	2,241,891

[1] this category is not homogeneous and not comparable for different countries due to different definitions of Urban Wastewater Treatment Plants (UWWTPs) below 2000 PE and connected/generated loads
[2] n.i.= no information

Figure 2-3 Land cover in the Baltic Sea catchment area. (Source: CORINE land cover, 2006)

Table 2-6 Land cover and land use of the Baltic Sea catchment area by country (in%). (Source: EEA 2010; Eurostat 2011; Federal State Statistics Service of Russia 2009)

Land cover	DK	EE	FI	DE	LV	LT	PL	RU	SE
Urban areas	8.6	3	2	4	2	5	6	2	3
Forests (incl. mountains)	12	44	51	15	44	31	29	55	67
Farmland (+ pastures)	76	30	7	72	39	54	60	12	8
Inland waters (lakes)	1.4	5	10	4	1	4	3	17	9
Wetlands and peatlands	1,7	17	27	-	5	2	-	13	12
Other	0.5	1	3	5	9	4	2	1	1

Land use	DK	EE	FI	DE	LV	LT	PL	RU	SE
Agriculture	64	27	7	64	32	53	53	32	8
Forestry	12	50	62	16	48	34	27	55	54
Heavy environmental impact	4	3	2	3	2	2	3	2	2
Services & residential	12	11	8	10	4	5	5	11	12
Other use	8	10	21	7	14	7	13		23

Land use	Area (km²)	% of total
Forest	835,000	47.9%
Arable land	352,900	20.2%
Pasture	104,000	6.0%
Open land	298,100	17.1%
Unknown land	33,600	1.9%
Populated area	13,100	0.8%
Inland water	106,800	6.1%

Agriculture is a major source of nutrient inputs to the Baltic Sea. Since the enlargement of the EU in the Baltic region, agricultural production and fertilizer use in the catchment area have increased. **Table 2-7** provides some basic statistics and estimates about the amount of mineral and organic fertilizers used. The figures for mineral fertilizers for Germany include consumption for the whole country.

Reducing nutrient loads from agriculture is more complicated than cutting loads from point sources. Although the implementation of agri-environmental measures is expected to promote reductions in nutrient loads from agriculture, there is evidently a considerable time lag between the implementation of agricultural water protection measures and visible effects in waterbodies, partly due to the retention of nutrients in soils, groundwater and inland surface water of the catchment area.

The generation of excessive amounts of organic nitrogen from animal manure may lead to over-fertilization and hence nitrogen surplus in soil, as demonstrated in **Figure 2-4**. Correspondingly, net

Table 2-7 Estimates of fertilizer consumption in the Baltic Sea catchment area during 2005-2006. Units: 1,000 tonnes of active ingredient. (Data sources: FAOSTAT 2010; Federal State Statistics Service of Russia 2009; National Statistical Committee of the Republic of Belarus 2010; Foged et al. 2010)

Country[1]	Nitrogen		Phosphorus		Total (N+P+K)	Organic N+P)	Agricultural land[2], km[2]
	Mineral (2006)	Organic	Mineral (P_2O_5)	Organic			
Contracting Parties							
Denmark	192	166	31	35			28,000
Estonia	28	24	7	8			11,600
Finland	158	85	44	22			23,870
Germany	1,785	90	274	16			228,480
Latvia	39	61	15	22			28,260
Lithuania	119	72	32	27			35,270
Poland	931	347	354	129			142,470
Russia	n.i.[3]	n.i.[3]	n.i.[3]	n.i.[3]	33	21	
Sweden	165	137	30	22			26,980
Non-Contracting Parties							
Belarus	479	n.i.[3]	205	n.i.[3]		2,840	

[1] for Germany and Denmark (mineral fertilizer) and Belarus – the data are for the whole country
[2] agricultural areas of the whole country
[3] n.i. = no information

application of phosphorus in many areas has led to an increase in phosphorus status in agricultural soils and phosphorus leaching in some areas.

Intensified development of industrial production of cattle, pigs and poultry in the Baltic Sea catchment area has led to the creation of a new segment of pollution point sources, adding significantly to nutrient loads. **Table 2-8** illustrates the number of livestock in the different Baltic Sea countries.

Table 2-8 Number of livestock in the Baltic Sea catchment area in 2006, in 1,000 heads. (Data sources: FAOSTAT 2010, Eurostat 2010, Federal Statistical Service of Russia 2009, National Statistical Committee of the Republic of Belarus 2010)

Country	Pigs	Poultry	Cattle	Sheep/ goats
Contracting Parties				
Denmark*	13,361	16,826	1,535	170
Estonia	347	1,854	250	52
Finland	1,437	5,366	949	123
Germany+	2,115	107,000	1,763	448
Latvia	428	3,480	385	57
Lithuania	1,115	9,201	800	51
Poland	18,881	124,870	5,607	431
Russia	274	22,947	489	157
Sweden	1,681	6,170	1,590	506
Non-Contracting Parties				
Belarus	1,577	11,741	1,681	72

* Denmark - for the whole country
+ Germany – animal statistics for federal lands of Mecklenburg-Vorpommern and Schleswig-Holstein, except poultry (for the whole country),

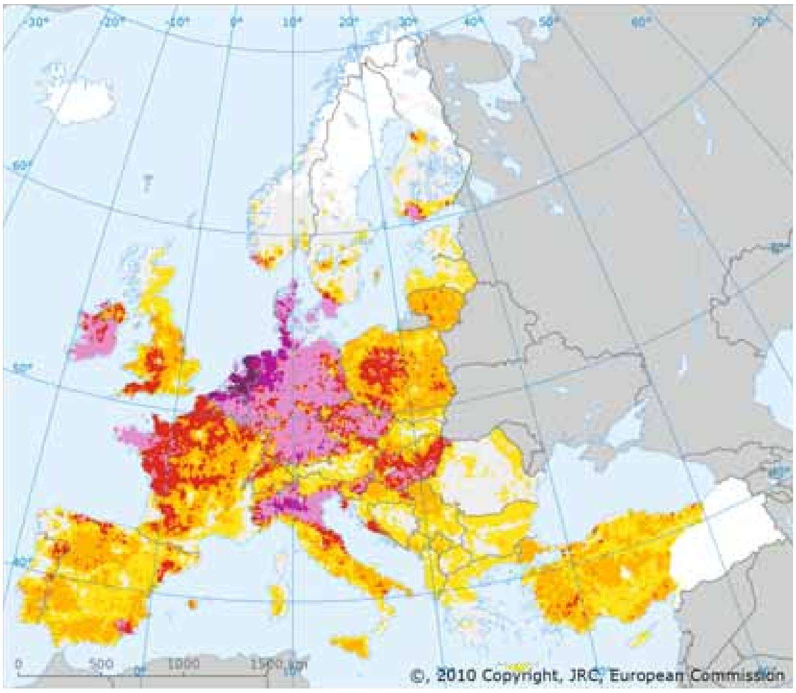


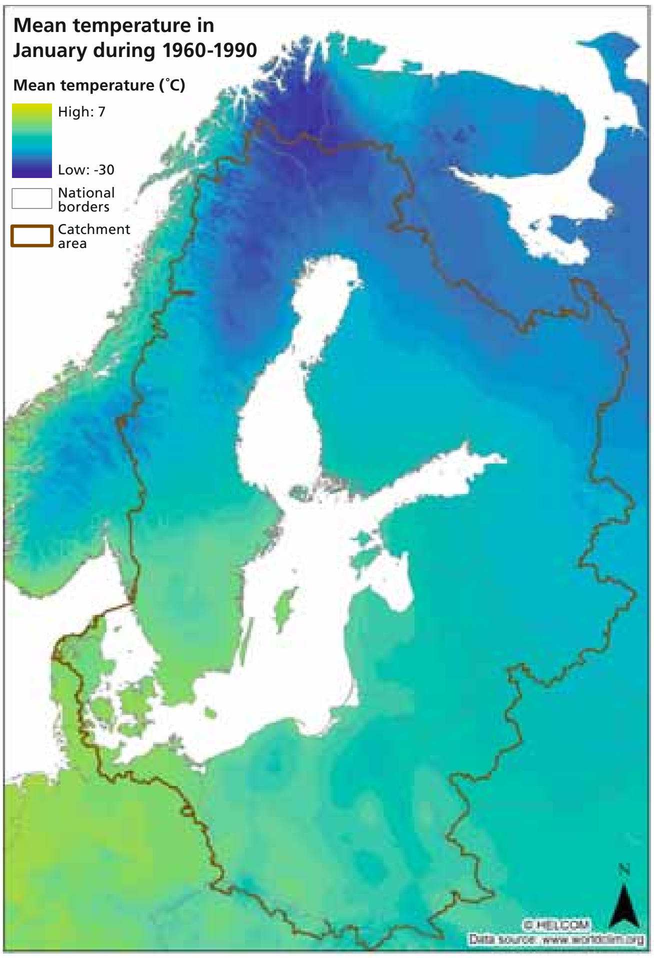
Figure 2-4 Estimated nitrogen surplus (the difference between inorganic and organic fertilizer application, atmospheric deposition, fixation and uptake by crops) for the year 2005 across Europe. (Source: EEA/JRC 2010)

2.3 The effects of hydrological conditions on nutrient loads

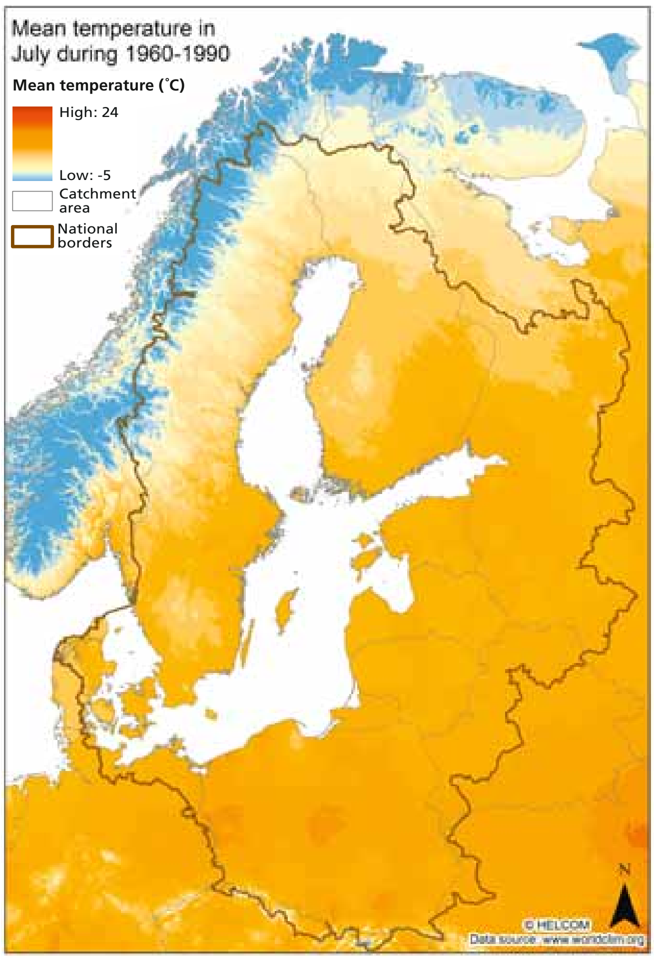
The input of nutrients to the marine environment is largely dependent on human activities in the catchment area, but variations in meteorological and hydrographical conditions also have a significant impact on the amount of nutrients entering the sea. Increased precipitation increases runoff from land, and wet years generally result in increased nutrient losses and inputs from diffuse sources to surface waters, including marine waters. In the northern Baltic Sea region, winter snow and ice cover help to reduce runoff during a large part of the year, and therefore warmer winters with less snow and ice cover will likely result in greater runoff and consequently higher nutrient loads. Furthermore, with more extreme rainfall events, more erosion will take place and enhance particulate inputs to surface waters.

The climate of the Baltic Sea basin is Atlantic-temperate in the southwestern part and more continental-temperate in the eastern part, the largest seasonal variation occurring in the more continental parts of the catchment area. Topography also plays an important role especially for precipitation amounts, which tend to be greater at high altitudes. In addition, there are land-sea contrasts in temperature and precipitation. **Figure 2-5** and **Figure 2-6** illustrate average summer and winter temperatures and monthly precipitation rates for the period 1961 to 1990.

Overall, runoff is governed by precipitation and evaporation over land and inland water bodies as well as changes in stored precipitation as snow and

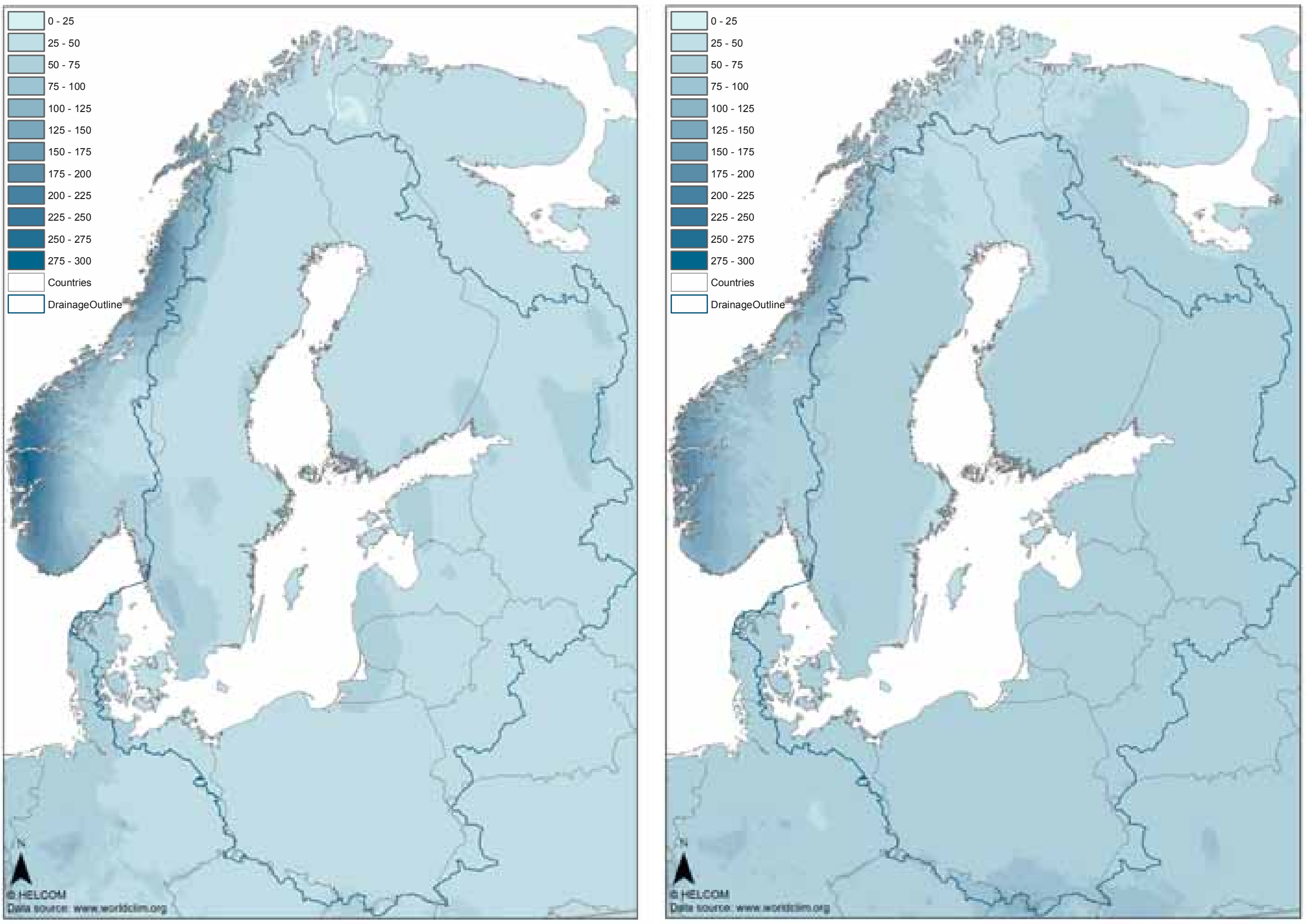


a)



b)

Figure 2-5 Mean temperature (in °C) for the months of a) January and b) July during the period 1961 to 1990 in the Baltic Sea region. (Data source: WorldClim 2011)



a) b)

Figure 2-6 Mean monthly precipitation (in mm) in a) winter (October to March) and b) summer (April to September) during the period 1961 to 1990 in the Baltic Sea region. (Source: WorldClim 2011)

ice on land and in lakes and groundwater. In all sub-regions of the Baltic Sea, a strong seasonal, annual and decadal variability can be identified (**Figure 2-7**). Longer periods with wet and dry conditions characterize the runoff patterns. The 1970s was a fairly dry period compared with the1980s and the latter part of the 1990s. Annual runoff is at about the same level into the Gulf of Finland and the Baltic Proper, whereas runoff into the Gulf of Riga contributes to a lesser extent and runoff into the Gulf of Bothnia to a larger extent to the total runoff.

2.4 Possible effects of climate change

In addition to natural variability in climate, global warming has been observed during the past century. In the Baltic Sea region, the warming trend has been reflected in a decrease in the number of very cold days during winter as well as a decrease in the duration of the ice cover and its thickness in many rivers and lakes, particularly in the eastern and southeastern Baltic Sea basin. In addition, the length of the frost-free season has increased and an increasing length of the growing season in the Baltic Sea basin has been observed during this period, especially during the past 30 years.

Scientists predict that in association with further warming, there would be changes in precipitation patterns, both geographically and seasonally. A general increase in annual precipitation is projected for the northern parts of the Baltic Sea basin. Seasonally, the increase in precipitation mainly would occur in winter. Regionally, the southern areas of the basin would be drier than northern areas, particularly during summer. These changes in precipitation

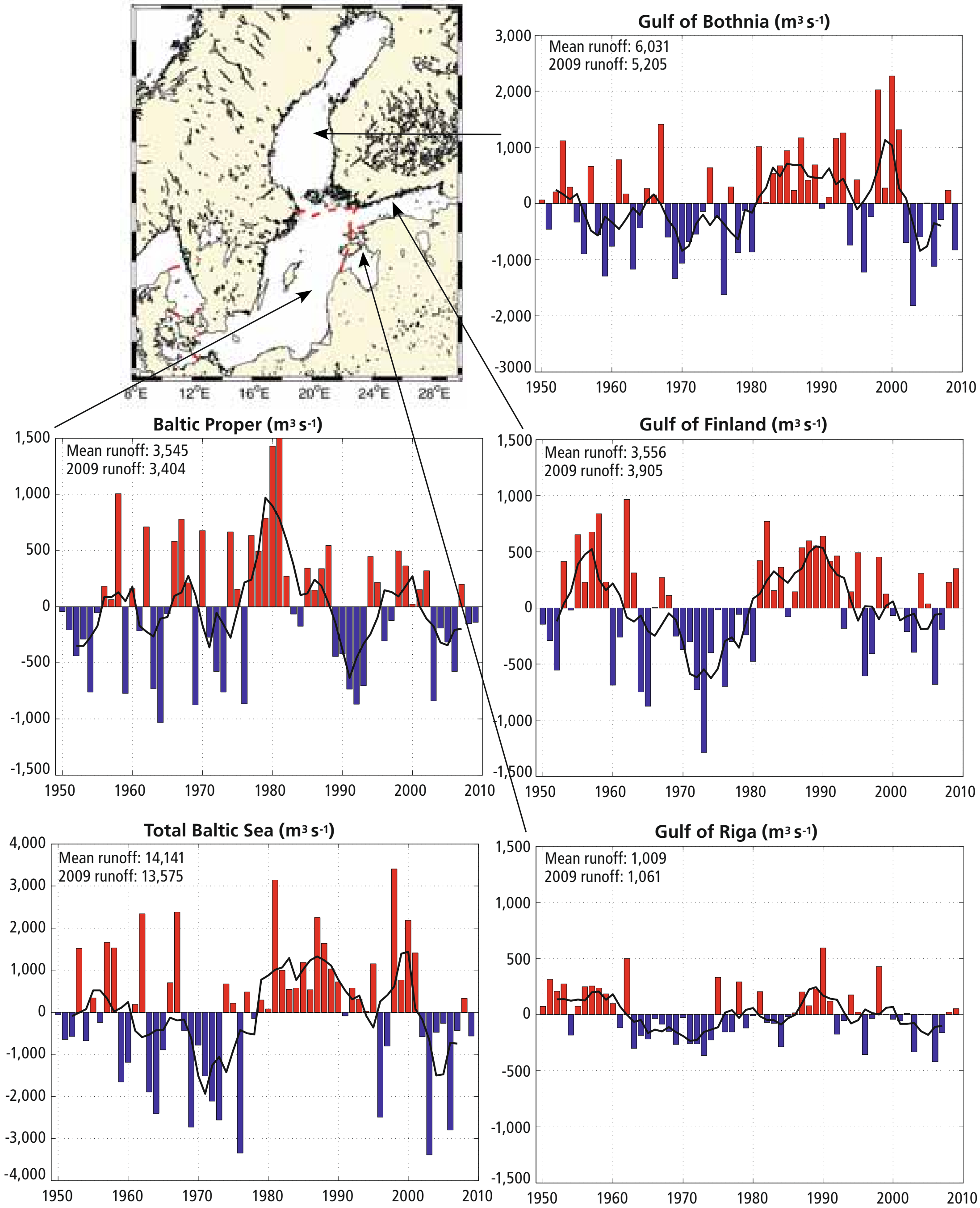


Figure 2-7 Total runoff deviation (in $m^3 s^{-1}$) during the years 1950 to 2009 to the Baltic sub-basins based on annual mean values. The mean runoff value and the 2009 value for each sub-basin are written within each figure. The black line is the running mean over five years. (Source: Kronsell and Andersson 2010)

will affect the runoff into the Baltic Sea, with potential increases in mean annual river flow in the northern catchments and decreases in the southernmost ones. River flows would tend to decrease in summer and increase in winter. Furthermore, there is a risk that more extreme precipitation events will create a higher frequency of, and more extreme, flooding and more soil and river bank erosion. Higher temperatures and longer growing seasons may further induce new or modified practices in agriculture and forestry and extend agricultural areas to the north, but the effects of such changes are generally difficult to predict.

For more information about the effects of climate change on the Baltic Sea, see the HELCOM thematic assessment on climate change in the Baltic Sea area (HELCOM 2007b).

3 Methodology and quality assurance

3.1 Methodology used for assessing point sources, diffuse sources, natural background losses, riverine inputs, retention and source apportionment

This report covers both point and diffuse sources of pollution in the catchment area of the Baltic Sea, located within the borders of the Contracting Parties. Discharges from point sources include municipal effluents, industrial effluents and pollution from fish farms. Diffuse sources of nutrients are defined as any anthropogenic sources of nutrients not accounted for as point sources, e.g., agriculture, forestry, storm water from built-up areas and atmospheric deposition to inland waters. Small, dispersed point source discharges (e.g., from scattered dwellings or localized agricultural sources such as farmyards) are also considered diffuse sources. Losses of nutrients from diffuse sources can be estimated either as the sum of all delivery pathways or by quantifying every individual pathway. Natural background losses are included among the diffuse sources and constitute losses from unmanaged land or the portion of the losses from managed land that would occur in the absence of anthropogenic activity. They include losses from mountain areas, forests, wetlands and part of the losses from agricultural soils and atmospheric deposition to inland waters and urban areas.

Obligatory measurement, sampling and calculation methods are described in the PLC-5 guidelines (HELCOM 2006). Arranging the sampling of discharges from all major point sources and establishing comprehensive national monitoring systems for inland waters are great challenges for all countries. In addition, the new challenge of quantifying diffuse sources is a complicated task, and no common agreement has been reached on the methodology to be applied.

Source apportionment is the estimation of the contribution of different sources to pollution. It deals with the pollution load actually entering the aquatic environment. The concept of source apportionment is described in detail in the guidelines for PLC-5. Different methods used in source apportionment are described in the EEA Report on "Source apportionment of nitrogen and phosphorus inputs into the aquatic environment" as well (EEA 2005).

According to the EEA report, two approaches can be used:

1. A load-oriented approach, whereby the diffuse loss is estimated as the difference between the total load measured at a river monitoring station and the measured emissions from point sources upstream of the monitoring station. Estimates of retention and losses in the river system are added to calculate the losses at source (before retention).
2. A source-oriented approach, whereby the diffuse losses are estimated using export coefficients from catchments with similar characteristics or by modelling. Natural background loss can be estimated using export coefficients from pristine or unmanaged catchments and the losses from agriculture can be estimated using export coefficients from catchments dominated by agriculture, taking into account climatic and soil characteristics as well as management practices, or by modelling. Estimates of retention and losses in the river system can be subtracted to estimate the total load at the river mouth (after retention).

In both approaches, discharges from point sources are estimated either from measurements or, in the case of small establishments lacking monitoring programmes, by using standards values. The main difference between the two approaches is the estimation of diffuse sources.

The load apportionment is done on the basis of the total riverine load taking into account the retention in inland surface waters. If the retention is not considered in these calculations, the nutrient load from point-sources, as well as from agriculture

and other diffuse sources, to inland waters will be underestimated.

Depending on the characteristics of the catchment area, and taking into account the presence of shallow lakes, deep lakes, small or large rivers, reservoirs, frequency of flooding, etc., nutrient retention is often quantified from mass balances of investigated lakes and rivers. Modelling tools can also can be used. The methods for calculation of retention are described in detail in the guidelines for PLC-5. In addition, the Annexes of the guidelines give three different approaches as examples for Contracting Parties for how to calculate retention for the riverine load apportionment.

Calculation of nutrient losses from diffuse losses in unmonitored catchments can either be performed in the same way as for monitored areas or by using export coefficients from nearby monitored catchments with similar characteristics.

The PLC-Water guidelines do not include a common methodology for quantifying diffuse sources or delivery pathways. Many different methodologies exist, and no common methodology has yet been agreed. Therefore, the Contracting Parties were requested to describe the methodology that they had used, including measurements. Unfortunately, not all Contracting Parties followed this request. Nor were the point source inventories extensive enough in many cases. As a consequence of these shortages, some results must be interpreted with reservations.

Altogether five Contracting Parties reported either some or all of the methodologies they used for assessing point sources, diffuse sources, natural background losses, riverine inputs, retention and source apportionment (see **Annex 3**).

3.2 Reporting of data

The PLC-5 data collection and reporting were to be carried out in accordance with the guidelines for the Waterborne Pollution Load Compilation. Monitoring variables to be reported were classified as obligatory or voluntary according to the specific pollution source (see **Table 8-1** of **Annex 1**). Most variables were obligatory.

Data reporting was generally carried out according to the agreed guidelines; however, there were some country-wise exceptions. **Table 8-2** of **Annex 1** summarizes the status of data reporting by the Contracting Parties, while the number of point sources and individual rivers reported is listed in **Table 3-1**. **Figure 3-1**, showing data reporting from municipal wastewater treatment plants (MWWTPs) gives an indication of gaps in the data.

3.3 Analytical methods

The PLC-5 guidelines contain recommended analytical methodologies for the different substances. These are well-tested, documented European or international methods (ISO or EN) or methods based on them, and the countries are strongly recommended to follow these standard methods. Mandatory use of the recommended methods was not specified because none of the parameters are dependent on the analytical method. Furthermore,

Table 3-1 **Number of individual point sources, individually reported rivers and their share in percent of the total catchment area by country in 2006.**

Country	Number of point sources						No. of monitored rivers	% monitored of total catchment
	MWWTP		Industry		Fish farm			
	Big	Small	Big	Small	Big	Small		
Denmark	152	754	83	48	155		38	35.3
Estonia	16		11				15	69.9
Finland	96	426	69	661	2	207	30	89.1
Germany	79	38	10				26	55.8
Latvia	14	2	10	9	1	2	8	77.7
Lithuania	26	918					3	73.2
Poland	205	4	9	10		4	12	91.9
Russia	57	125	48	37			3	89.6
Sweden	132	7	30	11			38	87.7

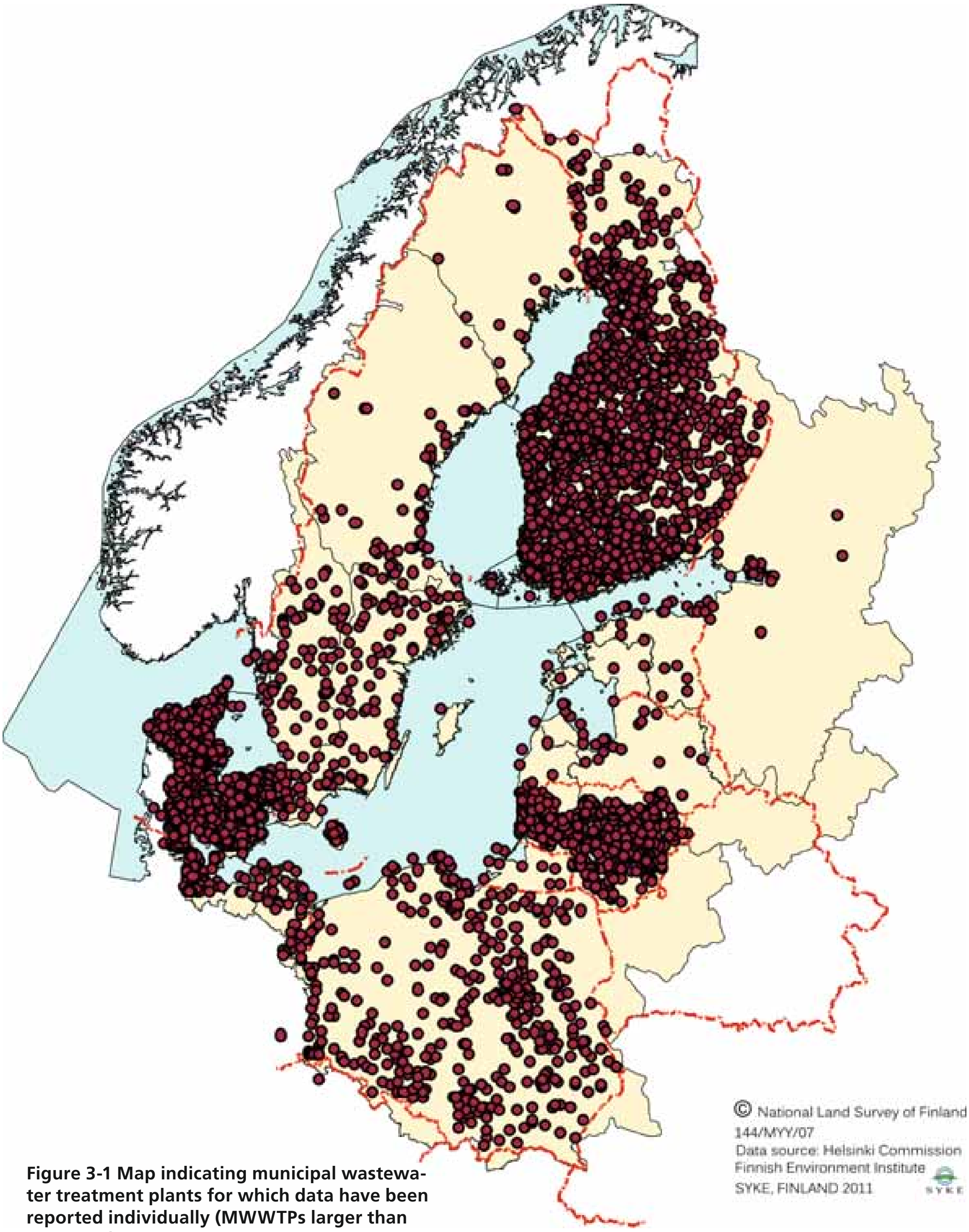


Figure 3-1 Map indicating municipal wastewater treatment plants for which data have been reported individually (MWWTPs larger than 10,000 PE) in 2006. Denmark, Finland and Lithuania also reported individual MWWTPs smaller than 10,000 PE, while information for some other countries was not reported in full.

the PLC-5 guidelines include instructions for avoiding possible errors.

In general, the analytical methods used corresponded quite well with the recommended analytical methods, especially for river water. For wastewater, more laboratories were involved and the analytical methodology applied varied more. However, with hundreds of laboratories involved in PLC-5, analytical methods and their application inevitably varied somewhat within and between Contracting Parties. The concentrations to be determined also varied between the Contracting Parties, along with their respective abilities to detect low concentrations. Compared with PLC-4, fewer laboratories were involved in determining the concentrations of the chemical substances due to consolidation within the laboratory branch.

In most of the Contracting Parties, it is assumed that data delivered to environmental authorities are provided by laboratories using accredited analytical methods, but not all Contracting Parties require the use of accredited laboratories. In addition, according to the PLC-5 guidelines, laboratories providing data to the PLC should employ a quality assurance system that follows the requirements of EN/ISO/IEC 17025 (ISO 2005).

The PLC-5 guidelines state that it is mandatory to report data on validations on uncertainty, limits of detection/limits of quantification and the use of control charts. In addition, some voluntary data should be reported at the national level and if the mandatory data are missing, this should be flagged. However, reporting these data was not included in the reporting scheme. Therefore, it is not possible to evaluate how and to what extent the individual laboratories have applied such quality assurance systems. For accredited laboratories, it usually is a requirement to follow EN/ISO/EC 17025.

Contrary to the conduct of PLC-4, no international laboratory comparison or intercalibration tests were performed between the countries and therefore the performance of the laboratories used cannot easily be compared. It is common that laboratories within countries participate in national tests or intercalibrations, but with few laboratories carrying out the more specialized analyses, such as for some heavy metals, these tests are difficult to conduct within some countries.

Detection limits and quantification limits

For chemical analyses, the PLC-5 guidelines recommend the use of limit of quantification (LOQ), which is the lowest quantifiable amount of a chemical substance. The guidelines include recommended values for LOQ. Some countries still use limit of detection (LOD), which is the lowest detectable amount of a chemical substance. LOQ are usually two to four times higher than LOD. The limit of quantification depends both on the sensitivity of the analytical method applied and on the capability of the individual laboratory.

Tables 8-3a and **8-3b** of **Annex 1** list the reported LOQ or LOD for analyses of river water and wastewater. LOQ (LOD) varied considerably between the Contracting Parties. Detection limits varied particularly for analyses of metals and nitrogen compounds in river water. LOQ (LOD) for chemical substances in wastewater can vary even within individual Contracting Parties, when several laboratories are involved. Furthermore, not all laboratories used the recommended methodology, but rather used alternative methods adjusted to the appropriate concentration level for different chemical substances.

The limit of quantification is critical where concentrations in water are low, which is the case for many substances in rivers in the Nordic Countries. In Denmark, Finland and Sweden, it is necessary to use highly sensitive methods, e.g., in determination of some of the heavy metals.

Contrary to PLC-4, LOQ has been used to assign a numerical value when handling low-concentration data. To take into account results below the detection limit when load estimates have been prepared, the estimated concentrations were recommended to be calculated as:

$(100\% - A) * LOQ$, where A is the percentage of samples below the LOQ.

With different LOQs (LODs) between countries and many concentrations below the LOQ, it is difficult to compare results for these chemical substances.

In PLC-6, the following quality assurance parameters should be reported: Limit of quantification (or limit of detection), uncertainty or standard deviation for the analytical result and the retrieval determined from analysis of a certified reference material.

3.4 Recommendations

With such a large number of laboratories involved in the PLC-5 programme, a major issue of concern is ensuring good data quality from each laboratory and ensuring that the data are comparable. The following recommendations for improving the quality of data for future pollution load compilations should be added to the PLC guidelines:

- Contracting Parties should use internationally validated and standardized analytical methods, such as ISO or EN methods, for the chemical analyses of river water and wastewater included in the PLC.
- All laboratories involved in monitoring should be accredited according to ISO 17025 and have a quality assurance programme according to ISO 17025.
- Laboratories should participate in international laboratory proficiency testing on a regular basis. Participation in proficiency testing is important as documentation of the performance ability of the laboratories. Such activities should be ensured for some parameters as soon as possible, with participation from laboratories delivering analytical results for the PLC preferably before PLC-6. The PLC guidelines should describe how these tests should be performed.
- The limit of quantification (and LOD) should be harmonized among the Contracting Parties by using the same standardized ISO/EN analytical methodologies and recommended common LOQs. Minimum requirements could be included in the guidelines for the most important procedures, such as how to treat samples with acid before metal analysis. The main challenge concerns determination of concentrations for some chemical substances such as heavy metals and total nitrogen in river water.
- Before PLC-6, an intercalibration or comparison test of sampling methods should be carried out for collecting water samples in rivers and from point sources and for monitoring discharges.
- Methodologies for quantification of sources, retention, quantification of background losses, and calculation of loads and inputs should be more harmonized and when different methodologies exist, they should be compared and evaluated

- The PLC guidelines should describe how comparison tests and proficiency testing on the analytical parameters are conducted and how to disseminate the results.
- There should be mandatory reporting of specified information on analytical quality.

4 Results

This chapter aims to give an overview of the amounts of waterborne nitrogen and phosphorus entering the Baltic Sea and the sources of these nutrients. Much of the requested load data on heavy metals have not been reported in PLC-5 or are non-existent. It is therefore impossible to present an overview of the total inputs of heavy metals into the Baltic Sea by sub-region and Contracting Party.The results are based on the data collected during PLC-5 for the year 2006.

It should be noted that all results presented refer only to waterborne inputs, and that atmospheric inputs are not taken into account, except for atmospheric deposition on inland surface waters.

4.1 Total nutrient loads to the Baltic Sea

4.1.1 Total waterborne load to the Baltic Sea

Waterborne nutrients enter the Baltic Sea via rivers or as direct discharges from sources located on the coast. Riverine nutrient loads consist of discharges and losses from different sources within a river's catchment area, including discharges from industry, municipal wastewater treatment plants, fish farms, scattered dwellings, storm water, leaching from agriculture and managed forests, atmospheric deposition on inland surface waters, as well as natural background losses. Natural background sources refer mainly to natural erosion and leakage from pristine areas as well as the fraction of losses from managed land that would occur in the absence of human activities (**Table 4-1**).

Direct point sources include discharges from municipalities, industries and fish farms discharging directly into the Baltic Sea. In 2006 the total waterborne inputs of nitrogen and phosphorus into the Baltic Sea amounted to about 638,000 tonnes and 28,370 tonnes, respectively (**Table 4-2**).

The distribution of annual nitrogen and phosphorus waterborne inputs into the Baltic Sea by HELCOM countries in 2006 is presented in **Figure 4-1** and the corresponding waterborne input into each sub-region of the Baltic Sea is shown in **Figure 4-2**. The main contributing countries to the nitrogen input were Poland (24%), Sweden (19%), and Russia (17%). The largest inputs of phosphorus originated from Poland (36%), Russia (14%), and Sweden (13%). These figures include waterborne inputs from all anthropogenic sources as well as the natural background load.

Table 4-1 Natural background concentrations and area-specific loads by country

Country	Total nitrogen in kg ha^{-1}	Total nitrogen in mg l^{-1}	Total phosphorus in kg ha^{-1}	Total phosphorus in mg l^{-1}
Denmark	2.6	1.5	0.088	0.05
Finland	0.5-2.0		0.02-0.06	
Estonia	3.0-3.2	1.1	0.11-0.12	0.04
Germany		1.0		0.25
Latvia	6.1		0.11	
Lithuania	0.4-1.6	0.42-0.72	0.02-0.07	0.01-0.04
Poland	0.1-9.0	0.3-1.2	0.01-0.28	0.04
Russia		0.68		0.013
Sweden	0.5-4.8	0.2-1.4	0.01-0.18	0.01-0.06

Table 4-2 Total waterborne loads (in tonnes) of nitrogen and phosphorus to the Baltic Sea (including monitored rivers, unmonitored areas and direct point source inputs) and the riverine flow ($m^3 s^{-1}$) in 2006 by a) country and b) sub-region. ***(Note: The figures include transboundary loads. Missing data: Russia – no monitered or coastal area load reported in 2006; Poland – no direct industries reported in 2006)***

a) Totals by country

Country	Flow ($m^3 s^{-1}$)	N_{tot} (t)	P_{tot} (t)
Denmark	320	53,000	1,520
Estonia [1]	440	20,400	790
Finland	2,050	79,000	3,490
Germany	110	16,900	490
Latvia	890	59,500	2,800
Lithuania	430	28,000	1,240
Poland [3]	1,650	152,600	10,240
Russia	2,120	107,600	4,070
Sweden [2]	5,610	121,000	3,730
Total	**13,620**	**638,000**	**28,370**

[1] Loads and flow of Narva river included in Estonia
[2] Loads and flow of Torniojoki/Torne Älv included in Sweden
[3] Loads and flow of river Oder included in Poland

b) Totals by sub-region

Sub-region	Flow ($m^3 s^{-1}$)	N_{tot} (t)	P_{tot} (t)
Archipelago Sea	80	8,200	600
Baltic Proper	2,920	232,300	13,040
Bothnian Bay [2]	2,890	52,600	2,270
Bothnian Sea	2,730	50,800	1,780
Gulf of Finland [1, 3]	2,750	129,700	5,010
Gulf of Riga	890	58,900	2,660
Kattegat	1,120	63,000	1,820
Sound	50	8,900	330
Western Baltic	190	33,600	860
Total	**13,620**	**638,000**	**28,370**

[1] Loads and flow of Narva river for Estonia
[2] Loads and flow of Torniojoki/Torne Älv for Sweden
[3] Loads and flow of river Oder included in Poland

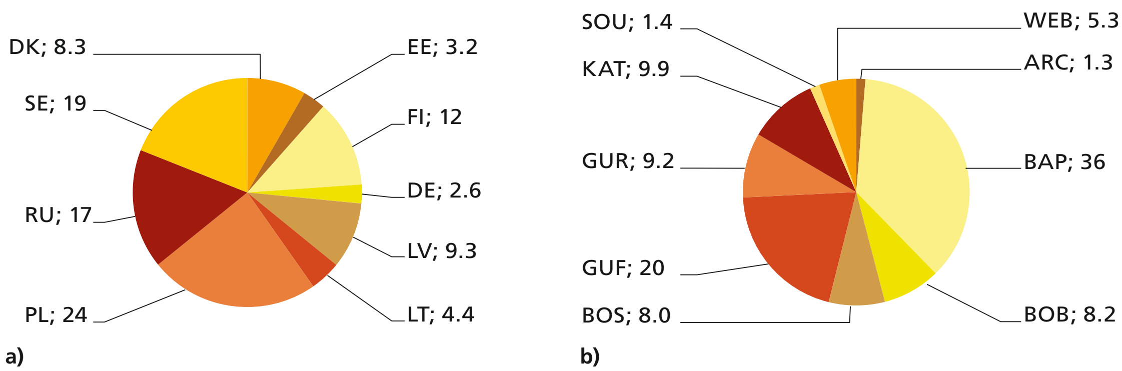


Figure 4-1 Total waterborne loads of nitrogen (N_{tot}) in percent to the Baltic Sea by a) HELCOM country and b) sub-region in 2006. Data included: Monitored rivers, unmonitored and coastal areas, and direct point sources. ***(Note: The figures include transboundary loads. Missing data: Russia – no monitered or coastal area load reported in 2006; Poland – no direct industries reported in 2006)***

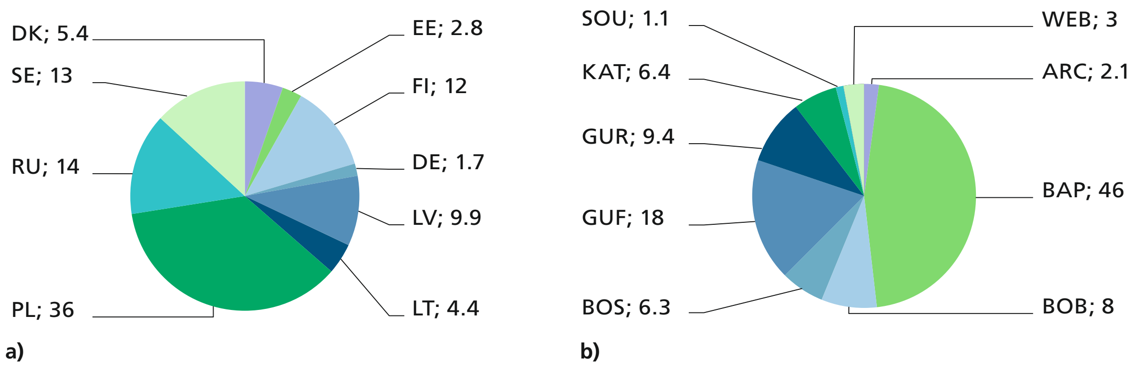
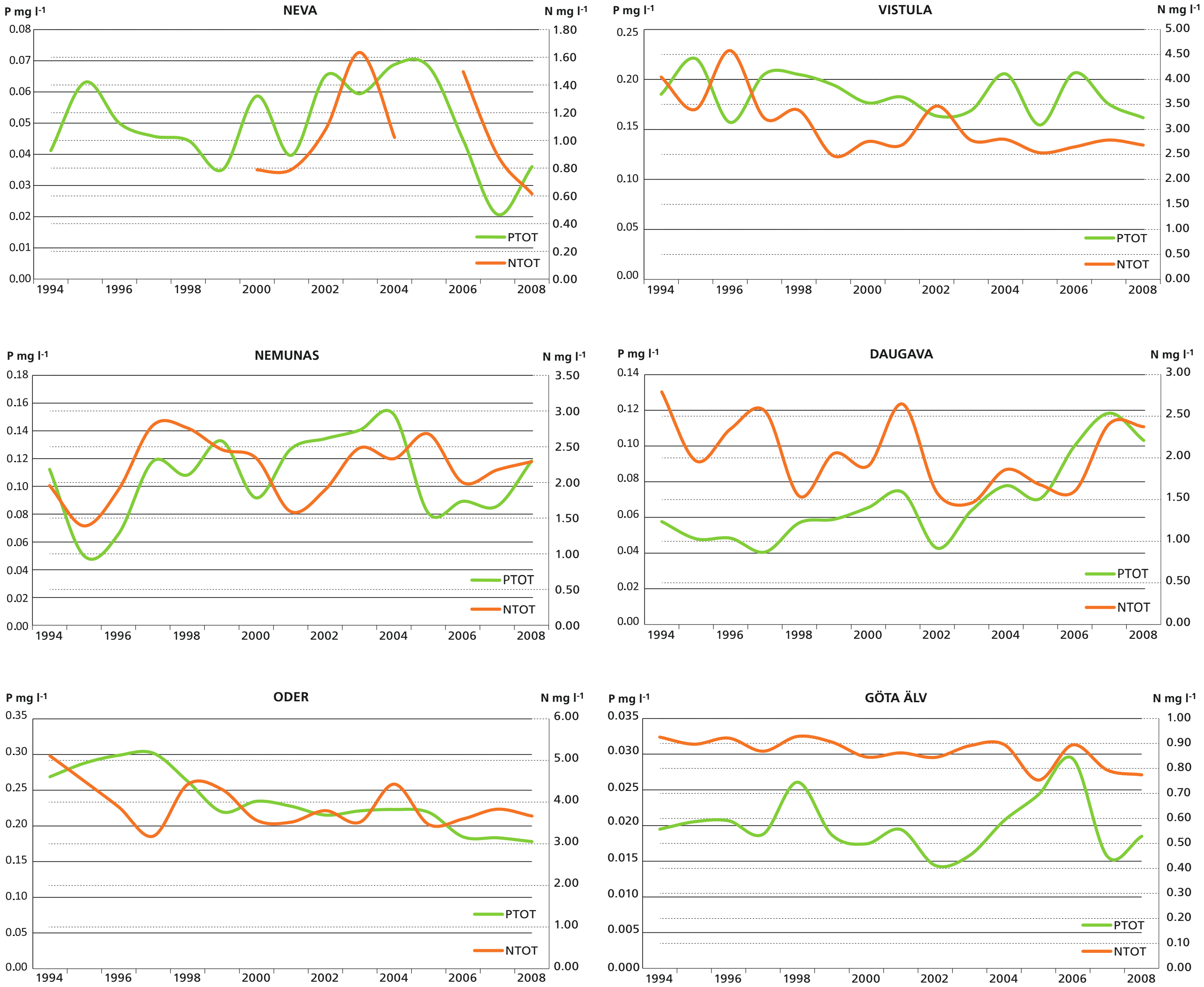


Figure 4-2 Total waterborne loads of phosphorus (P_{tot}) in percent to the Baltic Sea by a) HELCOM country and b) sub-region in 2006. Data included: Monitored rivers, unmonitored and coastal areas, and direct point sources. ***(Note: The figures include transboundary loads. Missing data: Russia – No unmonitored or coastal area load reported in 2006; Poland – No direct industries reported in 2006)***

Calculated flow-weighted nutrient concentrations in rivers can be used to compare the intensity of inputs from different countries and sub-regions, independent of the size of the catchment. The highest flow-weighted concentrations are seen in the rivers discharging from areas with high agricultural and/or high population density, as in the southern part of the Baltic Sea catchment areas (**Figure 4-3**). The lowest values are found in the northern part of the Baltic Sea catchment, with low population density and only small and scattered agricultural areas.



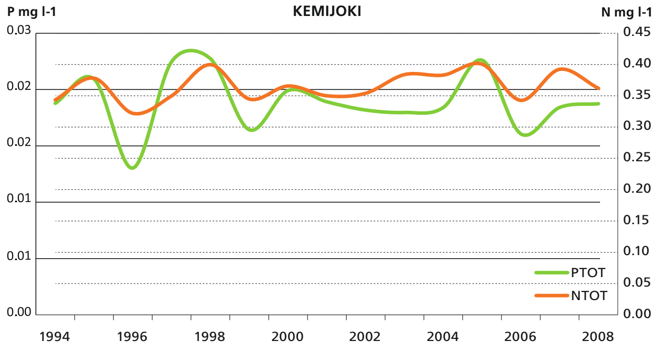


Figure 4-3 Calculated flow-weighted nutrient concentrations (in mg l^{-1}) for the period 1994 to 2008 of seven major rivers discharging into the Baltic Sea. Note the different scales on the y-axes.

4.1.2 Riverine and direct loads to the Baltic Sea

Information about the riverine loads of nitrogen and phosphorus and discharges from point sources entering directly into the Baltic Sea (**Figure 4-4a-d**) is of key importance for following long-term changes in nutrient loading on the sea. It can be used to identify individual hot spots which contribute significantly to the eutrophication of the Baltic Sea, and for assessing the effects of measures taken to reduce nutrient loading. About 75% of the nitrogen and more than 95% of the phosphorus enters the Baltic Sea as waterborne input (i.e., via rivers or as direct discharges). The atmospheric deposition of nitrogen directly onto the Baltic Sea comprises about one quarter of the total nitrogen load to the Baltic Sea. Phosphorus enters the Baltic Sea mainly as waterborne input, while atmospheric deposition supplies a minor amount, only 1–5% of the total phosphorus input.

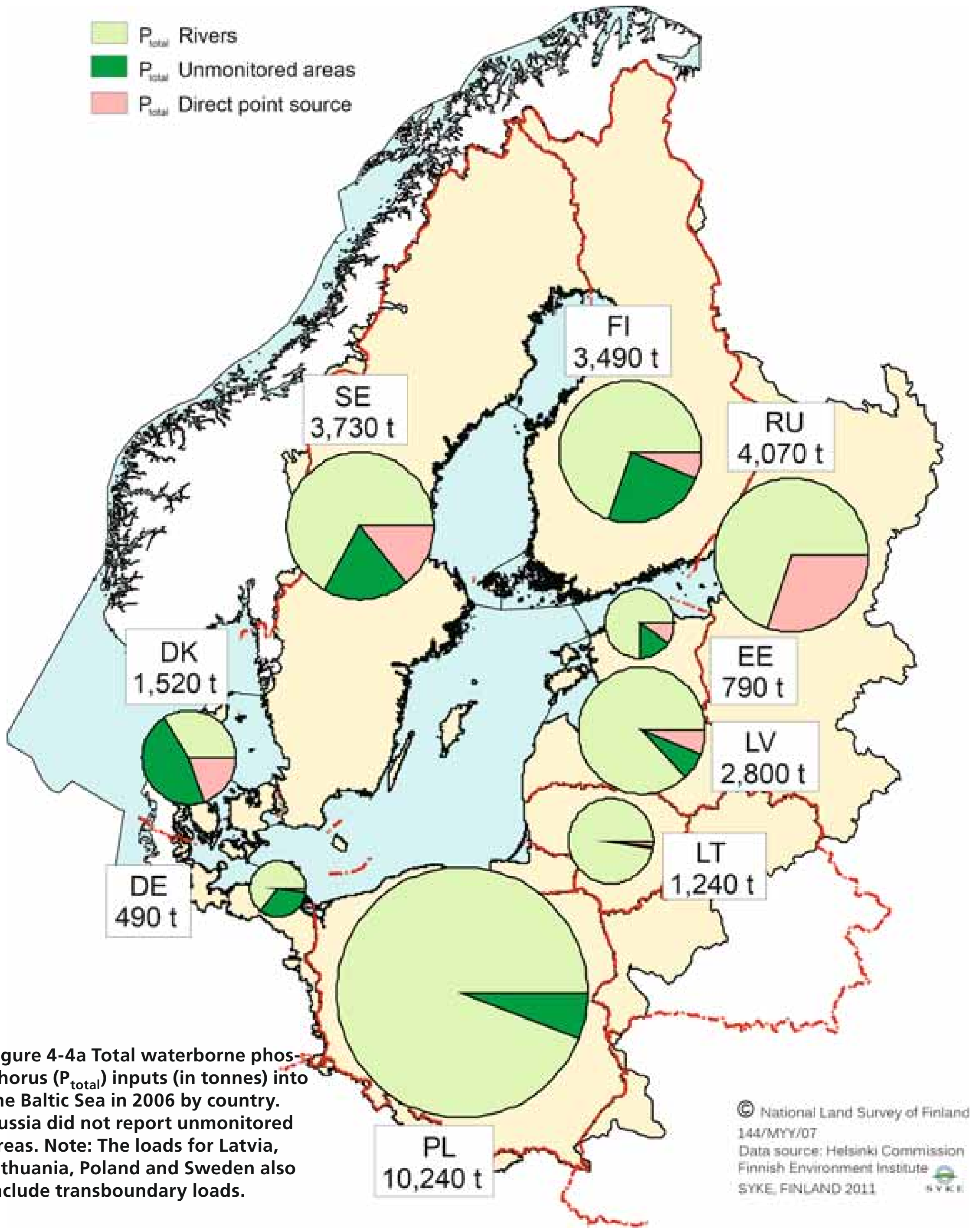


Figure 4-4a Total waterborne phosphorus (P_{total}) inputs (in tonnes) into the Baltic Sea in 2006 by country. Russia did not report unmonitored areas. Note: The loads for Latvia, Lithuania, Poland and Sweden also include transboundary loads.

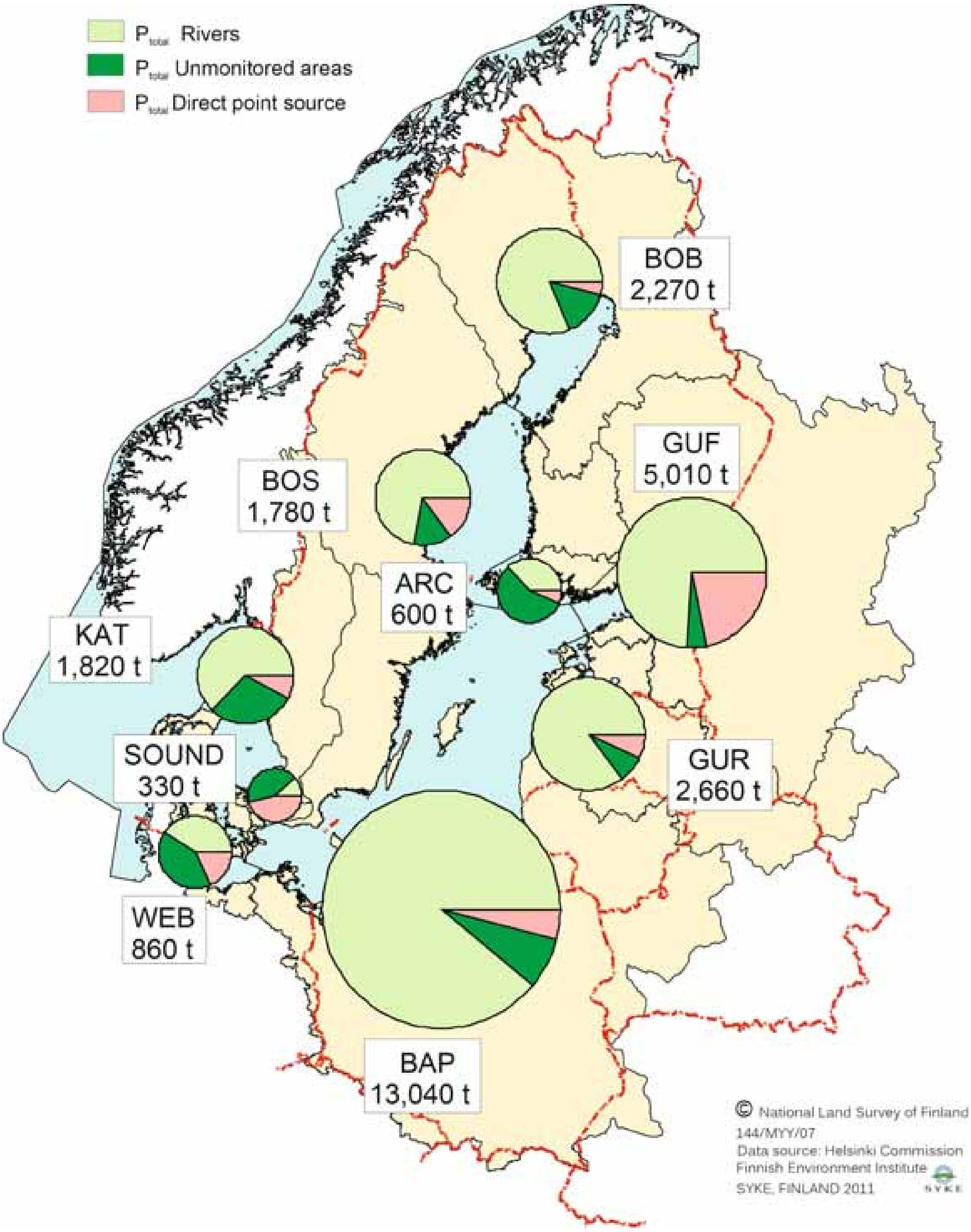


Figure 4-4b Total waterborne phosphorus (P_{total}) inputs (in tonnes) into the Baltic Sea by sub-region in 2006. Note: The loads for Latvia, Lithuania, Poland and Sweden also include transboundary loads.

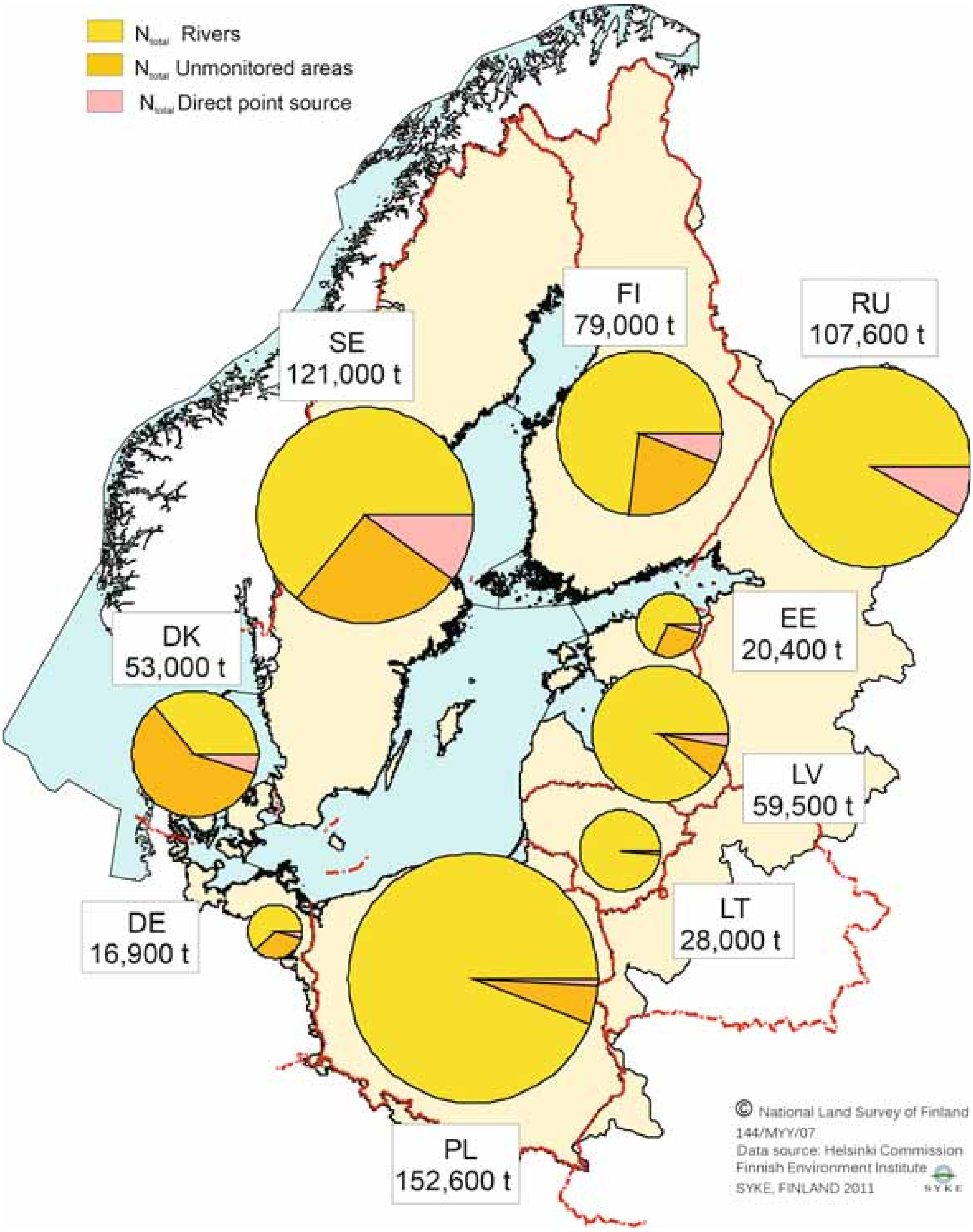


Figure 4-4c Total waterborne nitrogen (N_{total}) inputs (in tonnes) into the Baltic Sea by country in 2006.
Note: The loads for Latvia, Lithuania, Poland and Sweden also include transboundary loads.

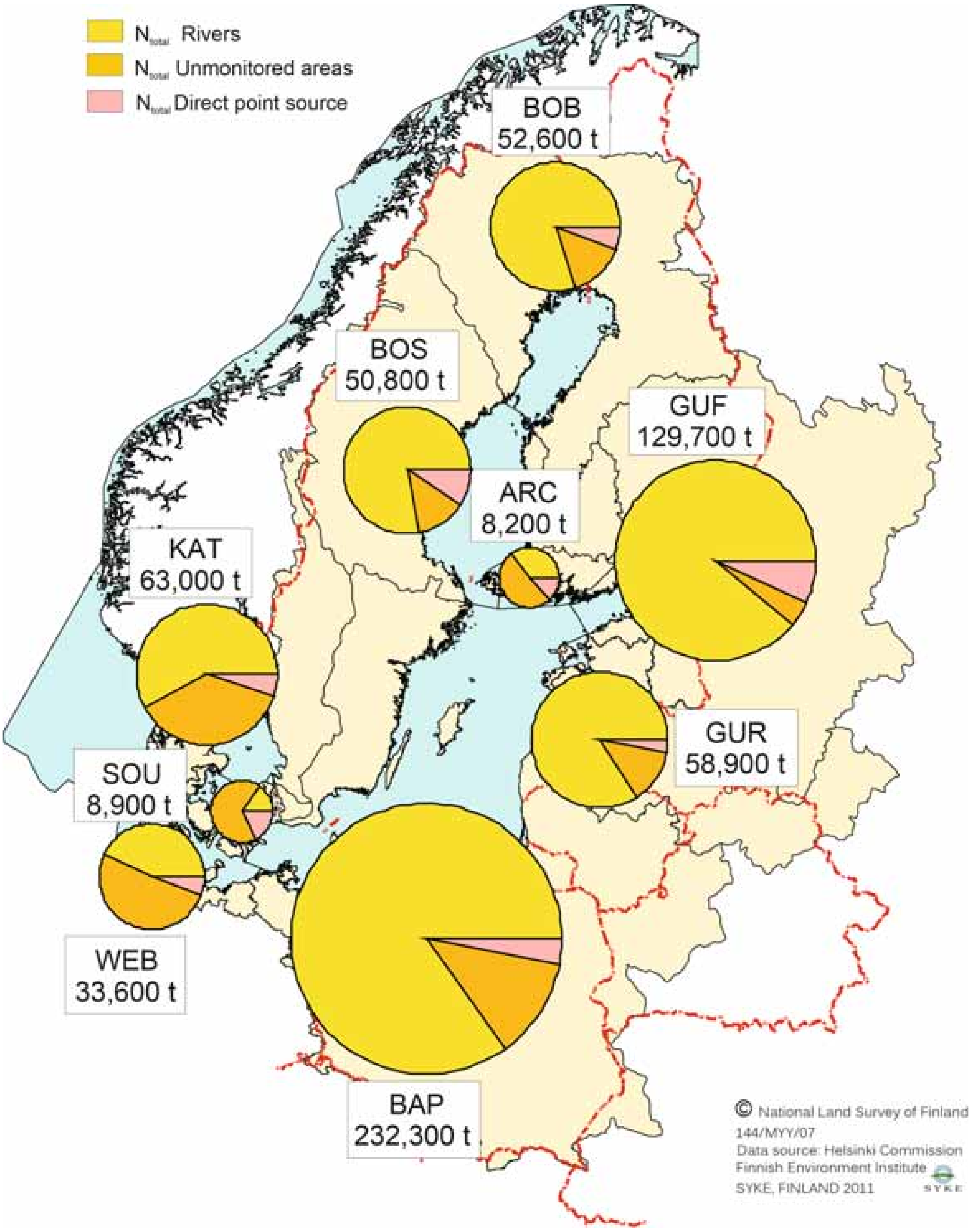


Figure 4-4d Total waterborne nitrogen (N_{total}) inputs (in tonnes) into the Baltic Sea by sub-region in 2006. Note: The loads for Latvia, Lithuania, Poland and Sweden also include transboundary loads.

4.1.3 Direct discharges of nitrogen and phosphorus into the Baltic Sea

The main source of direct nutrient discharges was municipal wastewater treatment plants (MWWTPs), which accounted for 70-90% of total direct nitrogen and phosphorus discharges (except for phosphorus discharges from Finland and Sweden). Discharges from industrial establishments constituted the second largest source of nitrogen and phosphorus inputs into the Baltic Sea. The proportion of direct industrial discharges was highest for the Bothnian Bay and the Bothnian Sea. That is due to large pulp and paper and metal processing industries located in this area, in both Finland and Sweden. Discharges from fish farms were of major importance only in the Archipelago Sea (Finland) and in the Western Baltic (Denmark), but they were in general of minor importance for the total direct point source load (**Figures 4-5** and **4-6**).

Sweden, Russia and Finland were the main contributors of direct nitrogen discharges, while Russia, Sweden and Denmark were the three largest sources of phosphorus discharges into the Baltic Sea. The proportions between countries may be variable because coastal sources have been defined according to somewhat different principles in different countries. Figures on direct discharges from Russia are based on reported data, but these are known to be only about 60-70% of the actual phosphorus and nitrogen load originating from Russia in 2006.

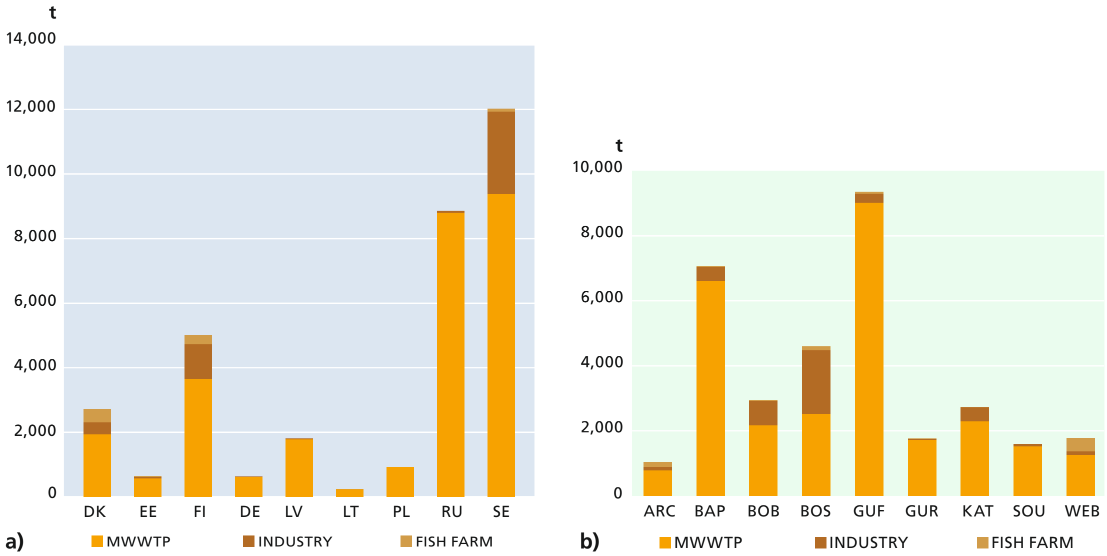


Figure 4-5 Direct point source nitrogen (N_{total}) load (in tonnes) into the Baltic Sea by a) country and b) sub-region in 2006. The proportions between countries may be variable because coastal sources have been defined according to somewhat different principles in different countries. (Missing data: No direct industries reported by Poland in 2006)

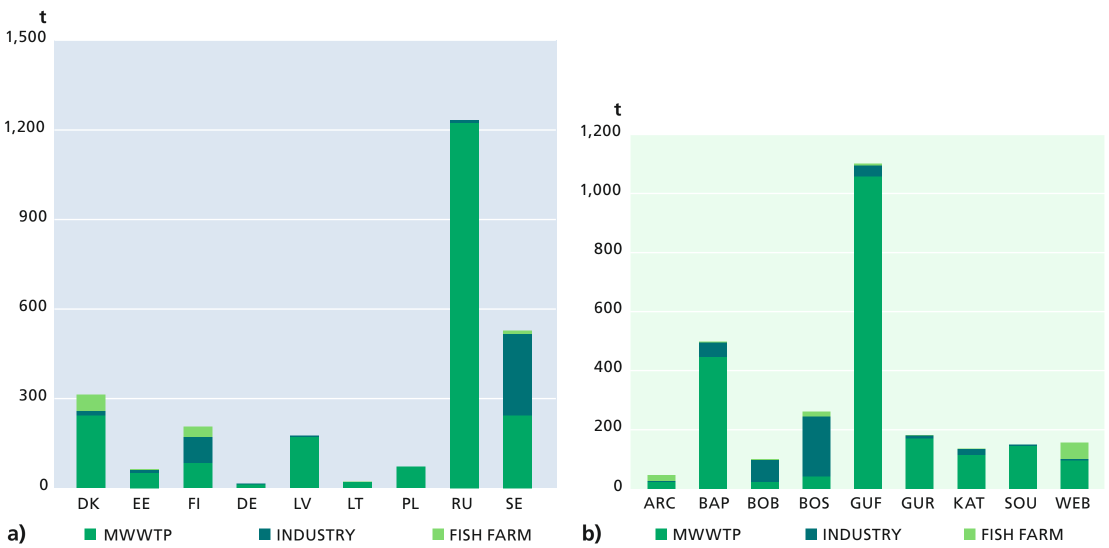


Figure 4-6 Direct point source phosphorus (P_{total}) load (in tonnes) into the Baltic Sea by a) country and b) sub-region in 2006. The proportions between countries may be variable because coastal sources have been defined according to somewhat different principles in different countries. (Missing data: No direct industries reported by Poland in 2006)

4.2 Sources of riverine N and P loads to the Baltic Sea

4.2.1 Introduction

Source apportionment of riverine load is a tool to evaluate the contribution from different inland point and diffuse sources to the total riverine nitrogen and phosphorus load entering the Baltic Sea. The objective is to assess the importance of different anthropogenic sources and the contribution of natural background losses.

Source apportionment can be performed using one of two approaches (see **Section 3.1**), either based on loads to inland waters (source approach or gross load) or at the river mouth (load approach or net load). These two approaches generally give different results because retention is normally lower for sources situated close to the coast and large rivers and higher for upland areas and because methodologies to estimated diffuse sources in the two approaches can be different.

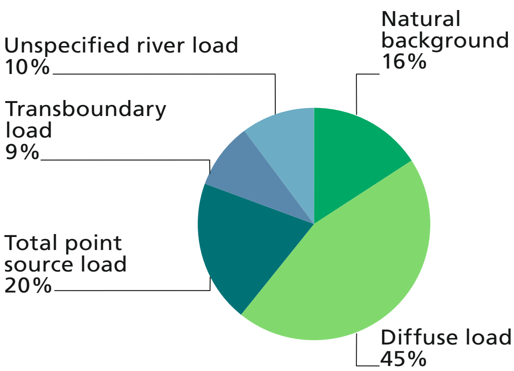
4.2.2 Results

When comparing the results in **Figure 4-7** to **Figure 4-9**, it should be stressed that the Contracting Parties have not always followed the methods described in the PLC-5 guidelines. This has led to the use of several apportionment methodologies, both for the load-oriented approach and even more for the source-oriented approach, which will influence both the results and the comparability between countries and sub-regions. Therefore, only indicative conclusions can be drawn about the contributions of different sources to riverine nitrogen and phosphorus loads.

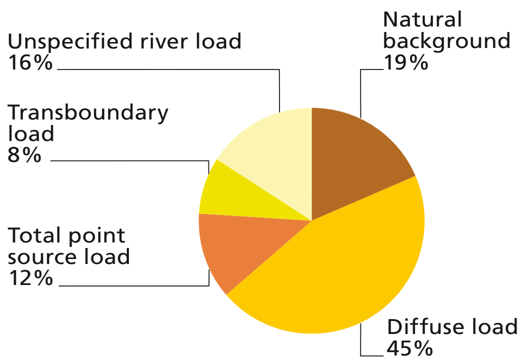
The results of riverine load apportionment indicate that the largest share, at least 45% of the total inputs of both phosphorus and nitrogen into the Baltic Sea, originated from diffuse sources. The proportion of the natural background load varies considerably among countries, but constitutes about 16% of the total phosphorus load and a bit higher for nitrogen (**Figure 4-7**). A considerable part of the unspecified and transboundary loads probably also originates from diffuse sources.

The apportionment of anthropogenic diffuse sources performed for selected countries (**Figure 4-9a-b**) indicates that agriculture contributed 70-90% of the riverine nitrogen load and 60-80% of the phosphorus load. Agriculture thus constitutes the largest share of the reported total diffuse loads to the sea (**Figure 4-9c-d**). In some countries, scattered dwellings, storm water and, for nitrogen, atmospheric deposition were also significant sources, although much smaller than agriculture.

The second largest anthropogenic source of nutrients originated from point sources, with municipalities as the main source (90%). The transboundary load (mainly from Belarus) could not be divided into sources. HELCOM has estimated that the percentage of the total riverine load of nitrogen and phosphorus from Belarus to the HELCOM downstream countries is more than 5% of the total load to the Baltic Sea, without taking into account riverine retention



a) Total waterborne phosphorus 28,370 t



b) Total waterborne nitrogen load 638,000 t

Figure 4-7 Proportion of different sources (in %) contributing to the a) total waterborne phosphorus and b) total waterborne nitrogen inputs into the Baltic Sea in 2006. (Russian and German data have been partially included as 'unspecified river load', because no sources were defined. Missing data: Russia – no monitored or coastal load reported in 2006; Poland – no industries reported in 2006.)

(HELCOM 2005). The main anthropogenic sources of nutrients are agriculture and municipalities.

Unspecified riverine load relates mainly to Russia, which did not perform any riverine load apportionment. It was decided not to make any quantitative estimate of the sources of this load, but taking into account the large share of forests, wetlands and inland waters in the catchment area of the Baltic Sea in Russia, it could be estimated that the proportion of natural background load is relatively high.

The results are further represented by country and sub-region in pie diagrams and bar graphs in **Figure 4-8a-d**. The usefulness and shortcomings of the data as well as problems with methodologies are discussed in **Chapter 6**.

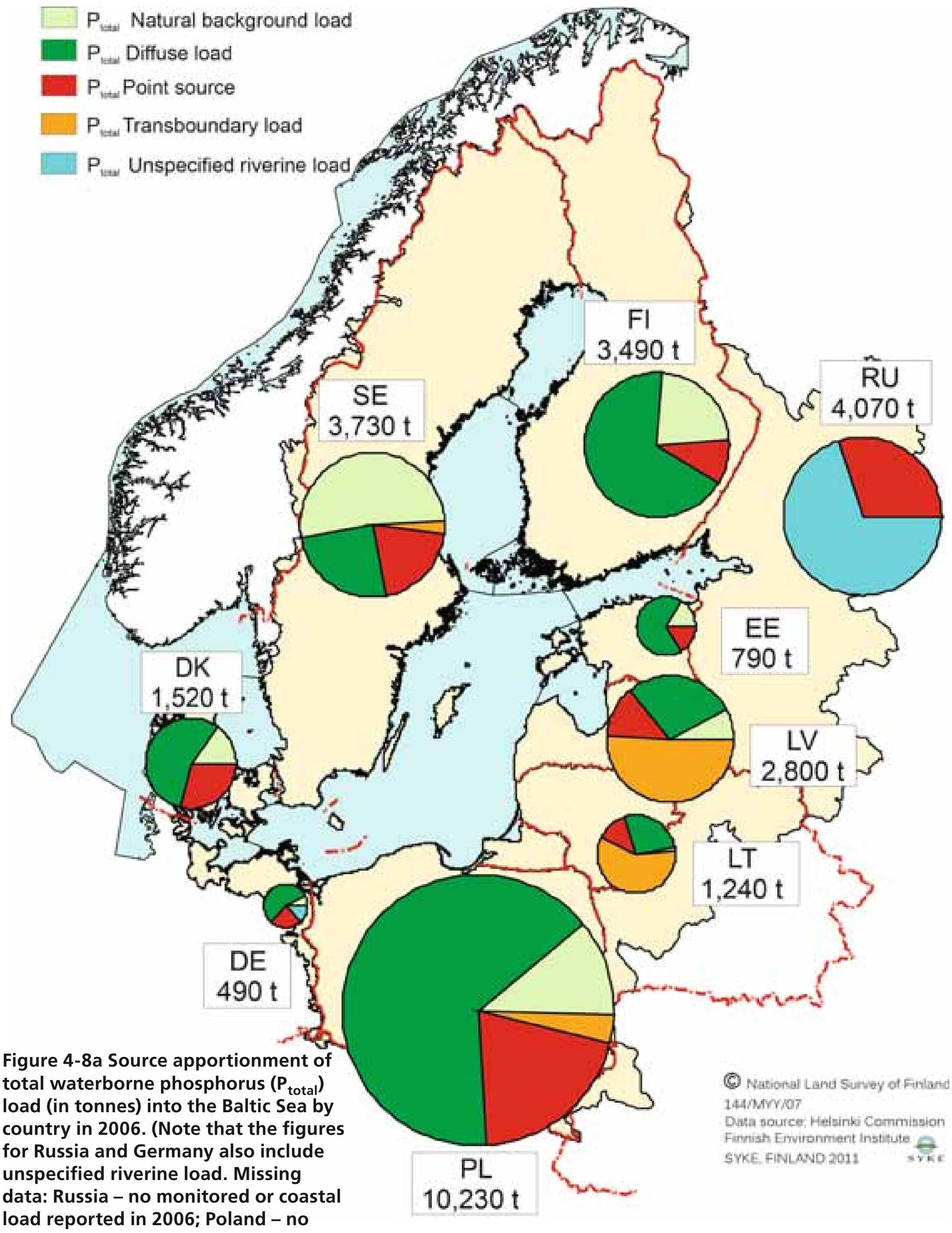


Figure 4-8a Source apportionment of total waterborne phosphorus (P_{total}) load (in tonnes) into the Baltic Sea by country in 2006. (Note that the figures for Russia and Germany also include unspecified riverine load. Missing data: Russia – no monitored or coastal load reported in 2006; Poland – no industries reported in 2006.)

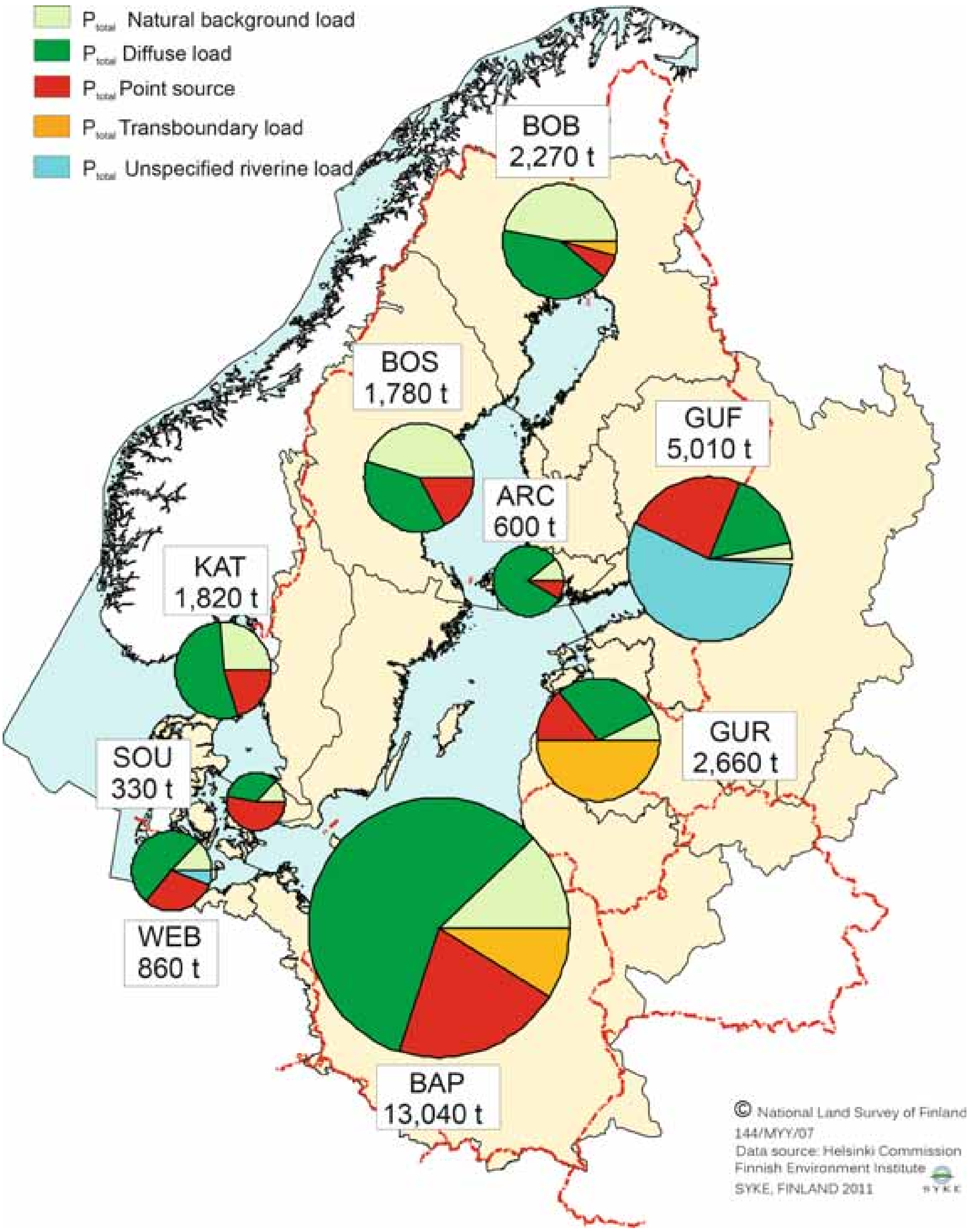


Figure 4-8b Source apportionment of total waterborne phosphorus (P_{total}) load (in tonnes) into the Baltic Sea by sub-region in 2006. Note that the figures for the Gulf of Finland (GUF) and the Western Baltic (WEB) also include unspecified riverine load.

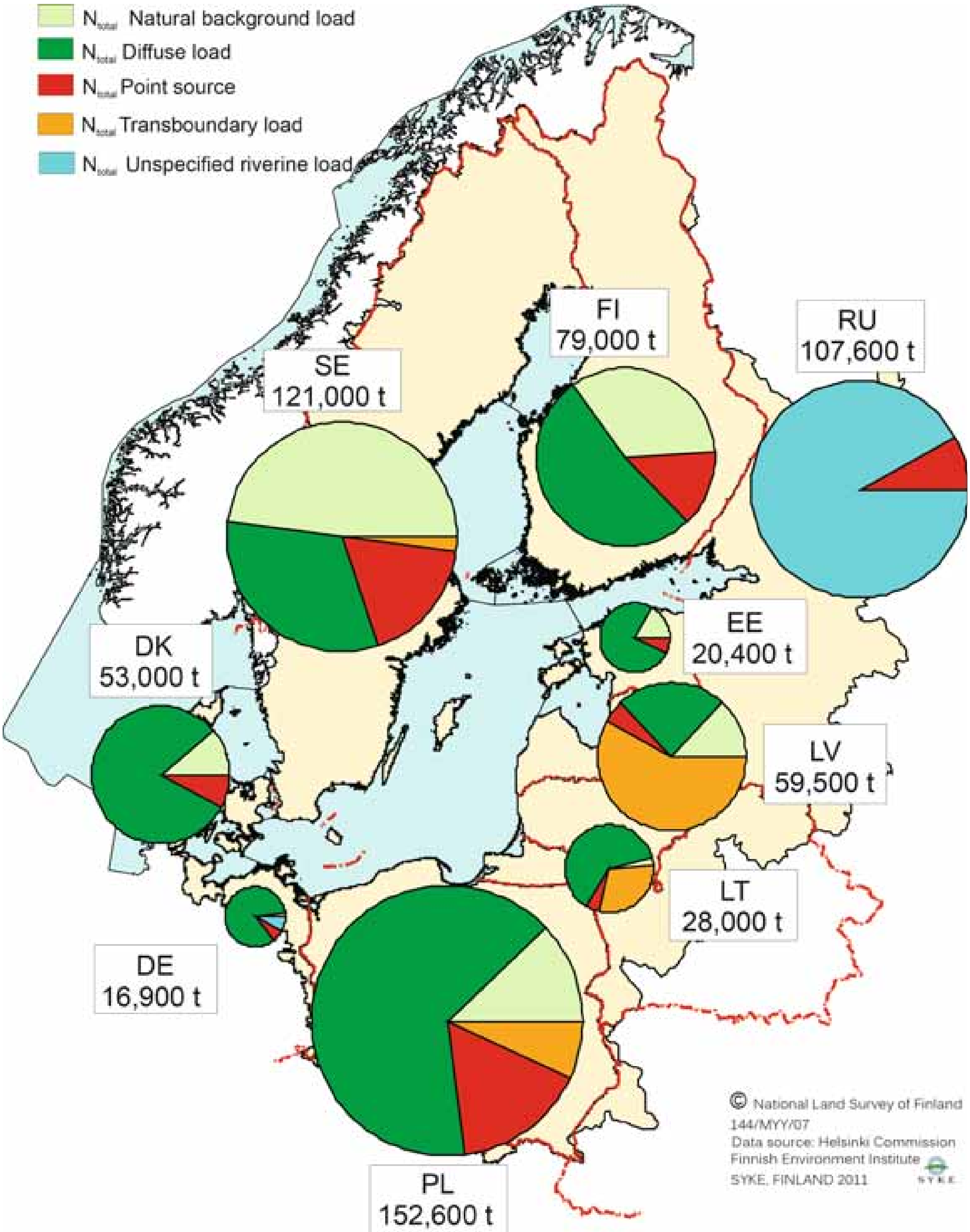


Figure 4-8c Source apportionment of total waterborne nitrogen (N_{total}) load (in tonnes) into the Baltic Sea by country in 2006. Note that the figures for Russia and Germany also include unspecified riverine load.

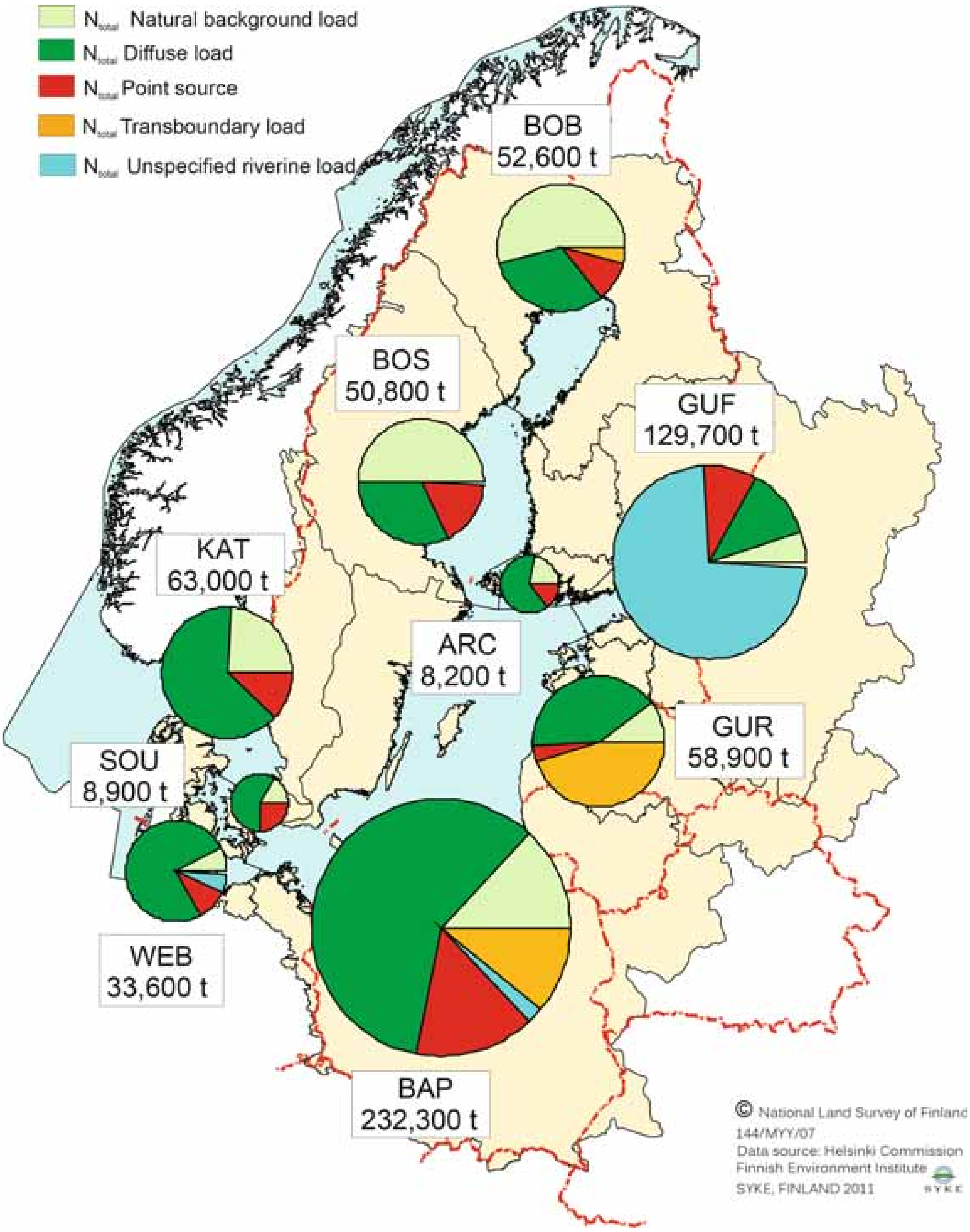


Figure 4-8d Source apportionment of total waterborne nitrogen (N_{total}) load (in tonnes) into the Baltic Sea by sub-region in 2006. Note, that the figures for Gulf of Finland (GUF), Baltic Proper (BAP) and Western Baltic (WEB) also include unspecified riverine load.

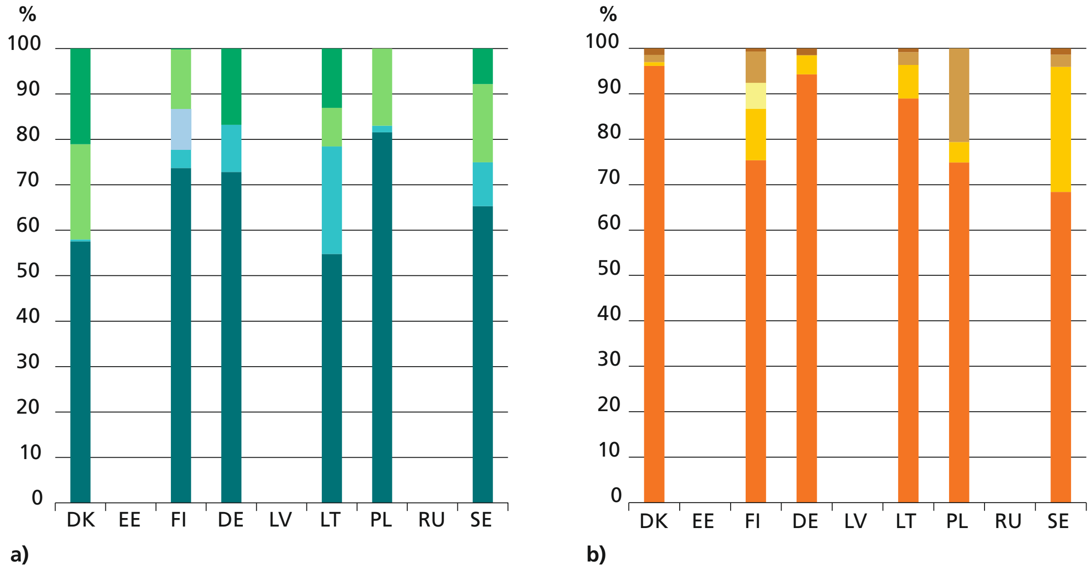


Figure 4-9a-b Anthropogenic diffuse a) P_{total} load and b) N_{total} load into the Baltic Sea by source (in %) and by country in 2006. (No Russian data were reported and Estonian and Latvian data were reported only as total diffuse load and have therefore been excluded)

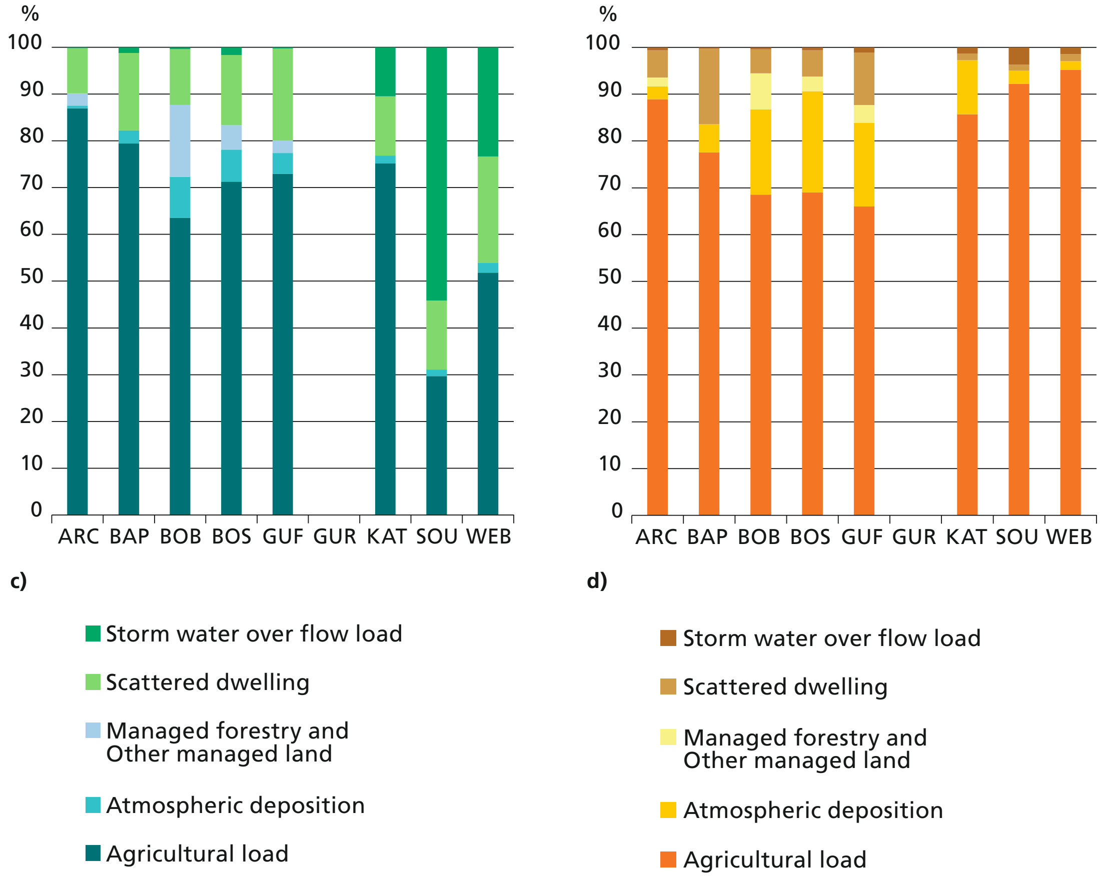


Figure 4-9c-d Anthropogenic diffuse c) P_{total} load and d) N_{total} load into the Baltic Sea by source (in %) and by sub-region in 2006. (No Russian data were reported and Estonian and Latvian data were reported only as total diffuse load and have therefore been excluded)

4.2.3 Retention in surface waters

Retention of nutrients is defined as the removal of phosphorus and nitrogen in surface waters of river systems, including adjoining lakes and the flooding of river valleys. Retention calculations are necessary to enable the quantification of discharges/losses of nutrients to marine areas from land-based sources. It is also necessary to have figures on nitrogen and phosphorus retention to compare and validate the figures on nutrient discharges/losses from land-based sources based on measurements at the river mouths. Furthermore, retention data can be used to assess the actual reduction of nutrient loads to the sea after implementation of mitigation measures directed towards inland sources.

Factors such as topography, geology, percentage of surface freshwaters and wetlands, hydrology, climate as well as the size and density of the human population vary considerably among the Baltic Sea countries, and even among regions within the same country. This makes it difficult to fully harmonize the methods of calculating the nutrient retention in inland surface waters. In 2006 the largest proportions of nitrogen and phosphorus retention in the catchment area, expressed as percent of the total load to inland waters, were reported or calculated by Estonia, Poland and Lithuania, whereas the lowest proportions of retention in river systems occurred in Denmark (**Table 4-3a-b** and **Figure 4-10a-d**). It is remarkable to note that in PLC-4 Lithuania reported the lowest proportions of nitrogen (0.9%) and phosphorus (2.3%) retention. Russia did not report any figures for retention, although the Institute of Limnology RAS (Russian Academy of Science) reported proportions of nutrient retention in Lake Ladoga. For phosphorus, retention is up to 75% and for nitrogen 30% (Kondratyev & Ignatieva 2007).

Owing to former excessive loads of phosphorus, some lakes currently display low or even negative phosphorus retention (e.g., some Danish lakes). This is a result of the presently low oxygen levels in the bottom waters of eutrophied lakes that result in the leaching of phosphorus from bottom sediments.

Not all Contracting Parties reported the methodologies used to calculate retention. Additionally, Contracting Parties that reported their methodologies have applied a variety of different methodologies. Moreover, the calculation of retention has been further complicated because the importance of the different processes involved varies across the Baltic Sea catchment area.

Table 4-3 Total retention of nitrogen and phosphorus in the catchment area (in %) by a) country and b) sub-region in 2006

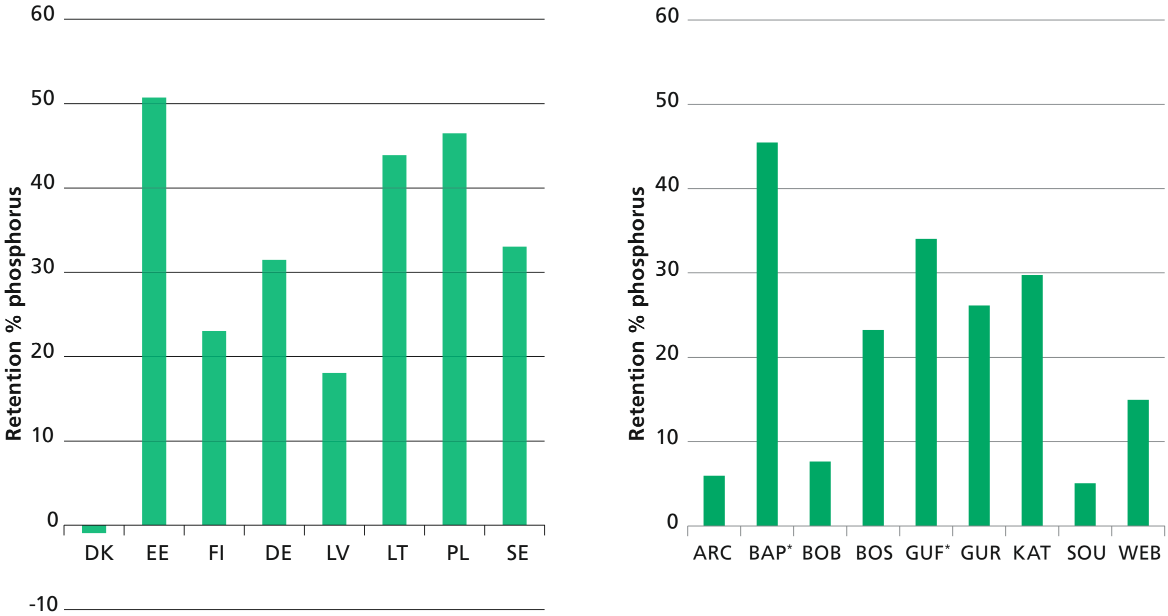
a)

Country	Total N retention (%)	Total P retention (%)
Denmark	11.4	-0.9
Estonia	55.9	50.7
Finland	18.7	23.0
Germany	29.0	31.5
Latvia	22.6	18.0
Lithuania	41.2	43.9
Poland	39.5	46.5
Russia		
Sweden	27.8	33.0

b)

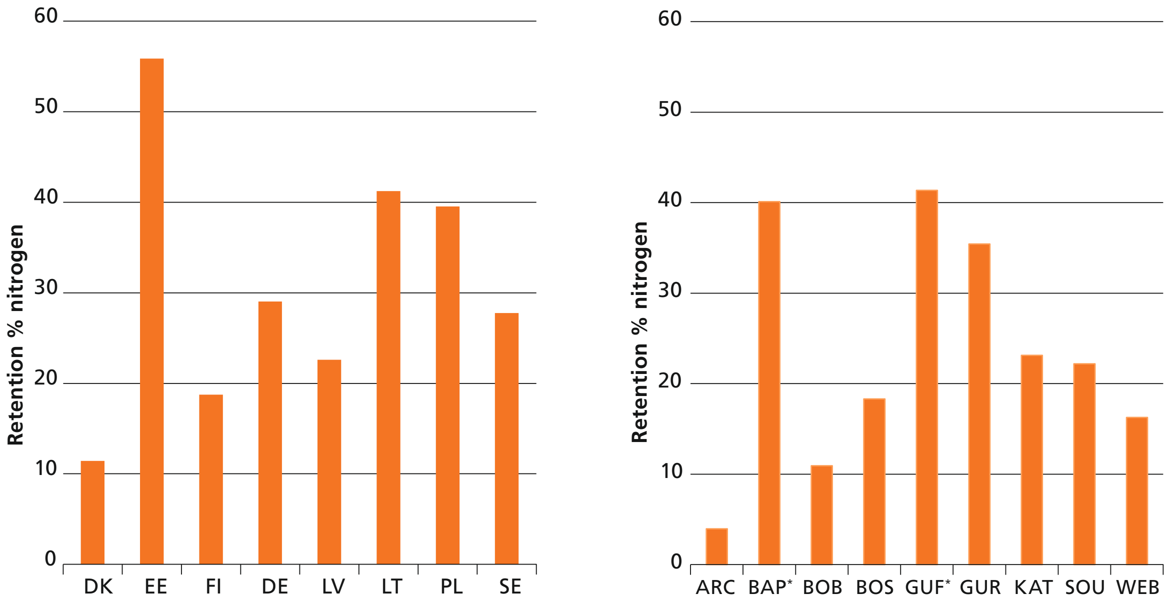
Sub-region	Total N retention (%)	Total P retention (%)
Archipelago Sea	4.0	6.0
Baltic Proper*	40.1	45.5
Bothnian Bay	10.9	7.6
Bothnian Sea	18.3	23.3
Gulf of Finland*	41.3	34.1
Gulf of Riga	35.4	26.1
Kattegat	23.1	29.8
Sound	22.2	5.1
Western Baltic	16.3	15.0

*No retention reported from Russia in 2006.



a) b)

Figure 4-10a-b Reported retention (in %) of phosphorus in the gross riverine loads in 2006 by country a) country and b) sub-region. *No Russian data included.



c) d)

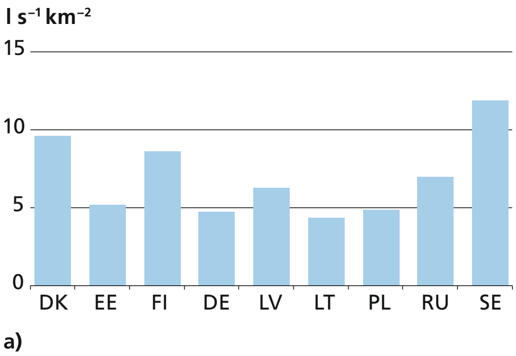
Figure 4-10c-d Reported retention (in %) of nitrogen in the gross riverine loads in 2006 by a) country and b) sub-region. *No Russian data included.

4.2.4 Area-specific load

The flow (runoff) from different countries and catchments expressed as area-specific flow (making it possible to directly compare runoff from catchments of different sizes) from monitored parts of the Baltic Sea catchment area (**Figure 4-11**) has been compared. In 2006 the specific flow was in the range of 4.5 l s^{-1} km^{-2} (Germany) to more than 16 l s^{-1} km^{-2} (Latvia) with an average of nearly 10 l $s^{-1} km^{-2}$. The large span in specific flow between Germany and Poland on the one hand and Latvia on the other is rather surprising, as differences in precipitation and other weather conditions in 2005 and 2006 cannot explain the large differences. The area-specific flow from the entire catchment is very close to that of the monitored parts of the catchment.

By calculating area-specific nutrient loads for 2006, expressed as kg km^{-2}, it was also possible to directly compare nutrient loads from different sub-regions and countries around the Baltic Sea, irrespective of their size (**Figures 4-12** and **4-13**). The highest area-specific nitrogen loads (per river catchment) were found in the catchment areas of the Sound (1830 kg N km^{-2}) and the Western Baltic (1460 kg N km^{-2}), while the highest values for phosphorus occurred in the catchment areas of the Archipelago Sea (62 kg P km^{-2}) and the Sound (40 kg P km^{-2}). Much lower area-specific loads were noted for the Bothnian Bay (200 kg N km^{-2}, 9 kg P km^{-2}) and the Bothnian Sea (210 kg N km^{-2}, 7 kg P km^{-2}) catchments, both of which have low population densities and much uncultivated land. A large catchment area may display high absolute losses from diffuse sources (in tonnes) but a low area-specific coefficient. This parameter could be taken into account when considering and applying measures to reduce diffuse nutrient losses.

Intensely cultivated countries with a relatively low proportion of wetlands result in by far the highest area-specific diffuse losses of nitrogen into inland surface waters in the Baltic Sea catchment area. High area-specific phosphorus loads are often related to high population densities (as in the Western Baltic and the Sound) and extensive agricultural activity. Factors such as agricultural activity, soil type and geology of the catchment areas (for example, around the Archipelago Sea), in combination with climatic factors and the occurrence of frozen soils and surface runoff, may also contribute to high area-specific phosphorus loads. For example, it is well known that clay soils tend have higher phosphorus losses than sandy soils, while the opposite is the case for nitrogen (Johansson & Hoffmann 1998). In many of the large catchment areas, low area-specific diffuse losses may be observed in vast areas with low human impact and a high proportion of wetlands that reduce diffuse losses to surface waters.



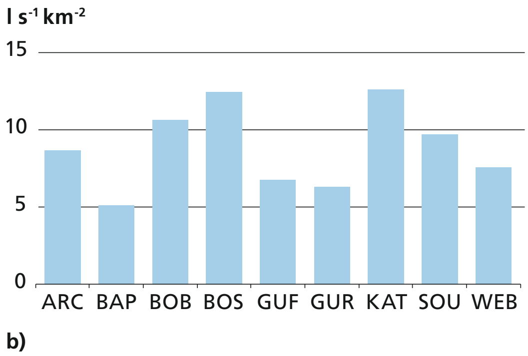


Figure 4-11 Area-specific water flow (in l s^{-1} km^{-2}) into the Baltic Sea by a) country and b) sub-region in 2006, excluding direct point and diffuse flow.

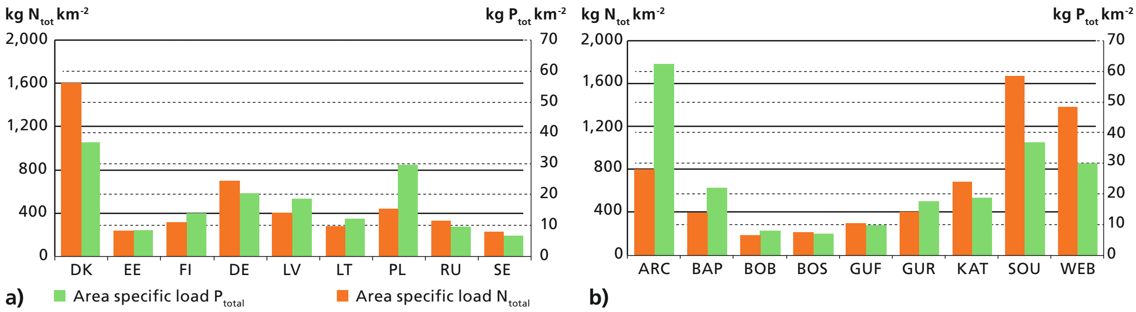


Figure 4-12 Area-specific waterborne load of nitrogen and phosphorus (kg km⁻²) into the Baltic Sea by a) country and b) sub-region in 2006 (direct point and diffuse sources not included).
***Phosphorus load of river Pregolya is missing**

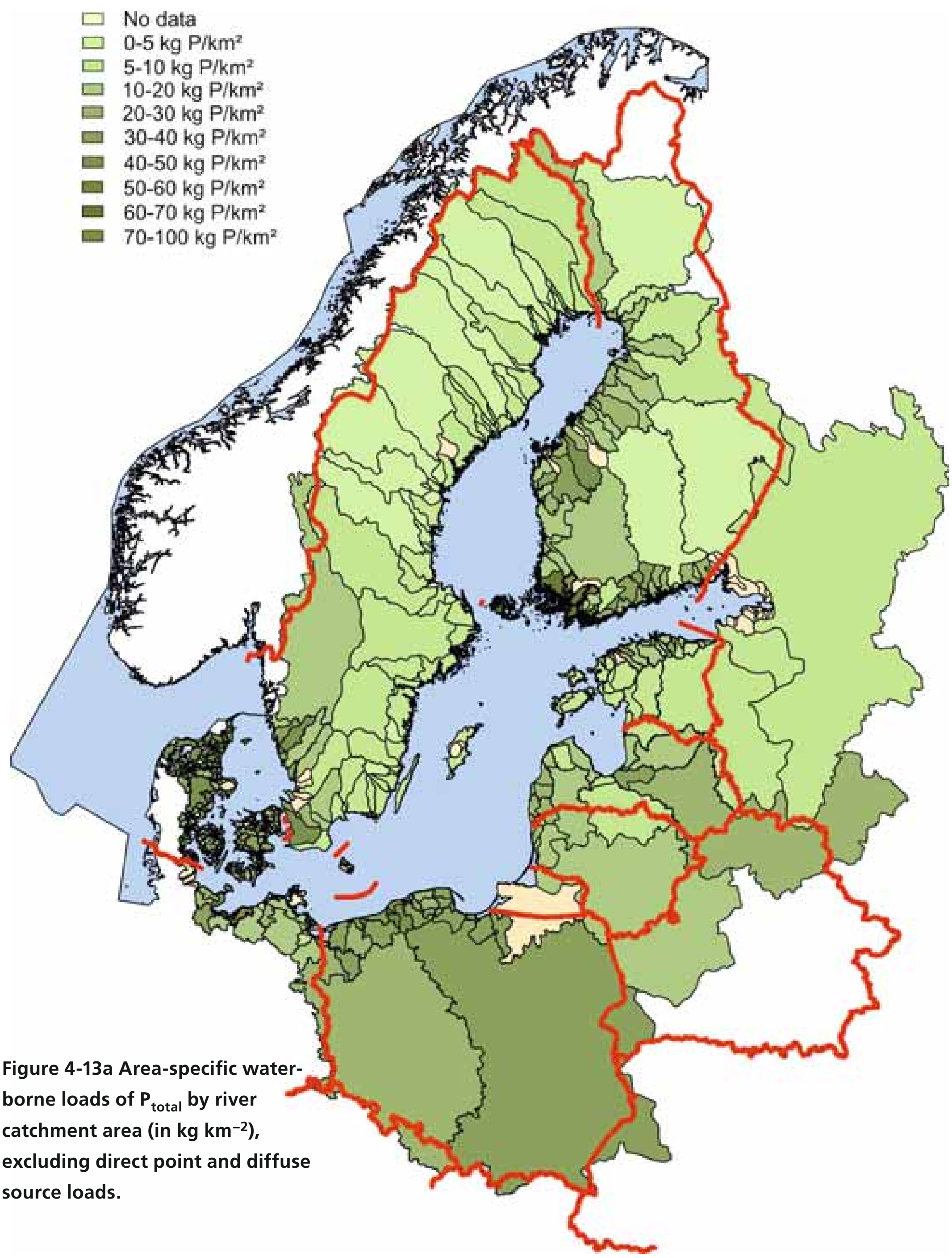


Figure 4-13a Area-specific waterborne loads of P_{total} by river catchment area (in kg km⁻²), excluding direct point and diffuse source loads.

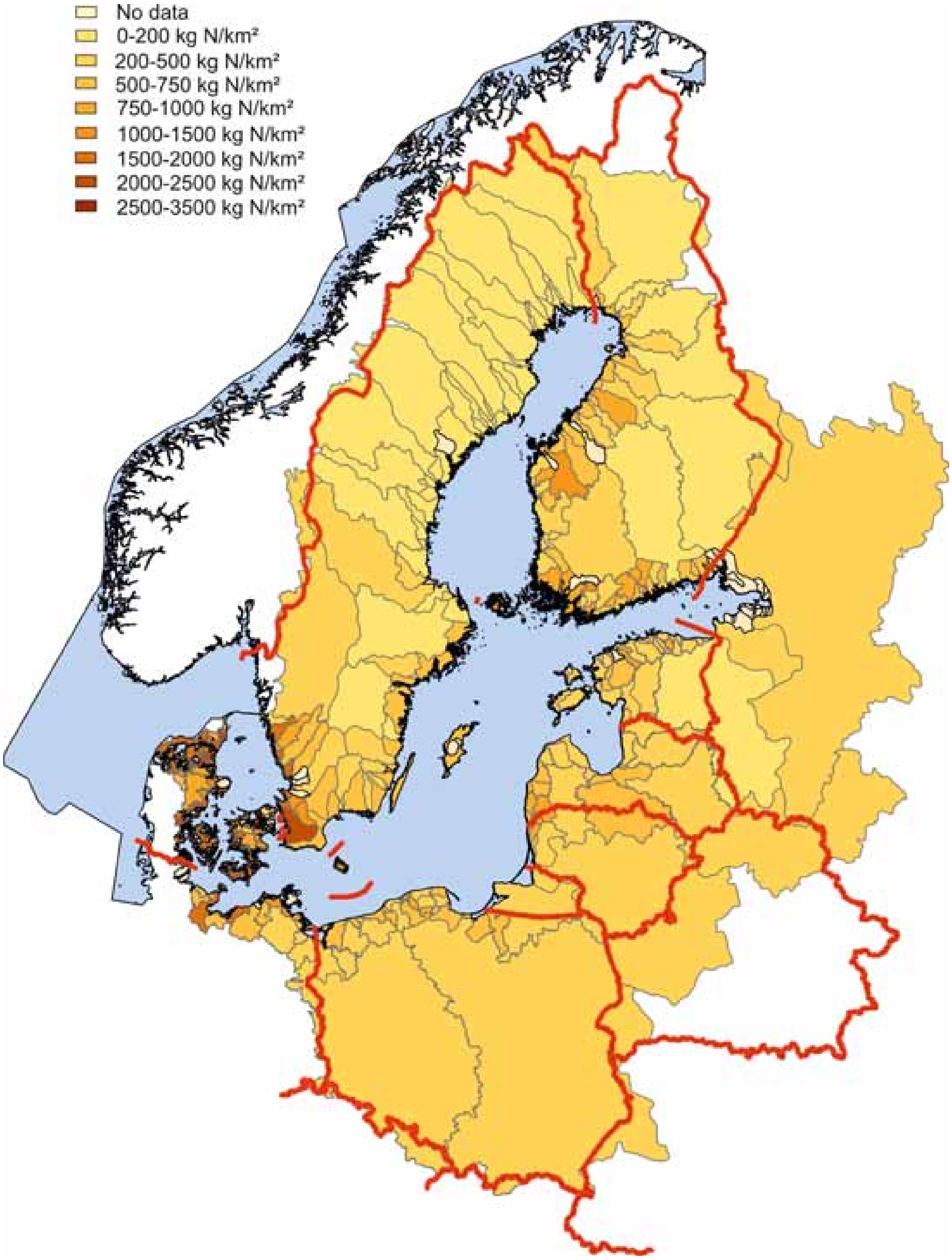


Figure 4-13b Area-specific waterborne loads of N_{total} by river catchment area (in kg km^{-2}), excluding direct point and diffuse source loads.

Figure 4-14 shows the division of the area-specific phosphorus and nitrogen loads to the Baltic Sea according to general source types, clearly indicating the differences in types of sources according to the characteristics of the various countries and sub-regions.

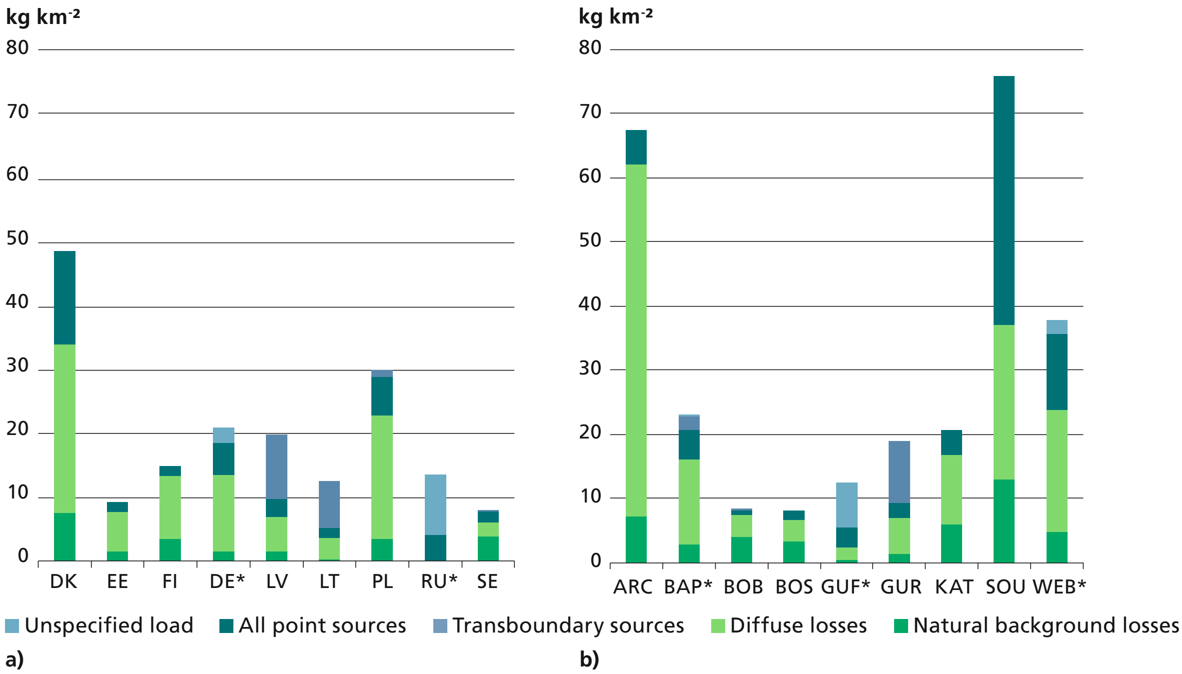


Figure 4-14a-b Area-specific waterborne phosphorus load (in kg km⁻²) into the Baltic Sea according to source type (including direct point and diffuse sources) by a) country and b) sub-region in 2006.
***No sources reported from Russia and from some German rivers.**

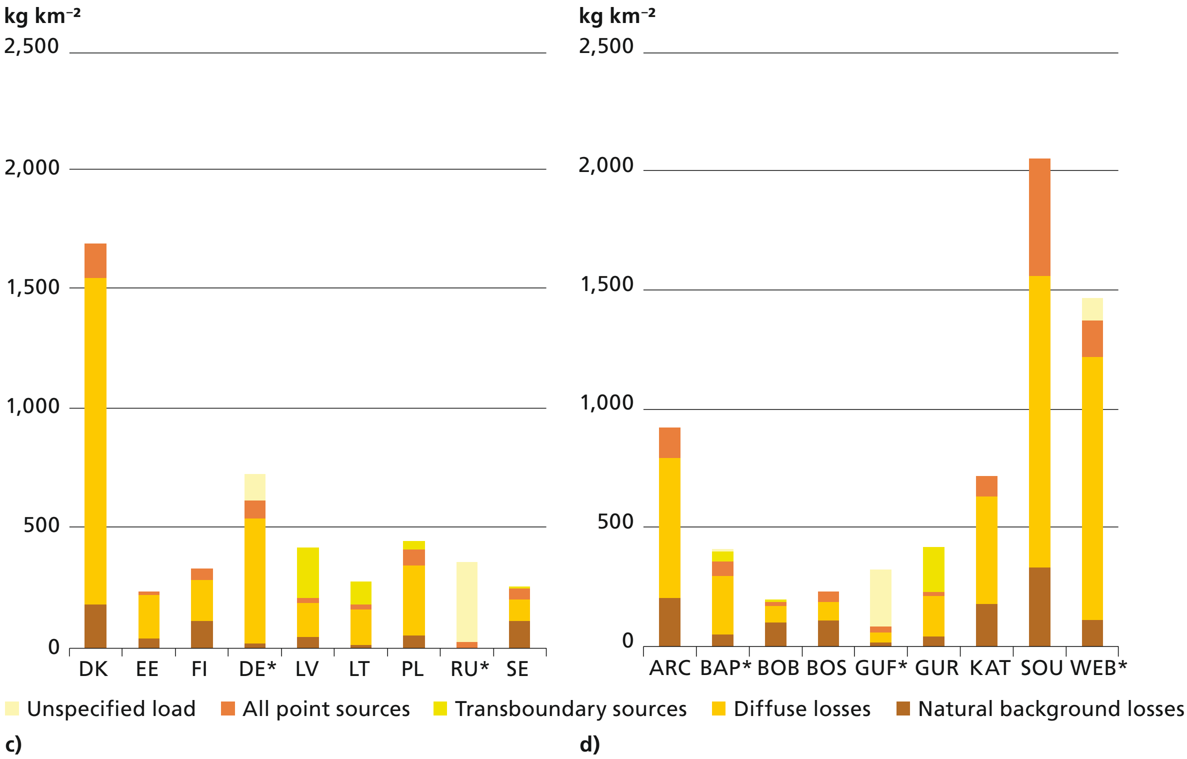


Figure 4-14c-d Area-specific waterborne nitrogen load (in kg km⁻²) into the Baltic Sea according to source type (including direct and diffuse point sources) by c) country and d) sub-region in 2006.
***No sources reported from Russia and from some German rivers.**

4.3 Discharges and losses into inland surface waters within the catchment area

The results presented in this section derive from the so-called **source-oriented approach** and concern the quantification of the discharges and losses into inland surface waters in the Baltic Sea catchment area from:

1. Municipal wastewater treatment plants
2. Industrial plants
3. Fish farms
4. Diffuse sources and
5. Natural background nutrient losses.

The quantification methods for nutrient loads to inland surface waters from point sources (including municipal and industrial effluents as well as discharges from fish farms) are the same as those used to quantify discharges of effluents directly into the Baltic Sea.

No common methodology for quantifying diffuse source pathways has been used by the countries, and not all countries submitted information on the methodology they applied. As a consequence, interpretation of the results should be made with caution. Information on the methodology is presented in **Section 3.1** and **Annex 3**.

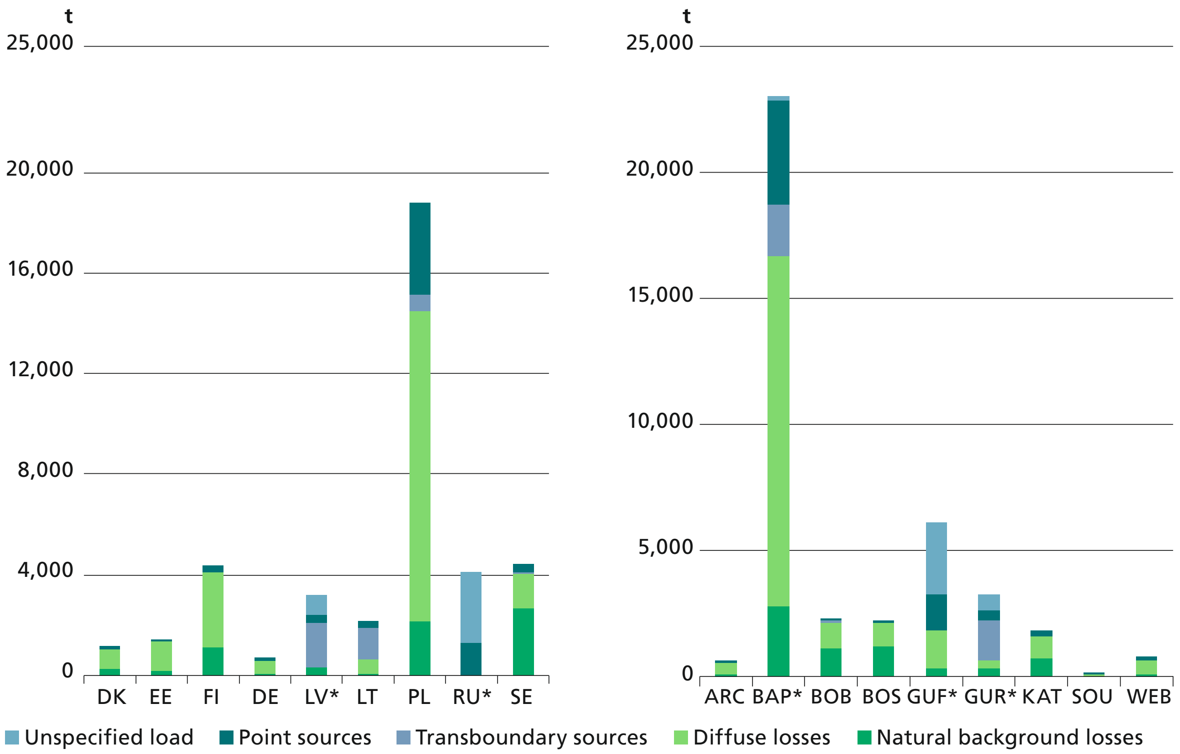
As shown in **Figure 4-15,** for all Contracting Parties, agricultural activities accounted for the majority of diffuse gross losses of nitrogen and phosphorus entering inland surface waters. The largest proportion of nitrogen and phosphorus losses from diffuse sources into inland surface waters occurred in the Baltic Sea catchment areas of Denmark, Estonia, Germany and Poland.

Overall, the picture is similar for losses to inland surface waters per country and sub-region as for total waterborne loads to the sea, with the largest nitrogen and phosphorus losses to inland waters in (and total waterborne loads to the sea) originating from Poland, Russia, Sweden and Finland. The nutrient losses to inland waters are in most cases higher than the total waterborne inputs to the Baltic Sea (shown in **Figure 4-16**), which reflects the importance of nutrient retention in lakes and rivers. Note, however, that **Figure 4-16** also includes direct point and diffuse sources and therefore does not fully reflect the effect of nutrient retention.

Diffuse anthropogenic losses of nitrogen and phosphorus to inland surface waters are in general the major source, except in Latvia and Lithuania where transboundary loads constitute the highest proportion (**Figures 4-15a,c** and **Figures 4-17a,c**). In Sweden, natural background losses of nitrogen and phosphorus constitute more than 40% of nitrogen and more than 50% of phosphorus losses to inland waters, which are large proportions compared with, e.g., Finland, where the corresponding figures are slightly more than 30% and 20% for nitrogen and phosphorus, respectively.

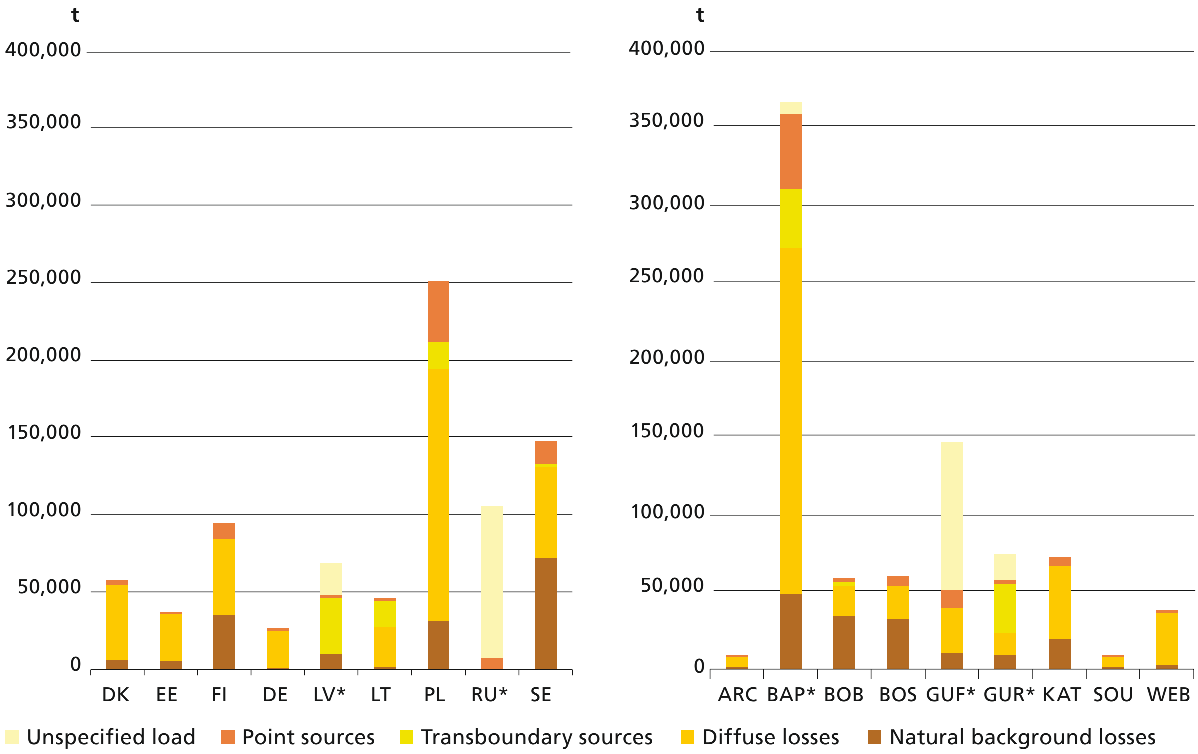
Area-specific losses to inland surface waters were also calculated by country and sub-region (**Figure 4-18**).

The overall picture with respect to the sub-regions with highest and lowest specific loads is similar to that for the area-specific riverine loads (**Figure 4-12**).



a) b)

Figure 4-15a,b Total losses and discharges of waterborne phosphorus (in tonnes) into inland surface waters by a) country and b) sub-region in 2006. *Source apportionment of riverine loads not specified by Latvia and Russia.



c) d)

Figure 4-15c,d Total losses and discharges of waterborne nitrogen (in tonnes) into inland surface waters by c) country and d) sub-region in 2006. *Source apportionment of riverine loads not specified by Latvia and Russia.

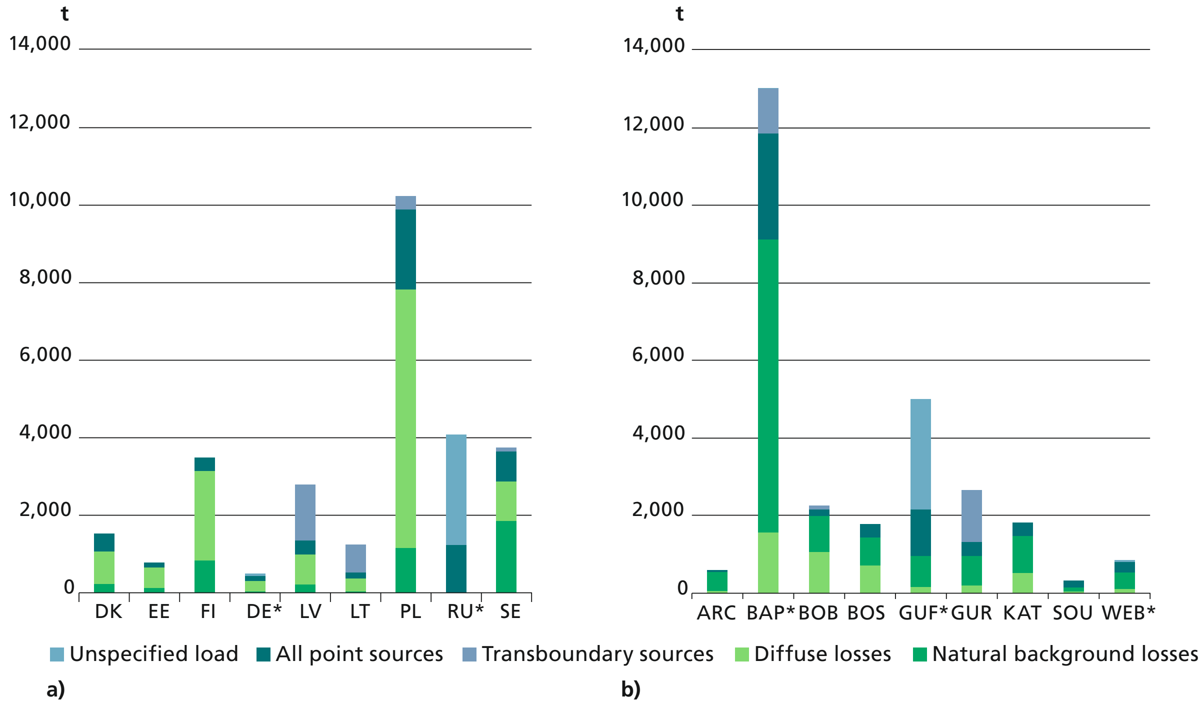


Figure 4-16a,b Source apportionment of total waterborne phosphorus (P_{total}) load (in tonnes) into the Baltic Sea (including direct point and diffuse sources) by a) country and b) sub-region in 2006.
***Note that the figures for Germany, Russia, Gulf of Finland (GUF), Baltic Proper (BAP) and Western Baltic (WEB) also include unspecified riverine load.**

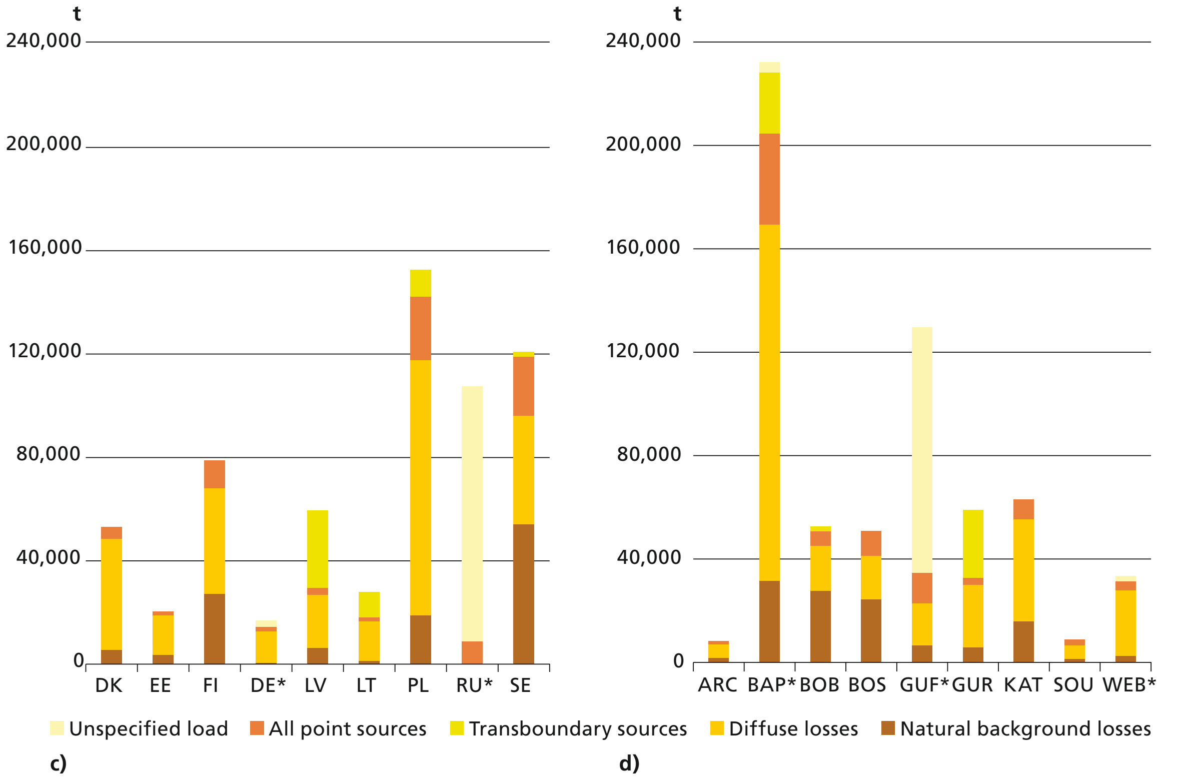


Figure 4-16c,d Source apportionment of total waterborne nitrogen (N_{total}) load (in tonnes) into the Baltic Sea (including direct point and diffuse sources) by c) country and d) sub-region in 2006.
***Note that the figures for Germany, Russia, Gulf of Finland (GUF), Baltic Proper (BAP) and Western Baltic (WEB) also include unspecified riverine load.**

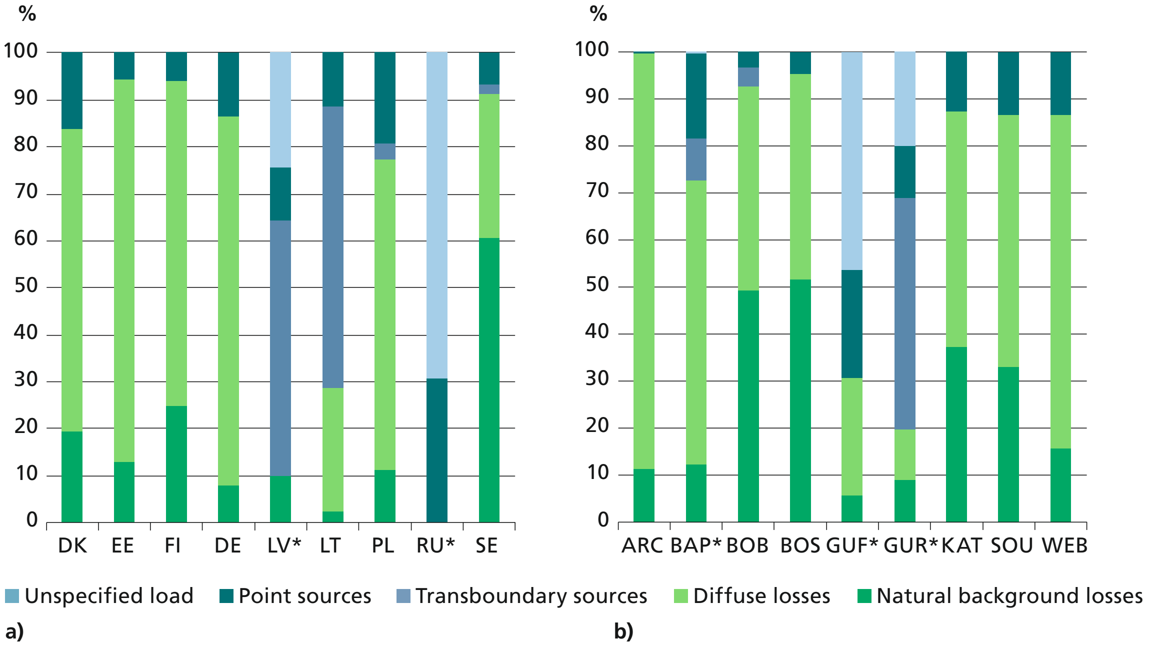


Figure 4-17a,b Phosphorus losses and discharges into inland surface waters by source (in %) and by a) country and b) sub-region. *Source apportionment of riverine loads not specified by Latvia and Russia

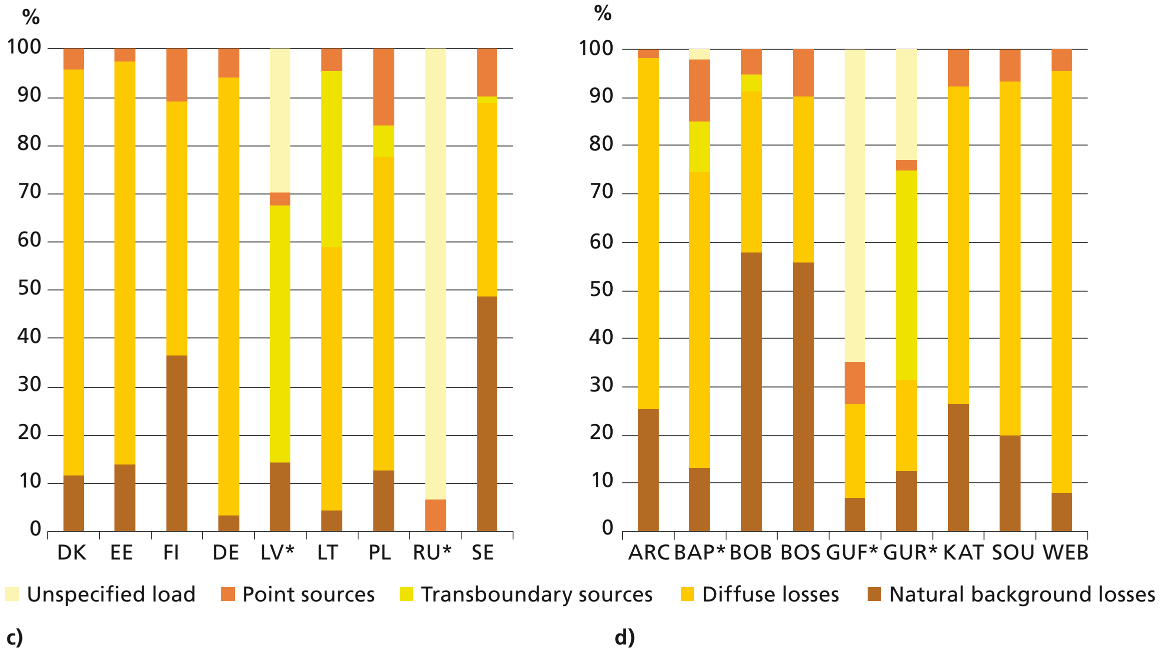
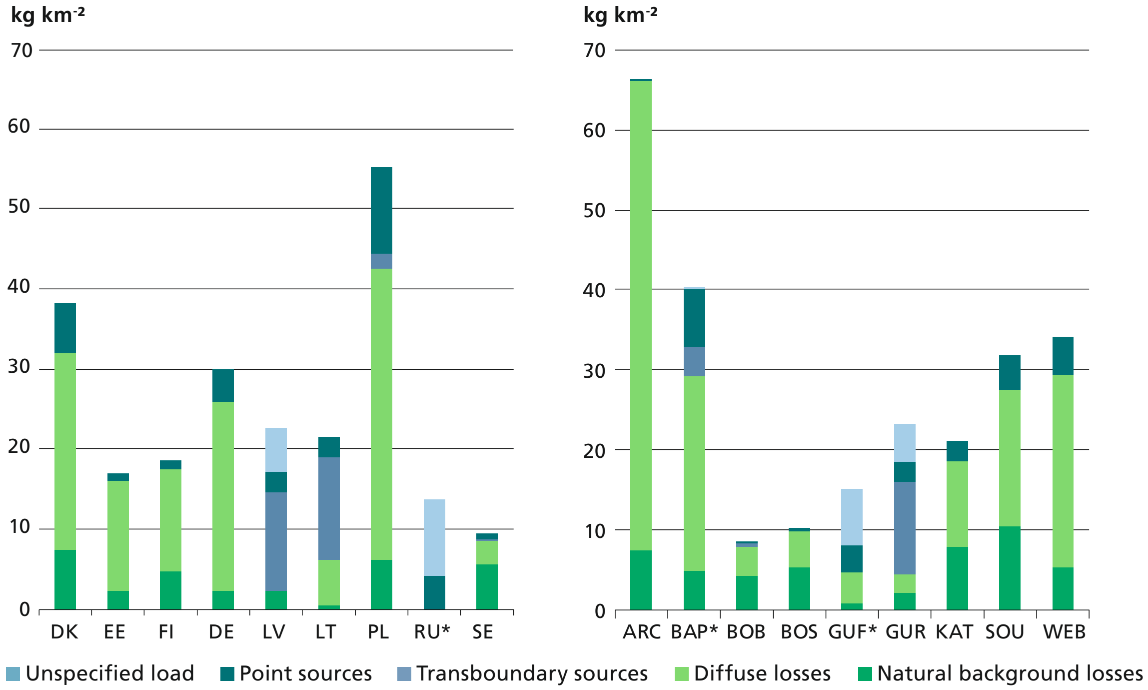
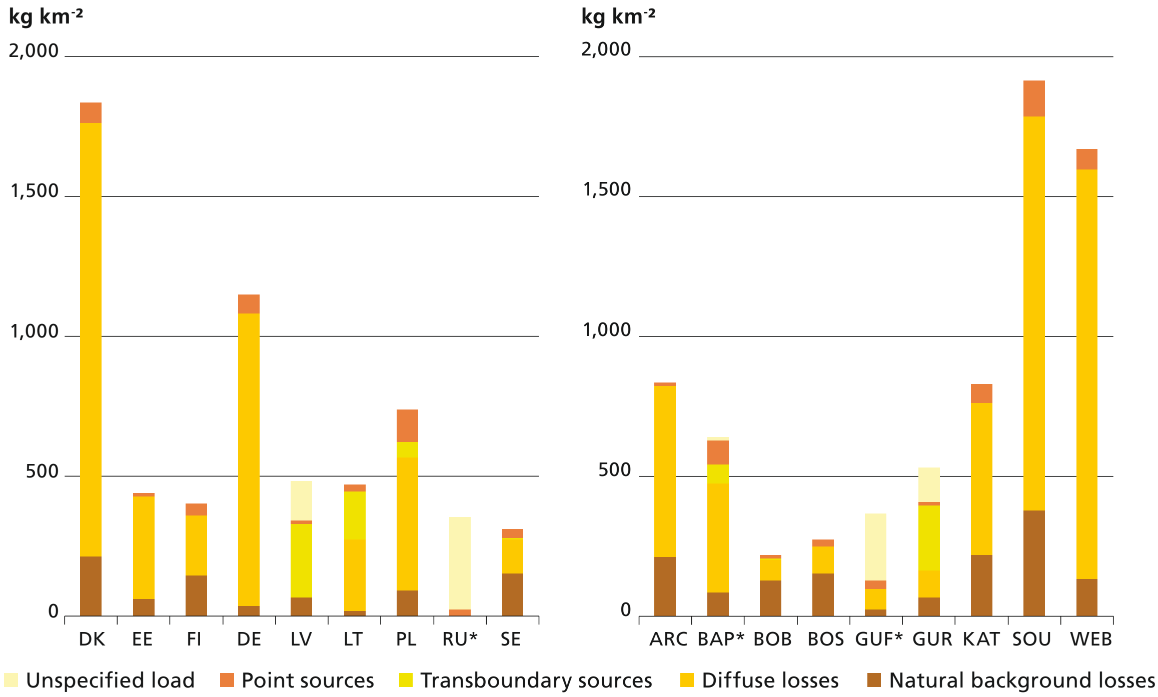


Figure 4-17c,d Nitrogen losses and discharges into inland surface waters by source (in %) and by c) country and d) sub-region in 2006. *Source apportionment of riverine loads not specified by Latvia and Russia



a) b)

Figure 4-18a,b Area-specific phosphorus losses and discharges (in kg km^{-2}) into inland surface waters (excluding direct point and diffuse sources) by a) country and b) sub-region in 2006.
***Source apportionment of riverine loads not specified by Latvia and Russia**



c) d)

Figure 4-18c,d. Area-specific nitrogen losses and discharges (in kg km^{-2}) into inland surface waters (excluding direct point and diffuse sources) by c) country and d) sub-region in 2006.
***Source apportionment of riverine loads not specified by Latvia and Russia**

4.4 Discharges and losses of heavy metals into the Baltic Sea

Heavy metals in rivers may originate from natural or anthropogenic sources, and excessive metal levels in surface waters may pose a health risk to humans and to the biota in the environment. In the Baltic Sea, unnaturally high mercury concentrations have been detected in samples such as fish tissue. Soil properties, industrial activity, high population density, the exploitation of minerals and other natural resources, the application of fertilizers in agricultural areas as well as atmospheric deposition from distant emission sources are the main factors which contribute to heavy metal inputs. More information about the causes and supply of heavy metals to the Baltic Sea can be found in HELCOM (2007e).

Shortcomings in national monitoring programmes and the lack of proper laboratory equipment have prevented the reporting of heavy metal figures in many cases. As a result, a clear picture of the heavy metal inputs entering the Baltic Sea could not be established in PLC-5, and many figures are missing.

According to the PLC-5 guidelines, mercury, cadmium, zinc, copper, and lead are obligatory parameters which should be reported wherever concentrations in rivers are not below the detection limit. On the other hand, some of the Contracting Parties have calculated heavy metal inputs even if the concentrations have been below the detection limit. The PLC-5 guidelines indicate methods for making estimates from measurements below the detection limit. Four Contracting Parties, namely, Denmark, Finland, Germany and Sweden, have reported the estimated heavy metal inputs from unmonitored rivers and coastal areas.

Based on reported heavy metal data, the Gulf of Finland received the largest cadmium, lead, copper and nickel inputs, while mercury inputs were highest for the Baltic Proper. However, it should be noted that the mercury input from Russia seems to be unreliably low.

A few major rivers accounted for very large proportions of the reported total riverine heavy metal inputs. For example, the lead and copper loads in Russian rivers (mainly the Neva) comprised the main proportion of the total riverine inputs for these pollutants.

According to **Figure 4-19** and **Table 4-4**, a large part of heavy metal data on inputs from rivers, coastal areas and unmonitored rivers is missing, making it impossible to present an overview of the total riverine inputs into the Baltic Sea by subregion. In spite of the lack of data, **Figure 4-19** presents an overview of riverine inputs into the Baltic Sea from each Contracting Party.

Table 4-4 a. Waterborne heavy metal inputs (in tonnes) to the Baltic Sea in 2006 by country. Due to false confidence ratio of laboratory analyses, inputs of mercury from Polish rivers are not included.

Country	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Denmark							
Estonia	0.11		110.41	0.17		12.71	47.26
Finland	3.32	75.41	127.94	0.25	205.69	30.51	722.27
Germany	0.12	0.25	8.03	0.04	8.42	1.58	27.98
Latvia	2.70	0.20	74.70	0.02	68.16	18.94	463.33
Lithuania	0.12	0.05	0.14		18.23	0.11	40.59
Poland	9.67	0.13	141.76	0.03	0.28	36.59	256.65
Russia	29.24	8.86	184.39	0.001	168.61	132.21	823.44
Sweden	2.41	66.73	238.90	0.33	122.57	49.47	775.74
Total	**47.7**	**151.6**	**886.3**	**0.8**	**592.0**	**282.1**	**3157.3**

Table 4-4 b. Waterborne heavy metal inputs (in tonnes) to the Baltic Sea in 2006 by sub-region. Due to false confidence ratio of laboratory analyses, inputs of mercury from Polish rivers are not included.

Sub-region	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Archipelago Sea	0.30	11.32	12.61	0.02	9.13	3.76	88.60
Baltic Proper	10.42	12.60	200.62	0.11	62.38	47.59	445.90
Bothnian Bay	1.33	43.62	136.74	0.22	136.88	20.84	404.45
Bothnian Sea	2.91	39.87	106.03	0.19	109.66	27.30	698.24
Gulf of Finland	29.49	20.29	290.31	0.19	185.33	145.91	918.88
Gulf of Riga	2.71	0.20	92.35	0.01	62.63	20.84	439.49
Kattegat	0.44	21.83	39.79	0.07	23.38	13.75	138.35
Sound	0.03	1.65	2.83	0.01	1.67	1.10	8.00
Western Baltic	0.05	0.24	5.00	0.01	0.90	1.02	15.35
Total	**47.7**	**151.6**	**886.3**	**0.8**	**592.0**	**282.1**	**3157.3**

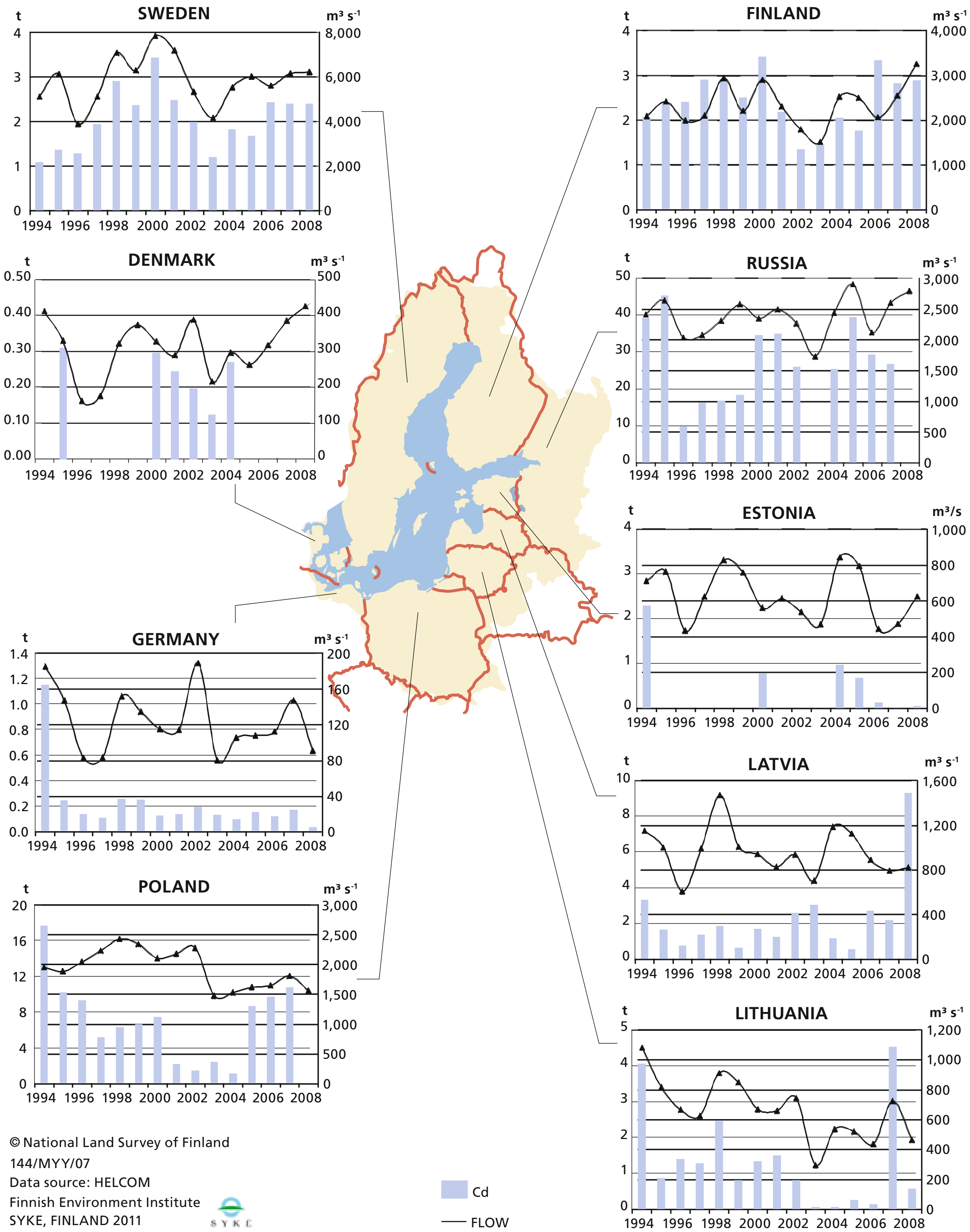


Figure 4-19a Riverine inputs (in tonnes) of cadmium to the sea by country from 1994 to 2008, together with average annual river flow (in m³ s⁻¹).

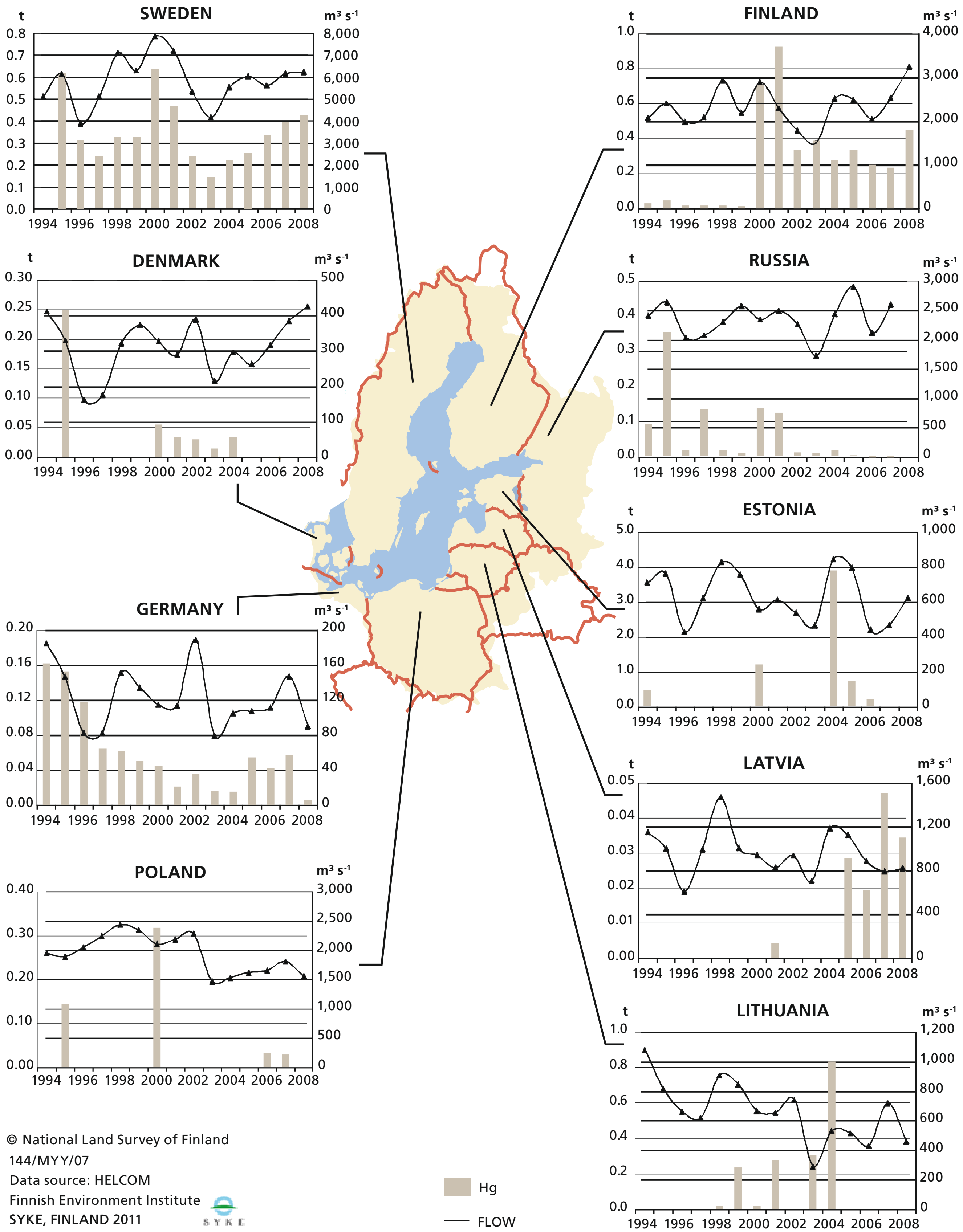


Figure 4-19b Riverine inputs (in tonnes) of mercury to the sea by country from 1994 to 2008, together with average annual riverine flow (in m³ s⁻¹). Due to false confidence ratio of laboratory analyses, inputs of mercury from Polish rivers are not included.

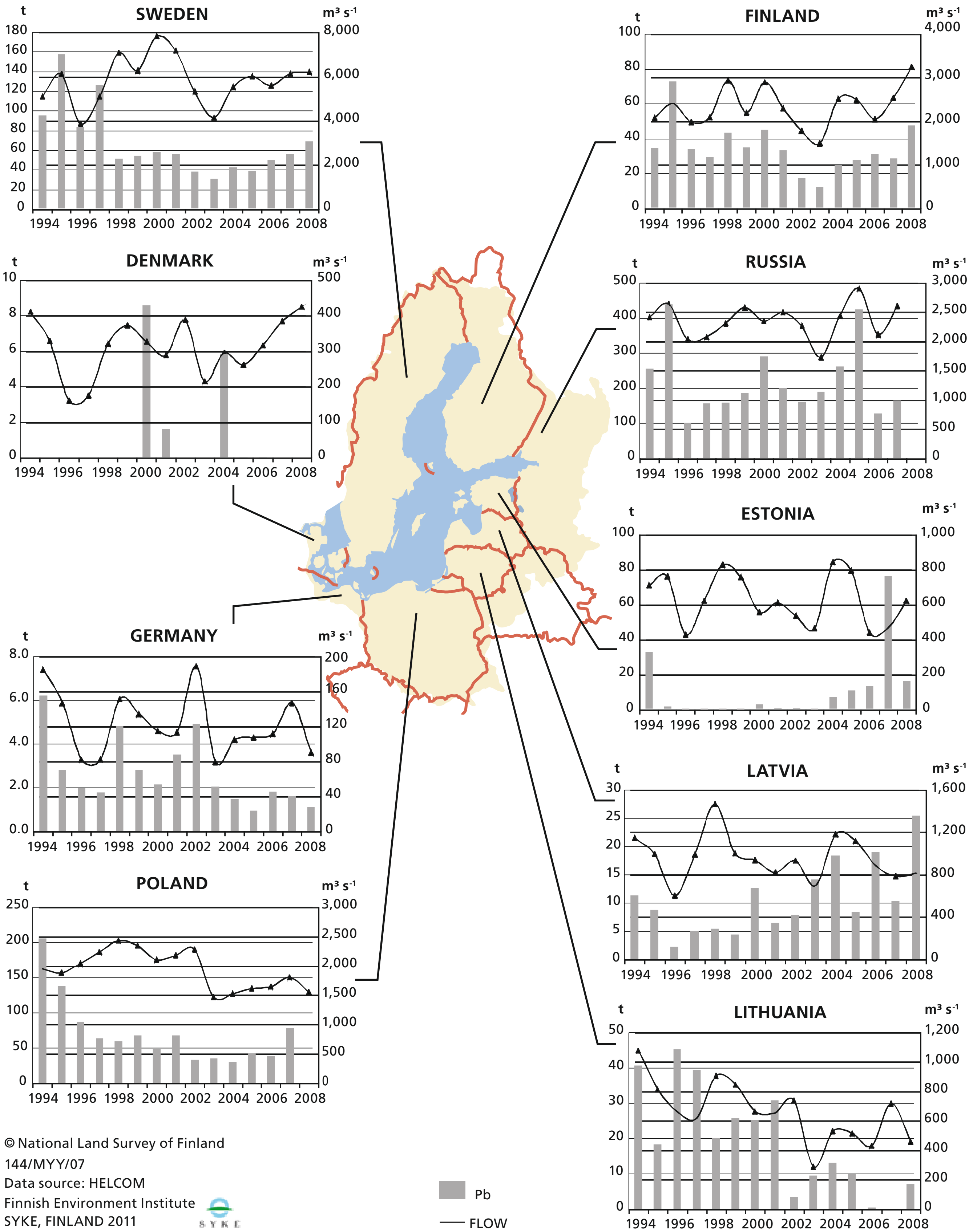


Figure 4-19c Riverine inputs (in tonnes) of lead to the sea by country from 1994 to 2008, together with average annual riverine flow (in m³ s⁻¹).

5 Development in waterborne nitrogen and phosphorus loads from 1994 to 2008

5.1 Waterborne nutrient loads to the Baltic Sea from 1994 to 2008

When comparing riverine inputs into the Baltic Sea from different years, the controlling influence of the runoff (related to climate) should be taken into account because there is a close correlation between runoff and nutrient loads. During years with heavy precipitation and associated high runoff, more nitrogen and phosphorus are leached and eroded from cultivated areas, and most probably also from natural background areas, than during dry years, resulting in higher riverine nutrient inputs to the Baltic Sea. For these reasons, all figures for the years 1994 to 2008 also show the riverine runoff in addition to the input figures (**Figures 5-1** and **5-2**). The average annual flow and the total annual inputs of nitrogen and phosphorus by country and sub-basin are listed in **Tables 8-4a-c** in **Annex 1**.

Water flow in rivers varies over time, mainly as a result of variations in rainfall and temperature. These fluctuations are often the main cause for variations in nitrogen and phosphorus loads, making it difficult to compare loads from one year to another without smoothing out the effect of flow by *flow-normalizing* the input data, which is introduced later in this section.

Based on non-normalized data on riverine nutrient discharges (**Figures 5-1** and **5-2**), only a few countries show decreased total waterborne loads from 1994 to 2008, including Denmark, Germany, Lithuania and Poland. For Lithuania and Poland, the decrease seems closely associated with a decrease in the runoff since 2000-2002, which is not seen for other countries (see further comments in **Chapter 6**).

Direct discharges of phosphorus and nitrogen from coastal municipal wastewater treatment plants (MWWTPs), industry and fish farms into the Baltic Sea (**Figures 5-3** and **5-4**) are generally independent of variations in precipitation, although some municipal wastewater plants may allow untreated overflows during heavy storm water events. For all these sources, there is an overall decrease during the period 1994 to 2008. For MWWTPs, the direct discharges during the period 2000 to 2005, especially for phosphorus, are higher than in both the preceding and subsequent years, which might be related to data errors in some countries (more in **Chapter 6**). Since 1990, the direct point source phosphorus load has decreased markedly, by 27% from 1994 to 2008, and the nitrogen load by 33% from 1994 to 2008 but the real decrease might be higher due to some missing data in the 1990s. **Chapter 6** discusses some major uncertainties in the direct point source inputs, as the datasets are not complete and not fully harmonized.

Country-wise direct loads from MWWTPs, industry and fish farms are displayed in **Figure 5-5**. Since 2000-2002, the total direct loads from fish farms seem more or less constant. However, if a longer period of time is considered, the load from fish farms has halved in Finland (1990-2000) and approximately the same in Denmark (Nordemann Jensen et al. 2010).

In **Figure 5-5**, time series from 1996 to 2008 for direct point source loads are divided into the categories MWWTP, industry and fish farm and shown by Contracting Party and sub-region. In Denmark and Finland, a decrease in direct discharges from MWWTPs and industry through the whole period is evident. For Poland, Russia and Latvia, some analytical and methodological problems may explain the less obvious development in direct discharges from MWWTPs.

Total nitrogen and phosphorus non-flow-normalized loads entering the Baltic Sea (as riverine and direct point source discharges) amounted to 891,000 tonnes and 51,100 tonnes, respectively; in 1990, according to the supplemented Second Baltic Sea Pollution Load Compilation (HELCOM 1993), compared with 638,000 tonnes nitrogen and 28,370 tonnes phosphorus in 2006. The reduction from 1990 to 2006 in *non-normalized loads* of total phosphorus was thus 45% and for total nitrogen 28%. The observed decrease is partly explained by the lower runoff in 2006 (-15% within the period 1990-2006). It should be noted that municipal phosphorus loads from the Nordic Contracting Parties and Germany had decreased significantly already before the 1988 Ministerial Declaration (HELCOM 1988) was agreed.

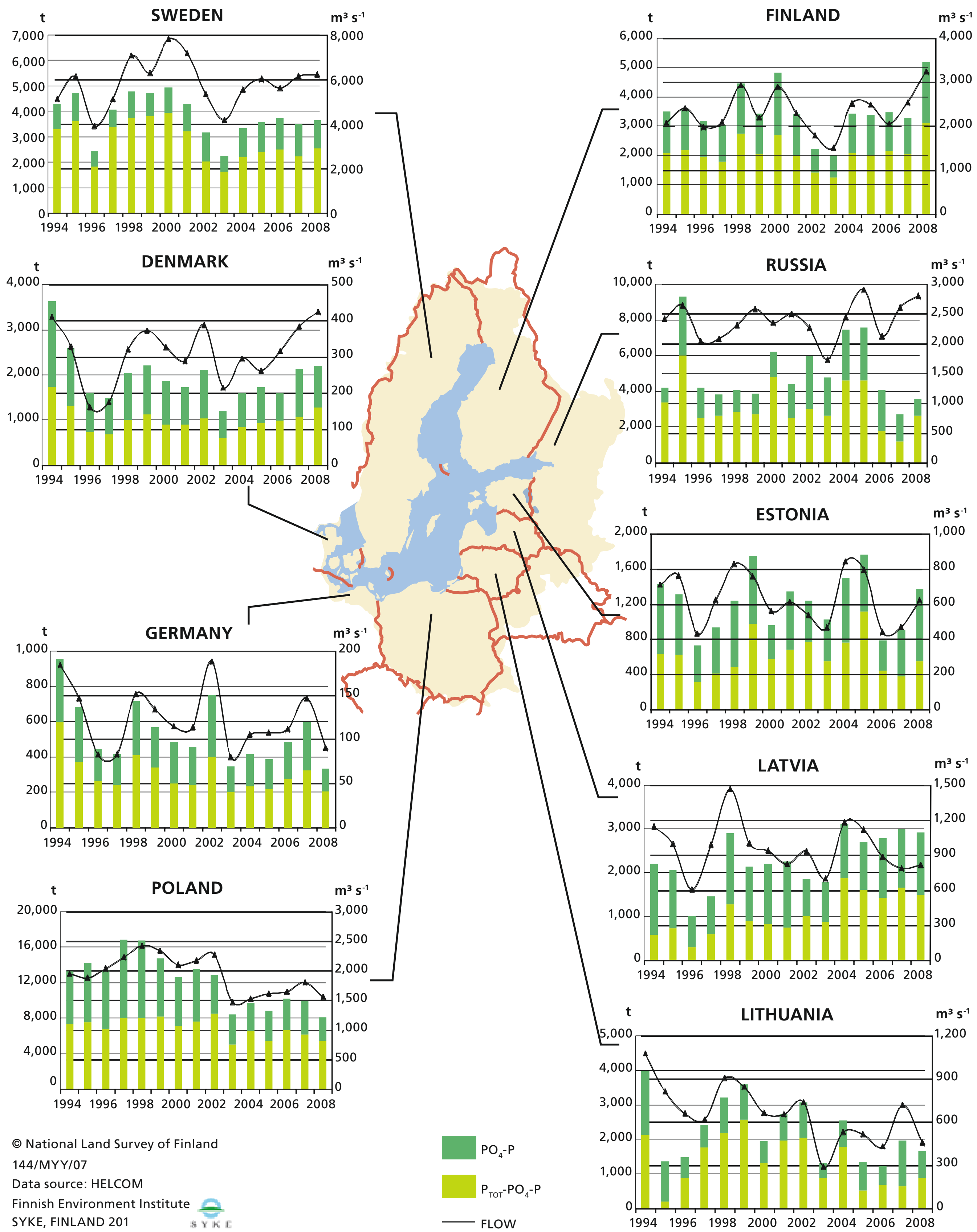
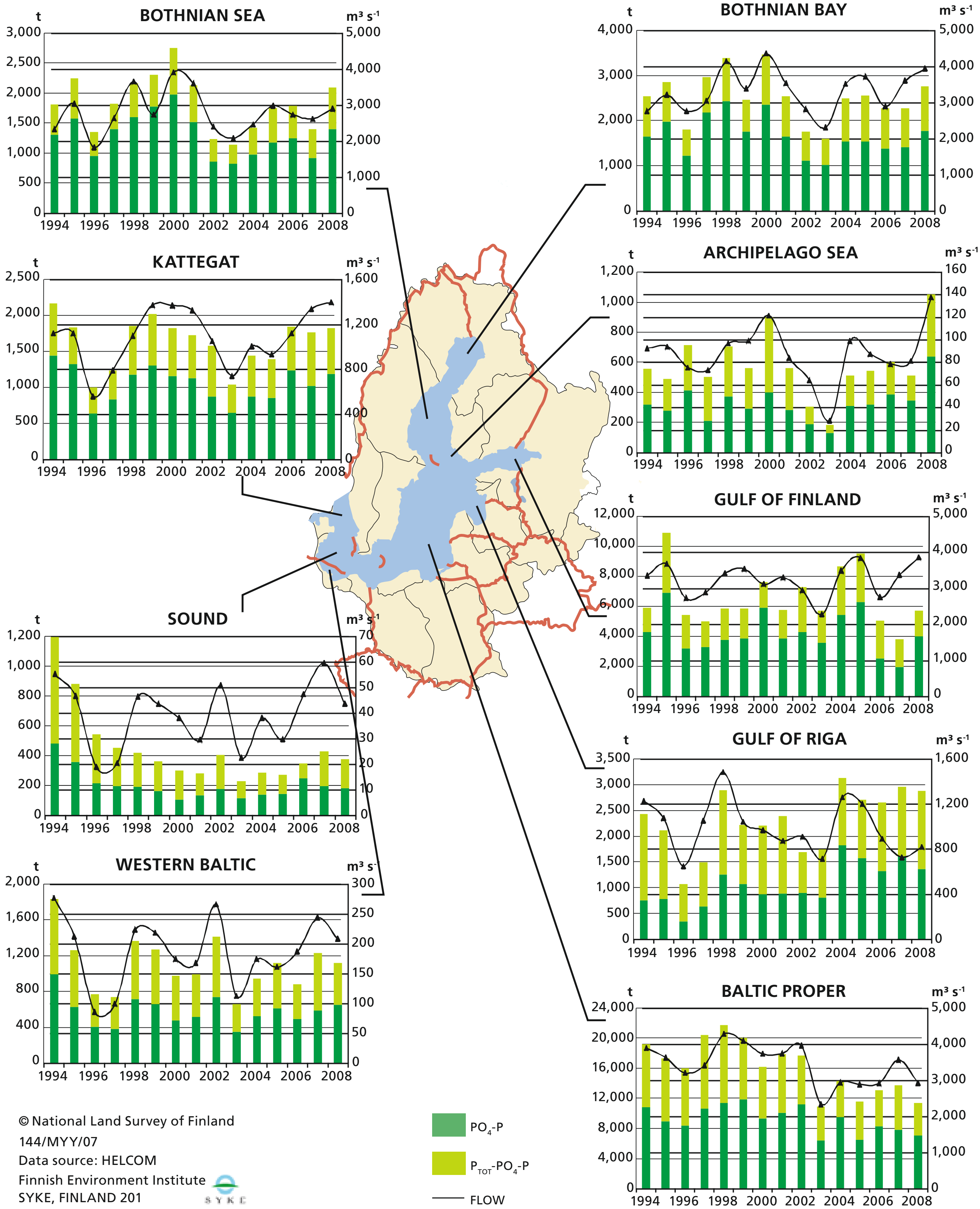


Figure 5-1a Average annual riverine flow (in m³ s⁻¹) and riverine plus direct point source load of phosphorus (in tonnes) from HELCOM countries into the Baltic Sea from 1994 to 2008.



Data source: HELCOM
Finnish Environment Institute
SYKE, FINLAND 201

Figure 5-1b Average annual riverine flow (in $m^3\ s^{-1}$) and riverine plus direct point source load of phosphorus (in tonnes) from the main catchment areas into the Baltic Sea from 1994 to 2008.

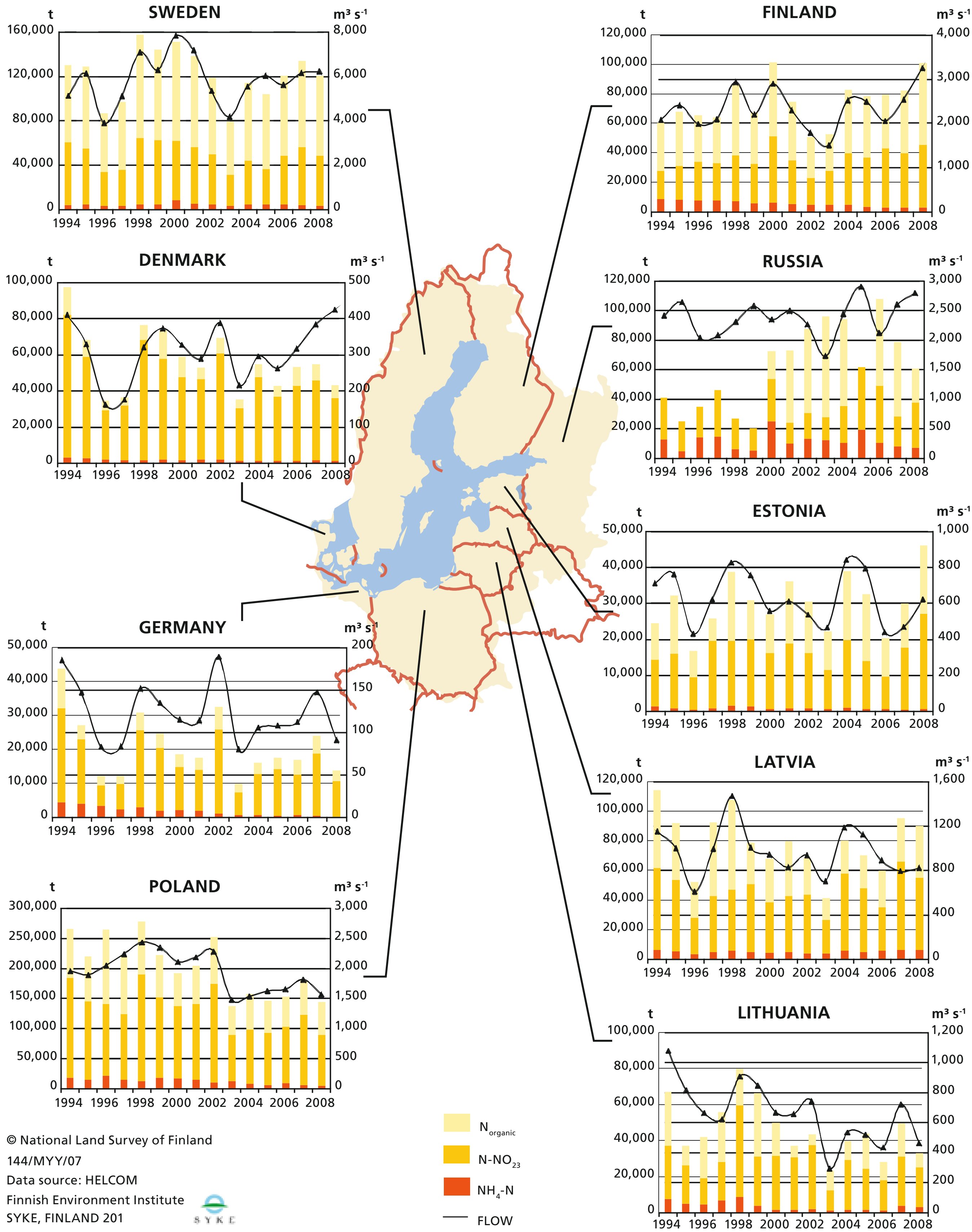


Figure 5-2a Average annual riverine flow (in $m^3 s^{-1}$) and riverine plus direct point source load of nitrogen (in tonnes) from HELCOM countries into the Baltic Sea from 1994 to 2008.

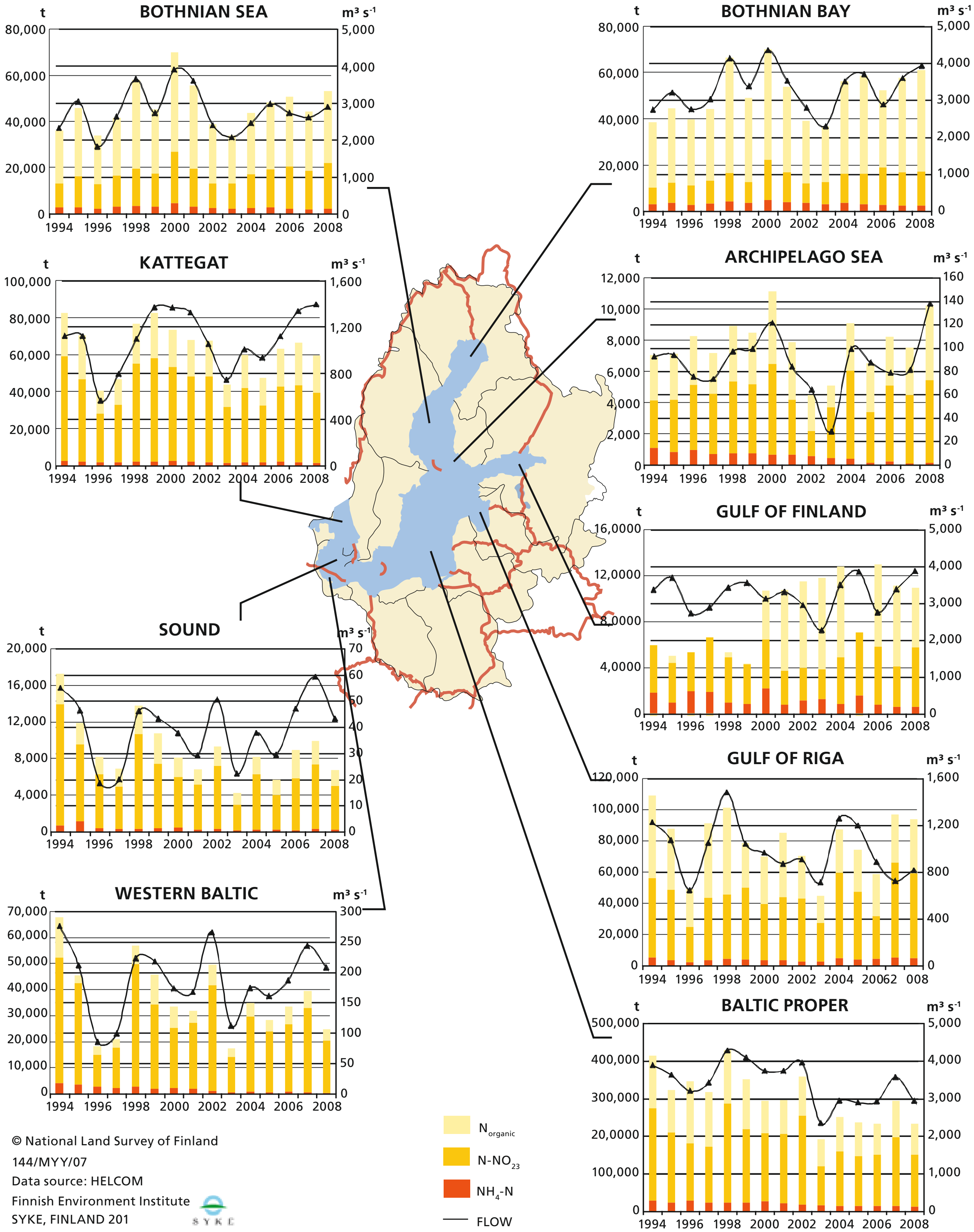
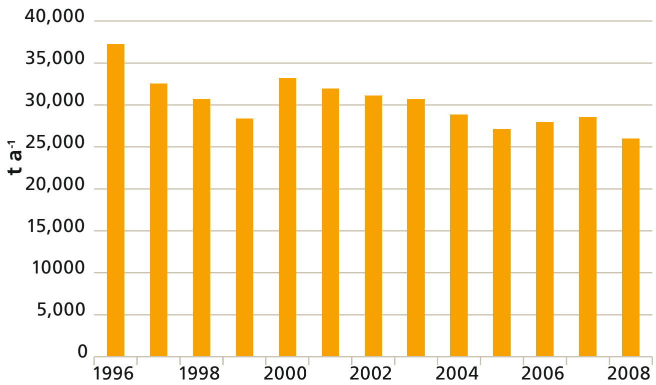
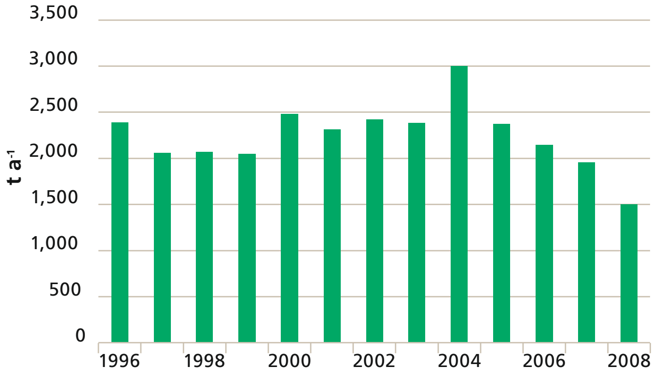


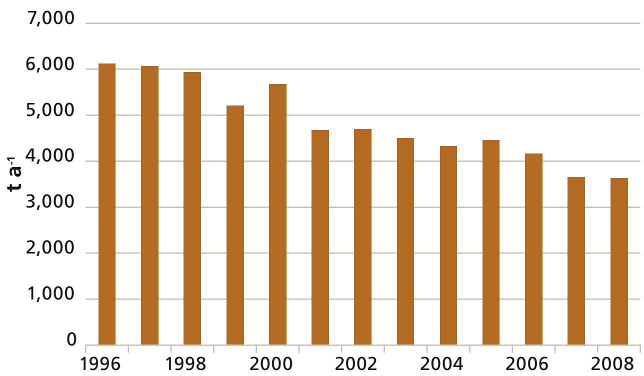
Figure 5-2b Average annual riverine flow (in $m^3 s^{-1}$) and riverine plus direct point source load of nitrogen (in tonnes) from the main catchment areas into the Baltic Sea from 1994 to 2008.



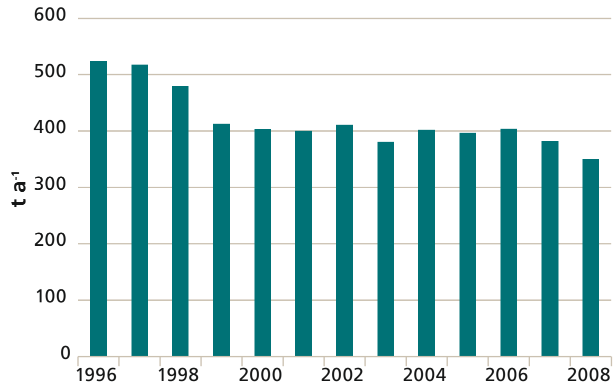
a) Direct N_{total} load, MWWTP



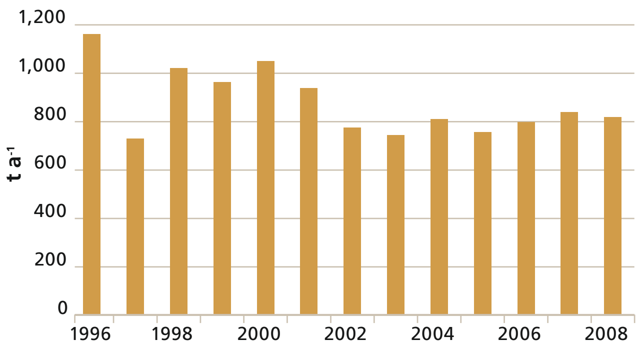
a) Direct P_{total} load, MWWTP



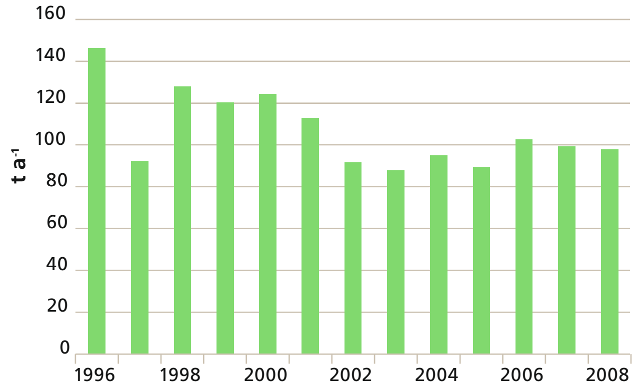
b) Direct N_{total} load, industry



b) Direct P_{total} load, industry



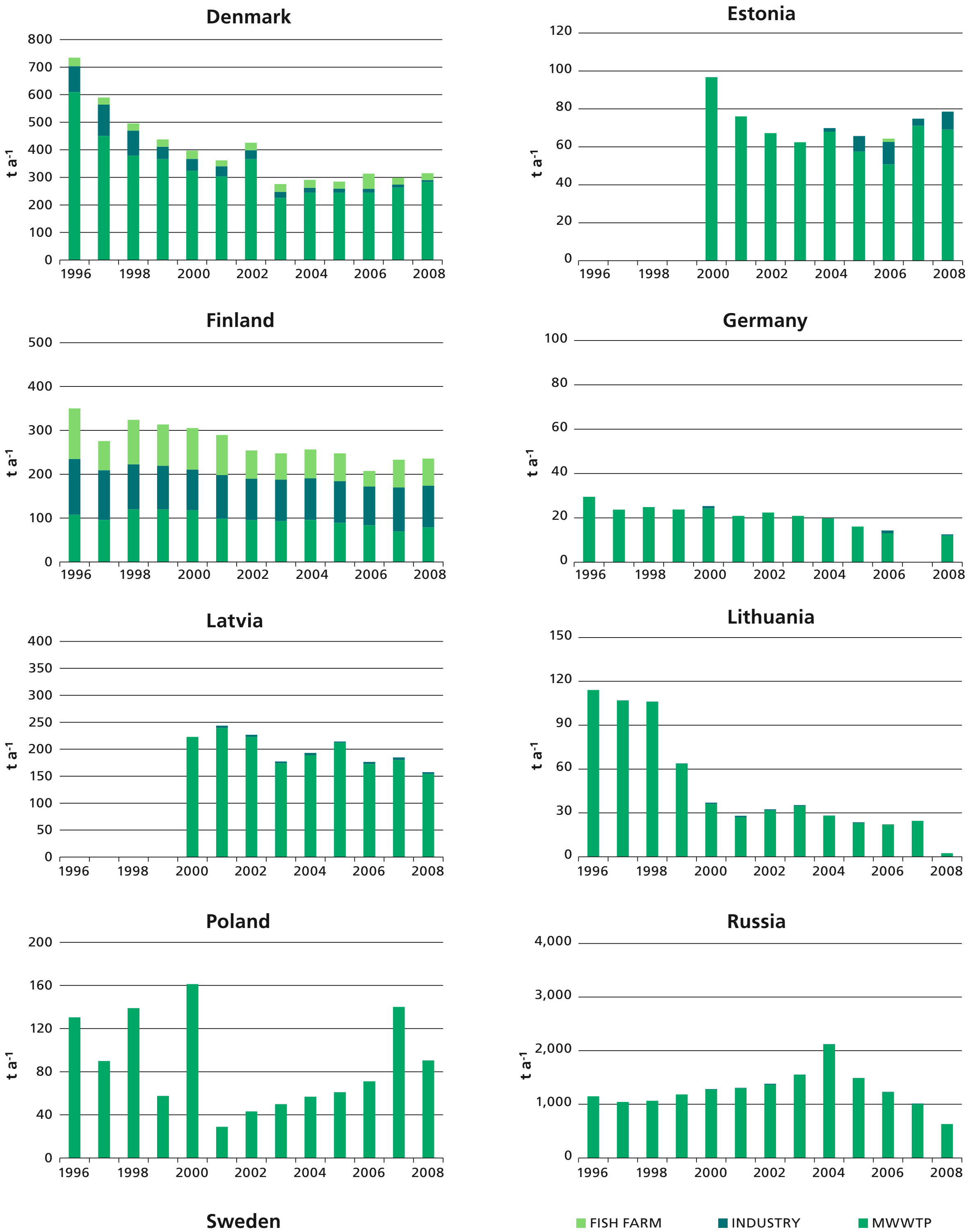
c) Direct N_{total} load, fish farms



c) Direct P_{total} load, fish farm

Figure 5-3 Direct phosphorus discharges (in t a^{-1}) from three categories of point sources to the Baltic Sea from 1996 to 2008: a) MWWTPs, b) industry, and c) fish farms.

Figure 5-4 Direct nitrogen discharges (in t a^{-1}) from three categories of point sources to the Baltic Sea from 1996 to 2008: a) MWWTPs, b) industry, and c) fish farms.



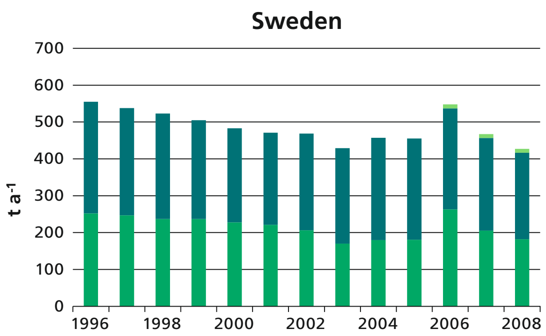
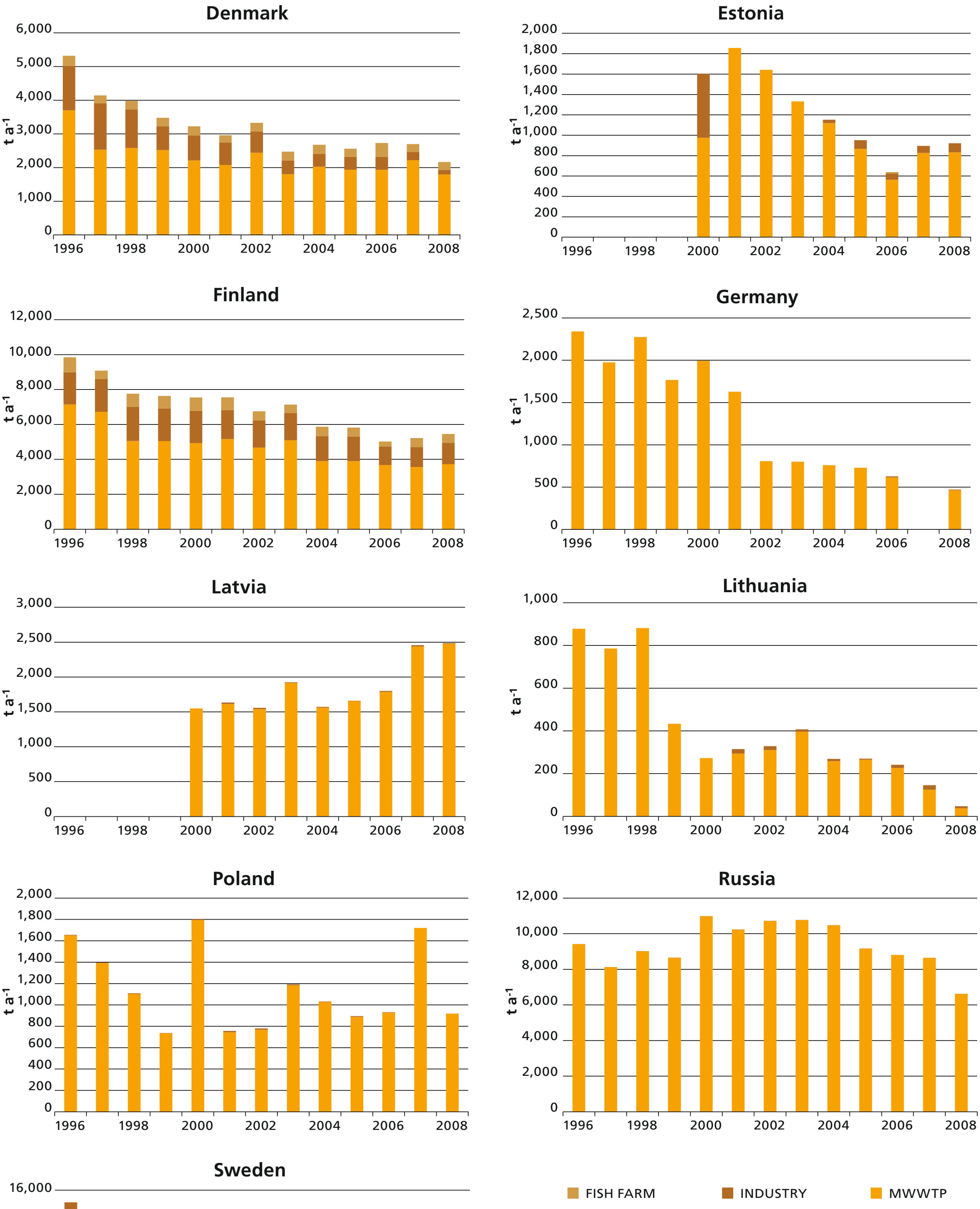


Figure 5-5a Direct total phosphorus discharges (in t a^{-1}) from different categories of point sources (MWWTP, industry and fish farm) to the Baltic Sea by country from 1996 to 2008. Note the different values on the y-axis for each country.



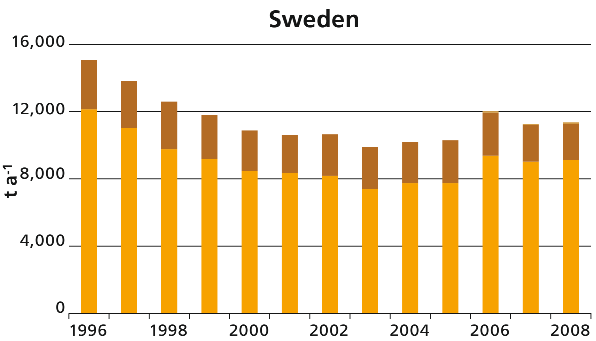


Figure 5-5b Direct total nitrogen discharges (in t a^{-1}) from different categories of point sources (MWWTP, industry and fish farm) to the Baltic Sea by country from 1996 to 2008. Note the different values on the y-axis for each country.

5.2 Normalizing load data

Flow-normalization of data provides a better opportunity to make a more correct evaluation of trends in the total waterborne loads to the Baltic Sea. Baltic Nest Institute (BNI 2009) has carried out a flow normalization of the riverine inputs on annual total riverine inputs per country and main Baltic Sea catchment sub-region. For Russia some years with missing total annual riverine inputs of nitrogen were estimated before normalization to obtain a complete time series. The flow-normalization methodology applied is described in **Box 1**. Normalization is not performed on the direct inputs from coastal point sources as these discharges are essentially independent of variations in precipitation and temperature.

Tables and figures describing the flow-normalization procedure and nitrogen and phosphorus loads from each country and by sub-basin are presented in **Annex 2**. This annex contains figures with flow-normalized riverine load, non-flow-normalized direct load from point sources and the sum of these (total waterborne loads) for nitrogen and phosphorus. Annex 2 also contains figures covering both non-normalized (TN and TP) as well as flow-normalized (Norm TN and Norm TP) loads in tonnes.

The importance of flow normalization is quite clear from the example in **Figure 5-6** in Box 1. Based on the observed riverine load data (solid lines in the bottom right figure in Box 1), it appears as though the loads of both phosphorus and nitrogen have decreased markedly since 1994. But based on the flow-normalized load of nitrogen and phosphorus (shown with the dotted lines), the decrease is less obvious.

To evaluate whether there are any statistically significant decreases or increases in waterborne nitrogen and phosphorus loads, a trend analysis was conducted.

5.3 Trend analysis of waterborne loads of nitrogen and phosphorus

As a first step before carrying out trend analyses on nitrogen and phosphorus loads, annual riverine flows are tested for trends (**Tables 5-1a-b**). If any significant trend is detected for the riverine flow, this could bias the flow-normalization of riverine nitrogen and phosphorus loads. The tests showed no significant trend in riverine flow by either country or sub-region except for Lithuania (as pointed out in **Chapter 6**, an unexplainable decrease in total riverine flows occurred after 2003; see also **Figure 5-1**). Because the homogeneity test for riverine flow had a P value greater than 0.05, the possibility cannot be excluded that there are comparable (homogeneous) trends in riverine flow between countries or between sub-regions.

Trend analyses were performed on flow-normalized annual riverine loads of nitrogen and phosphorus from 1994 to 2008 (**Tables 5-2a-d**), non-flow normalized direct coastal annual loads of nitrogen and phosphorus (**Tables 5-3a-d**) and the total waterborne annual loads for nitrogen and phosphorus (as the sum of flow-normalized riverine loads and non-flow-normalized direct loads) (**Tables 5-4a-d**). Significant trends are marked with bold type face. Riverine loads were flow-normalized as described in the previous section before the trend analysis. The trend analysis procedure is described in Box 2. The trend analyses are presented by country and by main Baltic Sea sub-region in the tables.

For flow-normalized annual riverine nitrogen loads from 1994 to 2008, only Denmark had significant decreasing loads, with a decrease of 1,521 tonnes nitrogen per year (31%) (**Table 5-2a**). In addition, five Contracting Parties had non-significant decreases in flow-normalized loads. Two Contracting Parties (Estonia and Finland) showed statistically significant increasing flow-normalized riverine nitrogen loads and Russia had a non-significant increase. The total flow-normalized riverine nitrogen load to the whole Baltic Sea decreased, but not significantly, from 1994 to 2008 (by about 4,600 tonnes nitrogen per year (24%)). Two subregions, the Kattegat (25%) and Danish Straits (24%), had significant decreases in flow-normalized riverine nitrogen loads, but there was a significant increase in the Bothnian Bay (**Table 5-2b**).

The homogeneity in trends from the different Contracting Parties and for the main Baltic Sea sub-regions was low (P was less than 0.05) in all trend analyses in **Tables 5.2** to **5.4**. The reason can be due to weak or non-significant trends in load data for some countries or sub-regions and because there is a combination of, e.g., significant decreases in loads for some countries and subregions combined with some significant increases.

From 1994 to 2008, Denmark, Germany, Poland and Sweden had significant decreasing flow-normalized riverine phosphorus loads (19%, 24%, 18% and 27% per year, respectively), while Latvia showed a significant increase (13%) (**Table 5-2c**). Two countries had non-significant increases in these loads (Estonia and Lithuania). For the whole Baltic Sea, a non-significant decrease was calculated. The corresponding loads divided by subregion yielded significant decreases for the Danish Straits (24%), Baltic Proper (13%), Bothnian Sea (24%) and Bothnian Bay (25%), but a significant increase for the Gulf of Riga (64%) **(Tables 5-2d**).

The riverine loads were mainly dominated by diffuse sources, with agriculture a major component. The lack of a decrease in flow-normalized riverine nitrogen and phosphorus loads in many areas indicates that the losses of nitrogen and phosphorus from agricultural activities either were not reduced or were increasing from 1994 to 2008 in these areas.

The direct coastal loads (not flow-normalized) from 1994 to 2008 to the Baltic Sea significantly decreased for both nitrogen and phosphorus, with an annual reduction of 1,173 tonnes of nitrogen (33%) and 78 tonnes of phosphorus (27%) (**Tables 5-3a-d**). These nitrogen loads significantly decreased for Germany (86%), Denmark (42%), Finland (58%), Lithuania (96%) and Sweden (31%), but significantly increased for Latvia. For direct coastal loads of phosphorus, there was a significant decrease from Germany (34%), Denmark (41%), Finland (39%), Lithuania (99%) and Sweden (27%). Estonia and Latvia showed a non-significant increase in these loads. The direct coastal loads of nitrogen decreased significantly to all main sub-regions except the Gulf of Riga, where it increased significantly. For phosphorus there were similar trends except for the Gulf of Finland, where the decrease was not significant, and the Gulf of Riga, where the increase was not significant.

For the total waterborne annual loads consisting of the flow-normalized riverine loads plus the direct coastal loads, Germany (14%), Denmark (34%) and Sweden (12%) had a significant decreasing nitrogen input from 1994 to 2008, while it increased significantly from Estonia (47%) (**Table 5-4a**). In addition, Finland and Russia had an increasing, but non-significant, total nitrogen load. Total waterborne nitrogen loads to the whole Baltic Sea decreased, but not significantly, from 1994 to 2008. The corresponding phosphorus loads showed a significant decrease for Germany (31%), Denmark (31%), Poland (18%), Sweden (28%) and for the whole Baltic Sea (the latter 339 tonnes per year (13%)), but a significant increase for Latvia, and a non-significant increase for Estonia and Lithuania (**Tables 5-4c**). Total waterborne loads of nitrogen to the Kattegat (26%), Danish Straits (35%) and Baltic Proper (16%) significantly decreased from 1994 to 2008, but increased significantly for the Bothnian Bay (12%) and increased non-significantly for the Gulf of Finland and Bothnian Sea (**Table 5-4b**). Regarding phosphorus, a significant decrease was calculated for all main sub-regions except the Gulf of Riga, which showed a significant increase (67%), and the Gulf of Finland with a non-significant decrease (**Tables 5-4d**).

Box 1. Flow normalization of waterborne loads

Variation in river discharge (runoff) is in most cases the main cause for variations in the loads of nitrogen and phosphorus, which means that loads cannot be compared without evening out differences in riverine discharges between years. Riverine flow is closely related to variations in precipitation and also temperature. Flow normalization of riverine loads of nutrients to the sea was carried out by the Baltic Nest Institute (BNI Stockholm) to smooth out variations in annual loads caused by hydrology (runoff). Flow normalization allows for a more correct evaluation of progress in load reduction measures. Other climatic factors can also be included in the normalization, but this would make the procedure much more complicated and these factors are less important to variation in loads of nitrogen and phosphorus than variation in flow (precipitation).

The observed riverine loads of nitrogen and phosphorus were log-normalized by conducting a regression between the log value of riverine loads and discharges, giving slope (b) and intercept (a), for observational data from 1994 to 2008. The log average flow for 1994 to 2008 ($q_{average}$) was thereafter entered into the regression equation and was divided with the same regression equation, but using the log discharge observed for a particular year (q_{year}), thus obtaining a ratio; see the equation below.

$$L_{normalized\_year} = L_{year} \cdot \frac{a + b \cdot q_{average}}{a + b \cdot q_{year}}$$

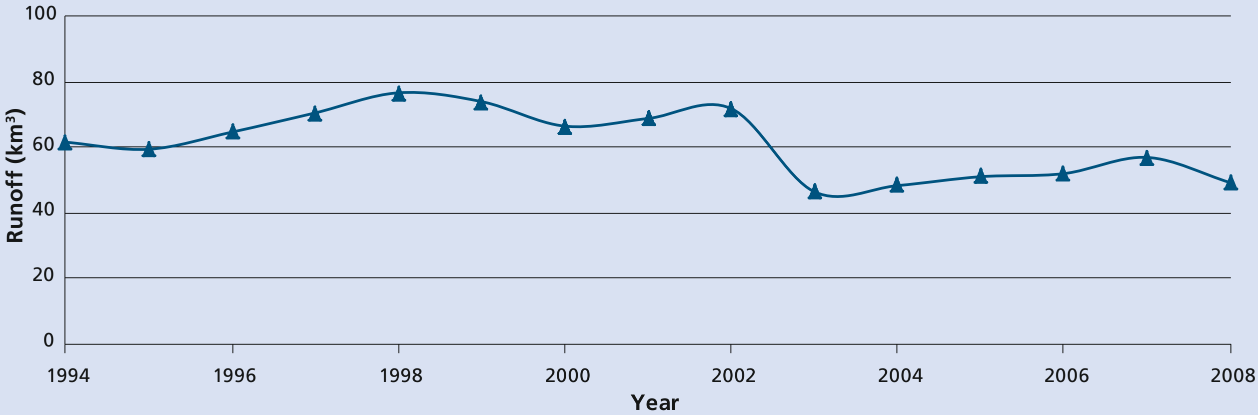
Where L = Load of N or P, a = intercept, b = slope, q = water discharge. The period used for the average is 1994 – 2008.

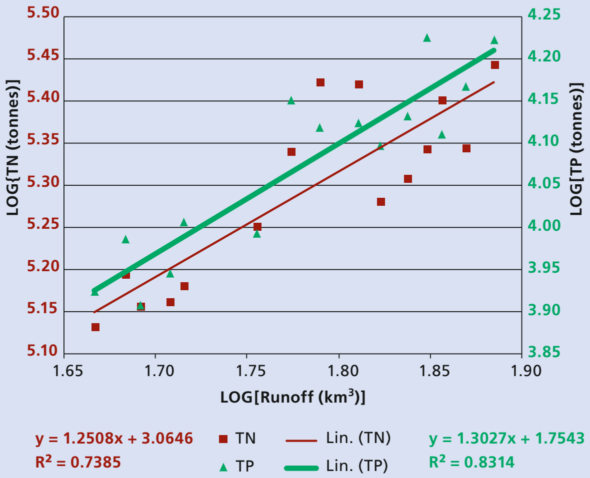
The ratio was multiplied by the observed load for a particular year (L_{year}). This procedure follows the recommendations outlined by Silgram and Schoumans (2004). An example is show in **Figure 5-6**. The results of these normalization calculations for each country and sub-basin are presented in **Annex 2**.

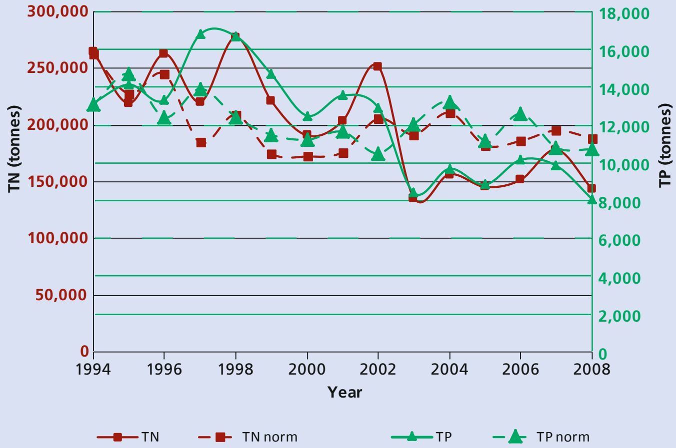
Figure 5-6 An example of the flow-normalization calculation using the EUROHARP* method, here for nutrient loads from Poland to the Baltic Proper (PL_BP). The bottom left figure shows the log relation between riverine discharges and the inputs of total nitrogen and total phosphorus to calculate the slope (b) and intercept (a). In the bottom right figure, solid lines indicate observed riverine load data and the dotted lines the normalized load data.

PL_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	61.58	264,763	13,168	262,643	13,060	1.79	5.42	4.12
1995	59.42	219,202	14,145	227,504	14,709	1.77	5.34	4.15
1996	64.67	262,730	13,331	244,898	12,403	1.81	5.42	4.12
1997	70.54	220,207	16,793	184,550	13,916	1.85	5.34	4.23
1998	76.69	277,350	16,695	208,907	12,431	1.88	5.44	4.22
1999	74.00	221,211	14,685	174,875	11,479	1.87	5.34	4.17
2000	66.49	190,811	12,493	172,204	11,222	1.82	5.28	4.10
2001	68.83	203,597	13,561	176,030	11,643	1.84	5.31	4.13
2002	71.88	251,566	12,915	205,609	10,505	1.86	5.40	4.11
2003	46.43	135,845	8,409	191,675	12,048	1.67	5.13	3.92
2004	48.29	156,580	9,689	210,845	13,230	1.68	5.19	3.99
2005	51.02	145,415	8,850	182,251	11,194	1.71	5.16	3.95
2006	51.96	151,684	10,164	185,908	12,590	1.72	5.18	4.01
2007	56.92	178,269	9,846	195,144	10,808	1.76	5.25	3.99
2008	49.21	143,576	8,092	188,331	10,709	1.69	5.16	3.91

* The EUROHARP project developed European harmonised procedures for quantification of nutrient losses from diffuse sources







Box 2. Trend analysis

Trend analyses of the annual time series of waterborne nutrient loads were carried out using Kendall's trend test and Kendall's seasonal trend test using the Contacting Parties as "seasons". These tests are robust non-parametric statistical tests for monotonic trends. They are robust towards non-normality (i.e., non-Gaussian data).

The test was introduced by Hirsch et al. (1982) and Hirsch and Slack (1984) and has become a very popular and effective method for trend analysis of water quality data. The statistical trend method can analyze both seasonal (e.g., monthly) and annual data. It provides a trend statistic together with the statistical significance (a P-value) and an estimate of the annual increase or decrease in nutrient loads. The slopes (size of the trend) are estimated by the Sen-Theil estimator (Hirsch et al. 1982).

Furthermore, by using the modified Van Belle and Hughes (1984) test for homogeneity, a homogeneity test of the separate country or sub-basin trend test can be performed to evaluate if the trends are comparable between the countries or sub-basins (when P is less than 0.05, there is a high possibility that trends between countries or sub-basins are not coherent).

The values in a time series of, e.g., loads are only significant decreasing (negative estimated slope) or increasing (positive estimated slope) when the P-value is equal to or less than 0.05 (i.e., the probability that the trend is statistically valid is equal to or more than 95%).

Table 5-1a Trend analysis of riverine flow (in km³ a⁻¹) from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P=0.18.

Country	P-value	Estimated slope (km³ per year)
Denmark	0.79	0.156
Estonia	0.43	-0.408
Finland	0.28	1.31
Germany	0.37	-0.086
Latvia	0.17	-0.449
Lithuania	**0.010**	**-0.980**
Poland	0.17	-1.27
Russia	0.32	0.720
Sweden	0.37	1.56
Baltic Sea	0.92	-0.769

Table 5-1b Trend analysis of riverine flow (in km³ a⁻¹) from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P=0.053.

Sub-basin	P-value	Estimated slope (km³ per year)
Kattegat	0.49	0.525
Danish Straits	0.84	0.042
Baltic Proper	0.092	-2.03
Gulf of Riga	0.11	-0.770
Gulf of Finland	0.55	0.448
Bothnian Sea	0.84	0.460
Bothnian Bay	0.17	1.70
Baltic Sea	0.92	-0.769

Table 5-2a Trend analysis of flow-normalized annual riverine loads (in t a⁻¹) for nitrogen from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Country	P-value	Estimated slope (tonnes per year)
Denmark	**0.029**	**-1,521**
Estonia	**0.018**	**811**
Finland	**0.018**	**1,121**
Germany	0.84	-31.6
Latvia	0.17	-1,774
Lithuania	1.00	-112
Poland	0.23	-2,880
Russia	0.55	148
Sweden	0.060	-821
Baltic Sea	0.11	-4,645

Table 5-2b Trend analysis of flow-normalized annual riverine loads (in t a⁻¹) for nitrogen from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Sub-basin	P-value	Estimated slope (tonnes per year)
Kattegat	**0.010**	**-1,270**
Danish Straits	**0.008**	**-813**
Baltic Proper	0.060	-3,847
Gulf of Riga	0.55	-899
Gulf of Finland	0.060	503
Bothnian Sea	0.14	387
Bothnian Bay	**0.003**	**478**
Baltic Sea	0.11	-4,645

Table 5-2c Trend analysis of flow-normalized annual riverine loads (in t a⁻¹) for phosphorus from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Country	P-value	Estimated slope (tonnes per year)
Denmark	**0.029**	**-23.0**
Estonia	0.55	6.41
Finland	0.32	-24.6
Germany	**0.003**	**-9.88**
Latvia	**0.002**	**101**
Lithuania	0.84	22.5
Poland	**0.023**	**-168**
Russia	0.69	-36.2
Sweden	**0.008**	**-79.6**
Baltic Sea	0.060	-225

Table 5-2d Trend analysis of flow-normalized annual riverine loads (in t a⁻¹) for phosphorus from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P=0.001.

Sub-basin	P-value	Estimated slope (tonnes per year)
Kattegat	0.14	-11.9
Danish Straits	**0.023**	**-21.4**
Baltic Proper	**0.029**	**-161**
Gulf of Riga	**0.004**	**94.7**
Gulf of Finland	0.62	-18.9
Bothnian Sea	**0.038**	**-38.7**
Bothnian Bay	**0.029**	**-53.2**
Baltic Sea	0.060	-225

Table 5-3a Trend analysis of non-flow-normalized direct coastal annual loads (in t a^{-1}) for nitrogen from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Country	P-value	Estimated slope (tonnes per year)
Denmark	**<0.001**	**-256**
Estonia	0.76	0
Finland	**<0.001**	**-352**
Germany	**<0.001**	**-221**
Latvia	**<0.001**	**155**
Lithuania	**<0.001**	**-64.7**
Poland	0.23	-37.2
Russia	0.32	-114
Sweden	**0.006**	**-350**
Baltic Sea	**<0.001**	**-1,173**

Table 5-3b Trend analysis of non-flow-normalized direct coastal annual loads (in t a^{-1}) for nitrogen from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Sub-basin	P-value	Estimated slope (tonnes per year)
Kattegat	**<0.001**	**-172**
Danish Straits	**<0.001**	**-482**
Baltic Proper	**<0.001**	**-340**
Gulf of Riga	**<0.001**	**172**
Gulf of Finland	**0.001**	**-389**
Bothnian Sea	**0.018**	**-38.1**
Bothnian Bay	**0.013**	**-40.4**
Baltic Sea	**<0.001**	**-1,173**

Table 5-3c Trend analysis of non-flow-normalized direct coastal annual loads (in t a^{-1}) for phosphorus from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Country	P-value	Estimated slope (tonnes per year)
Denmark	**<0.001**	**-42.3**
Estonia	0.16	3.22
Finland	**<0.001**	**-11.7**
Germany	**<0.001**	**-1.92**
Latvia	0.54	1.87
Lithuania	**<0.001**	**-7.20**
Poland	0.32	-4.84
Russia	0.92	-1.14
Sweden	**<0.001**	**-12.1**
Baltic Sea	**0.006**	**-78.0**

Table 5-3d Trend analysis of non-flow-normalized direct coastal annual loads (in t a^{-1}) for phosphorus from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P=0.004.

Sub-basin	P-value	Estimated slope (tonnes per year)
Kattegat	**<0.001**	**-13.1**
Danish Straits	**<0.001**	**-30.4**
Baltic Proper	**0.003**	**-19.5**
Gulf of Riga	0.42	4.06
Gulf of Finland	0.49	-21.5
Bothnian Sea	**0.002**	**-6.65**
Bothnian Bay	**0.002**	**-3.87**
Baltic Sea	**0.006**	**-78.0**

Table 5-4a Trend analysis of total waterborne annual loads (in t a^{-1}) for nitrogen from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Country	P-value	Estimated slope (tonnes per year)
Denmark	**0.002**	**-1,844**
Estonia	**0.029**	**766**
Finland	0.11	781
Germany	**0.038**	**-259**
Latvia	0.23	1,553
Lithuania	0.92	-182
Poland	0.23	-2,987
Russia	0.84	171
Sweden	**0.013**	**-1,158**
Baltic Sea	0.075	-5,478

Table 5-4b Trend analysis of total waterborne annual loads (in t a^{-1}) for nitrogen from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Sub-basin	P-value	Estimated slope (tonnes per year)
Kattegat	**0.002**	**-1,435**
Danish Straits	**<0.001**	**-1,463**
Baltic Proper	**0.048**	**-4,243**
Gulf of Riga	0.62	-727
Gulf of Finland	1.00	32.0
Bothnian Sea	0.23	335
Bothnian Bay	**0.006**	**428**
Baltic Sea	0.075	-5,478

Table 5-4c Trend analysis of total waterborne annual loads (in t a⁻¹) for phosphorus from 1994 to 2008 by country. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Country	P-value	Estimated slope (tonnes per year)
Denmark	**<0.001**	**-67.7**
Estonia	0.37	8.84
Finland	0.20	-36.7
Germany	**<0.001**	**-14.4**
Latvia	**<0.001**	**118**
Lithuania	0.84	13.9
Poland	**0.023**	**-172**
Russia	0.37	-38.5
Sweden	**0.003**	**-93.2**
Baltic Sea	**0.023**	**-339**

Table 5-4d Trend analysis of total waterborne annual loads (in t a⁻¹) for phosphorus from 1994 to 2008 by main Baltic Sea sub-basin. Trends are only statistically significant when P≤0.05. Homogeneity of trends: P<0.001.

Sub-basin	P-value	Estimated slope (tonnes per year)
Kattegat	**0.010**	**-27.3**
Danish Straits	**0.001**	**-59.6**
Baltic Proper	**0.018**	**-211**
Gulf of Riga	**<0.001**	**99.8**
Gulf of Finland	0.28	-53.2
Bothnian Sea	**0.048**	**-47.3**
Bothnian Bay	**0.018**	**-57.1**
Baltic Sea	**0.006**	**-339**

It is obvious that by using flow-normalized loads, a rather different but more correct picture of the development in loads is obtained. The analysis shows that only a few Contracting Parties achieved a statistically significant decrease in their total waterborne nitrogen and phosphorus loads from 1994 to 2008 and that some examples of significant increases in nitrogen and phosphorus loads occurred. Nonetheless, it is important to state that a country in reality may have reduced its load to the sea even if the data do not yet show a statistical significance at the P>0.05 (95% probability) level; however, if reductions continue, a statistically significant reduction should be able to be seen at a later stage. Furthermore, it should be considered that not all factors are taken into account in the flow-normalization process because data gaps in early years from some countries make it more complicated to analyze, assess and reach conclusions regarding trends.

Chapter 6 will further discuss the reasons why significant decreases in flow-normalized riverine and total waterborne loads of nitrogen and phosphorus were obtained for only some countries and Baltic Sea sub-regions.

5.4 Development of waterborne loads compared with BSAP targets

In the HELCOM Baltic Sea Action Plan (BSAP), the HELCOM Contracting Parties acknowledged:

> "that current environmental and nutrient reduction targets are provisional, though based on best available knowledge at the moment of elaboration of the BSAP and that all the figures related to targets and maximum allowable nutrient inputs *should be periodically reviewed and revised* using a harmonised approach based on updated information and starting in year 2008 taking into account the results of the PLC-5 and national river basin management plans.
>
> WE RECOGNISE that the reduction of water- and airborne inputs of nutrients within a HELCOM Contracting State contributing to the achievement of country-wise reduction targets should be accounted for."

To illustrate the progress towards the nutrient reduction targets of the BSAP, the figures in **Annex 2** on flow-normalized waterborne loads (as the sum of flow-normalized riverine loads and direct coastal loads) from 1994 to 2008 are accompanied by:

– the provisional maximum allowable inputs adopted in the BSAP;
– average waterborne loads (non-flow-normalized) from the HELCOM countries for the period 1997 to 2003, which were used as background information for the BSAP when the maximum allowable nitrogen and phosphorus inputs to the Baltic Sea were calculated and serve as the period to which reduction in loads are compared.

Annex 2 presents the temporal development of annual flow-normalized waterborne nitrogen and phosphorus loads between 1994 and 2008 as (1) total loads from all HELCOM countries and (2) country-wise figures for each of the HELCOM countries.

The provisional maximum allowable inputs given in the BSAP were estimated by the Baltic Nest Institute (BNI) using a coupled physical-biochemical model which is part of the decision support system NEST. The procedure for estimating the maximum allowable inputs and setting the country-wise nutrient reduction allocations is described in Box 3. The maximum allowable input to the Baltic Sea sub-basins is defined as the highest level of nutrient input that is allowable to reach HELCOM's ecological objective for eutrophication in the long term. This is one of the requirements for attaining good ecological status of the Baltic Sea.

The average waterborne loads for the BSAP reference period 1997-2003 are non-normalized and hence they do not represent an average of the values for the years 1997-2003 shown in the country-wise figures presented in **Annex 2**. They are nevertheless incorporated into the figures because they were the original reference loads used in the BSAP.

Since the adoption of the BSAP, the PLC data for 1997 to 2003 have been partly updated, leading to slightly different waterborne amounts than given in the BSAP. Some data on riverine and coastal loads from Russia (1995-1999, 2008) and riverine loads to the Baltic Proper from Germany (2008) and Estonia (2007-2008) are missing in the PLC-5 database and therefore were not included in this original assessment of the progress towards BSAP nutrient reduction targets. However, these data have been included in the latest assessment (third row, with corrected flow-normalized waterborne loads, in **Table 5-5**). Transboundary loads from Belarus were not excluded in the total riverine loads of Latvia and Lithuania to the Gulf of Riga and the Baltic Proper, respectively.

The importance of flow-normalization in evaluating the amount of the provisional reductions obtained is shown in **Table 5-5**. The flow-normalized total waterborne loads during each period differ considerably from the non-normalized loads. From 1997 to 2003, used as the reference period in the BSAP, the flow was higher than normal, while from 2000 to 2006 it was lower than normal and thus flow-normalization is necessary (the average flow for 1997-2003 was 486 km^3; for 2000-2006, 466 km^3 and for 2006-2008, 475 km^3). An analysis based on non-flow-normalized data showed that the total load of nitrogen was approximately 69,000 tonnes lower during the period 2000-2006 compared with 1997-2003 (9%) and for phosphorus the corresponding reduction was nearly 3,000 tonnes (8%). However, when comparing the same periods using the flow-normalized and corrected data, there is instead a decrease of approximately 10,000 tonnes of nitrogen (1%) and a decrease of 300 tonnes of phosphorus (1%). The total water flow during the period 2000-2006 was approximately 4% lower compared with 1997-2003 and can explain a minor part of the reduced total waterborne nitrogen and phosphorus loads in the latter period.

The table indicates that, when comparing 2006-2008 with 1997-2003, more countries show a decrease in total flow-normalized waterborne phosphorus loads (but not necessarily statistically significant) than when comparing the same loads from 2000-2006 with those in 1997-2003. On the other hand, for nitrogen fewer countries show a decrease in total waterborne loads when comparing 2006-2008 with 1997-2003 than when comparing 2000-2006 to 1997-2003. Flow-normalized waterborne nitrogen loads for the whole Baltic were nearly 13,000 tonnes higher (2%) in 2006-2008 compared with 1997-2003 ane the corresponding phosphorus load was 2,000 tonnes lower (6%).

Further discussion follows in **Chapter 6**.

Table 5-5 Total non-flow-normalized (total load) and total flow-normalized (log normalized) average waterborne loads (in tonnes) for 1997-2003, 2000-2006, 2006-2008 and their difference. (n.c. = not calculated; corrected = updated flow-normalization based on a more complete dataset)

	1997-2003		2000-2006		2006-2008		Difference 2000-2006 to 1997-2003		Difference 2006-2008 to 1997-2003	
	N	P	N	P	N	P	N	P	N	P
Total waterborne load to the Baltic Sea (BSAP)	723,184	35,301	647,973	31,391	n.c.	n.c.	-7,510	- 3,910	n.c.	n.c.
Flow-normalized total waterborne load to the Baltic Sea - original	702,674	33,803	685,599	32,992	n.c	n.c	-17,075	-812	n.c.	n.c.
Flow-normalized total waterborne load to the Baltic Sea - corrected	696,017	32,509	686,334	32,800	709,064	30.532	-9,683	292	13,047	-1,976
Flow-normalized total waterborne load Denmark	58,612	1,841	54,547	1,701	46,475	1,710	-4,065	-140	-12,138	-131
Flow-normalized total waterborne load Estonia	30,256	1,235	30,657	1,282	36,046	1,206	401	47	5,790	-29
Flow-normalized total waterborne load Finland	73,965	3,483	77,832	3,423	79,600	3,471	3,868	-61	5,635	-12
Flow-normalized total waterborne load Germany	20,243	539	19,601	500	19,608	492	-642	-39	-635	-48
Flow-normalized total waterborne load Latvia	74,670	2,073	67,536	2,422	92,837	3,284	-7,134	349	18,167	1,211
Flow-normalized total waterborne load Lithuania	49,684	2,588	45,163	2,365	43,599	1,944	-4,521	-223	-6,085	-644
Flow-normalized total waterborne load Poland	188,798	11,972	190,268	11,842	190,985	11,469	1,470	-130	2,187	-503
Flow-normalized total waterborne load Russia	77,439	4,921	82,708	5,721	82,813	3,528	5,269	799	5,374	-1,394
Flow-normalized total waterborne load Sweden	122,350	3,856	118,022	3,545	117,102	3,428	-4,328	-311	-5,247	-427

Box 3. Allocation of BSAP country-wise provisional nutrient reduction targets per sub-basin

The HELCOM Baltic Sea Action Plan (BSAP) contains provisional country-wise reduction requirements of waterborne nutrient inputs to be achieved by 2016 in order to reach good ecological and environmental status of the Baltic Sea by 2021.These reduction levels have been derived for each sub-basin by a step-wise procedure. The first step was to assess the *maximum allowable input* of nitrogen and phosphorus by applying a coupled physical-biogeochemical model to the specific conditions in each sub-basin and simulate the nutrient input to these sub-basins that fits the HELCOM goal for eutrophication. Specifically, values for Secchi depth were used as targets in the modelling that was performed with the Baltic Nest Model (Wulff et al. 2007). The second step was to calculate the specific reduction requirements for each sub-basin by subtracting the maximum allowable input from the mean load to the sub-basin during the period 1997-2003. The previously implemented load reduction measures in the municipal wastewater sector in the catchments, in accordance with the reduction levels in the EU wastewater treatment directive (91/271/EEC), were taken into account before calculating the reduction allocations. Thereafter, the reduction requirements were allocated to countries in proportion to their respective remaining inputs to the sub-basin. The table below shows the BSAP targets and the required country-wise waterborne reductions of nitrogen and phosphorus inputs to each sub-basin. The methodology is described in more detail in HELCOM (2007c). Both the maximum allowable inputs and country-wise reduction requirements are being revised and new targets are expected to be adopted at the HELCOM Ministerial Meeting in 2013.

Country-wise compilations have been made based on the background information above, flow-normalized riverine loads (PLC-5 data, normalized by the Baltic Nest Institute), as well as non-normalized direct coastal inputs of nutrients per country per sub-basin.

Table 5-6 Average annual waterborne nutrient loads for the period from 1997 to 2003, needed provisional reduction requirements and provisional maximum allowable inputs per country and per sub-basin (used for the HELCOM BSAP). All units are t a^{-1}.

Sub-basin	PHOSPHORUS	BEL	DE	DK	EE	FIN	LT	LV	RU	PL	SE	SUM
Baltic Proper	Average load 1997-2003	1,206	534	51	18	0	1,336	266	1,266	13,717	860	19,246
	Needed reduction	**1,206**	**242**	**16**	**10**	**0**	**873**	**142**	**724**	**8,755**	**291**	**12,259**
	Max. allowable input	*0*	*292*	*35*	*8*	*0*	*463*	*124*	*542*	*4,962*	*569*	*6,987*
Gulf of Finland	Average load 1997-2003	6	0	0	980	578	0	0	5,302	0	0	6,866
	Needed reduction	**0**	**0**	**0**	**190**	**146**	**0**	**0**	**1,661**	**0**	**0**	**1,999**
	Max. allowable input	*6*	*0*	*0*	*790*	*432*	*0*	*0*	*3,641*	*0*	*0*	*4,867*
Gulf of Riga	Average load 1997-2003	450	0	0	262	0	8	1,347	114	0	0	2,181
	Needed reduction	**450**	**0**	**0**	**22**	**0**	**8**	**156**	**114**	**0**	**0**	**750**
	Max. allowable input	*0*	*0*	*0*	*240*	*0*	*0*	*1,191*	*0*	*0*	*0*	*1,431*
	TOTAL reductions	**1,656**	**242**	**16**	**222**	**146**	**873**	**298**	**2,499**	**8,755**	**291**	**15,001**
	BSAP target	**1,660**	**240**	**16**	**220**	**150**	**880**	**300**	**2,500**	**8,760**	**290**	**15,016**

Sub-basin	NITROGEN	BEL	DE	DK	EE	FIN	LT	LV	RU	PL	SE	SUM
Baltic Proper	Average load 1997-2003	3,763	7,038	2,257	1,034	0	45,109	10,447	10,594	215,350	31,667	327,259
	Needed reduction	**3,763**	**1,701**	**542**	**257**	**0**	**11,746**	**2,562**	**2,821**	**62,395**	**8,087**	**93,874**
	Max. allowable input	*0*	*5,337*	*1,715*	*777*	*0*	*33,363*	*7,885*	*7,773*	*152,955*	*23,580*	*233,385*
Gulf of Finland	Average load 1997-2003	16	0	0	18,036	15,852	0	0	78,792	0	0	112,696
	Needed reduction	**16**	**0**	**0**	**639**	**1,199**	**0**	**0**	**4,145**	**0**	**0**	**6,000**
	Max. allowable input	*0*	*0*	*0*	*17,397*	*14,653*	*0*	*0*	*74,647*	*0*	*0*	*106,696*
Danish Straits	Average load 1997-2003		13,811	26,697	0	0	0	0	0	0	5,386	45,893
	Needed reduction		**4,348**	**8,486**	**0**	**0**	**0**	**0**	**0**	**0**	**1,733**	**14,761**
	Max. allowable input	*0*	*9,463*	*18,211*	*0*	*0*	*0*	*0*	*0*	*0*	*3,653*	*31,132*
Kattegat	Average load 1997-2003			28,547	0	0	0	0	0	0	35,710	64,257
	Needed reduction		**0**	**8,821**	**0**	**0**	**0**	**0**	**0**	**0**	**11,128**	**19,949**
	Max. allowable input	*0*	*0*	*19,726*	*0*	*0*	*0*	*0*	*0*	*0*	*24,582*	*44,308*
	TOTAL reductions	**3,779**	**6,049**	**17,849**	**896**	**1,199**	**11,746**	**2,562**	**6,966**	**62,395**	**20,948**	**134,584**
	BSAP target	**3,780**	**5,620**	**17,210**	**900**	**1,200**	**11,750**	**2,560**	**6,970**	**62,400**	**20,780**	**133,170**

6 Discussion, conclusions and future prospects

6.1 Shortcomings in PLC-5 concerning data, analysis and applied methodologies

In order to achieve the objectives of the Helsinki Convention, HELCOM needs reliable data on inputs into the Baltic Sea from land-based sources, as well as information about the significance of different pollution sources. This information is required to assess the effectiveness of measures taken to reduce pollution in the Baltic Sea catchment area and to support the development of HELCOM's environmental policies. It is also required for interpreting and evaluating the environmental status and related changes in the open sea and coastal waters of the Baltic Sea.

The HELCOM Contracting Parties are responsible for the quality and reliability of the data they submit to the HELCOM PLC-water database. The procedures for the collection of data, quality assurance, compilation and reporting methodology are described in the PLC-5 guidelines. The HELCOM Convention also requires the Contracting Parties, among other things, to *"ensure that measurements and calculations of emissions from point sources to water and air and of inputs from diffuse sources to water and air are carried out in a scientifically appropriate manner in order to assess the state of the marine environment of the Baltic Sea area and ascertain the implementation of this Convention."*

On the basis of the results reported and those not reported, and feedback from the Contracting Parties, the experience in interpreting the guidelines has not been entirely positive. Some concepts, such as for source apportionment vs. load apportionment methodologies, have not been clear for all submitters of results. The adoption of the source-oriented/load-oriented approach proved to be a major challenge already during the PLC-4 project and PLC-5 does not show much progress in this respect. In order to synchronize the reported inputs into the catchment area and the loads entering into the Baltic Sea, the Data Consultant has – in some cases – been forced to artificially adjust the data by adding the retention to or subtracting it from the reported figures.

Perhaps the most challenging task has been to obtain a complete picture of the nutrient load originating from Russia. The officially reported datasets have regularly been insufficient and partly also incorrect due to the methodologies applied and the limitations in the analytical capacity. Certain fractions of the total nutrient load were not reported at all and apportionment of the riverine load was not performed. All those shortcomings complicate especially the evaluation of long-term changes in Russian riverine loads.

6.1.1 Riverine load apportionment

The basic principle is that the sum of apportioned loads into the Baltic Sea originating from different sources should equal the totals reported from the monitored rivers, unmonitored and coastal areas and direct point sources. The sum of the loads from different sources reported by Denmark, Finland and Poland corresponded with the reported totals and has been used in the report as such. Sweden informed the PLC-5 project about a methodological difference: in their approach, calculated loads from inland sources and retention were flow-normalized by applying long-term averages for runoff and therefore did not fully equal the reported totals for the year 2006 (SEPA 2009).

The apportioned data from Estonia, Latvia and Lithuania included retention and thus the difference was systematic. Their data had to be adjusted in order to make the sums of the different sources correspond with the reported total loads. Recalculation of the data was carried out by calculating the proportions of the different sources and multiplying each proportion by the total load of the respective river/unmonitored coastal area, i.e., the retention was distributed among the sources according to their proportion of the total load.

Germany reported the total loads of monitored rivers, unmonitored and coastal areas and direct point source loads, and loads into the catchment area by sources, but only partially reported the total load into the sea by sources (load-oriented approach). Because the total apportioned loads into the catchment area and those to the sea did not correspond with each other, recalculation was necessary. Recalculation was done by calculating the proportions of the sources and multiplying each proportion by the total load of the respective river or unmonitored coastal area.

In cases where load-apportioned data for some rivers were missing, a new source category of 'unspecified load' had to be added.

As no source load data were reported by Russia, direct point source loads have been defined as 'point sources' and total river loads defined as 'unspecified load'.

6.1.2 Riverine flow

The riverine flow is of major importance for variations in annual loads of nitrogen and phosphorus. This means that loads cannot be compared without smoothing, or flow normalizing. The PLC-5 project Core Group, together with BNI, Sweden, performed a flow normalization of annual load data as a basis for trend analyses of country-wise and sub-basin loads to the Baltic Sea (**Chapter 5** and **Section 6.2.1**).Therefore, it is recommended that, in future compilations, the loads of nitrogen and phosphorus should also be reported as flow-normalized, based on a standardized methodology.

When evaluating the reported results, the PLC-5 Core Group considered some notable deviations in the riverine flows in several Contracting Parties. The catchment areas of the rivers Nemunas and Daugava are almost equal in size and they are situated near each other. However, despite the fact that the reported flow has been decreasing since 1994 for the Nemunas, the flow of the Daugava has remained roughly constant. Both rivers also have a significant share of their catchments in the territory of Belarus. The reported decrease in the riverine flow from the Nemunas entering the Baltic Sea is most probably due to the diversion of water flow via the Matrosofka channel. This part of the flow has not been reported since 2003. Recalculated loads for Nemunas will be included in the PLC-5.5 report, but have not been taken into account in this report owing to late clarification of this data gap.

The reported total riverine flow from Poland has decreased significantly since the early 2000s. The reason for this is unclear but it indicates that the simultaneous decrease in riverine phosphorus and nitrogen loads can mainly be explained by the decreasing flow.

6.1.3 Analytical methods and the limits of quantification

It is probable that the recommended analytical methods were followed more closely in PLC-5 than in previous pollution load compilations. According to the information received from different sources, the national standard for phosphorus analysis in Russia differs from the general instructions given in the guidelines; for PLC-water, total phosphorus analysis should be made *using unfiltered samples*. Filtration of samples before total phosphorus analysis leads to underestimation of the real total phosphorus concentration (and related loads) – the error being greater the more particulate phosphorus the samples contain.

In PLC-4, Russia reported a lowest detection limit for total phosphorus analysis of 40 µg l^{-1} while the recommended LOQ is 10 µg l^{-1} (Management Directive 52.24.387-95, in Russian). According to a study carried out by South-East Finland Regional Environment Centre, KAS, and the Russian Water Research Control Centre, WRCC, in 2000-2002, the average flow-weighted total phosphorus concentration in the River Neva varied from 21 to 30 µg l^{-1} (Pitkänen & Tallberg 2007). The reasons for the observed differences between the official Russian data and the results obtained from the Finnish-Russian research projects are most likely the high detection limit applied by the Russian laboratory and not using 50% of LOQ when measurements are under the LOQ. As a consequence, the reported total phosphorus load of the River Neva was probably much too high (up to 200%) in all years during the period 1994 to 2006. The reported load for the year 2007 seems to be at a reliable level, which is consistent with other information received (Knuuttila, personal communication). The lowest detection limit of the responsible laboratory is at present 20 µg l^{-1}. The flawed data make the evaluation of the long-term changes in the phosphorus load from Russia into the Gulf of Finland more difficult. Instead of an expected decrease – which is the likely development over the whole period – calculations based on the official data show a significant increase.

Before the year 2000, total nitrogen was not reported by Russia. Only soluble fractions were available until that year. This also complicates the analysis of long-term changes in nutrient loads. The significant increase between 2000 and 2006 (almost 100%) is not supported by the results obtained from the other sources which show that, on the contrary, there is a slight decrease in total nitrogen loads.

A large number of laboratories were involved in the PLC-5 project, which was a major issue of concern for ensuring good data quality from each laboratory and the comparability of the data. To solve these challenges, some important steps related to chemical analyses used in future PLCs would be:

- Contracting Parties should make use of internationally validated and standardized analytical methods such as ISO or EN methods for chemical analysis related to rivers and wastewater analysis.
- All laboratories involved in monitoring should be accredited according to ISO 17025 and have a quality assurance programme following the standards in ISO 17025.
- Laboratories should participate in international proficiency testing on a regular basis.
- Limits of quantification (and limits of detection) should be harmonized between the Contracting Parties.
- Before PLC-6, intercalibration or intercomparison tests should be carried out for analyses of water samples in rivers and from point sources and for monitoring discharges.
- The PLC guidelines should describe details for the conduct of intercalibration and intercomparison tests.
- There should be mandatory reporting of specified information on analytical quality.

6.1.4 Riverine loads including coastal areas

To perform an assessment of the development of riverine inputs into the Baltic Sea, it was intended that the Contracting Parties report annual riverine flows and loads in 2006 for the same rivers and monitoring stations as in previous assessments. This would ensure that the figures were based on the same rivers and the same area coverage. However, for the PLC-5 project some countries reported part of their rivers as aggregated, which previously had been reported individually.

Good understanding of the contributions of different sources to the total pollution loads is important. If the location of monitoring stations has changed, the Contracting Parties should ensure that reported inputs from the entire catchment are quantified and source apportioned using agreed and comparable methodologies.

Reporting of point sources in the river mouth or immediate vicinity of the river mouth has caused confusion in some cases and resulted in an inconsistent practice. A portion of the nutrient discharges from wastewaters has been reported as a direct point source and the remaining fraction has been included in the riverine load. In addition, the practice may have changed between the years for some countries. Moreover, some coastal loads may have been included in direct loads.

Russia reported loads only from the five largest rivers and some data from these rivers are missing, while no data at all were submitted for loads from coastal areas. For some years no riverine load was reported and instead estimates have been used for the missing years to allow for normalization and analysis.

6.1.5 Point-source loads

The effort to obtain information about the anthropogenic factors contributing to riverine loads, and to evaluate whether the reduction goals for different sources had been fulfilled, was not as successful as anticipated. Point source inventories, which in principle should be a technically relatively simple task, turned out once again to be a complex task for some countries. Compilation of information on the effectiveness of municipal wastewater treatment plants was considered especially important, because it is a known fact that the majority of the total point source phosphorus load originates from those sources. Therefore, this information is of key importance from the point of view of implementing the HELCOM BSAP.

In order to make reporting easier for the Contracting Parties, the questionnaire was simplified compared with the PLC-5 guidelines. As background information, the Contracting Parties were asked to compile a list of their MWWTPs with >10,000 PE and report the effectiveness of treatment plants with respect to the removal percentage of phosphorus and nitrogen, and the total share of the population served by public wastewater treatment. This information was mainly required to define the sub-regional reduction needs for nutrients and the establishment of a quota system for the Baltic Sea Action Plan. Most Contracting Parties failed to report this information in due time.

The PLC-5 project has again indicated that further improvements are needed to obtain reliable point source data for the entire Baltic Sea catchment area. There were particularly serious problems with data from Russia. The official data differ significantly from, e.g., the information obtained from the waterworks of the City of St. Petersburg, Vodokanal. Due to varying completeness of data reporting over the years, the reported loads from MWWTPs in the catchment area of Poland sharply contrast with the information on the treatment level of nutrients (see explanation in **Section 6.2.3**). This might have led to a significant underestimation of loads from MWWTPs in the catchment area of Poland.

It is difficult to evaluate the completeness of reported discharges from wastewater treatment plants with less than 10,000 PE from most countries. These uncertainties are even greater for fish farms, scattered dwellings and storm and rainwater constructions, where both the completeness of data and the quantification methodologies used differ between countries.

One of the challenges of future pollution load compilations will be to ensure that each HELCOM Contracting Party monitors, calculates and reports reliable and complete datasets on at least major point source nutrient loads, so that the total nutrient inputs entering into the Baltic Sea from its catchment area may be estimated with reasonable accuracy.

6.1.6 Diffuse losses

The data compiled on losses from diffuse sources are more uncertain than the data from point sources. Quantification of diffuse sources in PLC-5 was incomplete and the methodologies applied were only partly comparable between Contracting Parties, which has led to major difficulties in comparisons. Furthermore, it was not always clear how the Contracting Parties distributed the loads between losses from agriculture, other diffuse sources and natural background load, nor was it completely clear how and which retention rates were included in the assessment and how natural background figures were derived. In several cases, it was also difficult to determine how the Contracting Parties had taken into account transboundary loads and sources outside national territory. Finally, the countries also used different methodologies to estimate losses from diffuse sources in unmonitored and coastal areas. In conclusion, in the future methodologies for quantification of anthropogenic diffuse sources, background losses, and retention, as well as the calculation of point source loads should be harmonized as much as possible. Different methodologies should be compared and evaluated.

6.2 Changes in nutrient loading over a longer period of time

In most Contracting Parties, phosphorus and nitrogen loads from municipal and industrial sources are significantly lower than the levels in the1980s. The improving state of the coastal waters in many areas of the Baltic Sea confirms this development (HELCOM 2009). It has been much more difficult to curb emissions from agriculture, forestry and scattered settlements not connected to sewerage systems. In most countries, agriculture is currently the main source of nutrient inputs into the Baltic Sea.

6.2.1 Overall results

Based on the PLC-5 data, it is estimated that waterborne inputs to the Baltic Sea in 2006 amounted to 638,000 tonnes of nitrogen and 28,400 tonnes of phosphorus. About 5% of the nitrogen load originated from point sources discharging directly into the Baltic Sea, while the rest entered via rivers. For phosphorus the contribution from point sources was higher, about 8%. Atmospheric deposition additionally supplied the Baltic Sea with 196,000 tonnes of nitrogen in 2006 (Bartnicki et al. 2008), while the atmospheric deposition of phosphorus directly to the Baltic Sea could not be quantified but is considered low. The Baltic Proper and the Gulf of Finland received the largest amounts of waterborne nutrient inputs and the main contributing countries to the nitrogen input were Poland (24%), Sweden (19%), and Russia (17%). The largest loads of phosphorus originated from Poland (36%), Russia (14%), and Sweden (13%). These figures include waterborne inputs from all anthropogenic sources as well as natural background load and atmospheric deposition on inland waters.

During the period 1994 to 2008, discharges from direct coastal point sources to the Baltic Sea significantly decreased for both nitrogen and phosphorus, with an average annual reduction of 1,170 tonnes of nitrogen (33%) and 78 tonnes of phosphorus (27%); however, only Denmark, Germany, Finland and Sweden had significant reductions in both direct coastal nitrogen and phosphorus point source loads, while Latvia had increasing nitrogen and phosphorus loads.

Flow-normalized waterborne nitrogen loads for the whole Baltic Sea were 13,000 tonnes higher (2%) in 2006-2008 compared with 1997-2003, while the corresponding figure for phosphorus was 2,000 tonnes lower (6%). When considering this period for the whole Baltic Sea, the gap to the maximum allowable input has increased for nitrogen. Although there were no statistically significant changes in flow-normalized waterborne nitrogen loads during 1994-2008 the decrease in the corresponding phosphorus loads was significant. For nitrogen only Denmark (34%), Germany (14%) and Sweden (12%) had a significant reduction in flow-normalized waterborne load, while for Estonia it increased significantly (47%). For phosphorus Denmark (31%), Germany (31%), Poland (18%) and Sweden (28%) had a significant decrease, while Latvia had a significant increase (86%).

With regard to the reduction targets, it should be noted that comparing the 2006-2008 flow-normalized waterborne loads of nitrogen and phosphorus with the corresponding 2000-2006 figures, there was an increase of approximately 23,000 tonnes nitrogen (3%) and a decrease of 2,500 tonnes phosphorus (7%). As these are flow-normalized figures, increasing nitrogen loads should be a concern, but the main contributors to this increase were Latvia (25,300 tonnes) and Estonia (15,400 tonnes) while Demark had a marked reduction (8,100 tonnes). This is due to the above-mentioned uncertainties in some countries' figures, but also the fact that the flow-normalization methodology can not account for all interannual variations owing to climatic influence on loads.

An apportionment of anthropogenic diffuse sources performed for selected countries indicated that agriculture contributed from approximately 70% to over 90% of the anthropogenic diffuse riverine nitrogen load and 60-80% of the corresponding phosphorus load. Agriculture thus constitutes the largest share of the reported total diffuse loads to the sea.

A statistical analysis of flow-normalized annual riverine nitrogen loads from 1994 to 2008 showed that only Denmark had significant decreasing loads, at 1,520 tonnes (31%) nitrogen decrease per year. Five HELCOM Contracting Parties displayed no significant decrease in flow-normalized nitrogen loads, while two Contracting Parties (Estonia (50%) and Finland (28%)) showed statistically significant increasing riverine nitrogen loads and Russia non-significant increase.

Three sub-regions, the Kattegat (25%), Danish Straits (35%) and Baltic Proper (16%), received significant decreasing loads of flow-normalized waterborne nitrogen, while there was a significant increase for the Bothnian Bay (12%). Five sub-basins received a significant decrease in flow-normalized waterborne phosphorus loads (Kattegat (19%), Danish Straits (39%), Baltic Proper (17%), Bothnian Sea (24%) and Bothnian Bay (26%)) and one a significant increase (Gulf of Riga (67%)).

Based on reported heavy metal data, the Gulf of Finland received the largest cadmium, lead, copper and nickel inputs, while mercury inputs were highest for the Baltic Proper. The dataset for heavy metals is very incomplete, with no data from some countries, and the results are considered uncertain.

The next section discusses the results, evaluates uncertainties and shortcomings, and relates the results to some of the measures taken in the catchment areas to reduce nutrient inputs to the Baltic Sea.

6.2.2 Changes in the marine environment

A detailed discussion of the development of the marine environment is outside the scope of this report. However, it can be noted that the abatement measures taken are also reflected in the reduced nutrient concentrations in the Baltic Sea. After having increased until the 1980s, phosphorus concentrations have declined in all areas except the Gulf of Finland during the past two decades. Nitrogen concentrations have declined in the Gulf of Riga, Baltic Proper and Danish Straits. However, the recent HELCOM integrated assessment of eutrophication in the Baltic Sea (HELCOM 2009) shows that significant eutrophication effects are still observed in many areas and further reduction measures are definitely necessary.

6.2.3 Point source discharges

The municipal wastewater treatment and industrial sectors have had the most success in reducing their discharges into the Baltic Sea. In the Danish Straits, inputs of phosphorus had been reduced by 90% and nitrogen by 30% already by the 2000s (Ærtebjerg et al. 2003). This was the result of an increasing share of wastewater being treated as well as improved and more advanced treatment techniques in municipal and industrial facilities. It was also the result of closing down some heavily polluting industries, increased use of phosphorus-free detergents, etc. The improved wastewater treatment is reflected in the development of direct point source inputs into the Baltic Sea since the mid-1990s **(Figures 5-3, 5-4** and **5-5)**; Denmark, Germany, Lithuania and Sweden had significant decreases in direct point source inputs from 1994 to 2008 (**Tables 5-3a,c**). Although the remaining countries showed no significant decrease, there was a significant annual decrease in direct point source phosphorus inputs to the Baltic Sea as a whole between 1994 and 2008 of approximately 78 tonnes phosphorus per year (**Table 5-3c**).

Denmark, Finland, Germany, Lithuania and Sweden showed a significant decrease in point source inputs of nitrogen from 1994 to 2008, while Latvia had a significant increase in nitrogen inputs. Nevertheless, for the Baltic Sea as a whole there was a significant decrease in direct point source inputs of nitrogen during the same period, by about 1,173 tonnes (33%) per year (**Table 5-3a**).

The overall development in discharges from point sources into inland waters was similar to that from direct point sources into the sea. Within the PLC, however, the quantification of discharges from inland water point sources was performed only in 1995, 2000 and 2006, although 1995 data have many uncertainties and are incomplete.

From the 1970s to 2008 the overall phosphorus loads into the Baltic Sea have been cut by about half. This is mainly due to improved waste water treatment (figure 6-10). Since the highest levels of point source discharges recorded from 1975 to 1985, the phosphorus load from MWWTPs has decreased in the Nordic countries and Germany by more than 90%, and this partly explains why reductions from point sources in some of these countries, between 1995 and the present have been relatively small (**Figure 6-1**).

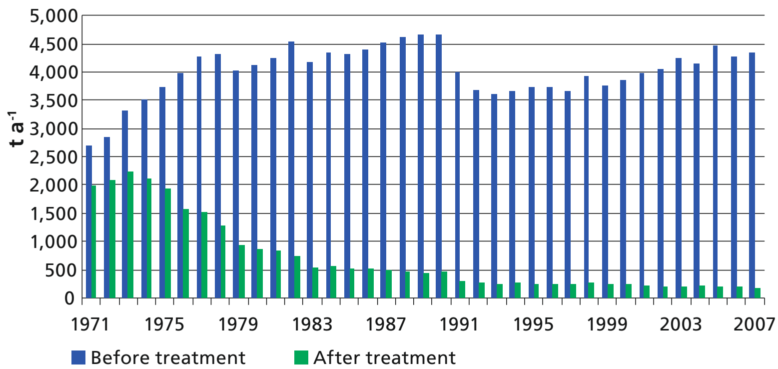


Figure 6-1 Phosphorus load (t a⁻¹) from all municipal wastewater treatment plants in Finland from 1971 to 2007. (Source: SYKE)

The removal of nitrogen has also improved, although the target level set in HELCOM Recommendation 28E/5 (70-80% reduction for plants > 10,000 PE) has only been fully achieved by Denmark and Germany (HELCOM 2007e).

Industrial discharges of phosphorus have also been reduced to a relatively small fraction of their levels in the 1980s in the same countries. In Denmark and Germany, phosphorus discharges from industry were reduced by approximately 85% between the late 1980s and 1995; thus, further reductions in point source phosphorus discharges are becoming increasingly difficult to achieve. In Sweden, discharges of phosphorus from industry have decreased by almost 95% since 1975, mainly as a result of the introduction of new cleaning technology and structural changes, especially in the chemical industry (SEPA 2004).

During recent years, global structural changes within the pulp and paper industry have entailed closedowns of several major plants in Finland and Sweden. Still today, regardless of a very significant decline, the largest nutrient discharges originate from the pulp and paper industry – mainly in Finland and Sweden – and to a smaller extent from the metal industry and the food processing industry. Outside the officially reported data, information has been received about significant industrial polluters in Russia within the pulp and paper, metal and chemical industry sectors (SEPA 2010).

In Estonia, Latvia and Lithuania, drastic decreases in pollution from all sources between the late 1980s and 1995 were mainly due to fundamental changes in the political and economic systems in the early 1990s (HELCOM 2003). Since the late 1980s, the treatment of municipal wastewater has also improved significantly in these countries as well as in Poland. The treatment levels have further improved since their accession into the EU in 2005, but there still is potential to reduce the inputs from point sources (HELCOM 2007d).

Further reductions in nutrient discharges from point sources are technically feasible by including tertiary wastewater treatment in new or existing plants. The largest potential exists in Poland where several hundred wastewater treatment plants are under construction and slightly more than 60% of the population is connected to municipal sewerage systems (62%, **Table 2-5**). In order to improve the treatment of municipal wastewater, Poland has recently reported that by 2015 it will achieve at least a 75% reduction in nutrients in municipal wastewater throughout the country (Chief Environmental Protection Inspectorate, Poland 2010). Implementation of Poland's national programme for the modernization of municipal WWTPs (implementation of the EU Urban Waste Water Directive) will result in annual reductions of 40,000 tonnes of nitrogen and 12,000 tonnes of phosphorus from levels in the year 2000 within 15 years. On the basis of the data reported for PLC-5 (and PLC-4), however, it is difficult to evaluate the present phosphorus and nitrogen removal percentages in relation to the Polish national/HELCOM target level, as well as the development in this sector in Poland since the year 2000.

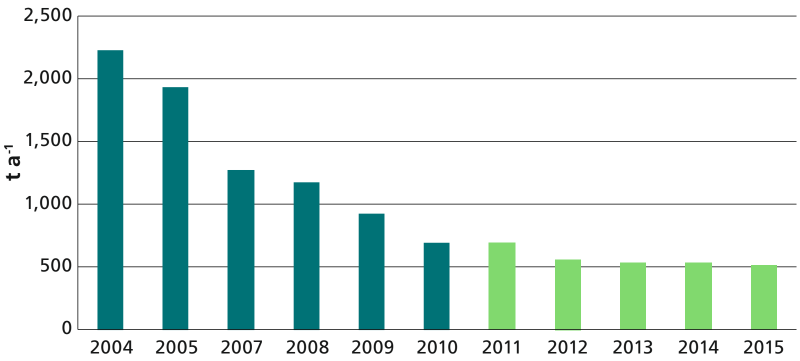


Figure 6-2 Phosphorus load (t a^{-1}) from the City of St. Petersburg from 2004 to 2010 and estimated development by the year 2015. (Source: Vodokanal; www.vodokanal.spb.ru)

Based on unofficial information, it can be concluded that nutrient discharges from Russia into the Gulf of Finland have decreased markedly since the early 1990s (Vodokanal St. Petersburg). In the Gulf of Finland and the entire Baltic Sea, the City of St. Petersburg has been the single largest individual source of phosphorus and nitrogen. Since 2004, after the construction of the South-West Wastewater Treatment Plant and implementation of chemical phosphorus removal at the city's three largest treatment plants, the phosphorus input into the Gulf of Finland has decreased significantly, by almost 1,500 tonnes annually (**Figure 6-2**). On the other hand, the wastewaters of the City of Kaliningrad are still discharged into the Baltic Proper without treatment. Russia did not report the nutrient load from Kaliningrad, but it can be estimated to be around 400 tonnes of phosphorus and 2,000 tonnes of nitrogen annually.

In the HELCOM Baltic Sea Action Plan, it was estimated that the achievement of good environmental status of the Baltic Sea calls for annual reductions of 15,000 tonnes of phosphorus and 135,000 tonnes of nitrogen compared with the non-flow-normalized average load from 1997 to 2003. Implementation of measures to improve the treatment of wastewater, e.g., by increasing phosphorus removal by up to 90%, will reduce phosphorus inputs into the Baltic Sea by 6,700 tonnes (2/3 allocated to Poland and Russia), almost half of the total required reduction (Wulff et al. 2007, HELCOM 2007c). For nitrogen, however, reductions of only about 24,000 tonnes, or 18% of the reduction target, could be achieved by measures in wastewater treatment. The quickest and most cost-efficient way of reducing the Baltic Sea phosphorus load would thus be to enforce stricter requirements for municipal wastewater treatment in all coastal countries. If HELCOM's Baltic Sea Action Plan Recommendation 28E/5 (HELCOM 2007e) concerning wastewater treatment removal of 90% of the phosphorus from communities with more than 10,000 residents is achieved, the phosphorus load of the Baltic Sea would be reduced by almost 20% compared to 1997-2003.

The nutrient losses from fish farms have not decreased significantly, which is due to greater production. However, the losses per kilogram of produced fish have decreased (Jochumsen & Svendsen 2010). For freshwater fish farms, improved and extended wastewater treatment and applying more advanced techniques including greater recirculation of water, are some reasons for reduced losses per kilogram of produced fish. Furthermore, improving the feed quality and improved handling of fish have reduced the loss per produced amount of fish. In Finland, fish farming is among the sectors that have had the greatest reductions of discharges into waterbodies. This is partly due to reduced production and partly because of better breeding techniques and better use of fish feed.

The EU has promoted fish production in fish farms as an alternative to meat, as fish is a healthy source of protein and provides employment in rural areas. Increased fish farming may result in higher total nutrient losses from fish farms, especially marine farms, because they have low potential for wastewater treatment. One way to compensate for nutrient losses from marine fish farms is the cultivation of mussels or seaweed near the farms.

6.2.4 Losses from agriculture

According to the results of PLC-5, nutrient losses from anthropogenic diffuse sources on average accounted for about 45% of the total reported phosphorus and nitrogen loads into the Baltic Sea (**Figure 4-7**), but with much higher proportions in some countries (**Figures 4-8a,c** and **4-9**). If transboundary and unspecified loads could have been further divided according to origin, the diffuse sector would have comprised more than half of the total annual discharge. The share emanating from agriculture is about 70-90% of the total anthropogenic diffuse losses of nitrogen and, correspondingly, 60-80% of total phosphorus.

Reducing nutrient losses from agriculture is much more complicated than decreasing discharges from point sources and will involve several measures. Due to retention in soils, groundwater and inland surface waters, a reduction of nitrogen or phosphorus in local discharges will result in much less reduction to the Baltic Sea. According to **Table 4-3** retention in surface waters is up to 55% for nitrogen and 40% for phosphorus. Thus, a nutrient reduction of 1,000 tonnes to the sea from inland sources can require a reduction as high as 2,000 tonnes at the local source or even much more in parts of the Baltic Sea catchment area. In addition, there is often a considerable time lag between the implementation of agricultural water protection measures and any observed effects in lakes and rivers, and even more so for marine waterbodies. This means that reductions in the loads in marine waterbodies will not be observable for years or even decades after water protection measures are implemented on sources within the catchment.

A review of nutrient reduction targets (HELCOM 2003) stated that in Finland, Denmark, Germany and Sweden, no decreases could be discerned in agricultural phosphorus losses into surface waters between the late 1980s and 2000, despite strong reductions in both the use of P-fertilizers, and corresponding phosphorus surpluses in agricultural land. The high usage of phosphorus fertilizers in the 1970s and 1980s in these countries resulted in a long-term accumulation of phosphorus in the soil, so even after reducing the net supply of phosphorus, a large release from agricultural soils into river systems is still seen. In Finland, for example, the agri-environment scheme from 1995 to 2006 did not essentially improve the water quality in waterbodies heavily loaded from agriculture despite the fact that annually about 300 million Euros have been allocated to that programme from the national budget since the beginning of Finland's EU membership in 1995 (Kuussaari et al. 2008). The measures included in the scheme have so far been insufficient, partly because it has not yet been possible to target agricultural subsidies to encourage actions specifically where they would best promote water protection.

Nitrogen losses from agriculture to surface waters decreased between the late 1980s and 2000 by nearly 50% in Denmark and about one third in Germany. Since the year 2000, no significant reduction in nitrogen losses have been observed in Denmark despite implementation of further reduction measures. In Sweden, the input from agriculture to the sea has been estimated to have been reduced by about 10% during the period 1995 to 2005 for both nitrogen and phosphorus, the major reasons being abandoned arable land, changed crop distribution, lower fertilization rates, and the use of catch crops and buffer zones along streams (SEPA 2008).

According to HELCOM (2003), Russia, Latvia, Lithuania and Estonia showed significant reductions from agriculture since the late 1980s. The observed reductions were mainly due to dramatic changes in the number of livestock, leading to a reduction in manure application, and reductions in the usage of mineral fertilizers. However, these drastic decreases in pollution from all sources between the late 1980s and 1995 were mainly due to the economic developments. It was predicted that agricultural production would rise after the EU enlargement, making it more difficult to achieve further decreases in nutrient discharges from diffuse sources. In Russia, large-scale livestock production is also increasing rapidly (HELCOM 2010).

According to the flow-normalized riverine nutrient load entering the Baltic Sea between 1994 and 2008, there is no significant trend for nitrogen or phosphorus loads. Only Denmark has a significant reduction in nitrogen loads (1,520 tonnes per year (31%)) and phosphorus loads (23 tonnes per year (19%)), while Estonia (50%) and Finland (28%), have significant increases in riverine nitrogen loads during this period. Overall, it seems that there has been relatively little progress in the reduction of losses of nutrients from agriculture within the Baltic Sea catchment area since 2000, with losses from agriculture appearing to increase in some Contracting Parties. Load figures for diffuse sources are uncertain due to the impact of climatic factors and different methodologies applied, making comparisons of load figures difficult.

The flow-normalized annual total phosphorus loads entering the Baltic Sea during 2006-2008 are still more than 9,000 tonnes above the target level of the BSAP. The agricultural sector is, in addition to the MWWTPs and discharges from scattered dwellings, the land-based source for which more effective reduction measures are needed. To decrease phosphorus and nitrogen discharges into the Baltic Sea, the losses from agricultural activities (and scattered dwellings) to the inland surface waters most probably must be reduced by at least 30% from the 1997–2003 average levels, depending on the importance of retention in different catchment areas (see also **Section 6.3**). It is important to stress that agriculture also contributes to the nitrogen input to the Baltic Sea due to ammonia evaporation to the atmosphere, resulting in a significant amount of nitrogen input by atmospheric deposition onto the Baltic Sea. However, most measures to reduce nitrogen losses from agriculture to inland surface waters will also lead to a reduced ammonia emissions and result in reduced nitrogen deposition onto the Baltic Sea.

In the future, the EU agricultural policy will play a major role in the development of the condition of the Baltic Sea. One such case includes the fact that Poland, Lithuania, Latvia, and Estonia are now covered by the EU farming subsidy system that will clearly increase the profitability of agriculture in these countries. This may increase the intensity of farming, with higher risks of nutrient leaching unless new agri-environmental schemes directed towards water quality are introduced in future rural development programmes. A worst-case scenario is that the amounts of nitrogen and phosphorus leaching into the Baltic Sea will increase. Around the Baltic Sea, the rise in the living standards of the newer EU member countries and in Russia will probably increase the proportion of animal-sourced food in people's diets. The increasing domestic animal production may require an expansion of the cultivated area, which might increase the leaching of nutrients (Hägg et al. 2010).

To reduce phosphorus and nitrogen losses from countless individual field plots and animal production units is a huge task that calls for identification of high-risk areas and implementation of cost-efficient agri-environmental measures. Such measures could include, for example, catch crops, buffer zones, restored and constructed wetlands, reduced mechanical treatment of soils, lime application, higher storage capacity for manure and applying less than yield-optimal fertilizer amounts. Animal farms enlarged in size and their clustered locations require more effective methods to store, process and distribute manure. Slurry could be processed chemically or mechanically in order to separate nitrogen- and phosphorus-rich components (liquid/fibre part) and further used for energy production. To this end, there is a need for interdisciplinary research, advice and recognition of economic, social and political constraints.

6.2.5 Losses from forestry, scattered dwellings and storm water

Only a few countries have reported nutrient loss data for forestry, managed forest land, scattered dwellings and storm water treatment, and thus only very general conclusions on these sources can be drawn.

Forestry measures causing elevated nutrient losses are mainly clear felling, soil scarification and, in some countries such as Finland and Sweden, also forest fertilization. Generally, these losses only constitute a minor part of the total losses from managed forest land, while losses from growing forests are near natural background levels. Forest cutting is the main anthropogenic source and this activity varies considerably with the economy of the timber market. In Sweden, e.g., final fellings have been reduced from 300,000 hectares annually in the early 1970s to about 200,000 hectares during the past few years. Forest fertilization has also been reduced considerably since the 1980s. In addition to these economic drivers, nutrient losses from commercially managed forests have declined in recent decades due to a decline in forest drainage schemes and water protection measures taken in forestry, such as buffer strips along streams and lakes and modified clear-cutting methods.

In some countries (e.g., Denmark), phosphorus losses from scattered dwellings and storm water constructions constitute more than one third of the anthropogenic diffuse sources and in some catchment areas they are the main sources of input to inland surface waters. The input with storm water is probably underestimated because it is difficult to assess. In Sweden, the load in storm water from urban areas was estimated at 2,000 tonnes of nitrogen and 200 tonnes of phosphorus in 2006, while public roads in rural areas contributed with another 500 tonnes of nitrogen and 50 tonnes of phosphorus. Losses have probably been reduced over time as a result of lower nitrogen deposition and the construction of treatment facilities such as dams and filter systems.

Around one million Finns live in rural areas in homes that are not connected to sewerage systems. Additionally, almost half a million holiday homes around Finland treat their own wastewater in local systems. The phosphorus loads entering waterbodies from unconnected households in rural areas and from holiday homes were estimated to amount to about 350 tonnes per year during the early 2000s (compared with the total phosphorus load of 175 tonnes annually from 4 million people connected to MWWTPs). In Sweden, the introduction of P-free detergents reduced the phosphorus load to inland waters by about 50 tonnes per year. Recently enacted Finnish legislation on the treatment of household wastewater outside sewerage systems facilitates improvements that will reduce the local loads burdening waterbodies. The same kind of legislation regarding scattered dwellings is in force in, e.g., Denmark and Sweden.

In addition to losses originating from agriculture, forestry, industry and single settlements, waterbodies may also be polluted by peat extraction and mining operations. The overall share of the phosphorus and nutrient loads entering waterbodies from these activities is very small, but on regional and local scales their impacts on the state of waterbodies may be significant.

6.2.6 Losses from natural background sources

Losses from natural background sources occur from all land areas regardless of human activity and to some extent also from built-up areas. Deposition rates of nitrogen are elevated due to human activities, causing increased nitrogen losses from unmanaged areas, especially in the southern part of the Baltic Sea catchment. It is assumed that it will not be possible within coming decades to reduce these losses significantly, and therefore reductions in nutrient losses will only take place for the anthropogenic diffuse and point source losses. Natural background sources typically have low specific nutrient loss rates but because they cover large areas, the total losses will be significant. Losses from managed forest land are only to a very small part considered anthropogenic. For Sweden, the losses from background sources constitute approximately 50% of total nitrogen and phosphorus losses to surface waters. In the other Contracting Parties, the corresponding value is between 5% and 35%. This is explained by the fact that Sweden to a large extent is covered by forests, peat lands and mountain areas with low human population density and activity; the same is true for Finland.

6.3 An approach to estimate the reduction potential in different sectors

6.3.1 Municipal wastewater treatment plants

On the basis of the percentage of the population connected to the wastewater treatment systems and the treatment level in MWWTPs in 2007-2009 (**Table 2-5**), the theoretical load reduction potential that could be achieved by improved sewage treatment from the present levels compared to the HELCOM Recommendation levels was calculated for each Contracting Party. For Belarus, the reduction potential was estimated as the sum of nine major cities with a total of 1.59 million inhabitants, out of the four million inhabitants situated in the catchment area of the Baltic Sea.

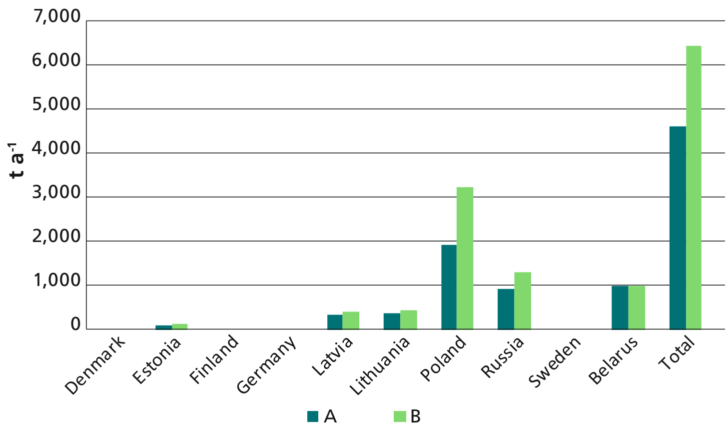


Figure 6-3 Phosphorus reduction potential in the MWWTPs according to two scenarios. A: An upgrade of plants with primary and secondary treatment to meet the 90% reduction target set by HELCOM; B: Upgrading also plants with tertiary treatment from 80% (reduction required by the EU UWWT Directive) to the level of 90%. The figures refer to the reduction in the load (in t a^{-1}) to the sea (net load) from the whole Baltic Sea catchment area after deduction of the retention in the catchment surface waters.

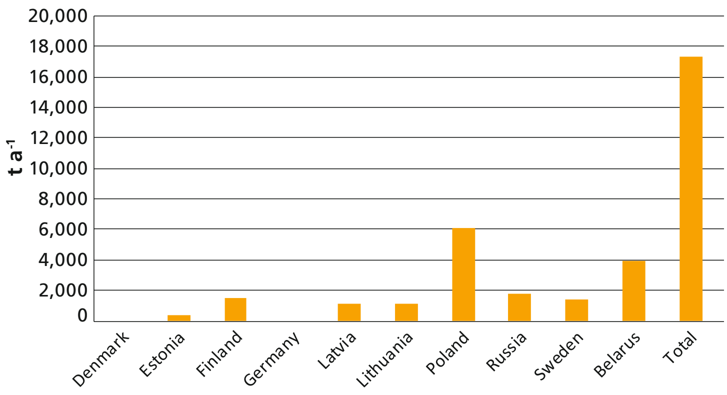


Figure 6-4 Nitrogen reduction potential in the MWWTPs assuming an improved nitrogen reduction up to 70% for all plants. The figures refer to the reduction in the loads (in t a^{-1}) to the sea (net load) from the whole Baltic Sea catchment area after deduction of the retention in the catchment surface waters.

The wastewater treatment levels required by HELCOM Recommendation 28E/5 are 70% to 80% reduction for nitrogen and 90% reduction for phosphorus for cities above 10,000 inhabitants. For cities between 2,000 and 10,000 inhabitants, the reduction targets are 80% for phosphorus and 30% for nitrogen. To estimate the potential reductions that would be achieved by applying Recommendation 28E/5 in comparison to the present situation (2007-2009), several assumptions have been made because no detailed data were available.

The nutrient removal percentage for the population connected to secondary treatment has been assumed to be 35% for both phosphorus and nitrogen, although it may in fact be higher in properly run MWWTPs. In addition, different removal targets according to the population of the municipalities were not applied. The basis of the calculation was the percentage of the total population connected to the wastewater treatment systems. In the case of phosphorus, the required level has already been achieved in Denmark, Finland, Germany, and Sweden. There is also no nitrogen reduction potential for Denmark and Germany as they have already achieved the HELCOM Recommendation (see **Section 6.2.3**).

The reduction potential for phosphorus was calculated by using two different assumptions:

A: An upgrade of primary and secondary treatment to meet the 90% reduction target;

B: As A, but also plants with tertiary treatment are upgraded from 80% reduction (required by the EU UWWT Directive) to the level up to 90%.

The results (**Figures 6-3** and **6-4**) are given as estimated amounts ultimately discharged into the Baltic Sea after deducting the retention (net load). The retention in the catchment area was assumed to be 30% on average in inland surface waters of the whole catchment area for both nitrogen and phosphorus.

6.3.2 Scattered settlements

The quantification of the nitrogen and phosphorus reduction potential from households not connected to public sewerage should be based on national average specific loss figures of nitrogen and phosphorus into waterbodies, taking into account the population size, the equipment used, treatment methods, pathways of discharge and the distance from the waterbodies. Because not all Contracting Parties were able to provide the information needed to calculate the reduction potential, we decided to use a very simplified approach (OSPAR Guidelines for Harmonized Quantification and Reporting Procedures for Nutrients, HARP-NUT, 2004).

Calculation principle: It was assumed that a large part of the unconnected households have improper treatment equipment, corresponding to simple separation tanks. For such households, the potential improvement can be calculated as the difference between specific load from the households with water flushed toilets and with no specific external treatment (except sedimentation tanks) and those fulfilling the HELCOM Recommendation 28E/6 treatment level (0.24 kg phosphorus per year) as compared to 0.43 kg phosphorus per year (OSPAR Guideline 5). No estimate was made for nitrogen because the maximum permissible daily per capita load for total nitrogen according to the HELCOM Recommendation is higher than the indicative specific loads of nitrogen in the respective OSPAR guidelines.

Three different scenarios (A to C) are presented in **Figure 6-5** according to the share of total scattered population living in the zone where reduction measures can be assumed to benefit water courses. The results are given both at source and as estimated amounts ultimately discharged into the Baltic Sea. The retention of nitrogen and phosphorus in the catchment area was assumed to be 30% in the whole catchment area.

No estimate of the reduction potential for rain and storm water overflows were performed because as statistics and data are poor, but it was assumed that the reduction potential is lower than that for scattered dwellings.

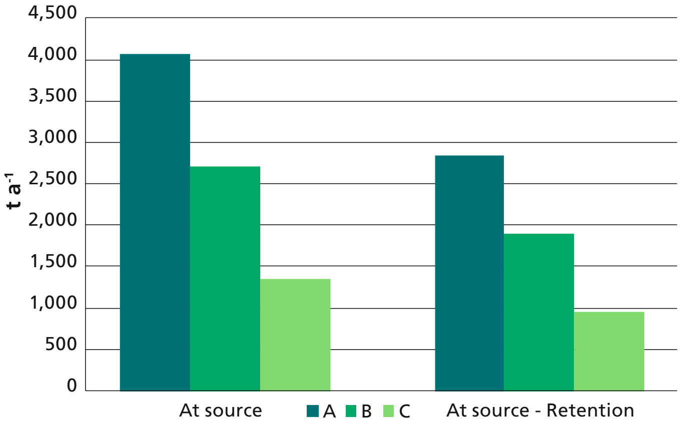


Figure 6-5 Phosphorus net reduction potential (in t a^{-1}) from scattered dwellings (about 21 million people) according to three scenarios. A: The whole population in areas where reduction can be assumed to benefit water courses; B: 2/3 of the population; and C: 1/3 of the population

6.3.3 Agriculture

According to the results of this report, nutrient loading from diffuse sources is currently the major source of anthropogenic nutrients in the Baltic Sea catchment area and agriculture is the main diffuse pollution source. The proportion of diffuse sources has constantly increased during recent decades since the water protection measures have mainly been addressed, and in general have also been the most successful and cost efficient, on point sources.

The results also indicate that the provisional nutrient load reduction targets set in the BSAP will not be attained with the nutrient reductions obtained by implementing the existing HELCOM Recom-

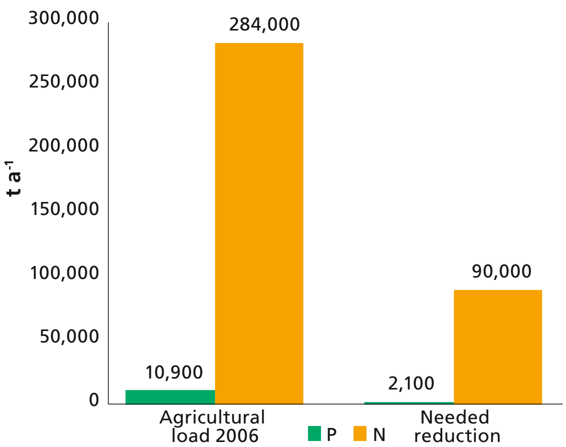


Figure 6-6 Waterborne nutrient load (based on flow-normalized figures) (in t a^{-1}) from agriculture into the Baltic Sea in 2006-2008 and reduction required with reference to the provisional reduction target of the BSAP, taking into account potential reductions of point source discharges.

mendations on improved wastewater treatment for urban and scattered dwellings alone. The additional provisional annual reductions needed are about 90,000 tonnes of nitrogen and 2,100 tonnes of phosphorus, and these reductions must be achieved mainly in agriculture (**Figure 6-6**).

Agricultural practices changed dramatically during the past century. New technologies, crops, animal breeding and particularly the introduction of chemical fertilizers after World War II increased productivity enormously. The introduction of chemical fertilizers in agriculture was followed by a change in the nutrient cycle on a national level, with the main agricultural sources of nutrients tending to move from areas of grain production to areas of livestock production.

At the same time, consumer preferences changed dramatically towards a larger proportion of meat in human consumption. These changes have been most pronounced in the western countries, but similar changes are now occurring in the new EU member states, as well as in Russia and Belarus. Higher living standards and EU agricultural subsidies are driving this development. The production units in animal husbandry can be very large and regionally concentrated. Manure is not adequately processed and thus nutrients are detached from the regional nutrient cycle. The production of manure from livestock farming can be much higher than needed for fertilizing the whole agricultural field area in the surroundings of concentrated production units. This can lead to over-fertilization and an increase in the leaching of nutrients into the water courses and ultimately into the Baltic Sea.

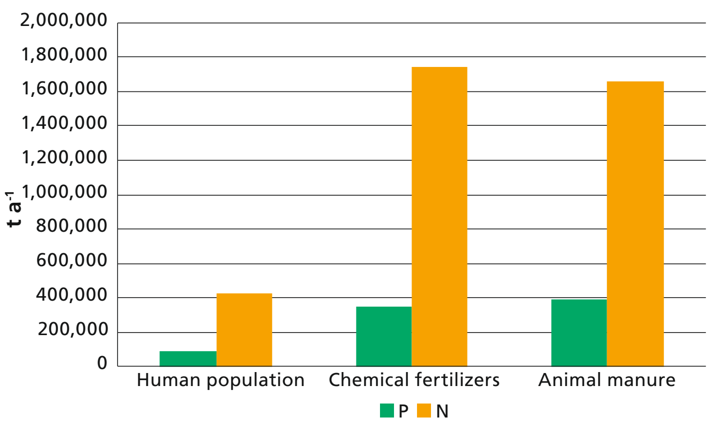


Figure 6-7 Nutrient production by humans versus livestock and the use of chemical fertilizers in agriculture (in t a^{-1}), in the total catchment area of the Baltic Sea. Estimates of fertilizer consumption in the Baltic Sea catchment area during 2005-2006: FAOSTAT 2010 (Russia and Belarus missing). Number of livestock in the Baltic Sea catchment area in 2006: FAOSTAT 2010, Eurostat 2010.

The total nutrient pool contained in the animal manure produced annually in the catchment area of the Baltic Sea is at present much higher than the respective amount produced by the whole human population in the catchment area (**Figure 6-7**). Most of the fertilizer and manure applied are used for crop growth, but there is still a net supply of nutrients to the soil, which can be leached and eroded to surface waters.

6.3.4 Concluding remarks

By comparing the flow-normalized load of nitrogen and phosphorus for 2006-2008 with the maximum allowable load defined in the BSAP, the remaining total reduction requirement can be estimated. This amounts to about 108,000 tonnes of nitrogen per year and 9,500 tonnes of phosphorus per year for the whole Baltic Sea. The calculations made above of the reduction potentials of phosphorus and nitrogen in MWWTPs and scattered dwellings in the whole Baltic Sea basin allow an estimate of the additional reduction requirements.

From **Figures 6-8** and **6-9**, it can be concluded that additional reductions have to be made mainly in agriculture. This is based on information on the total flow-normalized waterborne load in 2006-2008, the maximum allowable load according to the BSAP and the remaining total reduction requirement. This assessment does not include a possibility to reduce atmospheric nitrogen deposition onto the Baltic Sea, but agriculture is also a main contributor to that source together with emissions from the transport sector, including shipping and further combustion and energy production sectors. This assessment does not take into account the sub-basin-specific reduction requirements and should thus be considered a rough estimate of the total reduction potential in the catchment area of the Baltic Sea.

Obviously, the calculations presented here include many uncertainties. The reductions presented have been allocated to the measures in the relevant sectors in very rough terms. The results are also presented as single numbers without a range, which may give a false impression of a high degree of precision. For example, for agricultural loading the annual natural variations are large, sometimes approaching 50% due to natural climate-induced variations, but the variations are smoothed due to the use of flow-normalized load data. Nonetheless, results can be considered indicative and may provide an additional useful tool when HELCOM's BSAP is brought into effect.

In conclusion, it is unlikely that either good environmental status or the preconditions for good ecological status of the Baltic Sea can be achieved by 2021 if the nutrient reduction targets from only municipal wastewaters are fulfilled. Furthermore, the long residence time for nutrients in the catchment area implies that even if sufficient measures were implemented for various diffuse and point sources of nutrients during the next five years, the targeted input reduction to the Baltic Sea will not be reached by 2021.

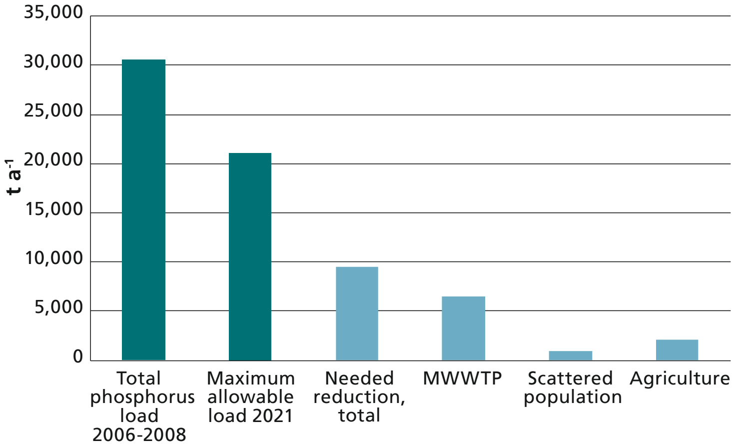


Figure 6-8 Total phosphorus load (flow-normalized) (in t a^{-1}) into the Baltic Sea in 2006-2008 and reduction required by 2021. Reduction scenarios: MWWTPs = scenario B in Figure 6-3, scattered dwellings = scenario C in Figure 6-5, agriculture= remaining.

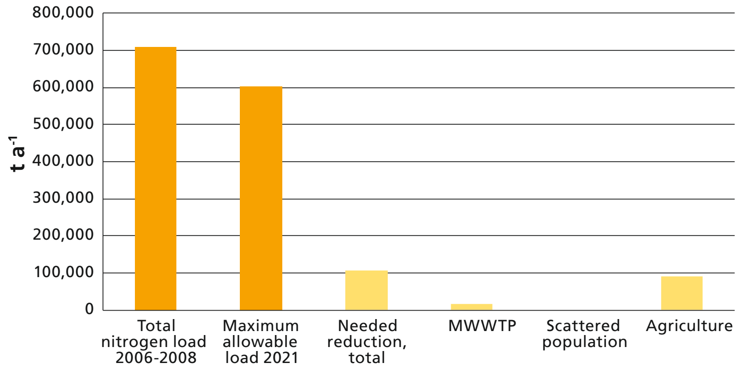


Figure 6-9 Total nitrogen load (flow-normalized) (in t a^{-1}) into the Baltic Sea in 2006-2008 and reduction required by 2021. Reduction scenarios: MWWTPs = Figure 6-4, scattered dwellings = no reduction, agriculture = remaining.

6.4 Lessons learned and future prospects

The aim of the PLC-5 project was to produce a report that is scientifically sound, understandable and relevant to policy- and decision-making. Managers and stakeholders are mainly interested in the level of discharges and loads and the sources of the substances (e.g., agriculture, industry, fish farming, and municipalities). It is fundamental to know which sources are the most important and where measures have to be taken. It is also important to know the pathways of pollutants from the source into the Baltic Sea, including the time lag from implementing a measure until the reduction of loads and effects are seen in the sea. It is also important to know the efficiency of different measures, e.g., the importance of retention for resulting nutrient load reductions to the sea. After the adoption of the HELCOM BSAP, more focus has been directed towards the efficiency of measures to mitigate pollution and the extent to which countries are approaching their nutrient reduction targets and the maximum allowable inputs.

6.4.1 What data should be compiled in the future?

The main focus should be on producing reliable and comparable data on the total loads of nitrogen and phosphorus entering the Baltic Sea, since this is of utmost importance to monitor the progress in load reduction towards the maximum allowable input into the Baltic Sea sub-basins and the BASP nutrient reduction targets. To ensure comparability, the effect of changing climatic factors on the loads should be reduced by normalization calculations (flow-normalization). The source apportionment of loads to the sea should receive further attention and the comparability and quality must be improved. Apart from nutrients, there is also need for information on the input of metals, and in the long run also hazardous organic substances in order to support the hazardous substances section of the BSAP. Atmospheric nitrogen deposition directly to the sea should also be integrated into future assessments of waterborne loads, otherwise it is not possible to obtain a full assessment of the main input sources to the Baltic Sea.

6.4.2 How to improve the completeness and reliability of data?

During the compilation of the PLC-5 report, we identified several significant gaps in the data reported. Some of those are so serious that they complicate the interpretation of, e.g., the trend analysis and the importance of different sources. It is also frustrating to present the results of a sophisticated analysis bearing in mind all the uncertainties and discrepancies in the data. We have tried to indicate the uncertainties in the relevant chapters, but we have sometimes been forced to present results in figures and tables in a more precise manner than the actual data merit. For the future, it is important to focus on data completeness and to improve the comparability between countries. The new expert group HELCOM LOAD, which will focus on methodologies for load assessments, should be a useful tool in this work. In addition, several approaches should be considered to improve the situation. These include:

1) To improve the PLC guidelines, e.g., by more detailed descriptions of how to quantify and assess loads from unmonitored areas and point sources, from diffuse sources and retention in lakes and rivers, and reach agreement on applying comparable methodologies. Another action could be to insert tables with default values, key figures and indexes that will help countries to check their data.
2) To supplement the reporting format with a questionnaire about methodology and background information, which would be helpful for the data centre.
3) To make the PLC database available on the Internet, which should improve possibilities to assess and compare data continuously and facilitate quality assurance.
4) To arrange common workshops at which experiences in monitoring, data collection and assessments could be discussed, and to use the HELCOM LOAD group to discuss shortcomings and doubtful data and results
5) To increase bilateral cooperation between countries in order to improve the assessment systems
6) Concerning chemical analysis, internationally validated and standardized analytical methods should be used, such as ISO or EN methods for chemical analysis related to rivers and wastewater. All laboratories involved in monitoring should be accredited according to ISO 17025 and have a quality assurance programme following the standards in ISO 17025. Reporting of specified information on analytical quality should be mandatory. Laboratories should participate in international proficiency testing on a regular basis.
7) Intercalibration or intercomparison tests of sampling methodologies should be carried out on a regular basis.
8) Speeding up reporting of data will improve the possibilities for communication between the data providers and the data manager.

6.4.3 Water monitoring

Most countries have well-developed river monitoring systems. A problem is that some countries do not report unmonitored areas and occasionally not even all monitored areas, resulting in underestimation of the actual total loads. It is absolutely essential that countries report results that represent entire and consistent area coverage. Otherwise, comparable time series of data usable for trend assessments cannot be produced. These shortcomings should, in principle, be reasonably easy to overcome. It is more difficult to fill in gaps and to correct earlier measurements made with unsatisfactory analytical methods.

Changes in methodologies or in monitoring networks will necessitate updating of previously reported data. In many countries, improved methodologies for modelling losses from unmonitored areas and quantifying losses from diffuse sources have been developed, which makes it obvious to recalculate old data including total inputs and source apportionment. Therefore, in the future even stricter updating of old, recalculated and corrected data should be part of the regular reporting requirements, as is done with climate change data reported to the United Nations Framework Convention on Climate Change. Unless this is done, comparisons between different Pollution Load Compilations will be almost impossible and make trend evaluation of loads very uncertain.

6.4.4 Improvement in assessing individual sources

Municipal wastewater

The main point source of waterborne nutrients is municipal wastewater. Even if discharges from municipal wastewater treatment plants are reasonably well covered in the reporting, there is room for considerable improvement. To have a solid basis for the assessment, it is important to report discharges individually for as many MWWTPs as possible, at least plants larger than 10,000 PE, but preferably also for plants down to 2,000 PE. Furthermore, the reliability of data on discharges from each plant can be checked by a comparing them with calculated data using simple default values based on connected PE and the removal technology applied in each plant. Aggregated information, often used in the riverine load apportionment, is more difficult to analyze. Another, but less optimal, possibility for EU member states could be to use data reported every second year to the European Union for compliance with the urban wastewater directive. At present, not all countries report actual data on discharges to the EU.

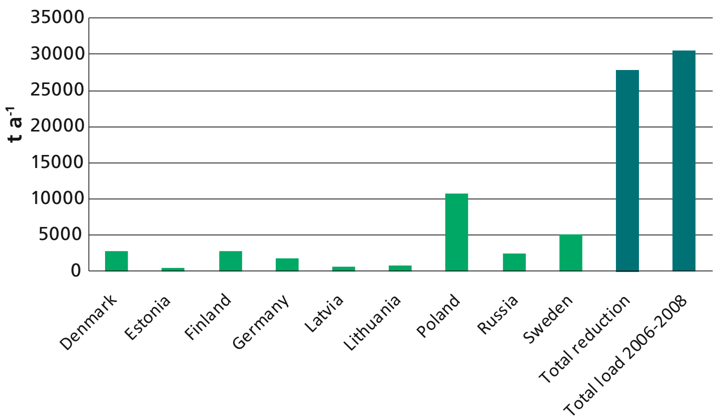


Figure 6-10 Reduction of phosphorus load from municipal waste waters entering into the Baltic Sea (net load) from 1970 to 2008 and the total waterborne (flow-normalized) phosphorus load into the Baltic Sea in 2006–2008.

Agriculture

In many countries, agriculture is the largest source of inputs of nitrogen and phosphorus to both inland waters and the sea. Reliable data on this source are thus necessary in order to make a load apportionment and to assess the effectiveness of different measures to reduce losses from this sector. Several countries use numerical or empirical models to calculate loads and this may be a way forward for other countries as well. The most challenging part is to develop leaching coefficients for the large variety of soils, crops, fertilizer regimes, agricultural practices and climatic conditions that have to be taken into account. In most countries, this will be an extensive task. This requires a well-developed infrastructure in terms of good, comparable and updated agricultural statistics and experimental research. Availability of input data for models could be improved by information exchange between countries and by amending the PLC guidelines with a matrix of default data on leaching rates for different situations. Ideally, different models should be run for the whole Baltic Sea catchment area to evaluate the resulting quantification of losses from agriculture and provide a basis for further assessments. Some Baltic Sea-wide projects are carrying out such exercises and will provide data, for approximately 135 major catchments, on losses from agriculture and for retention, but there are some difficulties to obtain updated, comparable agricultural statistics.

Other diffuse sources and retention

Riverine load apportionment is an important tool for identifying the most important sources of nutrient loading to the sea. As in PLC-4, this activity was again found rather difficult to carry out for many countries owing to incomplete information and methodologies. Basically, the source apportionment of nutrient losses to waters in the catchment (gross load) is straightforward for point sources, atmospheric deposition and background losses, but is challenging to carry out for losses from diffuse anthropogenic sources such as agriculture. Furthermore, quantification of retention in soils and inland surface waters seems to be a major challenge and this is crucial for the source apportionment of the load entering the sea. It is very important to quantify the retention when evaluating effects and efficiency of measures on different sources for the resulting input to surface waters including the Baltic Sea. For this topic, it is also necessary to exchange information between countries and perhaps to provide common databases with results from different catchments. There are several methodologies developed and accessible, e.g., from the EUROHARP project, and described in the PLC guidelines. Another possibility is to make assessments of diffuse loads in a common project, utilizing the same methodology and the same assessment tools. However, this is a very large and costly task, and it is necessary to conduct the exercise on a regular basis to follow trends in the losses from diffuse sources.

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Annexes

Annex 1

PLC-5 data were collected for the year 2006 as total annual loads and losses and average, total, long-term and minimum or maximum flows. Loads and losses were to be reported as tonnes per year, flows of rivers and unmonitored areas as $m^3 s^{-1}$ and for point sources as $m^3 a^{-1}$, respectively. The reported parameters are listed in Table 8-1.

Table 8-1 Parameters to be reported for the PLC-5

Parameters	Point sources (discharging either into inland surface waters or directly to the Baltic Sea)			Diffuse sources[8,9] (discharging either into inland surface waters or directly to the Baltic Sea)	Natural background losses	Monitored rivers*	Unmonitored Areas[9]
	Municipal Effluents*	Industrial Effluents*	Fish farming*				
BOD_5[4]	+	+[3]	+	+[10]		+[1]	+[1]
COD_{Cr}	v	v[4]					
TOC		v[4]				v	v
AOX	v	+[3]					
P_{total}	+	+	+	+	+	+	+
P_{PO4}	+[12]	v[3]				+	+
N_{total}	+	+	+	+	+	+	+
N_{NH4}	+	v[3]				+	+
N_{NO2}[7]	v	v[3]				+[7]	+[7]
N_{NO3}[7]	v	v[3]				+[7]	+[7]
Hg	+[2]	+[3]				+[1]	+[1]
Cd	+[2]	+[3]				+[1]	+[1]
Zn	+[2]	+[3]				+[1]	+[1]
Cu	+[2]	+[3]				+[1]	+[1]
Pb	+[2]	+[3]				+[1]	+[1]
Ni	+[2]	+[3]				v[1]	v[1]
Cr	+[2]	+[3]				v[1]	v[1]
Oil[6]		+[6]		+		+[6]	+[6]
Flow	+	v	+[11]			+	+

\+ obligatory
v voluntary
[1] Except for rivers where all BOD_5 and heavy metal concentrations are below the detection limit
[2] Heavy metals are obligatory for municipal WWTPs larger than 10,000 PE
[3] BOD_5, AOX, nutrients and heavy metals are obligatory variables for relevant industries if these vari¬ables are regulated by sector-wise HELCOM Recommendations and exceed the threshold according to Annex A1 of the EPER decision (see PLC-5 guidelines)
[4] Only for untreated industrial effluents
[5] If BOD_7 is measured, a conversion factor ($BOD_5 = BOD_7/1.15$) should be used in order to calculate BOD_5
[6] Oil should be reported for the major assessments for the following rivers: Neva, Vistula, Nemunas, Daugava, Oder, Narva, Göta Älv, and at the largest oil refinery in each Contracting Party using the analytical method EN-ISO 9377-2
[7] Can be monitored and reported as $NO_{2,3}$-N
[8] Nutrient losses from diffuse sources can be estimated either as the total for all delivery pathways without dividing into path-ways or as losses by each individual pathway
[9] Diffuse sources discharging directly to the sea combine loads from scattered dwellings and from rainwater overflows
[10] Only from diffuse sources discharging directing into the Baltic Sea
[11] For fish farms where it is relevant (outlet for discharges)
[12] Should be measured or calculated
* In those cases where concentrations are below the detection limit, the estimated concentration should be calculated using the equation: Estimation = (100%-A) x LOD, where A=percentage of samples below LOD. This is according to one of the options listed in the guidance document on monitoring adopted by EU under the IPPC Directive Changes in methodology reported by the Contracting Parties.

Table 8-2 The status of PLC data not reported by the Contracting Parties

Country	Flow	Nitrogen	Phosphorus	Lead	Cadmium	Mercury
Denmark	Direct point sources 1994, 1996-1999, 2001-2005, 2008			Monitored and coastal area 1994, 1996-1999, 2002-2003, 2005-2008; point sources 1994-2008	Monitored and coastal area 1994, 1996-1999, 2002-2003, 2005-2008; point source 1994, 1996-2008	Monitored 1994-1999, 2002-2003, 2005-2008 coastal area 1994-1999, 2004-2008; point source 1994-2008
Estonia	Coastal area BAP, GUF, GUR 2007-2008, direct point sources 1994, 1996-1999	Direct MWWTPs 1994, 1996-1999, direct industries 1994, 1996-2003		Monitored 1995-1999, 2001-2003; coastal area 1994-2005;point sources BAP 2007-2008, GUF and GUR 1994-1996-1999	Monitored 1995-1999, 2001-2003, GUR 2007-2008; coastal area 1994-2005, 2007-2008; point sources 1994-2008	Monitored 1995-1999, 2001-2003, 2007-2008; coastal area 1994-2008; point sources 1994-2008
Finland				Point sources ARC 1997-2001, 2002-2003, 2007-2008	Point sources ARC 1996-1999, 2001, 2004-2006, bos 2000, 2005-2006, GUF 2000, 2006, 2008	Monitored and coastal area no relevant measures before year 2000
Germany	Coastal area 2008, direct point sources 2007	Coastal area 2008, direct point sources 2007	Partially missing 2008, point source data of 2007-2008	Coastal area and point source data 2008, aggregated rivers 2003-2008, point sources 1994, 1996-1999, 2001-2005, 2007-2008	Coastal area and point source data 2008, aggregated rivers 2003-2008, point sources BAP 2001-2004, 2007, WEB 2007	Coastal area and point source data 2008, aggregated rivers 2003-2008, point sources BAP 2001-2004, 2007, WEB 2007-2008
Latvia	Coastal area 1995-2003, 2007-2008, direct point source 1994, 1996-1999, 2004-2005	Point sources 1994-1999		Coastal area 2001, 2004-2008, Point source 1994, 1996-1999, 2001-2005, 2007-2008	Coastal area 2001, 2004-2008	Monitored and coastal area; point source 1994-2000, 2004; GUR 1994-2004
Lithuania				Monitored and coastal areas 2007, point seources 1994, 1996-1999, 2001-2005, 2007-2008	Coastal area 2000, 2003, point source 1994-2008	Monitored 1994-1997, 2002, 2006-2008; costal area 1994-1997, 1999, 2001-2008; point source 1994-2008
Poland	Direct point sources 1994, 1996-1999, 2001-2002	Fish farms 1994-2008		Monitored and coastal area 2008, point source 1994, 1996-1999, 2001-2005, 2007-2008	Point source 1994, 1996-1999, 2001-2005, 2008	Monitored and coastal area 2008, point source 1994, 1996-1999, 2001-2006, 2008
Russia	BAP monitored 1994-1999, coastal area 1994-2008, direct point sources 1994-1999	BAP monitored (Kaliningrad) 1994-2003, 2007-2008; GUF 1994-1999, 2005; coastal area 1994-2008, point sources 1994-1999	BAP monitored 1994-2008; coastal area 1994-2008; point sources 1994-1999	Monitord BAP 1994-2008, GUF 2008; coastal area 1994-2008; point sources BAP 1994-2008, GUF 1994, 1996-2008	Monitord BAP 1994-2008; coastal area BAP, GUF 1994-2008; point sources BAP 1994-2003, 2007-2008; GUF 2003, 2005-2008	Monitored and coastal area and point source 1994-2008
Sweden	Direct point sources 1994-999, 2001, 2007	Fish farms 1994-2008	Fish farms 1994-2008	Point source 1994, 1996-1999, 2001-2005, 2007-2008; sou 1995, 2000	Point source 1994, 1996-1999, 2001-2005, 2007-2008	Monitored and coastal areas 1994; point source 1994, 1996-1999, 2001-2005, 2007-2008

Table 8-3a Detection limits for different variables in river water in the Contracting Parties

Contracting Party	DE	DK	EE	FI	LI	LV	PL	RU	SE
AOX in µg/l	10			5					
BOD in mg/l	0.5	0.5	0.5-2	1-3	0.5	0.5-3.6	0.1-1	1	
CODCr in mg/l			5			5		1-5	4
TOC in mg/l	0.5	0.5		0.5-2					0.3
NH4-N in µg/l	10	10	2	2-10	3-8	10	8-20	20	1
NO3-N (+NO2-N) in µg/l		20	20, 100	10	10	1, 10	10-100	10	1
Ntotal in µg/l	30	60	150	50	10	7	100	50	50
PO4-P in µg/l		5	2	2	5	4	10-15	10	1
Ptotal in µg/l	10	10	2	5	5	6	15	40	1
Cd in µg/l	0.04	0.005	0.02	0.03	0.05	0.03	0.1-1	0.5	0.005
Cr in µg/l	0.04	0.04		0.2	0.5		0.2-3	2	0.05
Cu in µg/l	0.04	0.04	0.1	0.1	0.5	0.28	0.5-5	0.5	0.04
Ni in µg/l	0.03	0.03		0.2	1		0.4-5	2	0.05
Pb in µg/l	0.025	0.02	0.2	0.03	1	0.32	0.3-5	2	0.02
Zn in µg/l	0.5	0.05	2	0.1-10	2.5	2	0.1-5	1	0.2
Hg in µg/l	0.005	0.005	0.1	0.002	0.1		0.1-0.5	0.2	0.0001
Mineral oil in µg/l			**10**	**100**	**50**	**30, 90**	**100**	**40**	

Table 8-3b Detection limits for different variables in wastewater in the Contracting Parties

Contracting Party	DE	DK	EE	FI	LI	LV	PL	RU	SE
AOX in µg/l	10			5					
BOD in mg/l	3	2	3	1-7	0.5	3		0.5-5	
CODCr in mg/l			15	14	3-50	30			4.0-5.0
TOC in mg/l	0.5	0.5		0.5-20					
NH4-N in µg/l	10	100	10	2-2,000	3-8	6-200		20-50	
NO3-N (+NO2-N) in µg/l	1		20, 40	5-500	10	3-20		6-500	
Ntotal in µg/l	100	50	1000	20-200	10	60-1,000		50-1,000	
PO4-P in µg/l			2	0.5-20	5	2-70		20-200	
Ptotal in µg/l	10	50	2	2-100	5	5-10		10-40	
Cd in µg/l	0.05	0.05	0.1	0.03-5	0.05	10-100	0.1-10	0.05-0.1	
Cr in µg/l	0.1	0.2		0.1-100	0.5	0.2-300	0.2-20	0.2-10	
Cu in µg/l	0.1	0.5	1	0.1-100	0.5	0.5-100	0.5-20	0.1-1.0	
Ni in µg/l	0.05	0.1		0.04-100	1	7-40	0.4-20	0.2-1.0	
Pb in µg/l	0.1	0.5	1	0.03-20	1	0.5-50	0.5-20	0.2-1.0	
Zn in µg/l	1	5	10	1-50	2.5	10-100	0.3-5	1.0-5.0	
Hg in µg/l	0.05	0.05	0.05	0.1-1	0.1	0.04-0.58	0.5-1	0.01-0.05	
Mineral oil in µg/l			**10**		**50**	**40-120**		**5-50**	

8-4a Average annual riverine flow (in $m^3 s^{-1}$) by country and sub-basin for the period 1994-2008

Country	Sub-region	1994	1995	1996	1997	1998	1999
Denmark	Baltic Proper	14	9	5	5	12	12
	Kattegat	213	183	110	114	171	208
	Sound	16	23	4	5	13	13
	Western Baltic	168	127	43	51	125	140
	Total Denmark	**411**	**341**	**162**	**176**	**321**	**373**
Estonia	Baltic Proper	17	17	10	13	13	14
	Gulf of Finland	500	545	316	453	636	576
	Gulf of Riga	194	199	105	156	177	167
	Total Estonia	**711**	**761**	**431**	**622**	**827**	**756**
Finland	Archipelago Sea	93	94	76	74	97	99
	Bothnian Bay	1,197	1,414	1,241	1,334	1,913	1,365
	Bothnian Sea	343	400	291	332	446	342
	Gulf of Finland	446	498	374	352	475	392
	Total Finland	**2,078**	**2,407**	**1,983**	**2,091**	**2,931**	**2,198**
Germany	Baltic Proper	77	59	40	35	53	56
	Western Baltic	108	90	43	48	98	78
	Total Germany	**185**	**149**	**82**	**83**	**151**	**134**
Latvia	Baltic Proper	116	121	62	95	165	128
	Gulf of Riga	1,033	877	544	897	1,305	877
	Total Latvia	**1,149**	**998**	**606**	**992**	**1,470**	**1,005**
Lithuania	Baltic Proper	1,079	814	663	621	907	847
	Total Lithuania	**1,079**	**814**	**663**	**621**	**907**	**847**
Poland	Baltic Proper	1,953	1,887	2,045	2,237	2,432	2,346
	Total Poland	**1,953**	**1,887**	**2,045**	**2,237**	**2,432**	**2,346**
Russia	Baltic Proper						
	Gulf of Finland	2,412	2,612	2,037	2,077	2,309	2,577
	Total Russia	**2,412**	**2,612**	**2,037**	**2,077**	**2,309**	**2,577**
Sweden	Baltic Proper	633	723	378	410	696	686
	Bothnian Bay	1,551	1,795	1,518	1,703	2,219	2,018
	Bothnian Sea	1,981	2,638	1,532	2,301	3,201	2,388
	Kattegat	907	940	449	677	925	1,163
	Sound	39	29	15	15	34	31
	Total Sweden	**5,111**	**6,125**	**3,892**	**5,106**	**7,075**	**6,286**
Total Baltic Sea		**15,088**	**16,095**	**11,901**	**14,005**	**18,423**	**16,522**

2000	2001	2002	2003	2004	2005	2006	2007	2008
7	8	13	5	9	7	7	11	9
206	174	213	145	173	152	181	193	244
15	9	16	7	10	9	14	19	16
109	97	146	59	103	94	114	160	155
338	**289**	**388**	**216**	**295**	**262**	**316**	**383**	**425**
12	15	12	9	18	17	8		
424	446	399	365	609	577	333	391	506
123	150	125	93	215	199	100	78	116
559	**611**	**537**	**466**	**842**	**793**	**441**	**469**	**622**
122	84	64	29	99	88	79	81	138
1,898	1,376	1,093	1,050	1,546	1,568	1,250	1,556	1,886
438	398	278	184	352	370	353	409	573
436	437	349	241	518	463	370	493	649
2,893	**2,295**	**1,784**	**1,504**	**2,516**	**2,490**	**2,052**	**2,539**	**3,246**
47	43	69	27	34	40	39	64	37
70	71	119	53	71	67	73	83	53
117	**114**	**189**	**80**	**105**	**108**	**112**	**147**	**90**
95	102	150	78	141	122	97	142	115
845	723	785	623	1,043	1,001	791	649	703
940	**825**	**935**	**701**	**1,184**	**1,123**	**888**	**790**	**818**
666	655	741	292	533	517	433	720	461
666	**655**	**741**	**292**	**533**	**517**	**433**	**720**	**461**
2,104	2,182	2,279	1,474	1,529	1,620	1,650	1,808	1,559
2,104	**2,182**	**2,279**	**1,474**	**1,529**	**1,620**	**1,650**	**1,808**	**1,559**
88	75	65	59	71	97	70	110	83
2,259	2,419	2,199	1,670	2,366	2,808	2,049	2,491	2,712
2,347	**2,494**	**2,264**	**1,729**	**2,438**	**2,904**	**2,119**	**2,601**	**2,795**
714	656	628	400	603	467	616	711	663
2,455	2,153	1,713	1,259	1,963	2,140	1,640	2,046	2,049
3,469	3,199	2,119	1,893	2,103	2,606	2,379	2,204	2,322
1,164	1,150	838	596	830	781	938	1,145	1,152
28	20	35	15	28	21	33	40	27
7,829	**7,179**	**5,332**	**4,162**	**5,528**	**6,014**	**5,605**	**6,145**	**6,215**
17,793	**16,645**	**14,449**	**10,624**	**14,970**	**15,831**	**13,616**	**15,603**	**16,230**

8-4b Total waterborne phosphorus inputs (in tonnes) by country and sub-basin for the period 1994-2008

Country	Sub-region	1994	1995	1996	1997	1998	1999
Denmark	Baltic Proper	132	95	68	43	77	63
	Kattegat	1,247	917	564	613	828	1,036
	Sound	996	757	460	357	283	231
	Western Baltic	1,247	819	511	476	851	884
	Total Denmark	**3,621**	**2,588**	**1,603**	**1,489**	**2,039**	**2,214**
Estonia	Baltic Proper	37	31	21	17	17	22
	Gulf of Finland	966	955	494	706	970	1,341
	Gulf of Riga	423	330	221	215	254	385
	Total Estonia	**1,426**	**1,316**	**736**	**938**	**1,241**	**1,748**
Finland	Archipelago Sea	560	489	718	505	706	565
	Bothnian Bay	1,569	1,639	1,108	1,476	2,124	1,465
	Bothnian Sea	653	783	639	577	818	770
	Gulf of Finland	726	675	730	483	828	637
	Total Finland	**3,507**	**3,587**	**3,195**	**3,040**	**4,475**	**3,438**
Germany	Baltic Proper	371	249	195	154	208	188
	Western Baltic	584	437	252	264	509	380
	Total Germany	**955**	**686**	**447**	**418**	**717**	**568**
Latvia	Baltic Proper	190	270	148	187	278	303
	Gulf of Riga	2,016	1,791	862	1,284	2,640	1,845
	Total Latvia	**2,205**	**2,060**	**1,010**	**1,471**	**2,919**	**2,149**
Lithuania	Baltic Proper	3,986	1,373	1,496	2,418	3,228	3,612
	Total Lithuania	**3,986**	**1,373**	**1,496**	**2,418**	**3,228**	**3,612**
Poland	Baltic Proper	13,345	14,319	13,462	16,883	16,834	14,740
	Total Poland	**13,345**	**14,319**	**13,462**	**16,883**	**16,834**	**14,740**
Russia	Baltic Proper	0	0	0	0	0	0
	Gulf of Finland	4,192	9,263	4,188	3,811	4,049	3,866
	Total Russia	**4,192**	**9,263**	**4,188**	**3,811**	**4,049**	**3,866**
Sweden	Baltic Proper	1,070	1,014	525	639	1,014	1,102
	Bothnian Bay	967	1,212	691	1,476	1,263	986
	Bothnian Sea	1,149	1,457	708	1,236	1,345	1,535
	Kattegat	914	916	433	615	1,016	977
	Sound	197	123	83	95	135	129
	Total Sweden	**4,297**	**4,722**	**2,439**	**4,061**	**4,773**	**4,729**
Total Baltic Sea		**37,535**	**39,914**	**28,574**	**34,528**	**40,275**	**37,064**

2000	2001	2002	2003	2004	2005	2006	2007	2008
36	50	64	25	40	44	38	58	47
965	808	908	587	710	617	760	928	952
199	193	267	171	189	187	185	269	287
665	664	859	415	639	870	542	874	905
1,865	**1,715**	**2,098**	**1,198**	**1,578**	**1,718**	**1,524**	**2,129**	**2,191**
11	31	16	18	32	24	12	12	32
779	944	1,042	795	1,090	1,440	615	648	946
175	371	180	211	380	298	160	241	392
965	**1,346**	**1,237**	**1,023**	**1,502**	**1,763**	**787**	**900**	**1,370**
901	563	305	186	512	544	603	513	1,055
2,068	1,523	1,101	1,095	1,507	1,529	1,513	1,384	1,764
1,090	774	419	364	573	656	799	703	1,180
777	547	414	357	843	654	573	693	1,214
4,835	**3,407**	**2,239**	**2,001**	**3,435**	**3,382**	**3,488**	**3,292**	**5,213**
182	132	201	108	117	139	168	249	123
306	326	551	238	302	249	321	349	210
488	**458**	**752**	**346**	**418**	**388**	**488**	**598**	**333**
173	240	342	254	362	295	296	281	439
2,034	2,027	1,520	1,543	2,759	2,417	2,500	2,730	2,489
2,207	**2,267**	**1,863**	**1,797**	**3,121**	**2,712**	**2,796**	**3,011**	**2,928**
1,950	2,734	3,073	1,324	2,565	1,359	1,241	1,968	1,678
1,950	**2,734**	**3,073**	**1,324**	**2,565**	**1,359**	**1,241**	**1,968**	**1,678**
12,559	13,590	12,958	8,458	9,746	8,911	10,235	9,919	8,137
12,559	**13,590**	**12,958**	**8,458**	**9,746**	**8,911**	**10,235**	**9,919**	**8,137**
150	115	129	186	719	178	251	235	0
6,046	4,262	5,828	4,561	6,711	7,387	3,820	2,460	3,553
6,196	**4,377**	**5,957**	**4,746**	**7,429**	**7,565**	**4,071**	**2,695**	**3,553**
958	963	901	478	697	594	795	943	784
1,383	1,003	652	502	978	1,014	755	887	996
1,653	1,354	805	766	850	1,091	986	688	907
851	907	661	447	723	772	1,056	829	866
101	84	135	57	94	81	142	157	88
4,946	**4,311**	**3,155**	**2,250**	**3,342**	**3,552**	**3,734**	**3,505**	**3,641**
36,012	**34,204**	**33,331**	**23,144**	**33,136**	**31,350**	**28,365**	**28,018**	**29,044**

8-4c Total waterborne nitrogen inputs (in tonnes) by country and sub-basin for the period 1994-2008

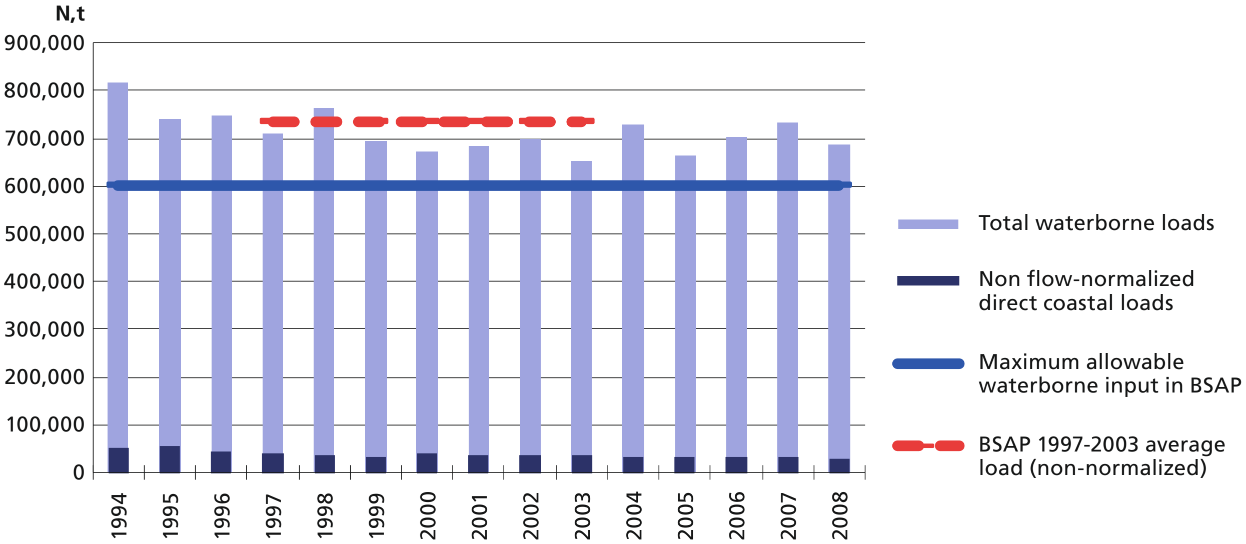
Country	Sub-region	1994	1995	1996	1997	1998	1999
Denmark	Baltic Proper	4,506	2,503	1,624	1,506	3,862	2,803
	Kattegat	42,675	33,110	18,965	19,988	33,630	36,969
	Sound	7,712	5,694	3,165	2,562	4,241	3,307
	Western Baltic	42,647	27,122	10,654	12,218	34,661	30,478
	Total Denmark	**97,541**	**68,428**	**34,408**	**36,274**	**76,394**	**73,558**
Estonia	Baltic Proper	1,025	1,097	644	1,014	1,022	950
	Gulf of Finland	12,514	19,082	9,626	14,272	25,787	18,583
	Gulf of Riga	10,861	12,006	6,543	10,452	11,979	11,432
	Total Estonia	**24,401**	**32,185**	**16,813**	**25,738**	**38,788**	**30,965**
Finland	Archipelago Sea	7,074	7,171	8,293	7,222	8,951	8,519
	Bothnian Bay	23,390	26,970	24,100	27,035	39,938	26,742
	Bothnian Sea	13,159	15,552	13,996	15,893	18,832	16,011
	Gulf of Finland	16,742	17,913	19,453	14,090	18,686	15,956
	Total Finland	**60,365**	**67,606**	**65,842**	**64,239**	**86,407**	**67,228**
Germany	Baltic Proper	18,496	8,830	4,309	3,353	8,595	9,662
	Western Baltic	25,060	18,367	7,772	8,820	22,028	15,112
	Total Germany	**43,556**	**27,197**	**12,081**	**12,173**	**30,623**	**24,774**
Latvia	Baltic Proper	15,554	15,731	8,471	11,003	17,706	10,887
	Gulf of Riga	98,567	75,977	42,943	81,235	89,765	67,648
	Total Latvia	**114,121**	**91,708**	**51,413**	**92,238**	**107,471**	**78,535**
Lithuania	Baltic Proper	67,226	37,271	41,999	55,836	79,901	66,379
	Total Lithuania	**67,226**	**37,271**	**41,999**	**55,836**	**79,901**	**66,379**
Poland	Baltic Proper	266,069	220,585	264,382	221,599	278,453	221,944
	Total Poland	**266,069**	**220,585**	**264,382**	**221,599**	**278,453**	**221,944**
Russia	Baltic Proper	0	0	0	0	0	0
	Gulf of Finland	10,306	12,834	9,412	8,120	9,016	8,651
	Total Russia	**10,306**	**12,834**	**9,412**	**8,120**	**9,016**	**8,651**
Sweden	Baltic Proper	42,040	37,163	24,908	23,276	39,266	39,108
	Bothnian Bay	15,268	17,832	15,755	17,230	26,546	22,571
	Bothnian Sea	23,131	30,467	19,701	25,621	39,461	29,363
	Kattegat	39,980	37,540	21,711	26,893	43,039	45,757
	Sound	9,573	6,241	5,010	4,332	9,593	7,467
	Total Sweden	**129,992**	**129,241**	**87,085**	**97,351**	**157,905**	**144,266**
Total Baltic Sea		**813,575**	**687,055**	**583,435**	**613,568**	**864,958**	**716,298**

2000	2001	2002	2003	2004	2005	2006	2007	2008
1,636	2,267	2,799	932	1,845	1,618	1,829	2,033	1,450
33,652	28,097	33,470	21,653	27,121	20,611	26,470	24,607	22,074
2,444	2,236	3,645	1,796	2,565	2,221	2,783	3,179	2,092
21,240	20,359	29,514	10,794	23,264	18,169	21,897	24,814	17,387
58,972	**52,958**	**69,428**	**35,175**	**54,794**	**42,620**	**52,978**	**54,632**	**43,002**
1,061	1,255	1,130	820	1,383	1,040	646	646	1,493
15,905	19,845	15,686	11,610	20,988	18,967	11,928	16,449	26,724
9,908	15,093	13,614	9,898	16,666	12,576	7,852	12,871	18,013
26,874	**36,192**	**30,430**	**22,328**	**39,037**	**32,583**	**20,427**	**29,966**	**46,230**
11,143	7,879	4,512	5,127	9,106	6,543	8,224	7,533	10,255
43,104	30,961	22,535	24,496	36,064	35,448	34,578	36,719	42,022
26,668	19,379	10,781	11,082	18,392	20,024	20,644	19,873	26,415
20,453	16,354	13,194	12,230	18,727	16,421	15,500	17,715	21,874
101,368	**74,573**	**51,022**	**52,935**	**82,289**	**78,435**	**78,946**	**81,840**	**100,566**
6,269	5,818	12,551	3,053	4,418	7,159	5,243	9,650	6,215
12,333	11,722	19,876	6,915	11,663	10,415	11,656	14,404	7,608
18,602	**17,541**	**32,426**	**9,968**	**16,081**	**17,574**	**16,899**	**24,054**	**13,823**
7,325	9,141	11,046	5,411	9,028	7,855	8,451	11,078	13,780
60,168	70,468	56,978	35,315	70,814	62,082	51,068	84,176	76,183
67,493	**79,610**	**68,024**	**40,726**	**79,843**	**69,937**	**59,520**	**95,254**	**89,963**
49,818	37,335	43,528	23,422	39,927	43,777	27,965	49,492	32,845
49,818	**37,335**	**43,528**	**23,422**	**39,927**	**43,777**	**27,965**	**49,492**	**32,845**
191,752	204,341	252,334	137,029	157,608	146,303	152,612	179,989	144,499
191,752	**204,341**	**252,334**	**137,029**	**157,608**	**146,303**	**152,612**	**179,989**	**144,499**
2,033	1,419	1,446	1,393	6,207	6,510	5,296	1,415	0
70,092	71,120	86,019	94,278	87,934	7,842	102,254	77,053	60,802
72,125	**72,539**	**87,465**	**95,671**	**94,141**	**14,352**	**107,550**	**78,468**	**60,802**
34,971	34,496	34,205	19,620	30,227	21,864	30,210	40,278	32,116
27,077	22,898	16,733	12,349	20,257	23,467	17,976	21,031	19,046
43,461	36,360	28,151	22,773	25,424	28,277	30,204	24,401	26,972
39,934	39,985	34,173	22,176	32,972	26,745	36,510	41,789	37,672
5,627	4,590	5,699	2,436	5,559	3,422	6,086	6,700	4,608
151,069	**138,329**	**118,962**	**79,354**	**114,439**	**103,774**	**120,986**	**134,198**	**120,413**
738,073	**713,419**	**753,618**	**496,607**	**678,160**	**549,356**	**637,882**	**727,892**	**652,143**

Annex 2 Temporal development of flow-normalized waterborne loads and BSAP targets

GENERAL – ALL HELCOM COUNTRIES

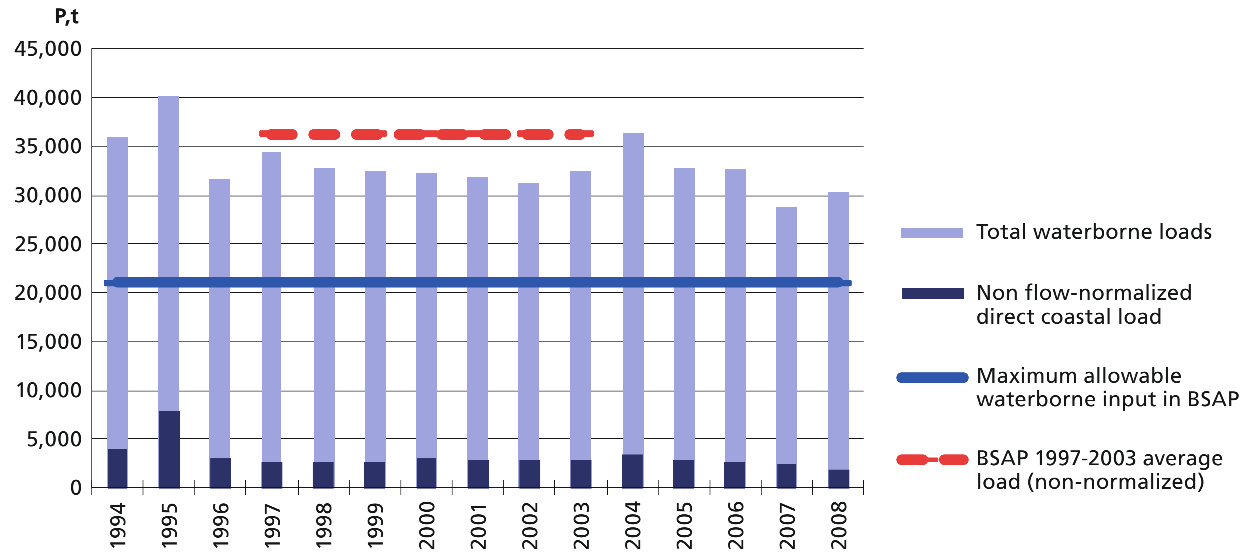
Total flow-normalized waterborne load of nitrogen (in tonnes) from all HELCOM countries to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Non flow-normalized direct coastal loads	50,249	57,483	44,539	39,343	37,631	34,498
Flow-normalized riverine load	764,991	684,131	708,024	665,736	725,388	663,512
Total waterborne loads	815,240	741,614	752,562	705,079	763,020	698,010
Maximum allowable waterborne input in BSAP	601,720	601,720	601,720	601,720	601,720	601,720
BSAP 1997-2003 average load (non-normalized)				736,720	736,720	736,720
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Non flow-normalized direct coastal loads	4,095	7,819	3,045	2,654	2,663	2,566
Flow-normalized riverine load	31,892	32,441	28,575	31,789	30,238	29,857
Total waterborne loads	35,987	40,260	31,620	34,443	32,901	32,423
Maximum allowable waterborne input in BSAP	21,060	21,060	21,060	21,060	21,060	21,060
BSAP 1997-2003 average load (non-normalized)				36,310	36,310	36,310

NOTE: Data on loads from Russia are partly missing in the PLC-5 database and could not be included in this assessment of the progress. Transboundary loads from Belarus were not excluded from total riverine loads from Latvia and Lithuania to the Gulf of Riga and the Baltic Proper, respectively.

Total flow-normalized waterborne load of phosphorus (in tonnes) from all HELCOM countries to the Baltic Sea, 1994-2008

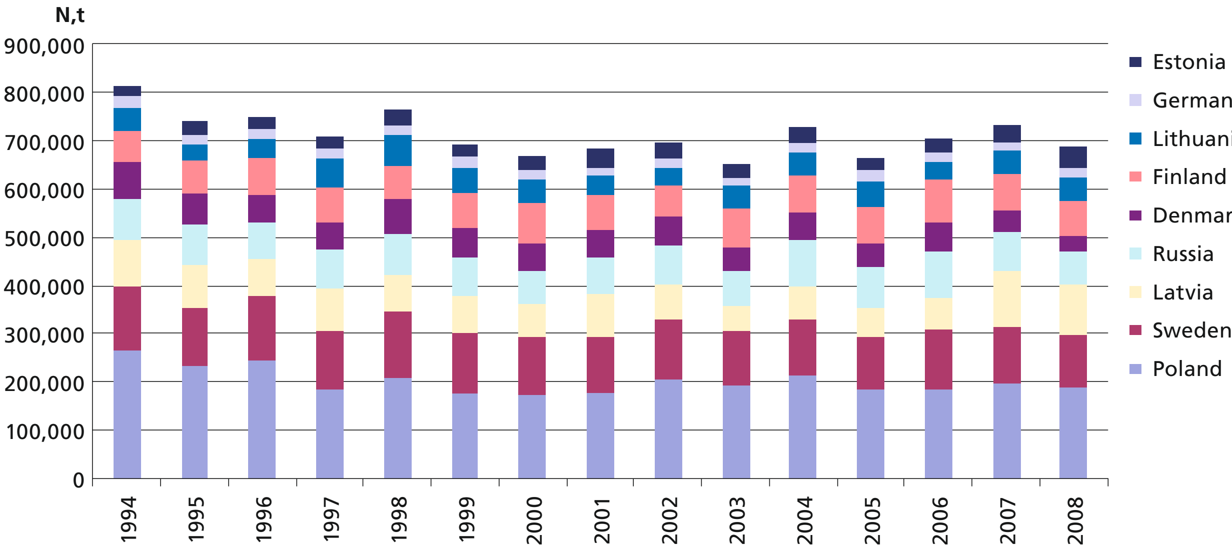


2000	2001	2002	2003	2004	2005	2006	2007	2008
40,109	37,550	36,566	35,916	34,000	32,360	32,855	33,065	30,436
641,995	645,795	661,014	617,225	695,846	633,585	671,441	701,348	658,047
682,103	683,345	697,580	653,141	729,846	665,945	704,296	734,413	688,484
601,720	601,720	601,720	601,720	601,720	601,720	601,720	601,720	601,720
736,720	736,720	736,720	736,720					

2000	2001	2002	2003	2004	2005	2006	2007	2008
2,976	2,787	2,878	2,810	3,498	2,860	2,630	2,439	1,952
29,191	29,097	28,461	29,588	32,797	30,055	29,969	26,248	28,359
32,167	31,884	31,339	32,398	36,295	32,915	32,599	28,687	30,311
21,060	21,060	21,060	21,060	21,060	21,060	21,060	21,060	21,060
36,310	36,310	36,310	36,310					

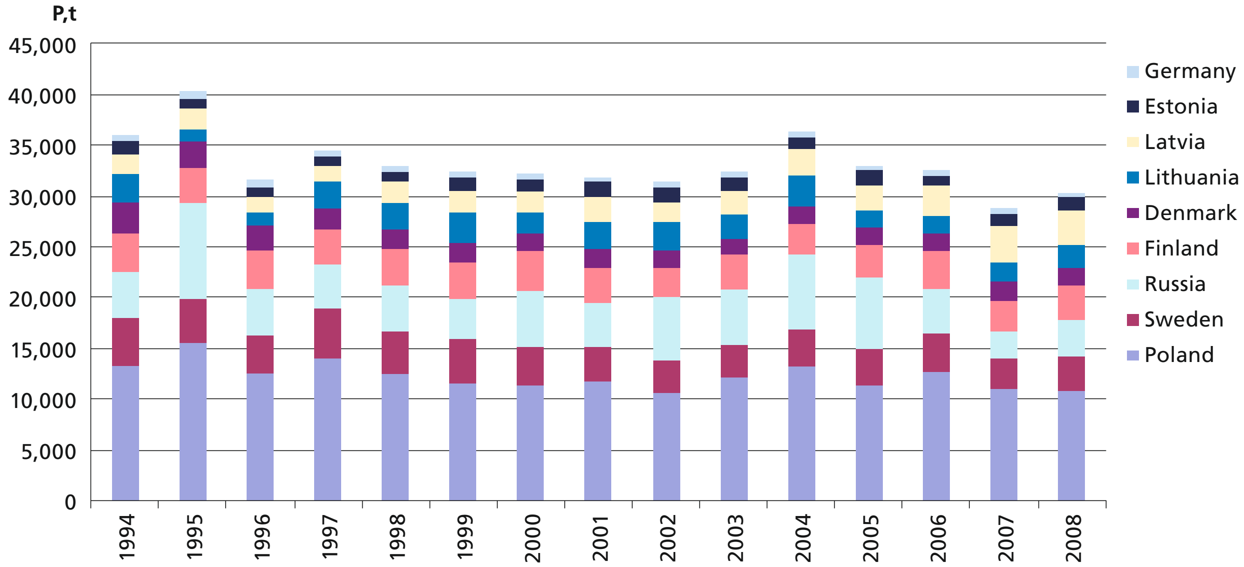
GENERAL – ALL HELCOM COUNTRIES

Share of different HELCOM countries in total waterborne load of nitrogen to the Baltic Sea, 1994-2008



Nitrogen	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Denmark	76,447	67,328	56,979	57,311	72,459	62,812
Estonia	22,654	28,809	22,582	26,157	30,952	26,946
Finland	66,502	66,152	75,831	70,923	71,539	70,406
Germany	25,113	22,190	20,374	20,512	23,012	21,889
Latvia	99,544	89,286	73,731	90,290	77,641	75,866
Lithuania	45,307	31,649	41,962	59,125	60,987	53,842
Poland	263,941	232,710	246,550	185,943	210,010	175,608
Russia	82,267	81,910	76,916	80,317	82,990	77,916
Sweden	133,464	121,494	133,265	119,194	135,207	128,017
Total	815,240	741,528	748,191	709,772	764,796	693,302
Phosphorus	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Denmark	3,106	2,563	2,370	2,123	1,983	1,931
Estonia	1,281	1,129	1,061	959	946	1,441
Finland	3,842	3,441	3,883	3,456	3,626	3,633
Germany	660	598	670	619	580	527
Latvia	1,925	2,018	1,407	1,447	2,119	2,076
Lithuania	2,691	1,197	1,495	2,549	2,517	2,951
Poland	13,237	15,487	12,533	14,006	12,570	11,537
Russia	4,532	9,371	4,508	4,416	4,569	4,019
Sweden	4,713	4,457	3,695	4,868	3,990	4,307
Total	35,987	40,260	31,620	34,443	32,901	32,423

Share of different HELCOM countries in total waterborne load of phosphorus to the Baltic Sea, 1994-2008

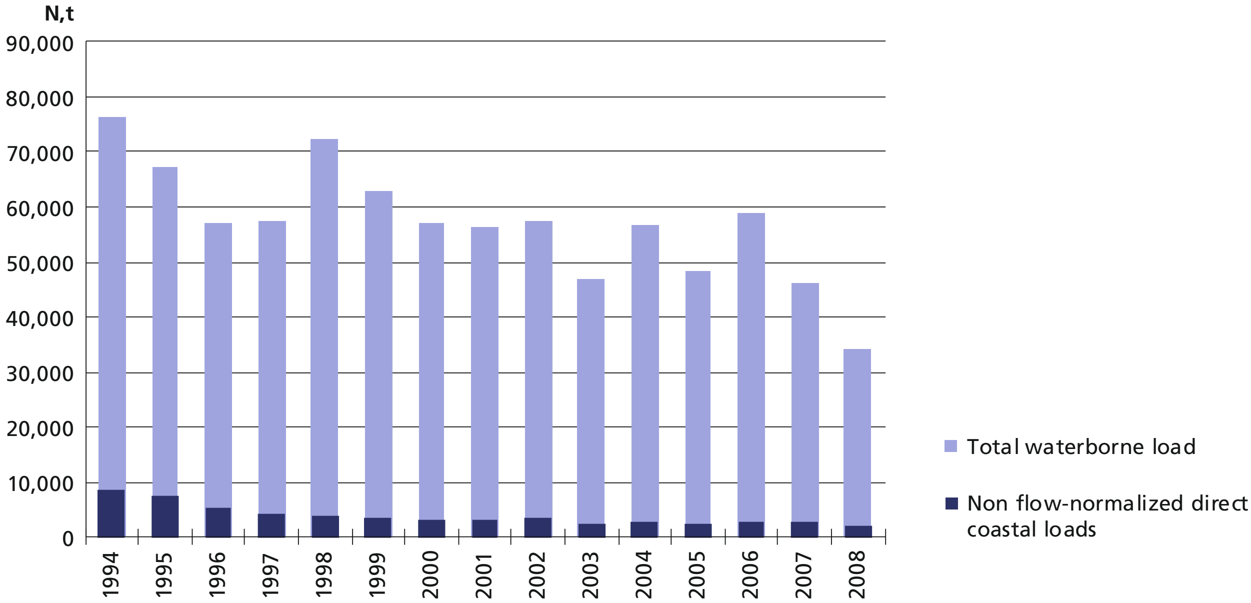


2000	2001	2002	2003	2004	2005	2006	2007	2008
57,164	56,265	57,284	46,992	56,751	48,332	59,042	46,118	34,264
29,230	37,215	34,015	27,275	32,256	27,852	26,753	36,216	45,168
84,474	74,781	63,881	81,748	77,408	74,348	88,185	76,724	73,891
20,568	19,477	17,858	18,382	20,080	21,511	19,329	18,186	21,308
68,575	89,716	69,535	51,070	68,195	62,338	63,324	113,496	101,691
49,558	37,727	39,682	46,868	48,012	54,319	39,976	46,139	44,682
174,013	176,774	206,377	192,859	211,874	183,139	186,836	196,864	189,254
68,365	74,322	83,865	74,301	95,558	84,187	98,358	82,259	67,823
118,235	117,066	125,084	113,645	119,711	109,918	122,493	118,413	110,401
670,183	683,345	697,580	653,141	729,846	665,945	704,296	734,413	688,484

2000	2001	2002	2003	2004	2005	2006	2007	2008
1,787	1,800	1,785	1,478	1,572	1,889	1,598	1,833	1,699
1,071	1,397	1,470	1,359	1,161	1,419	1,098	1,158	1,361
3,928	3,371	2,903	3,466	3,174	3,202	3,914	3,058	3,442
546	490	496	517	476	439	535	495	445
2,228	2,520	1,882	2,238	2,683	2,435	2,967	3,589	3,297
1,941	2,762	2,802	2,591	3,077	1,648	1,731	1,845	2,256
11,374	11,672	10,549	12,098	13,287	11,255	12,661	10,948	10,800
5,598	4,317	6,119	5,409	7,380	6,941	4,280	2,641	3,663
3,693	3,554	3,334	3,243	3,485	3,688	3,815	3,120	3,349
32,167	31,884	31,339	32,398	36,295	32,915	32,599	28,687	30,311

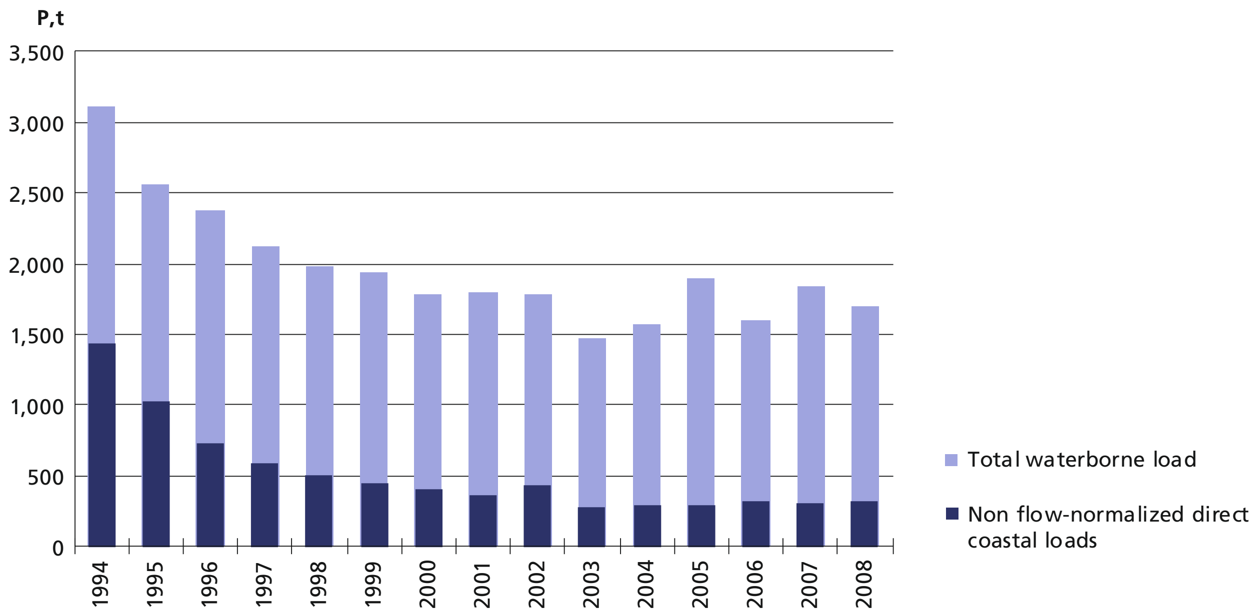
1. DENMARK: TOTAL

Total flow-normalized waterborne load of nitrogen (in tonnes) from Denmark to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	67,932	59,791	51,661	53,168	68,476	59,334
Non flow-normalized direct coastal loads	8,515	7,537	5,318	4,143	3,983	3,478
Total waterborne loads	76,447	67,328	56,979	57,311	72,459	62,812
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,676	1,531	1,634	1,530	1,485	1,491
Non flow-normalized direct coastal loads	1,430	1,032	736	593	498	441
Total waterborne loads	3,106	2,563	2,370	2,123	1,983	1,931

Total flow-normalized waterborne load of nitrogen (in tonnes) from Denmark to the Baltic Sea, 1994-2008

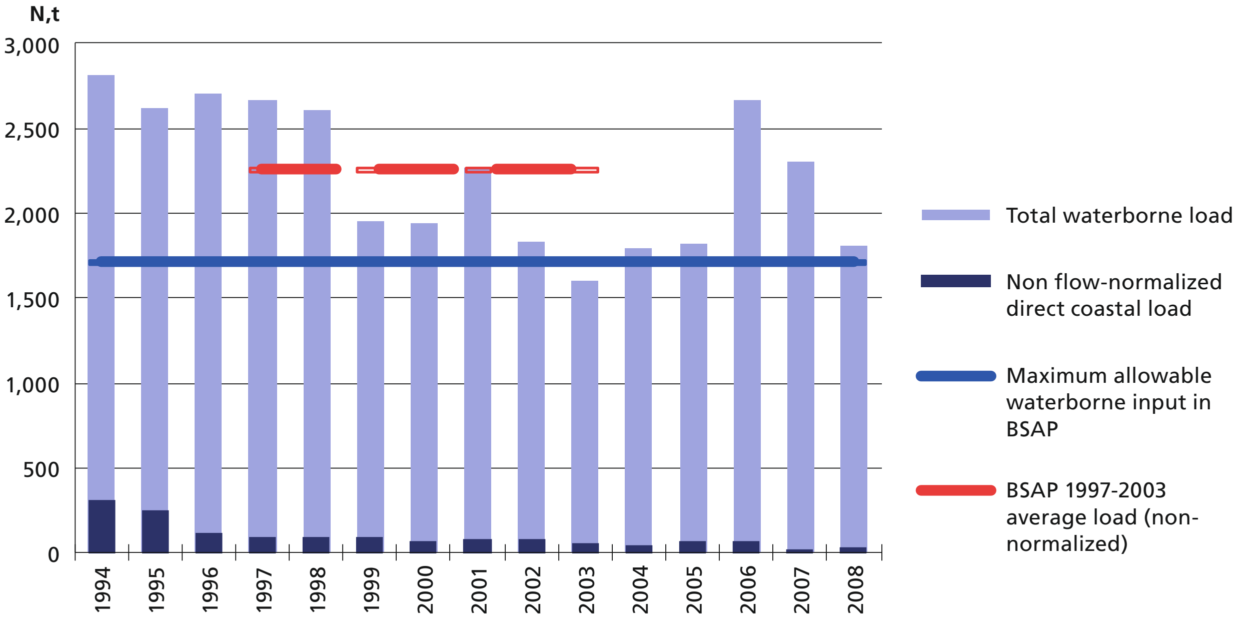


2000	2001	2002	2003	2004	2005	2006	2007	2008
53,937	53,307	53,953	44,518	54,075	45,769	56,311	43,419	32,097
3,227	2,958	3,330	2,474	2,676	2,563	2,731	2,699	2,167
57,164	56,265	57,284	46,992	56,751	48,332	59,042	46,118	34,264

2000	2001	2002	2003	2004	2005	2006	2007	2008
1,379	1,438	1,359	1,202	1,281	1,604	1,284	1,534	1,384
408	362	425	276	291	285	314	299	315
1,787	1,800	1,785	1,478	1,572	1,889	1,598	1,833	1,699

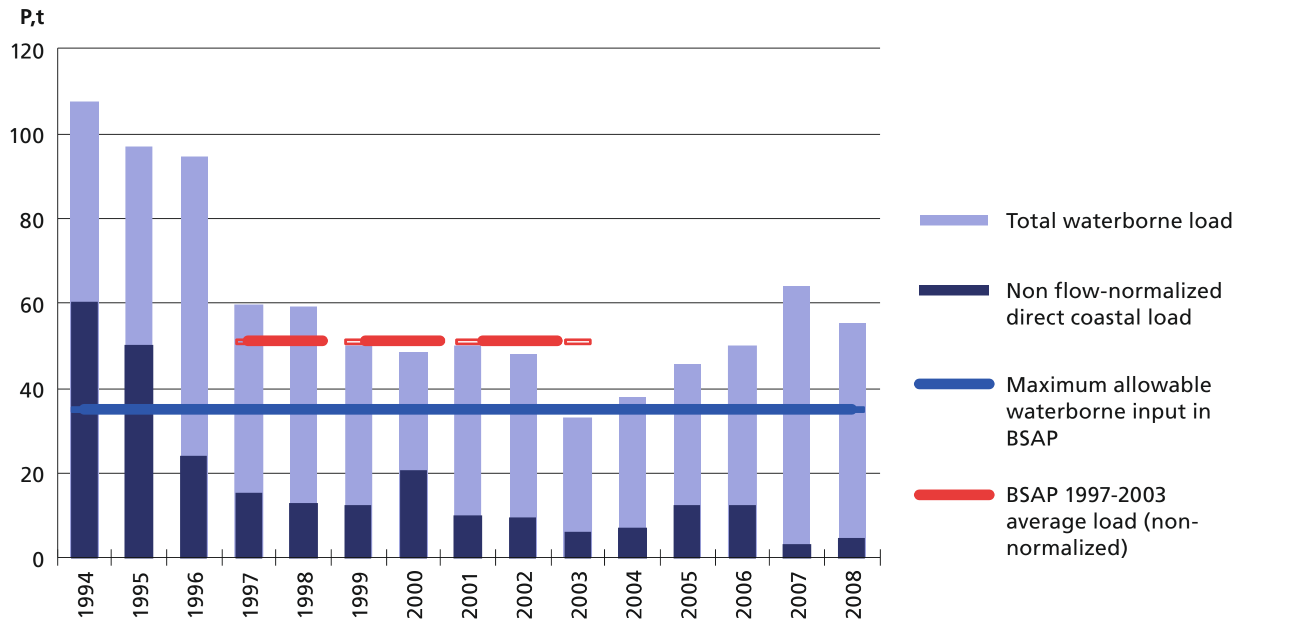
DENMARK: BALTIC PROPER

Total flow-normalized waterborne load of nitrogen (in tonnes) from Denmark to the Baltic Proper, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	2,498	2,362	2,586	2,580	2,504	1,869
Non flow-normalized direct coastal loads	310	252	112	90	97	87
Total waterborne loads	2,808	2,614	2,698	2,669	2,601	1,956
Maximum allowable waterborne input in BSAP	1,715	1,715	1,715	1,715	1,715	1,715
BSAP 1997-2003 average load (non-normalized)				2,257	2,257	2,257
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	47	47	71	44	46	37
Non flow-normalized direct coastal loads	60	50	24	15	13	13
Total waterborne loads	107	97	95	60	59	50
Maximum allowable waterborne input in BSAP	35	35	35	35	35	35
BSAP 1997-2003 average load (non-normalized)				51	51	51

Total flow-normalized waterborne load of phosphorus (in tonnes) from Denmark to the Baltic Proper, 1994-2008

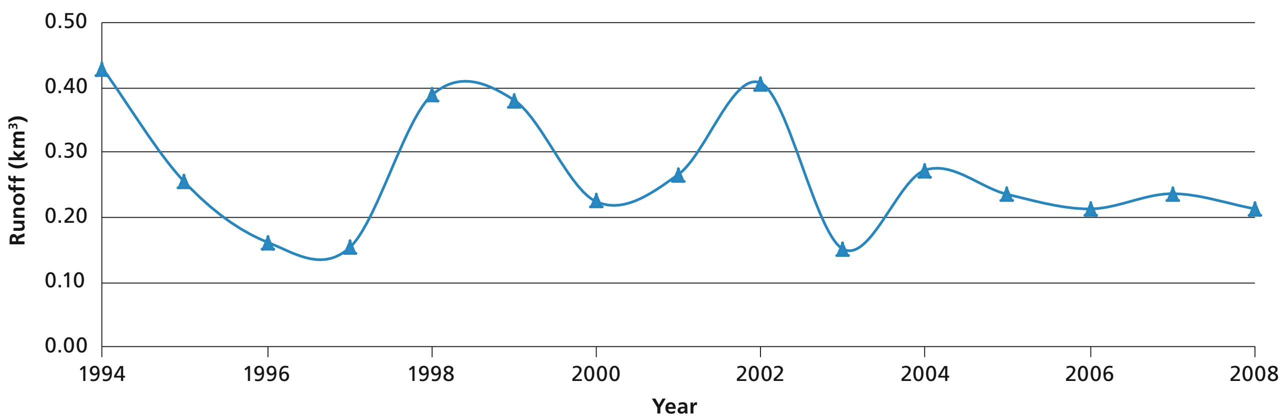


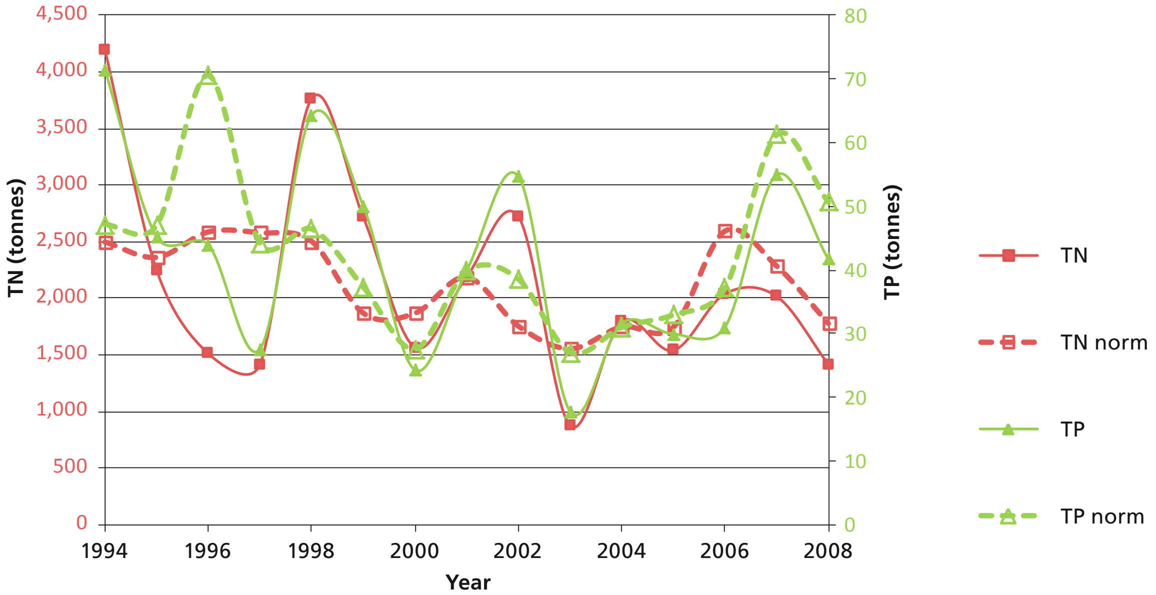
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	1,869	2,187	1,755	1,554	1,747	1,745	2,594	2,285	1,778
	69	76	77	50	43	72	72	16	31
	1,938	2,263	1,832	1,605	1,790	1,817	2,666	2,301	1,809
	1,715	1,715	1,715	1,715	1,715	1,715	1,715	1,715	1,715
	2,257	2,257	2,257	2,257					

	2000	2001	2002	2003	2004	2005	2006	2007	2008
	28	40	39	27	31	33	37	61	51
	21	10	9	6	7	13	13	3	5
	48	50	48	33	38	46	50	64	56
	35	35	35	35	35	35	35	35	35
	51	51	51	51					

DK_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	0.43	4,196.76	71.48	2,498.18	47.16	-0.37	3.62	1.85
1995	0.25	2,250.94	45.21	2,362.09	47.00	-0.59	3.35	1.66
1996	0.16	1,512.19	43.98	2,586.25	70.58	-0.79	3.18	1.64
1997	0.15	1,416.39	27.59	2,579.51	44.16	-0.82	3.15	1.44
1998	0.39	3,764.82	64.32	2,503.61	46.44	-0.41	3.58	1.81
1999	0.38	2,716.47	50.04	1,869.13	37.35	-0.42	3.43	1.70
2000	0.22	1,566.92	24.30	1,868.73	27.57	-0.65	3.20	1.39
2001	0.27	2,190.57	39.90	2,187.02	39.85	-0.57	3.34	1.60
2002	0.41	2,721.89	54.70	1,754.71	38.57	-0.39	3.43	1.74
2003	0.15	876.82	17.81	1,554.35	27.05	-0.82	2.94	1.25
2004	0.27	1,794.97	31.63	1,747.35	31.00	-0.56	3.25	1.50
2005	0.24	1,539.26	29.95	1,745.02	32.95	-0.63	3.19	1.48
2006	0.21	2,040.34	31.04	2,594.27	37.15	-0.67	3.31	1.49
2007	0.24	2,016.72	54.95	2,285.14	61.23	-0.63	3.30	1.74
2008	0.21	1,416.58	41.71	1,778.28	50.64	-0.67	3.15	1.62

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

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4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
TN (tonnes)
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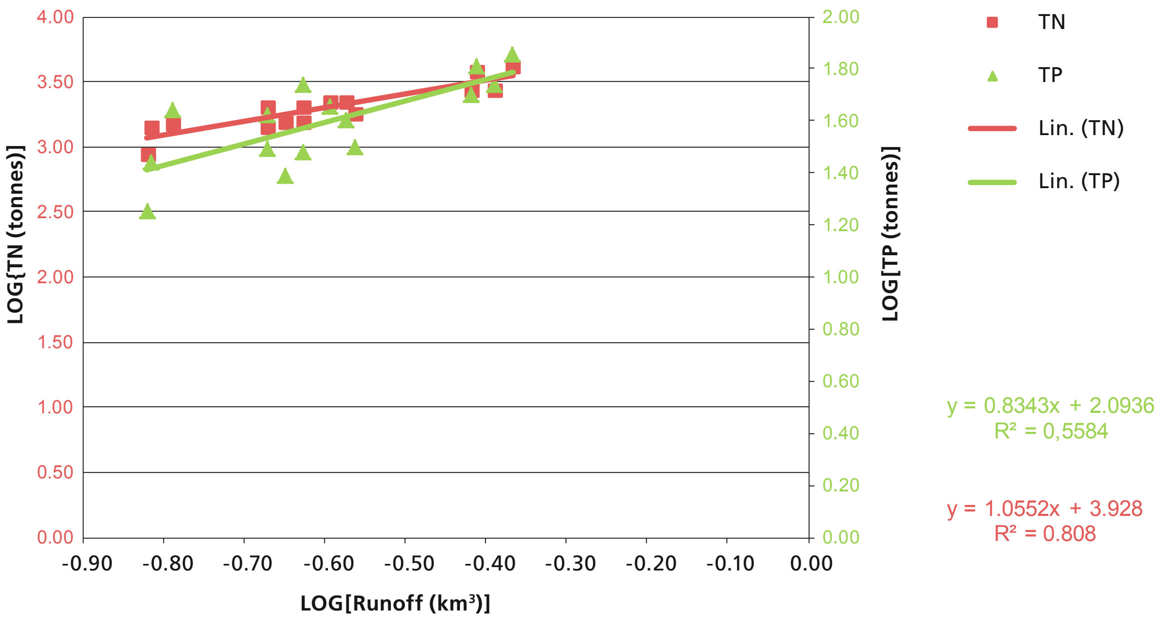
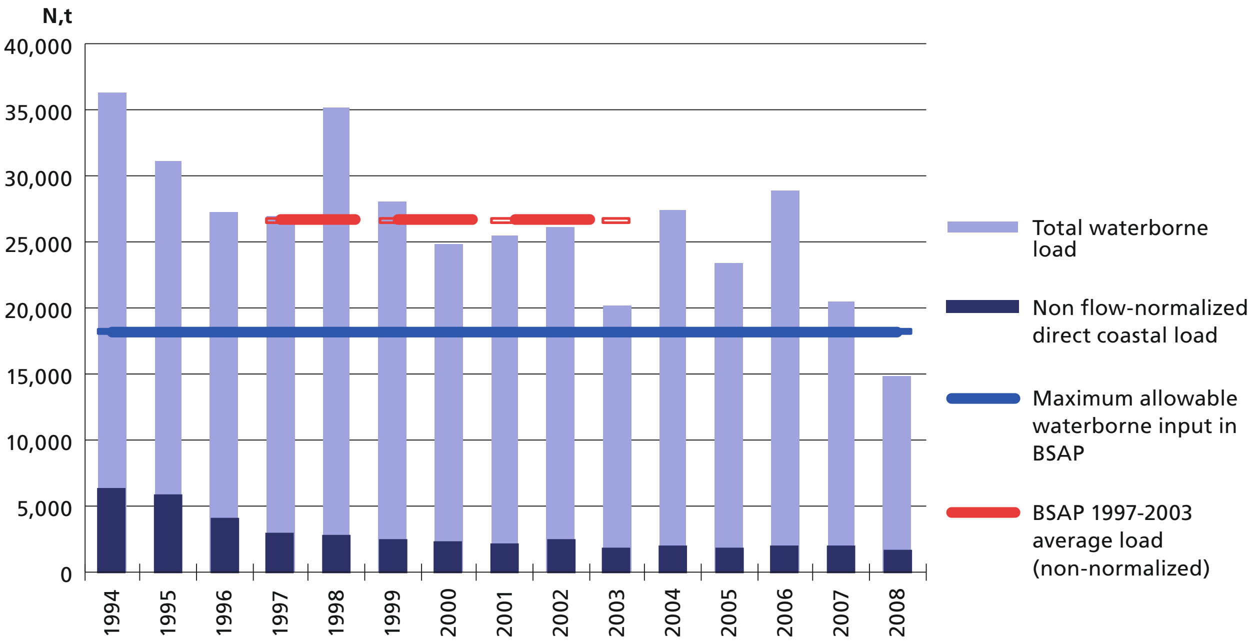
70
60
50
40
30
20
10
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
LOG[TN (tonnes)]
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
LOG[TP (tonnes)]
-0.90
-0.80
-0.70
-0.60
-0.50
-0.40
-0.30
-0.20
-0.10
0.00
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.8343x + 2.0936
R² = 0,5584
y = 1.0552x + 3.928
R² = 0.808

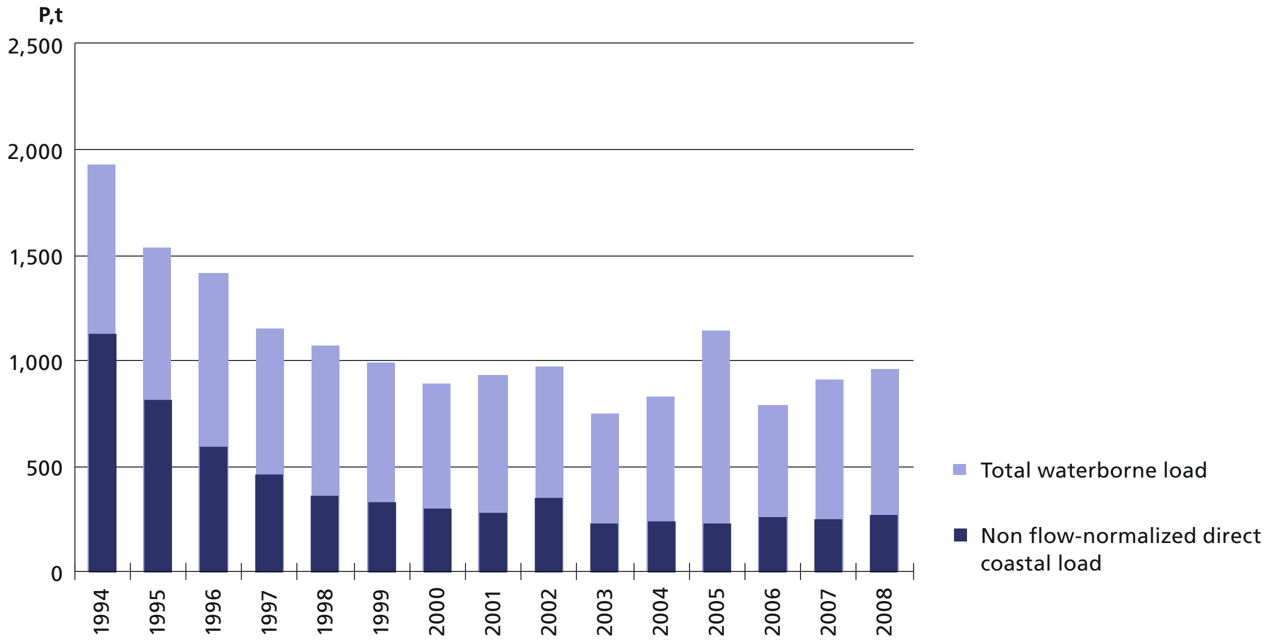
DENMARK: DANISH STRAITS

Total flow-normalized waterborne load of nitrogen (in tonnes) from Denmark to the Danish Straits, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	29,961	25,385	23,230	23,981	32,362	25,514
Non flow-normalized direct coastal loads	6,377	5,879	4,131	3,075	2,854	2,540
Total waterborne loads	36,338	31,264	27,361	27,056	35,217	28,053
Maximum allowable waterborne input in BSAP	18,211	18,211	18,211	18,211	18,211	18,211
BSAP 1997-2003 average load (non-normalized)				26,697	26,697	26,697
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	797	720	820	695	707	661
Non flow-normalized direct coastal loads	1,131	818	595	460	360	330
Total waterborne loads	1,928	1,538	1,415	1,155	1,067	990
Maximum allowable waterborne input in BSAP	0	0	0	0	0	0
BSAP 1997-2003 average load (non-normalized)				0	0	0

Total flow-normalized waterborne load of phosphorus (in tonnes) from Denmark to the Danish Straits, 1994-2008

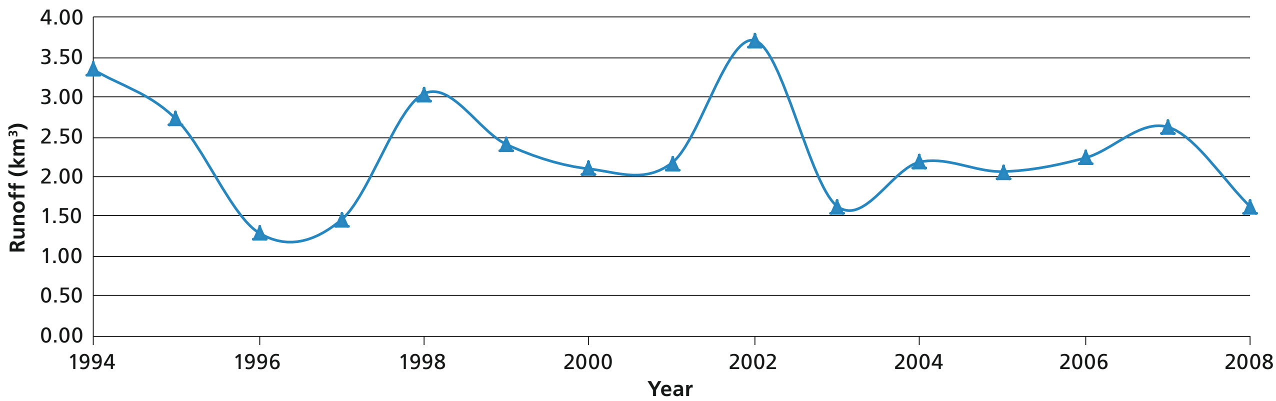


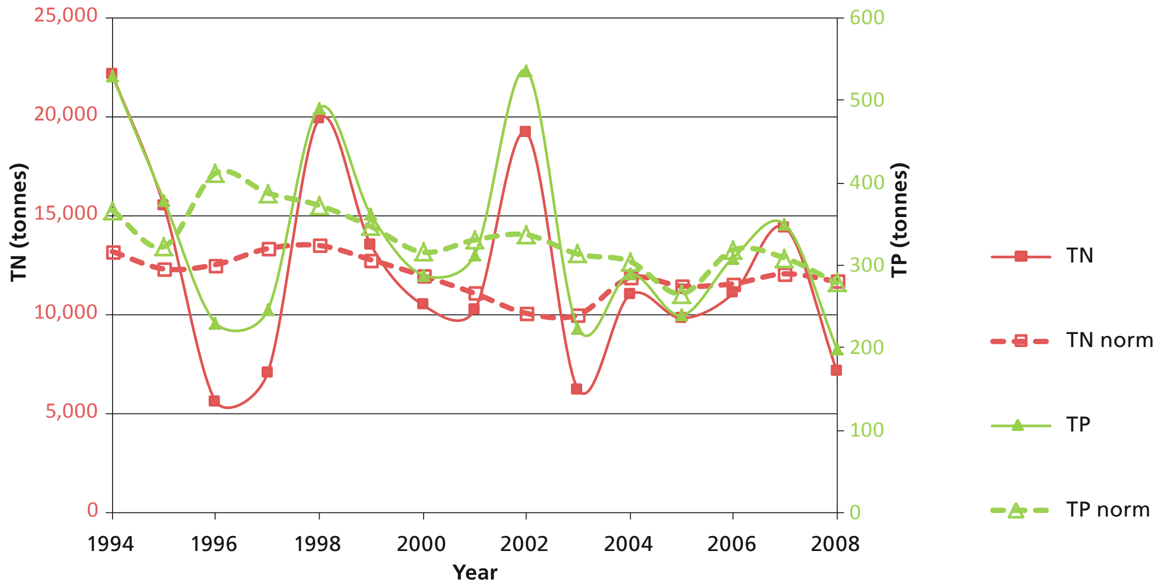
2000	2001	2002	2003	2004	2005	2006	2007	2008
22,450	23,309	23,722	18,295	25,365	21,647	26,971	18,445	13,202
2,367	2,149	2,468	1,932	2,039	1,858	2,025	2,097	1,715
24,818	25,458	26,190	20,227	27,404	23,504	28,996	20,542	14,917
18,211	18,211	18,211	18,211	18,211	18,211	18,211	18,211	18,211
26,697	26,697	26,697	26,697					

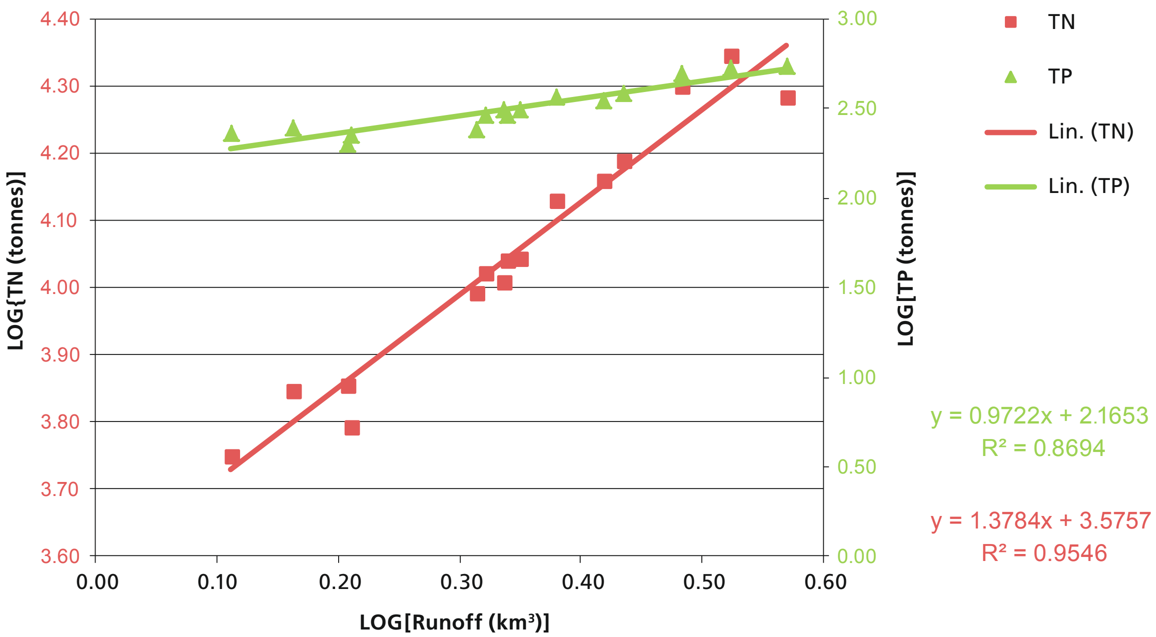
2000	2001	2002	2003	2004	2005	2006	2007	2008
593	642	627	523	588	918	528	666	686
297	283	345	227	235	229	257	244	270
890	926	972	750	824	1,146	785	909	957
0	0	0	0	0	0	0	0	0
0	0	0	0					

DK_DANISH STRAITS	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	3.34	22,134.00	529.50	13,187.20	366.50	0.52	4.35	2.72
1995	2.72	15,476.70	378.36	12,309.02	322.31	0.43	4.19	2.58
1996	1.29	5,620.10	229.62	12,525.98	411.66	0.11	3.75	2.36
1997	1.46	7,029.62	244.98	13,332.77	387.49	0.16	3.85	2.39
1998	3.04	19,883.04	490.57	13,491.22	372.39	0.48	4.30	2.69
1999	2.40	13,514.89	360.88	12,767.26	346.66	0.38	4.13	2.56
2000	2.10	10,490.68	287.94	11,965.43	315.70	0.32	4.02	2.46
2001	2.17	10,220.31	312.10	11,077.15	330.49	0.34	4.01	2.49
2002	3.71	19,177.21	535.89	10,068.29	336.80	0.57	4.28	2.73
2003	1.63	6,221.75	223.57	9,987.85	313.23	0.21	3.79	2.35
2004	2.18	10,995.96	289.09	11,852.31	304.58	0.34	4.04	2.46
2005	2.06	9,822.20	238.96	11,444.75	265.21	0.31	3.99	2.38
2006	2.24	11,072.98	308.96	11,558.46	318.43	0.35	4.04	2.49
2007	2.62	14,403.97	349.10	12,061.28	308.51	0.42	4.16	2.54
2008	1.62	7,159.33	198.86	11,674.52	278.13	0.21	3.85	2.30

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

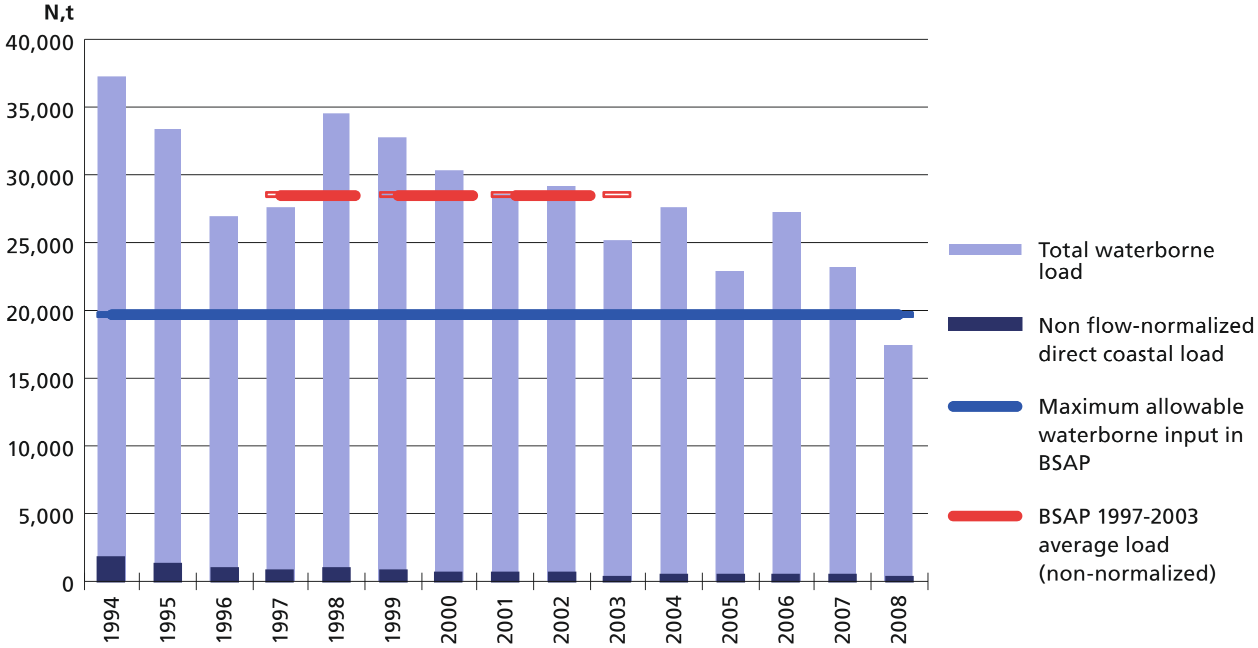



25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
600
500
400
300
200
100
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


4.40
4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
LOG{TN (tonnes)]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
LOG[TP (tonnes)]
0.00
0.10
0.20
0.30
0.40
0.50
0.60
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.9722x + 2.1653
R² = 0.8694
y = 1.3784x + 3.5757
R² = 0.9546

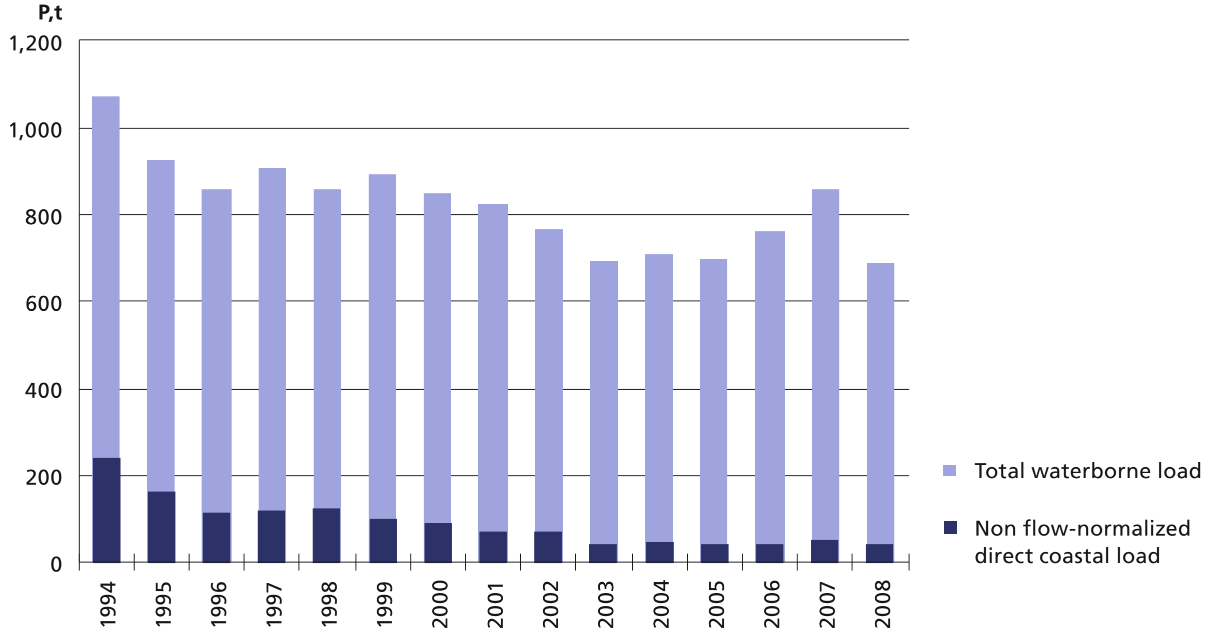
DENMARK: KATTEGAT

Total flow-normalized waterborne load of nitrogen (in tonnes) from Denmark to the Kattegat, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	35,473	32,044	25,844	26,608	33,610	31,951
Non flow-normalized direct coastal loads	1,828	1,406	1,076	978	1,031	851
Total waterborne loads	37,301	33,450	26,920	27,586	34,642	32,803
Maximum allowable waterborne input in BSAP	19,726	19,726	19,726	19,726	19,726	19,726
BSAP 1997-2003 average load (non-normalized)				28,547	28,547	28,547
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	832	763	744	791	732	793
Non flow-normalized direct coastal loads	239	164	117	117	125	99
Total waterborne loads	1,071	928	860	909	857	891
Maximum allowable waterborne input in BSAP	0	0	0	0	0	0
BSAP 1997-2003 average load (non-normalized)				0	0	0

Total flow-normalized waterborne load of phosphorus (in tonnes) from Denmark to the Kattegat, 1994-2008

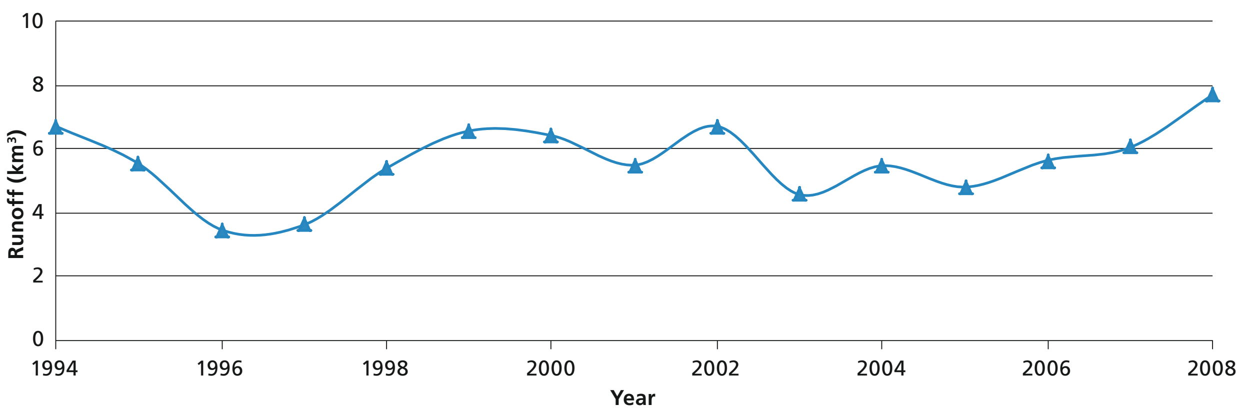


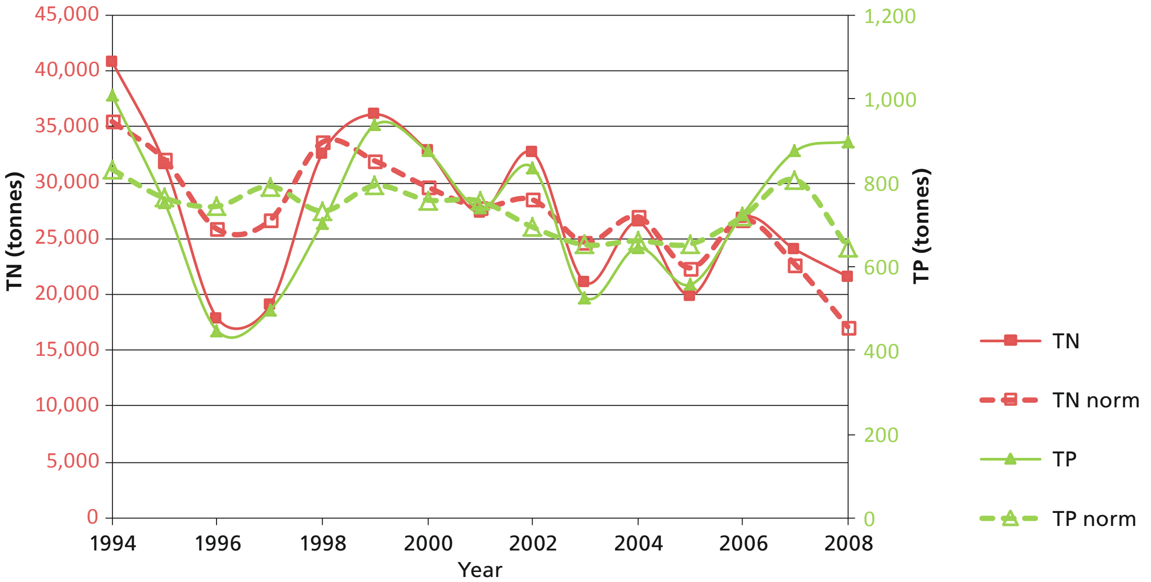
2000	2001	2002	2003	2004	2005	2006	2007	2008
29,618	27,811	28,477	24,669	26,963	22,377	26,746	22,689	17,117
790	734	785	492	594	633	633	586	421
30,408	28,544	29,262	25,161	27,557	23,010	27,379	23,275	17,538
19,726	19,726	19,726	19,726	19,726	19,726	19,726	19,726	19,726
28,547	28,547	28,547	28,547					

2000	2001	2002	2003	2004	2005	2006	2007	2008
759	756	694	652	662	653	720	807	647
90	68	71	43	49	44	44	52	40
849	824	765	695	710	697	763	860	687
0	0	0	0	0	0	0	0	0
0	0	0	0					

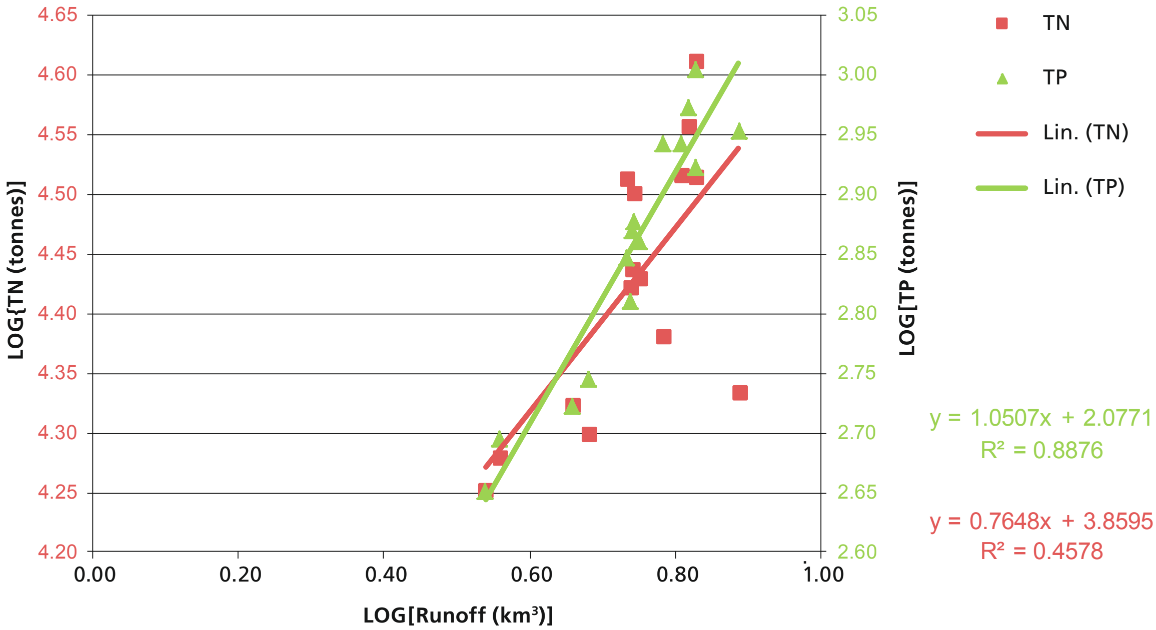
DK KATTEGAT	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	6.71	40,846.90	1,008.24	35,472.87	831.71	0.83	4.61	3.00
1995	5.53	31,704.40	752.37	32,044.48	763.37	0.74	4.50	2.88
1996	3.46	17,889.08	447.00	25,844.40	743.68	0.54	4.25	2.65
1997	3.61	19,009.84	495.44	26,607.72	791.33	0.56	4.28	2.69
1998	5.39	32,598.57	702.68	33,610.14	732.18	0.73	4.51	2.85
1999	6.57	36,117.62	937.31	31,951.13	792.57	0.82	4.56	2.97
2000	6.42	32,861.37	874.68	29,617.95	758.66	0.81	4.52	2.94
2001	5.49	27,362.91	739.35	27,810.79	756.07	0.74	4.44	2.87
2002	6.71	32,685.01	836.76	28,477.18	694.11	0.83	4.51	2.92
2003	4.56	21,090.80	526.62	24,669.03	651.95	0.66	4.32	2.72
2004	5.47	26,461.14	644.90	26,962.80	661.50	0.74	4.42	2.81
2005	4.80	19,913.19	556.51	22,377.22	653.42	0.68	4.30	2.75
2006	5.64	26,867.23	724.03	26,746.14	719.56	0.75	4.43	2.86
2007	6.05	24,018.69	875.04	22,688.63	807.09	0.78	4.38	2.94
2008	7.71	21,594.23	897.94	17,116.90	646.83	0.89	4.33	2.95

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





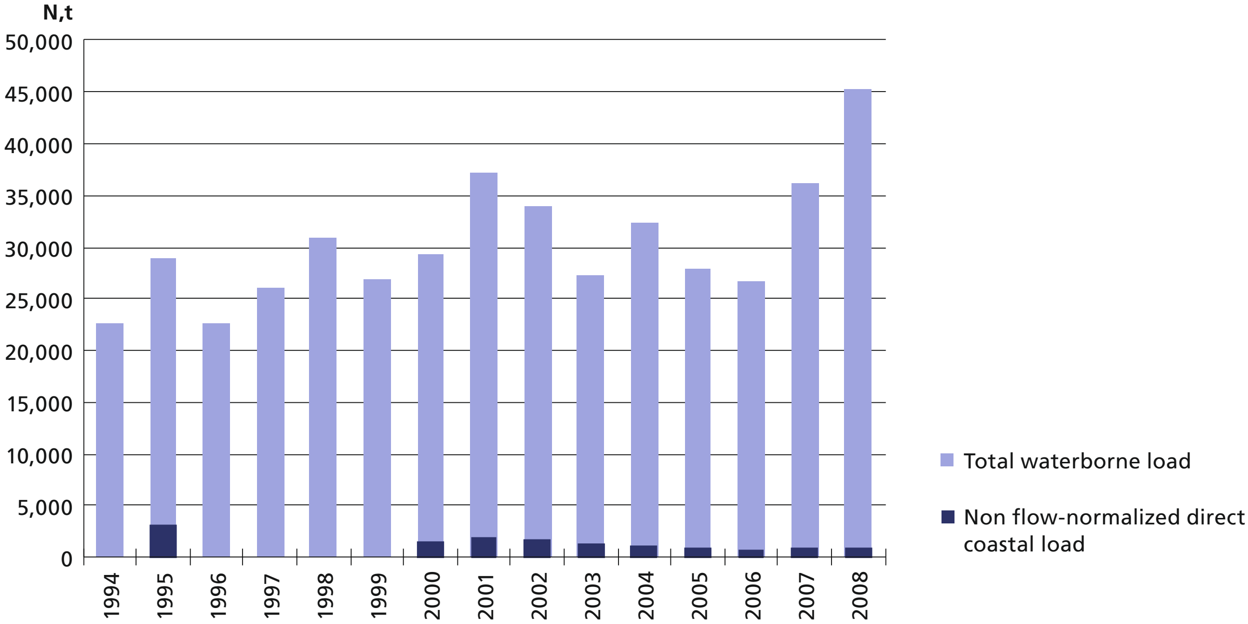
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
1,200
1,000
800
600
400
200
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
LOG[TN (tonnes)]
3.05
3.00
2.95
2.90
2.85
2.80
2.75
2.70
2.65
2.60
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.0507x + 2.0771
R² = 0.8876
y = 0.7648x + 3.8595
R² = 0.4578

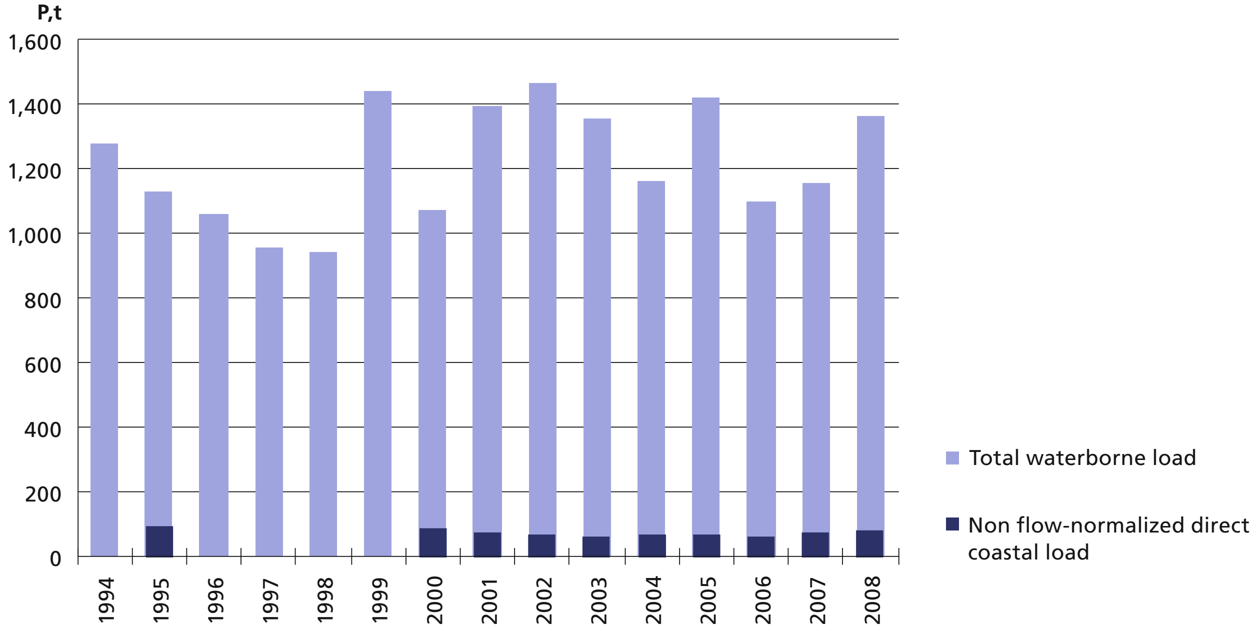
2. ESTONIA: TOTAL

Total flow-normalized waterborne load of nitrogen (in tonnes) from Estonia to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	22,654	25,584	22,582	26,157	30,952	26,946
Non flow-normalized direct coastal loads	0	3,225	0	0	0	0
Total waterborne loads	22,654	28,809	22,582	26,157	30,952	26,946
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,281	1,034	1,061	959	946	1,441
Non flow-normalized direct coastal loads	0	95	0	0	0	0
Total waterborne loads	1,281	1,129	1,061	959	946	1,441

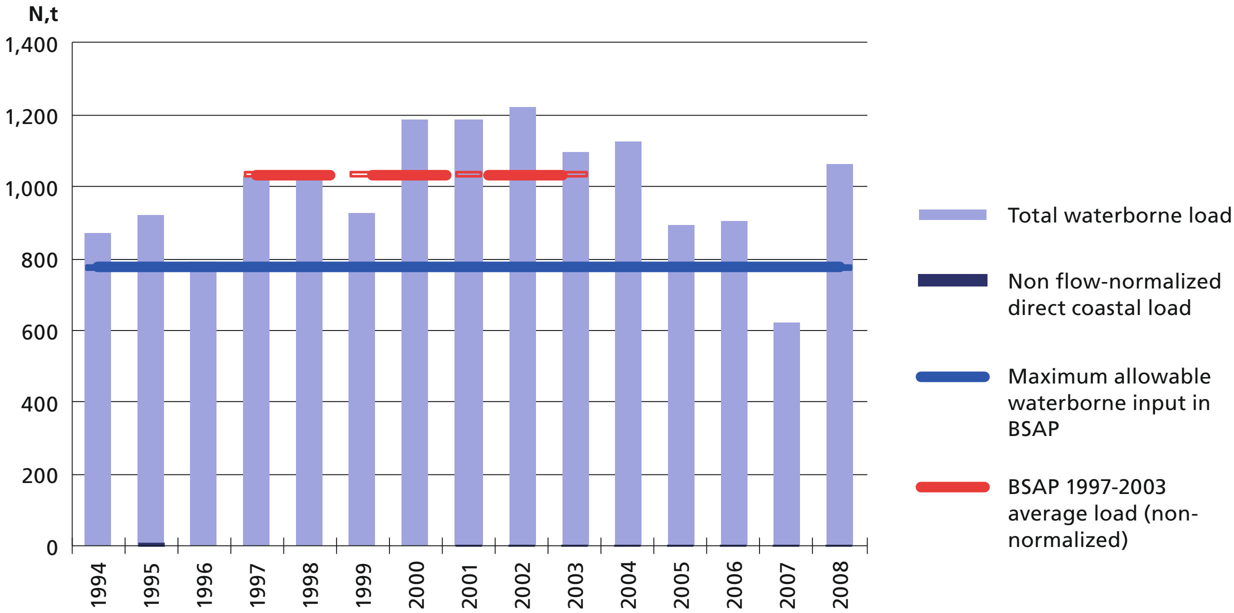
Total flow-normalized waterborne load of phosphorus (in tonnes) from Estonia to the Baltic Sea, 1994-2008



2000	2001	2002	2003	2004	2005	2006	2007	2008
27,629	35,358	32,374	25,942	31,104	26,900	26,114	35,320	44,247
1,601	1,857	1,642	1,332	1,152	952	639	895	921
29,230	37,215	34,015	27,275	32,256	27,852	26,753	36,216	45,168
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
982	1,321	1,403	1,296	1,091	1,354	1,034	1,083	1,283
88	76	67	62	70	66	64	75	79
1,071	1,397	1,470	1,359	1,161	1,419	1,098	1,158	1,361

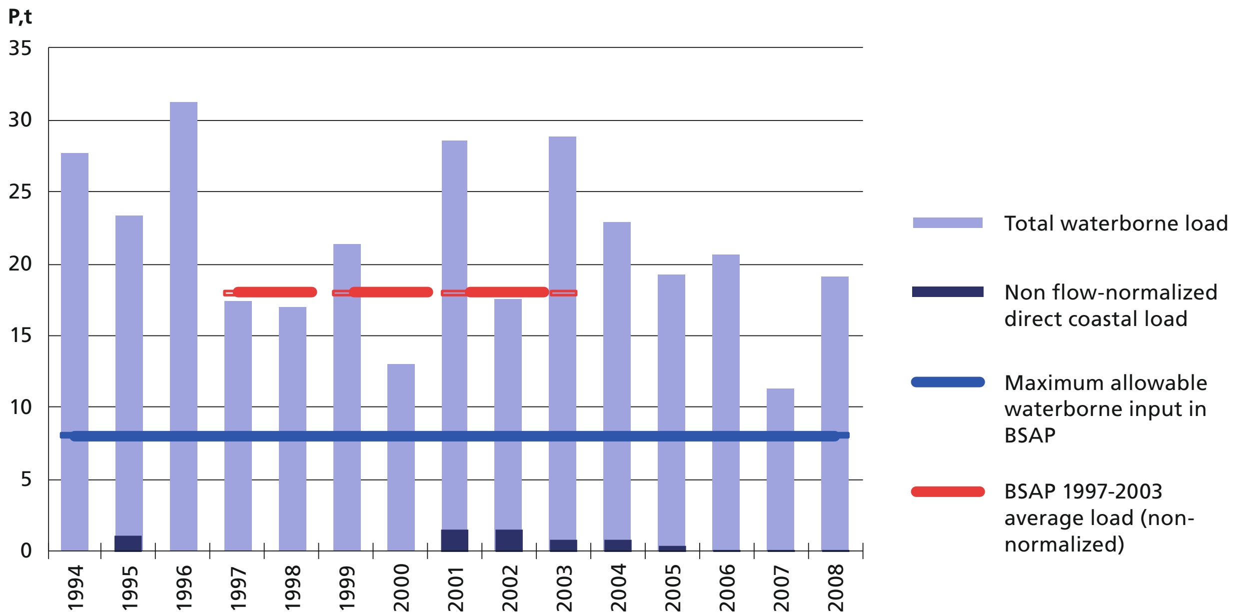
ESTONIA: BALTIC PROPER

Total flow-normalized waterborne load of nitrogen (in tonnes) from Estonia to the Baltic Proper, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	874	912	794	1,028	1,020	930
Non flow-normalized direct coastal loads	0	9	0	0	0	0
Total waterborne loads	874	921	794	1,028	1,020	930
Maximum allowable waterborne input in BSAP	777	777	777	777	777	777
BSAP 1997-2003 average load (non-normalized)				1,034	1,034	1,034
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	28	22	31	17	17	21
Non flow-normalized direct coastal loads	0	1	0	0	0	0
Total waterborne loads	28	23	31	17	17	21
Maximum allowable waterborne input in BSAP	8	8	8	8	8	8
BSAP 1997-2003 average load (non-normalized)				18	18	18

Total flow-normalized waterborne load of phosphorus (in tonnes) from Estonia to the Baltic Proper, 1994-2008

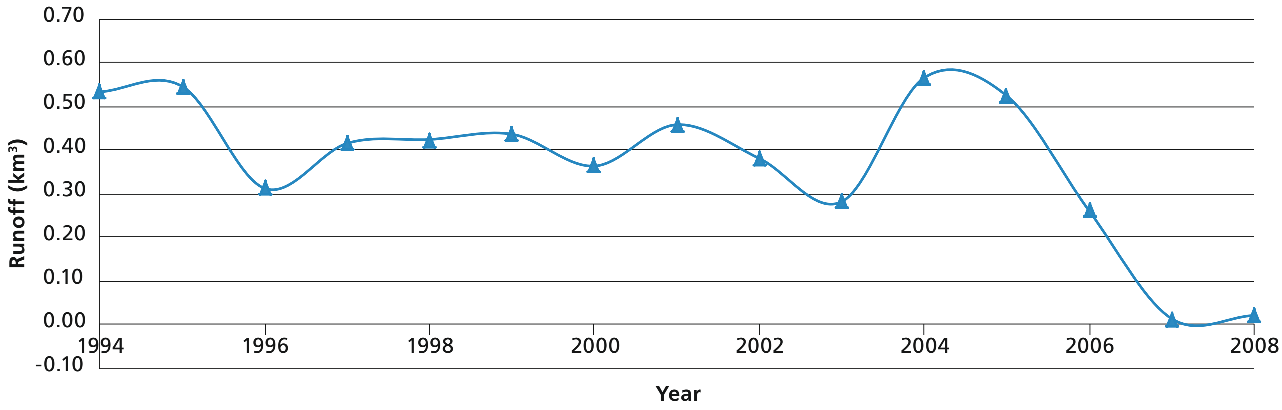


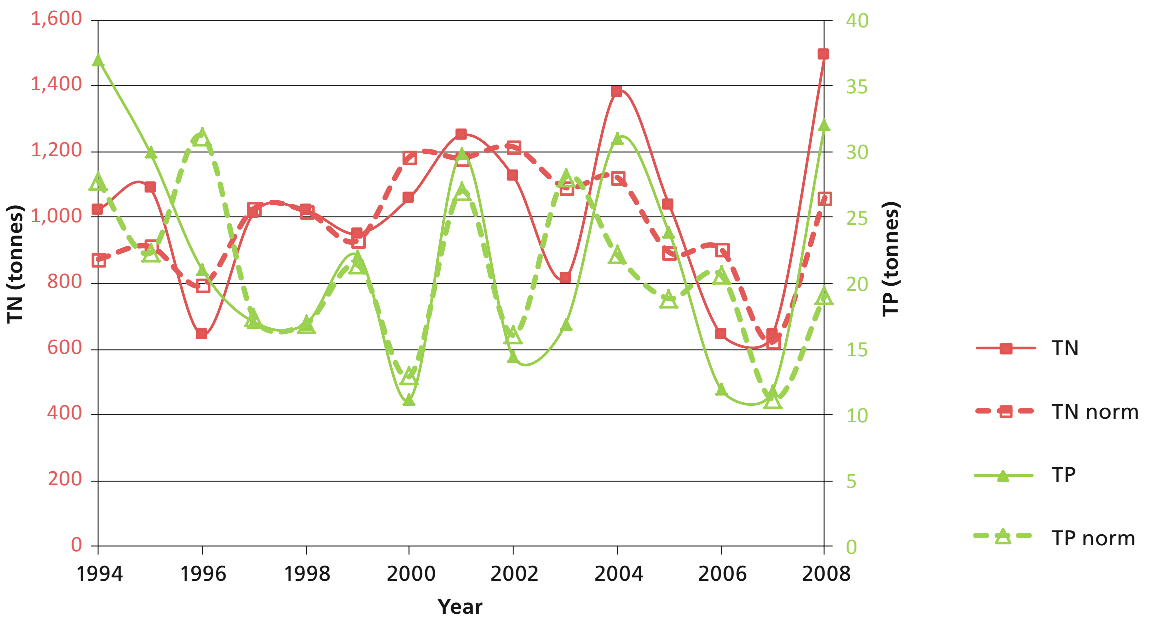
2000	2001	2002	2003	2004	2005	2006	2007	2008
1,185	1,181	1,215	1,092	1,122	895	904	623	1,061
0	4	5	4	1	1	0	0	0
1,185	1,185	1,220	1,096	1,123	896	904	623	1,062
777	777	777	777	777	777	777	777	777
1,034	1,034	1,034	1,034					

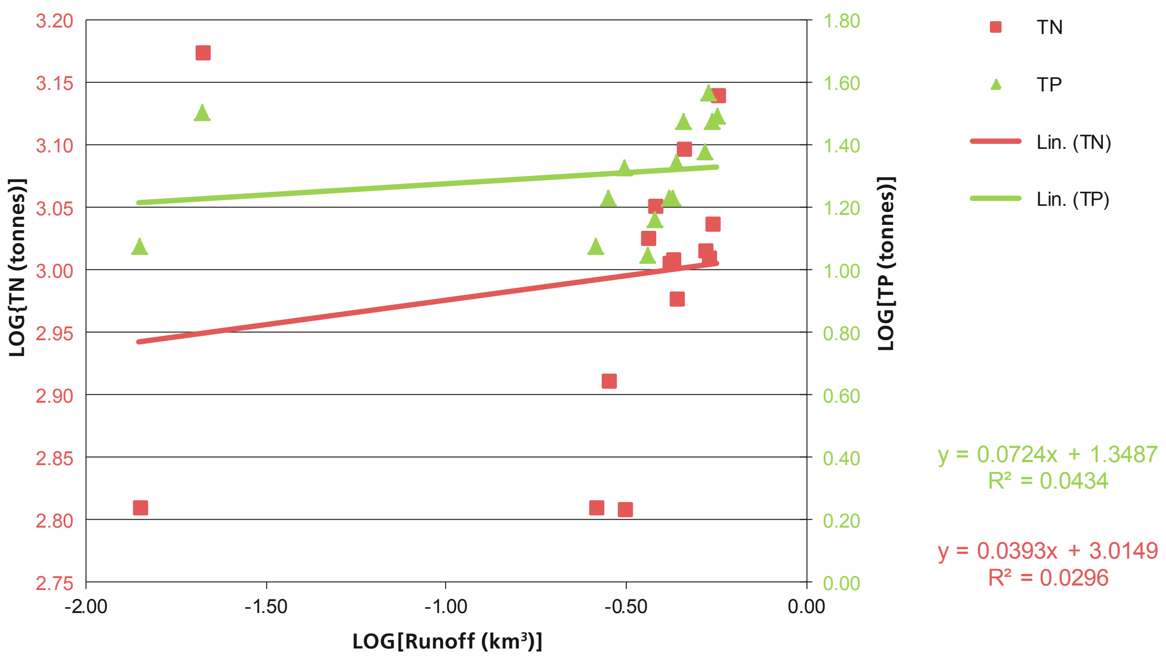
2000	2001	2002	2003	2004	2005	2006	2007	2008
13	27	16	28	22	19	21	11	19
0	2	2	1	1	0	0	0	0
13	29	18	29	23	19	21	11	19
8	8	8	8	8	8	8	8	8
18	18	18	18					

EE_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	0.53	1,025.50	37.01	873.58	27.76	-0.27	3.01	1.57
1995	0.54	1,088.64	29.94	912.15	22.30	-0.26	3.04	1.48
1996	0.31	644.47	21.07	793.92	31.21	-0.51	2.81	1.32
1997	0.42	1,014.38	17.06	1,027.65	17.40	-0.38	3.01	1.23
1998	0.42	1,021.98	16.95	1,020.19	16.91	-0.37	3.01	1.23
1999	0.44	950.43	22.14	930.45	21.38	-0.36	2.98	1.35
2000	0.36	1,061.05	11.19	1,185.06	12.95	-0.44	3.03	1.05
2001	0.46	1,251.00	29.80	1,181.23	27.02	-0.34	3.10	1.47
2002	0.38	1,125.00	14.40	1,214.99	16.07	-0.42	3.05	1.16
2003	0.28	816.00	16.90	1,091.83	28.07	-0.55	2.91	1.23
2004	0.56	1,382.00	31.00	1,122.00	22.15	-0.25	3.14	1.49
2005	0.52	1,039.00	23.86	894.95	18.85	-0.28	3.02	1.38
2006	0.26	645.89	11.94	904.15	20.63	-0.58	2.81	1.08
2007	0.014	646.00	11.90	622.89	11.19	-1.85	2.81	1.08
2008	0.021	1,493.00	32.00	1,061.20	19.08	-1.68	3.17	1.51

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

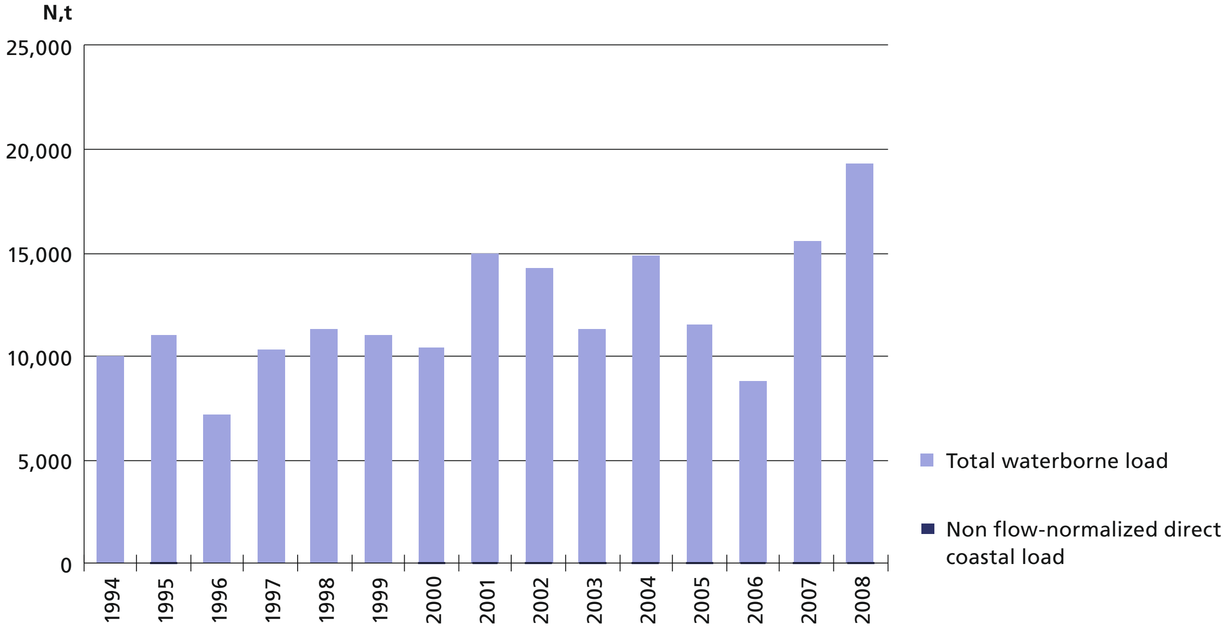



1,600
1,400
1,200
1,000
800
600
400
200
0
TN (tonnes)
40
35
30
25
20
15
10
5
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


3.20
3.15
3.10
3.05
3.00
2.95
2.90
2.85
2.80
2.75
LOG{TN (tonnes)]
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
LOG[TP (tonnes)]
-2.00
-1.50
-1.00
-0.50
0.00
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.0724x + 1.3487
R² = 0.0434
y = 0.0393x + 3.0149
R² = 0.0296

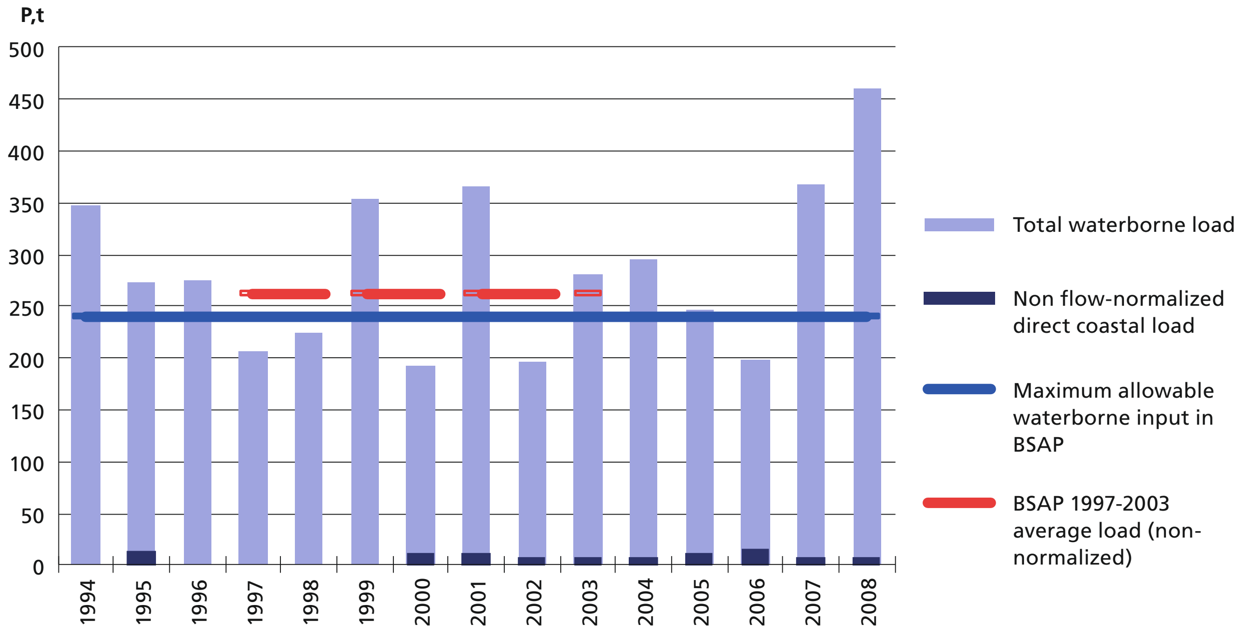
ESTONIA: GULF OF RIGA

Total flow-normalized waterborne load of nitrogen (in tonnes) from Estonia to the Gulf of Riga, 1995-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	10,018	10,924	7,166	10,257	11,331	11,015
Non flow-normalized direct coastal loads	0	85	0	0	0	0
Total waterborne loads	10,018	11,009	7,166	10,257	11,331	11,015
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	349	260	274	206	225	353
Non flow-normalized direct coastal loads	0	14	0	0	0	0
Total waterborne loads	349	273	274	206	225	353
Maximum allowable waterborne input in BSAP	240	240	240	240	240	240
BSAP 1997-2003 average load (non-normalized)				262	262	262

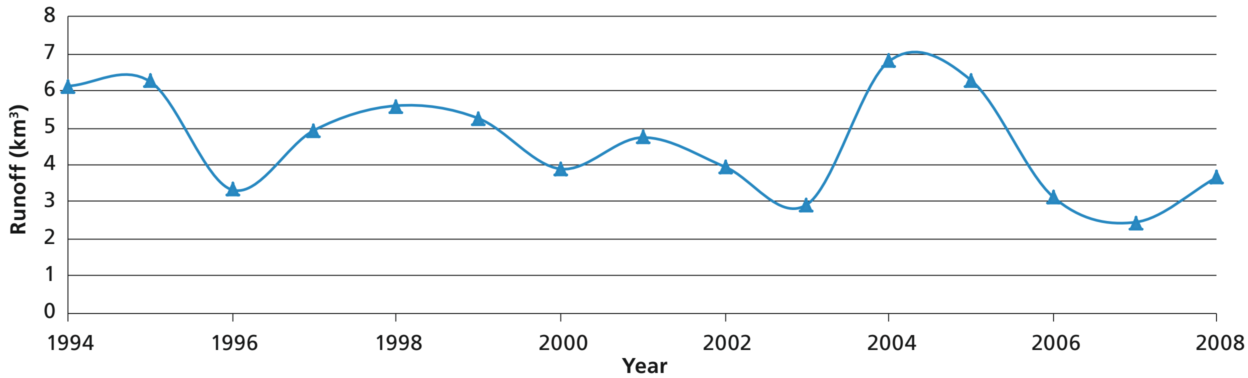
Total flow-normalized waterborne load of phosphorus (in tonnes) from Estonia to the Gulf of Riga, 1995-2008

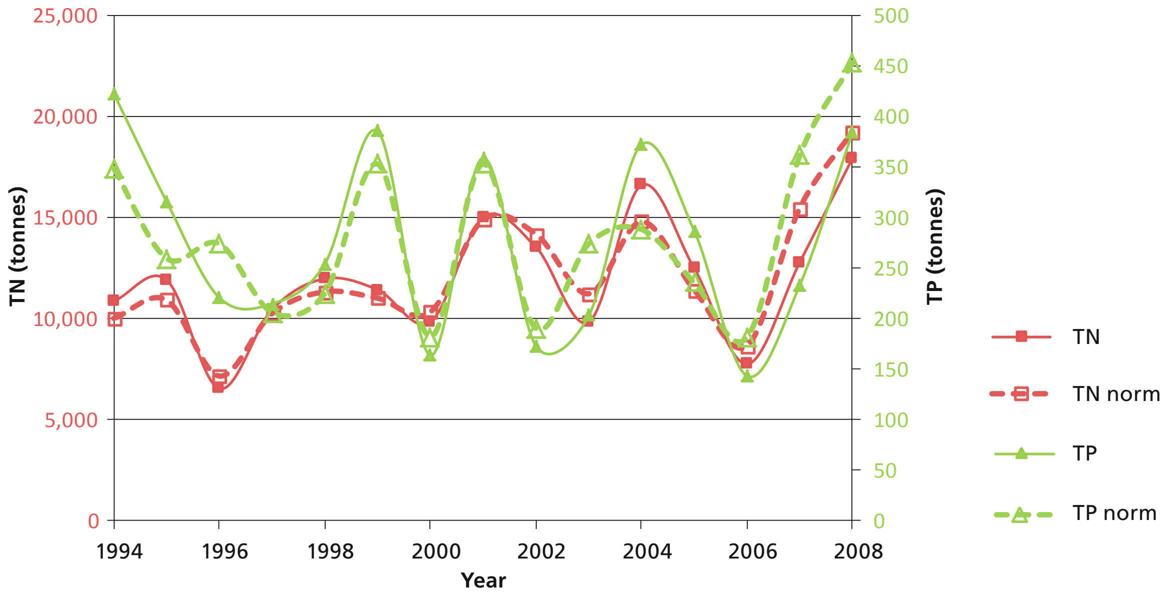


2000	2001	2002	2003	2004	2005	2006	2007	2008
10,335	14,902	14,186	11,234	14,798	11,418	8,659	15,476	19,257
73	80	75	60	63	91	92	81	69
10,408	14,982	14,261	11,293	14,861	11,509	8,750	15,557	19,325
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
182	353	190	274	288	236	182	361	453
11	12	7	8	8	12	17	7	7
193	365	197	282	296	247	198	369	461
240	240	240	240	240	240	240	240	240
262	262	262	262					

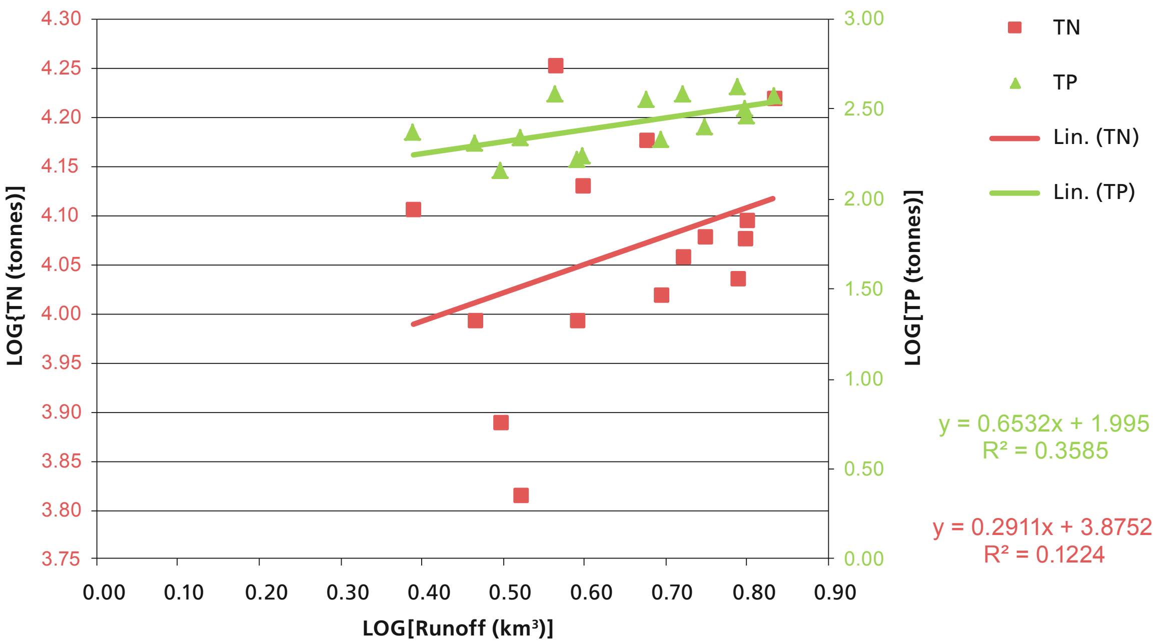
EE_GULF OF RIGA	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	6.13	10,861.03	422.68	10,018.47	348.54	0.79	4.04	2.63
1995	6.25	11,921.07	315.97	10,923.87	259.65	0.80	4.08	2.50
1996	3.32	6,542.99	220.86	7,165.62	274.13	0.52	3.82	2.34
1997	4.93	10,451.72	214.81	10,257.31	206.24	0.69	4.02	2.33
1998	5.60	11,978.58	254.16	11,331.30	225.16	0.75	4.08	2.41
1999	5.26	11,431.64	385.32	11,014.56	352.84	0.72	4.06	2.59
2000	3.89	9,835.08	163.97	10,335.31	182.12	0.59	3.99	2.21
2001	4.74	15,013.00	358.94	14,902.29	352.90	0.68	4.18	2.56
2002	3.95	13,539.00	172.93	14,186.41	190.43	0.60	4.13	2.24
2003	2.92	9,838.00	202.92	11,233.62	273.94	0.47	3.99	2.31
2004	6.80	16,602.39	372.02	14,798.34	288.27	0.83	4.22	2.57
2005	6.29	12,484.60	286.71	11,418.24	235.63	0.80	4.10	2.46
2006	3.13	7,760.61	143.42	8,658.59	181.62	0.50	3.89	2.16
2007	2.45	12,790.00	233.31	15,475.64	361.32	0.39	4.11	2.37
2008	3.67	17,944.00	384.40	19,256.53	453.13	0.56	4.25	2.58

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





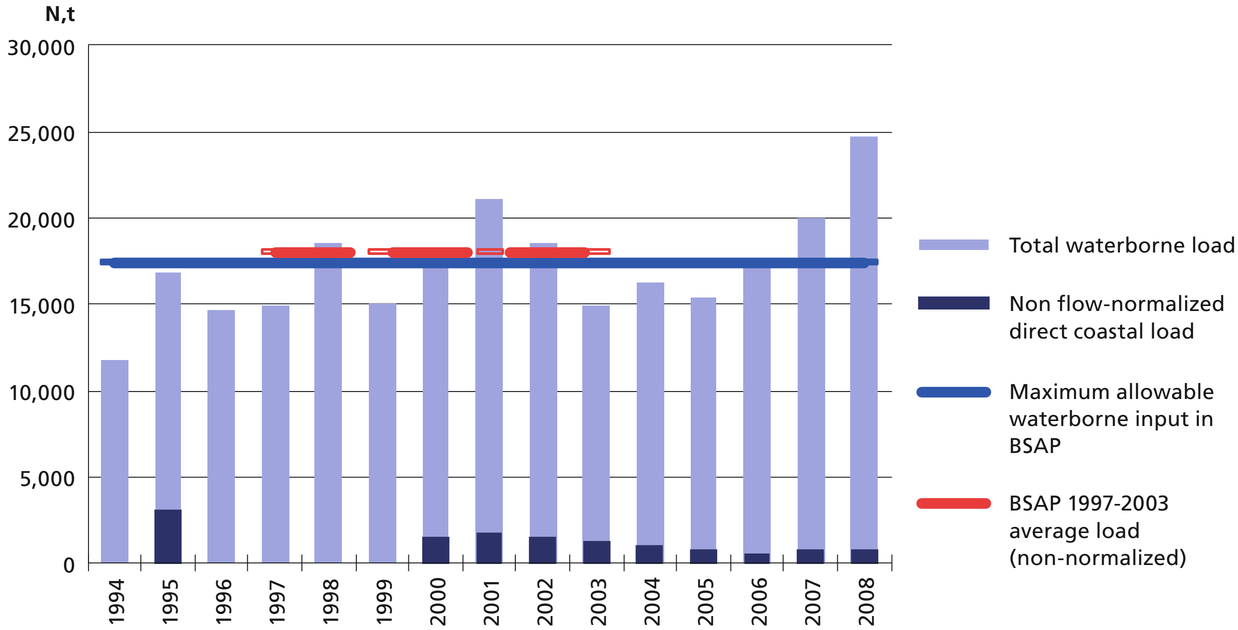
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
500
450
400
350
300
250
200
150
100
50
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.30
4.25
4.20
4.15
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
LOG{TN (tonnes)]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
LOG[TP (tonnes)]
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.6532x + 1.995
R² = 0.3585
y = 0.2911x + 3.8752
R² = 0.1224

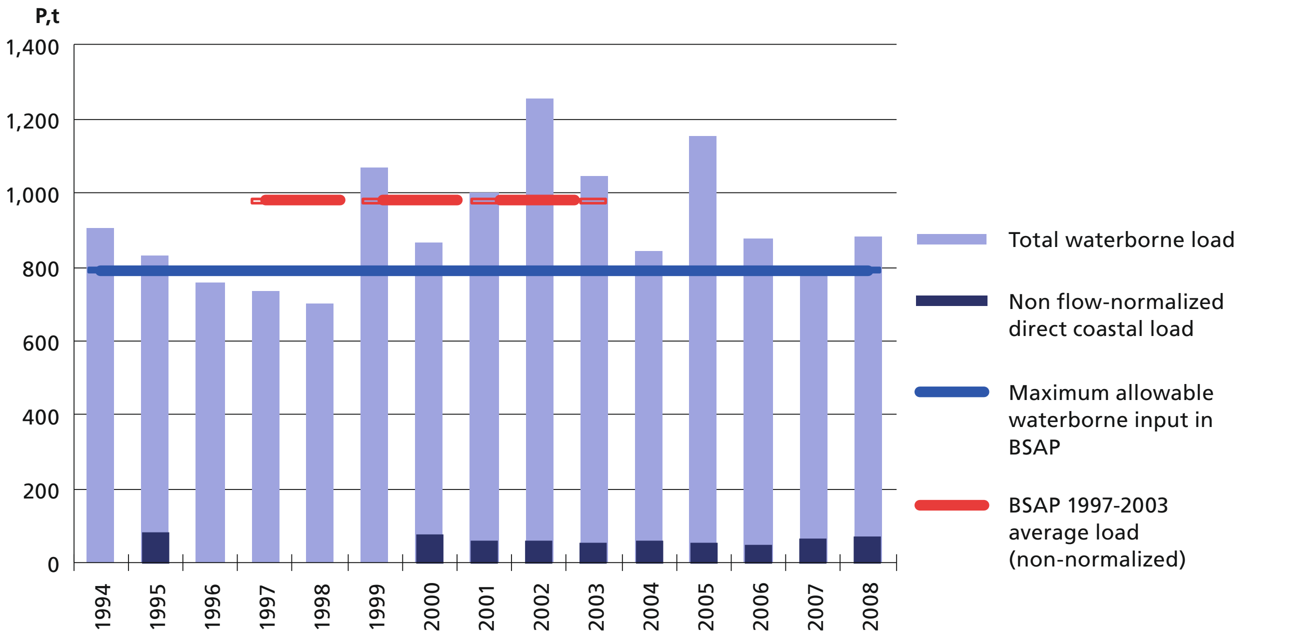
ESTONIA: GULF OF FINLAND

Total flow-normalized waterborne load of nitrogen (in tonnes) from Estonia to the Gulf of Finland, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	11,762	13,747	14,623	14,872	18,601	15,001
Non flow-normalized direct coastal loads	0	3,131	0	0	0	0
Total waterborne loads	11,762	16,879	14,623	14,872	18,601	15,001
Maximum allowable waterborne input in BSAP	17,397	17,397	17,397	17,397	17,397	17,397
BSAP 1997-2003 average load (non-normalized)				18,036	18,036	18,036
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	904	752	755	736	704	1,067
Non flow-normalized direct coastal loads	0	80	0	0	0	0
Total waterborne loads	904	832	755	736	704	1,067
Maximum allowable waterborne input in BSAP	790	790	790	790	790	790
BSAP 1997-2003 average load (non-normalized)				980	980	980

Total flow-normalized waterborne load of phosphorus (in tonnes) from Estonia to the Gulf of Finland, 1994-2008

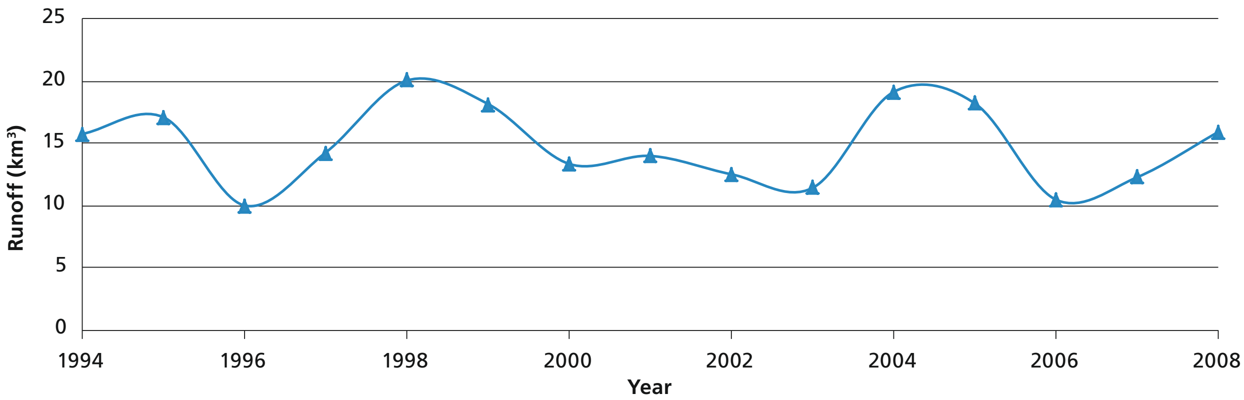


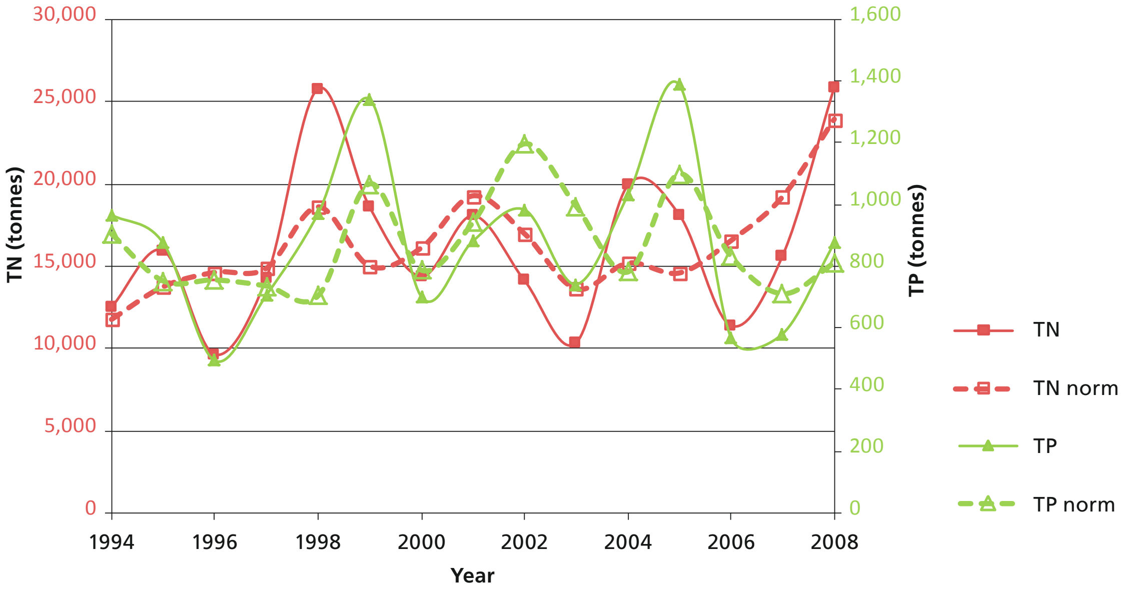
2000	2001	2002	2003	2004	2005	2006	2007	2008
16,109	19,274	16,972	13,617	15,184	14,587	16,551	19,222	23,929
1,528	1,774	1,561	1,269	1,088	859	547	814	852
17,636	21,048	18,534	14,886	16,271	15,446	17,099	20,036	24,782
17,397	17,397	17,397	17,397	17,397	17,397	17,397	17,397	17,397
18,036	18,036	18,036	18,036					

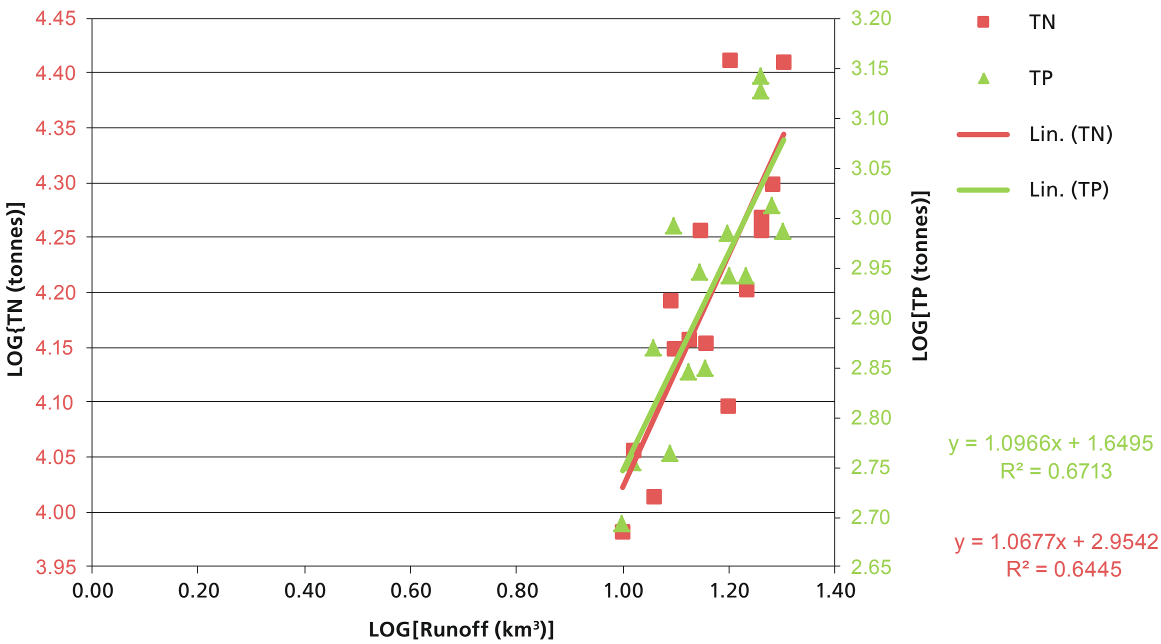
2000	2001	2002	2003	2004	2005	2006	2007	2008
787	941	1,196	994	781	1,099	831	711	810
77	62	59	54	62	54	47	67	71
864	1,003	1,255	1,048	843	1,153	879	778	881
790	790	790	790	790	790	790	790	790
980	980	980	980					

EE_GULF OF FINLAND	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	15.76	12,514.42	966.23	11,762.39	904.29	1.20	4.10	2.99
1995	17.10	15,950.28	875.22	13,747.49	751.78	1.23	4.20	2.94
1996	9.99	9,625.63	493.63	14,622.94	755.29	1.00	3.98	2.69
1997	14.28	14,271.51	705.65	14,872.19	735.69	1.15	4.15	2.85
1998	20.06	25,787.31	969.58	18,600.52	703.58	1.30	4.41	2.99
1999	18.16	18,583.27	1,340.68	15,000.56	1,066.73	1.26	4.27	3.13
2000	13.34	14,377.10	701.39	16,108.58	787.04	1.13	4.16	2.85
2001	13.99	18,071.27	881.13	19,274.47	941.10	1.15	4.26	2.95
2002	12.51	14,124.46	982.79	16,972.20	1,196.45	1.10	4.15	2.99
2003	11.42	10,341.25	741.19	13,616.95	994.19	1.06	4.01	2.87
2004	19.15	19,900.21	1,028.66	15,183.54	780.99	1.28	4.30	3.01
2005	18.21	18,108.13	1,386.75	14,587.30	1,099.16	1.26	4.26	3.14
2006	10.46	11,380.93	567.63	16,551.29	831.30	1.02	4.06	2.75
2007	12.27	15,634.91	580.39	19,221.80	710.57	1.09	4.19	2.76
2008	15.92	25,871.43	874.60	23,929.30	810.35	1.20	4.41	2.94

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

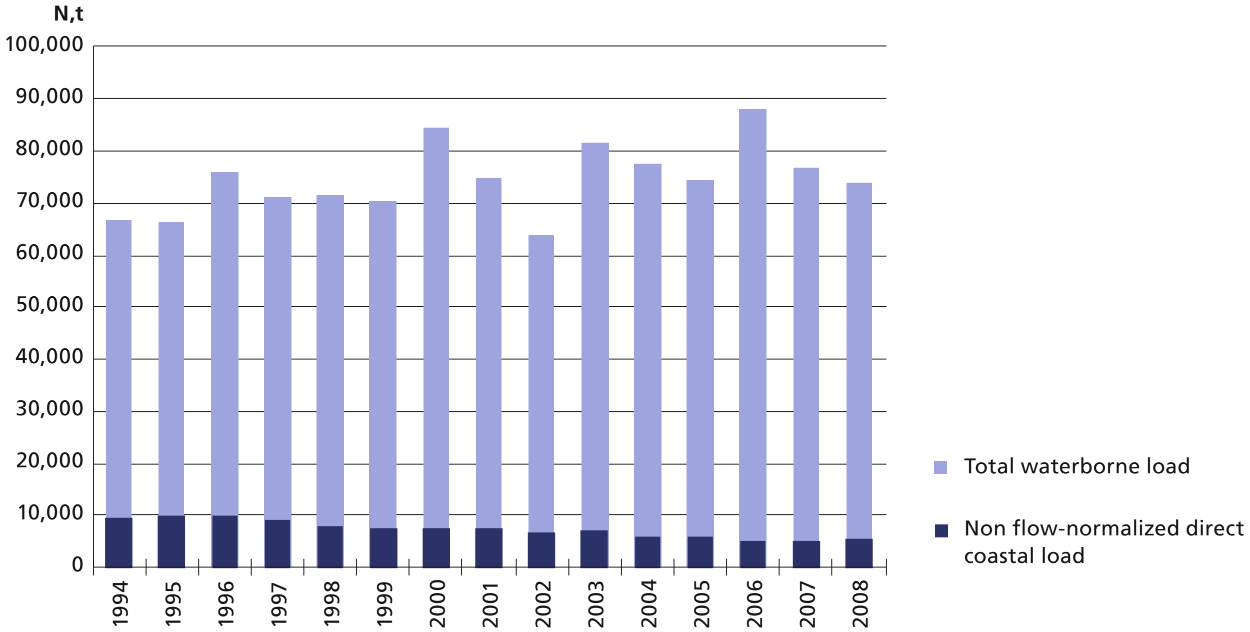



30,000
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
1,600
1,400
1,200
1,000
800
600
400
200
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


4.45
4.40
4.35
4.30
4.25
4.20
4.15
4.10
4.05
4.00
3.95
LOG{TN (tonnes)]
3.20
3.15
3.10
3.05
3.00
2.95
2.90
2.85
2.80
2.75
2.70
2.65
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.0966x + 1.6495
R² = 0.6713
y = 1.0677x + 2.9542
R² = 0.6445

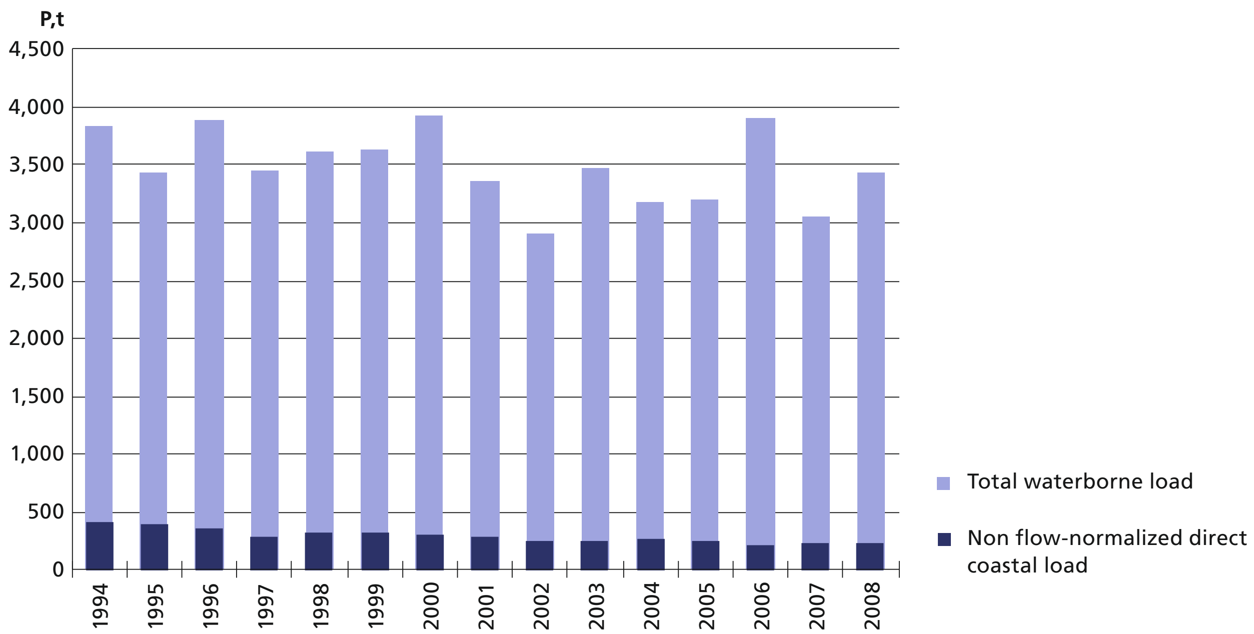
3. FINLAND: TOTAL

Total flow-normalized waterborne load of nitrogen (in tonnes) from Finland to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	56,929	56,252	65,982	61,835	63,774	62,773
Non flow-normalized direct coastal loads	9,573	9,900	9,849	9,088	7,765	7,633
Total waterborne loads	66,502	66,152	75,831	70,923	71,539	70,406
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	3,423	3,046	3,532	3,180	3,302	3,319
Non flow-normalized direct coastal loads	419	395	350	276	324	313
Total waterborne loads	3,842	3,441	3,883	3,456	3,626	3,633

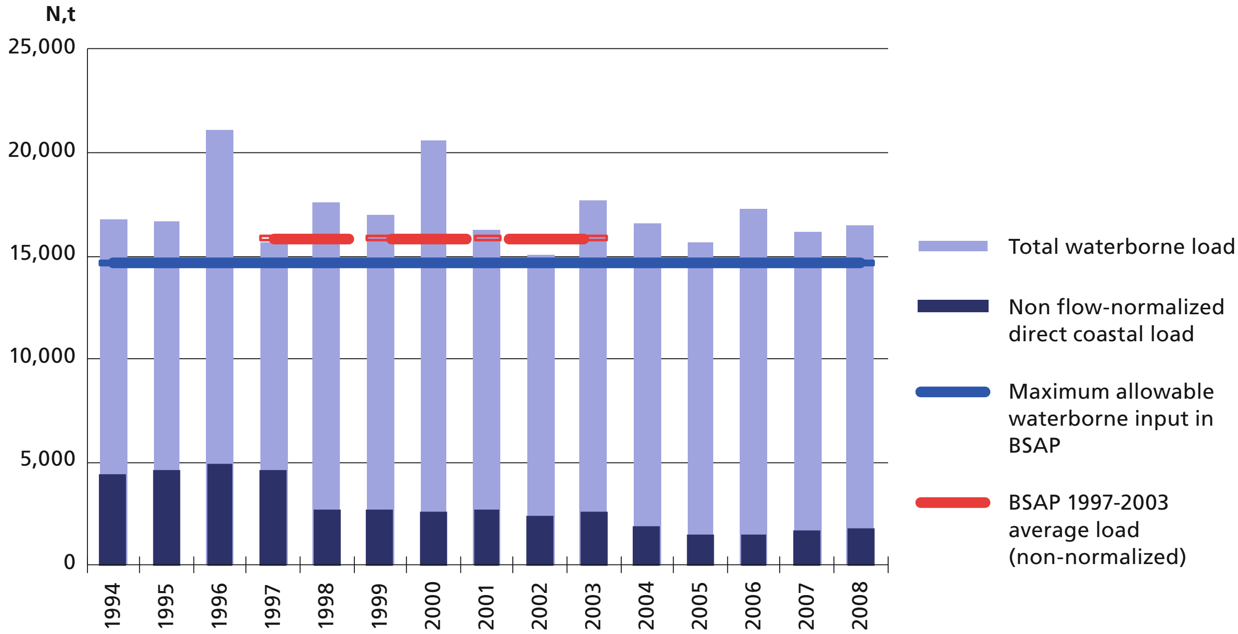
Total flow-normalized waterborne load of phosphorus (in tonnes) from Finland to the Baltic Sea, 1994-2008



2000	2001	2002	2003	2004	2005	2006	2007	2008
76,927	67,230	57,128	74,609	71,537	68,529	83,164	71,504	68,440
7,547	7,551	6,753	7,140	5,871	5,819	5,021	5,219	5,451
84,474	74,781	63,881	81,748	77,408	74,348	88,185	76,724	73,891
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
3,623	3,082	2,649	3,218	2,918	2,954	3,707	2,825	3,206
305	289	254	248	257	248	207	233	236
3,928	3,371	2,903	3,466	3,174	3,202	3,914	3,058	3,442

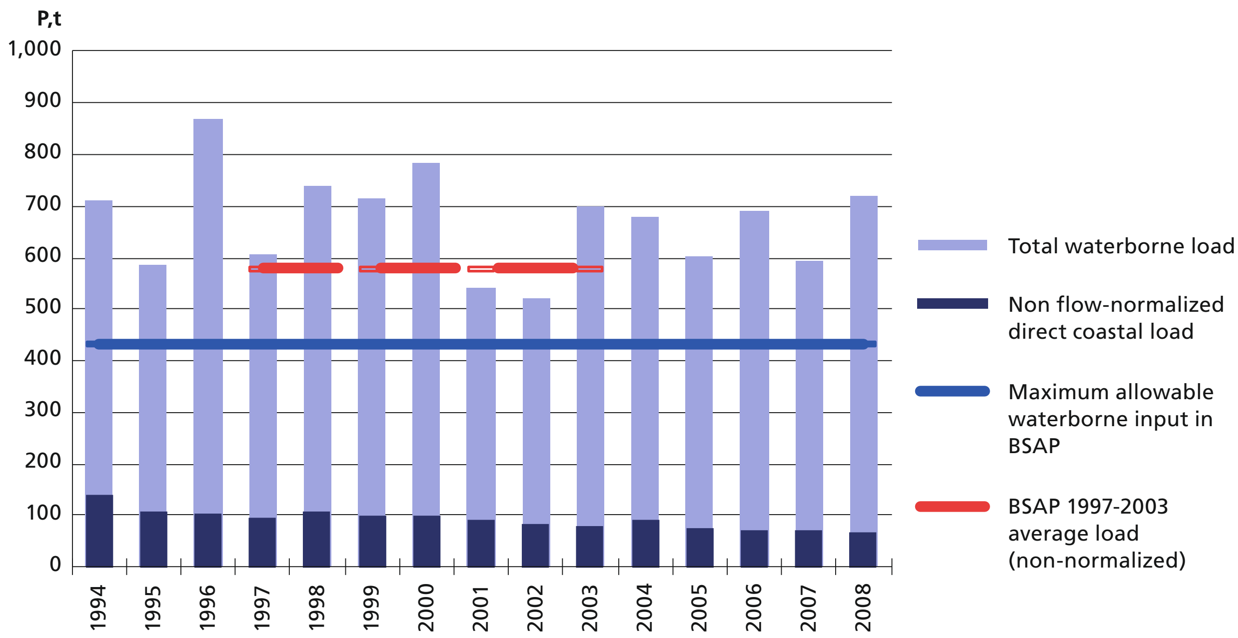
FINLAND: GULF OF FINLAND

Total flow-normalized waterborne load of nitrogen (in tonnes) from Finland to the Gulf of Finland, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	12,302	12,110	16,247	11,101	14,869	14,275
Non flow-normalized direct coastal loads	4,431	4,556	4,869	4,568	2,724	2,708
Total waterborne loads	16,733	16,666	21,116	15,669	17,593	16,983
Maximum allowable waterborne input in BSAP	14,653	14,653	14,653	14,653	14,653	14,653
BSAP 1997-2003 average load (non-normalized)				15,852	15,852	15,852
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	575	477	764	514	634	614
Non flow-normalized direct coastal loads	138	108	104	93	106	101
Total waterborne loads	712	585	868	607	741	715
Maximum allowable waterborne input in BSAP	432	432	432	432	432	432
BSAP 1997-2003 average load (non-normalized)				578	578	578

Total flow-normalized waterborne load of phosphorus (in tonnes) from Finland to the Gulf of Finland, 1994-2008

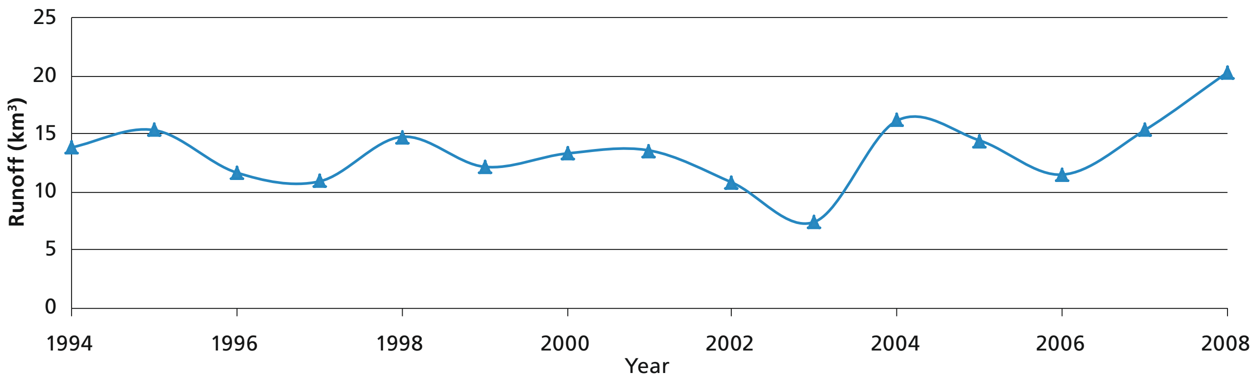


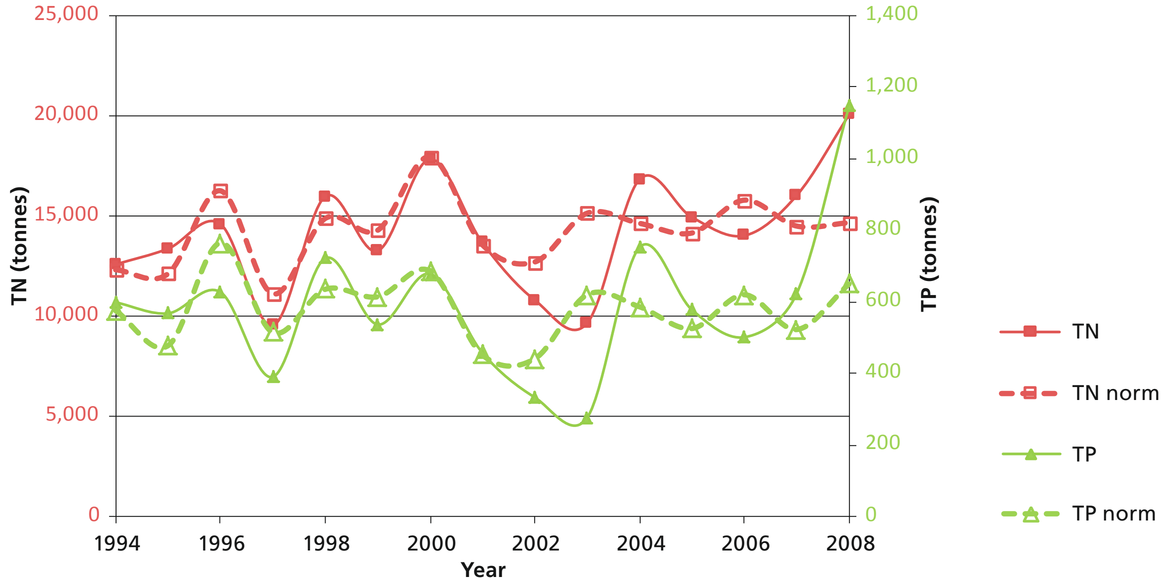
2000	2001	2002	2003	2004	2005	2006	2007	2008
17,948	13,553	12,694	15,127	14,623	14,141	15,780	14,488	14,654
2,626	2,697	2,401	2,590	1,912	1,495	1,490	1,696	1,823
20,574	16,250	15,095	17,717	16,536	15,636	17,270	16,184	16,477
14,653	14,653	14,653	14,653	14,653	14,653	14,653	14,653	14,653
15,852	15,852	15,852	15,852					

2000	2001	2002	2003	2004	2005	2006	2007	2008
686	451	440	619	586	525	619	522	649
99	90	81	81	92	77	73	70	68
785	541	522	700	677	601	692	592	717
432	432	432	432	432	432	432	432	432
578	578	578	578					

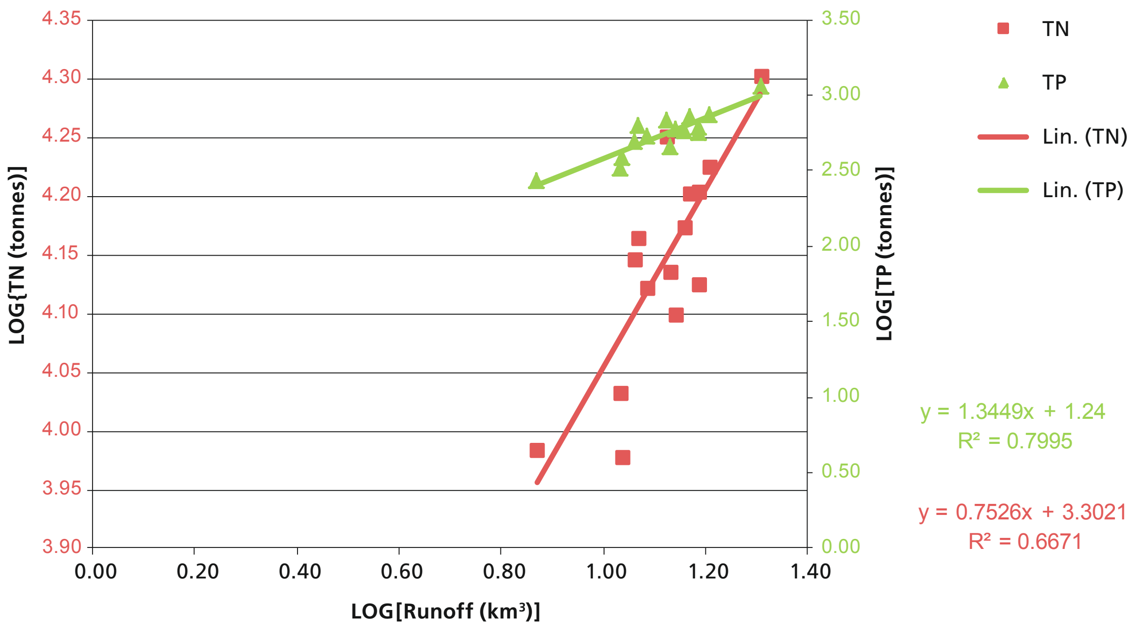
FI_GULF OF FINLAND	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	13.83	12,574.57	598.01	12,302.18	574.71	1.14	4.10	2.78
1995	15.33	13,357.00	567.30	12,109.82	477.17	1.19	4.13	2.75
1996	11.66	14,584.00	626.46	16,246.85	764.33	1.07	4.16	2.80
1997	10.89	9,522.00	389.70	11,101.23	513.90	1.04	3.98	2.59
1998	14.75	15,962.00	721.20	14,868.71	634.41	1.17	4.20	2.86
1999	12.16	13,248.00	536.12	14,275.44	613.52	1.09	4.12	2.73
2000	13.31	17,827.00	677.41	17,947.89	685.67	1.12	4.25	2.83
2001	13.57	13,657.00	457.00	13,552.55	450.98	1.13	4.14	2.66
2002	10.80	10,793.00	332.47	12,694.12	440.44	1.03	4.03	2.52
2003	7.41	9,640.00	275.58	15,126.98	619.30	0.87	3.98	2.44
2004	16.16	16,815.00	751.68	14,623.48	585.61	1.21	4.23	2.88
2005	14.43	14,926.00	577.30	14,141.36	524.87	1.16	4.17	2.76
2006	11.49	14,010.00	500.60	15,779.83	619.34	1.06	4.15	2.70
2007	15.33	16,012.00	622.39	14,487.67	522.05	1.19	4.20	2.79
2008	20.32	20,036.00	1145.92	14,654.00	649.23	1.31	4.30	3.06

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





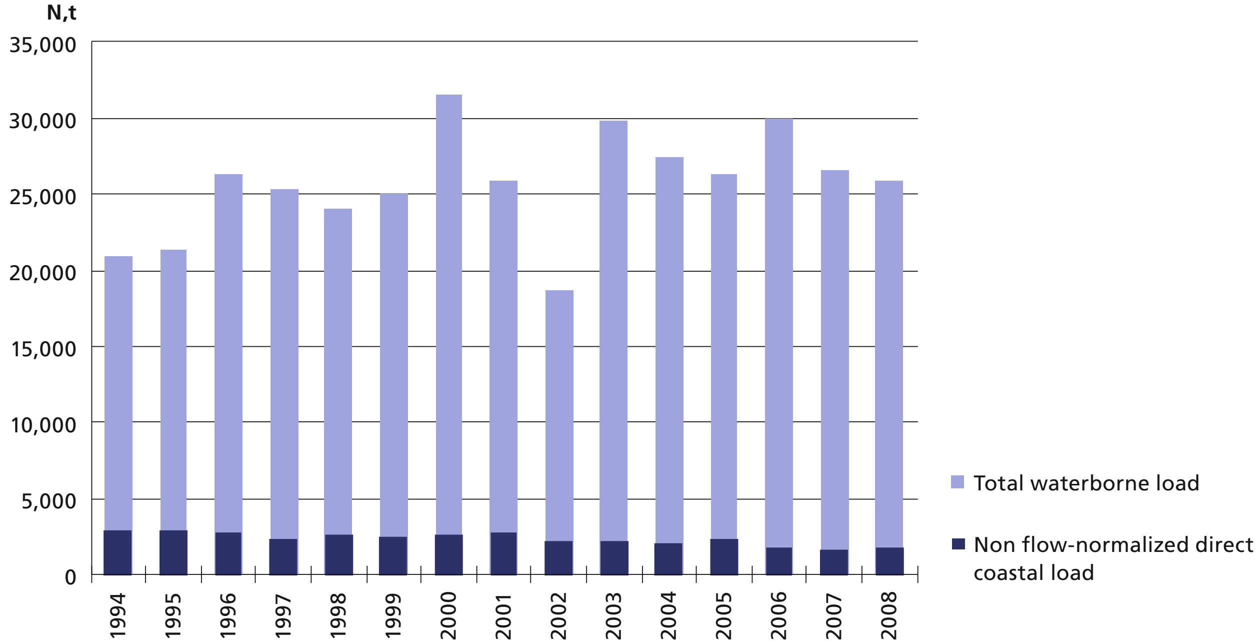
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
1,400
1,200
1,000
800
600
400
200
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.35
4.30
4.25
4.20
4.15
4.10
4.05
4.00
3.95
3.90
LOG{TN (tonnes)]
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.3449x + 1.24
R² = 0.7995
y = 0.7526x + 3.3021
R² = 0.6671

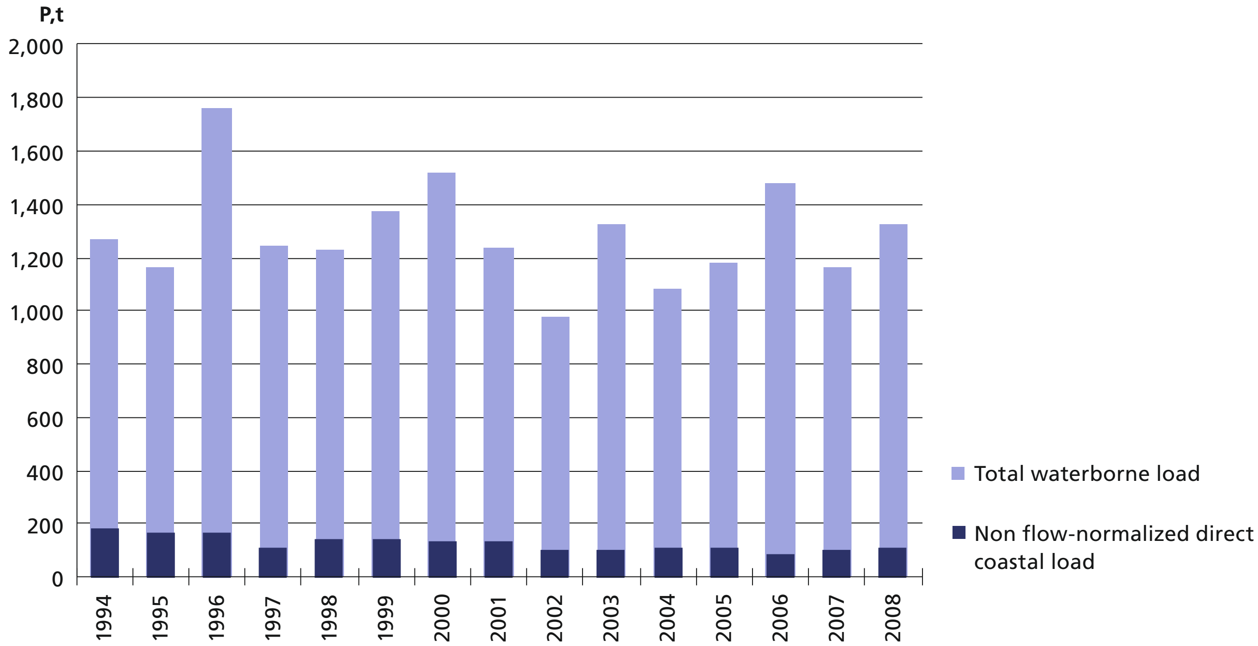
FINLAND: BOTHNIAN SEA

Total flow-normalized waterborne load of nitrogen (in tonnes) from Finland to the Bothnian Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	18,001	18,441	23,477	23,061	21,435	22,464
Non flow-normalized direct coastal loads	2,867	2,925	2,812	2,296	2,571	2,532
Total waterborne loads	20,869	21,366	26,289	25,356	24,006	24,997
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,086	995	1,590	1,136	1,087	1,235
Non flow-normalized direct coastal loads	185	167	168	106	139	139
Total waterborne loads	1,271	1,161	1,758	1,242	1,226	1,374

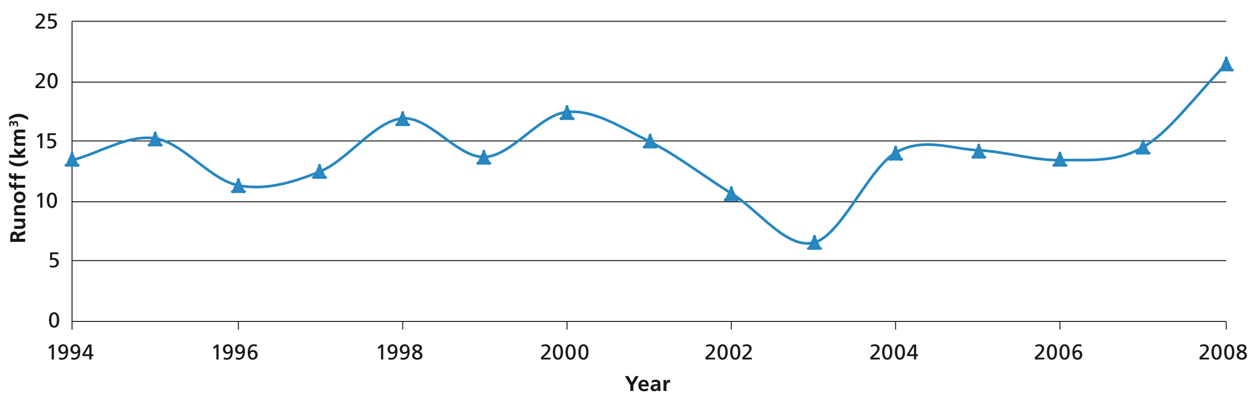
Total flow-normalized waterborne load of phosphorus (in tonnes) from Finland to the Bothnian Sea, 1994-2008

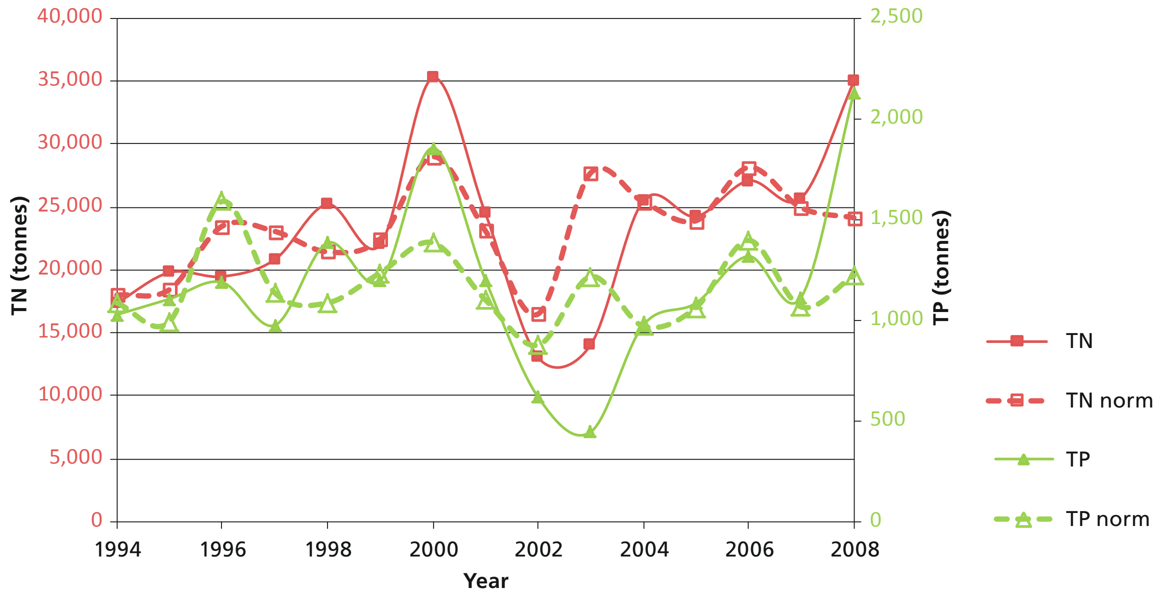


2000	2001	2002	2003	2004	2005	2006	2007	2008
28,993	23,114	16,499	27,707	25,404	23,911	28,151	24,935	24,144
2,570	2,755	2,230	2,162	2,003	2,319	1,787	1,699	1,715
31,563	25,869	18,728	29,869	27,406	26,229	29,938	26,634	25,859
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1,385	1,102	876	1,217	971	1,063	1,397	1,067	1,222
135	136	105	104	109	114	85	100	107
1,520	1,237	981	1,322	1,080	1,177	1,482	1,167	1,329

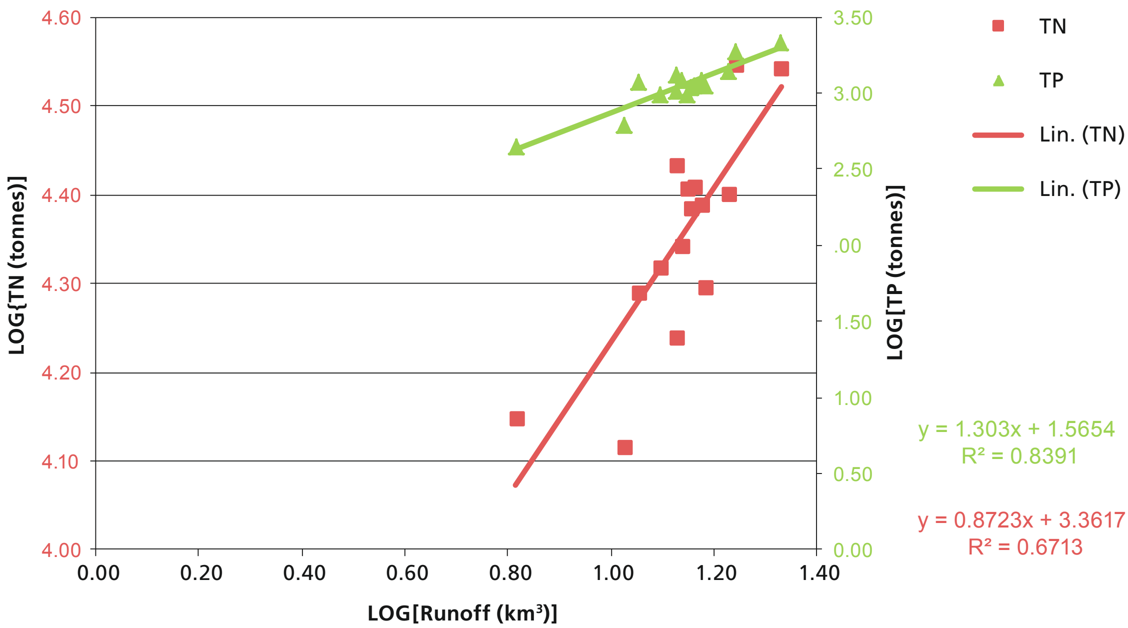
FI_BOTHNIAN SEA	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	13.45	17,365.00	1,028.10	18,001.50	1,085.89	1.13	4.24	3.01
1995	15.25	19,798.00	1,106.00	18,441.11	994.53	1.18	4.30	3.04
1996	11.33	19,477.00	1,188.20	23,476.74	1,590.04	1.05	4.29	3.07
1997	12.48	20,819.00	975.50	23,060.52	1,136.20	1.10	4.32	2.99
1998	16.93	25,211.00	1,384.30	21,434.69	1,086.52	1.23	4.40	3.14
1999	13.70	21,997.00	1,196.70	22,464.12	1,235.36	1.14	4.34	3.08
2000	17.47	35,241.00	1,855.90	28,993.11	1,385.16	1.24	4.55	3.27
2001	15.00	24,503.00	1,201.30	23,114.43	1,101.65	1.18	4.39	3.08
2002	10.64	13,063.00	619.50	16,498.63	876.40	1.03	4.12	2.79
2003	6.53	14,046.80	445.81	27,707.32	1,217.43	0.82	4.15	2.65
2004	14.09	25,495.00	975.86	25,403.62	970.81	1.15	4.41	2.99
2005	14.26	24,248.00	1,085.50	23,910.55	1,063.34	1.15	4.38	3.04
2006	13.44	27,082.00	1,317.70	28,150.94	1,396.76	1.13	4.43	3.12
2007	14.53	25,706.00	1,115.30	24,935.17	1,066.60	1.16	4.41	3.05
2008	21.41	34,955.00	2,128.30	24,144.39	1,221.86	1.33	4.54	3.33

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





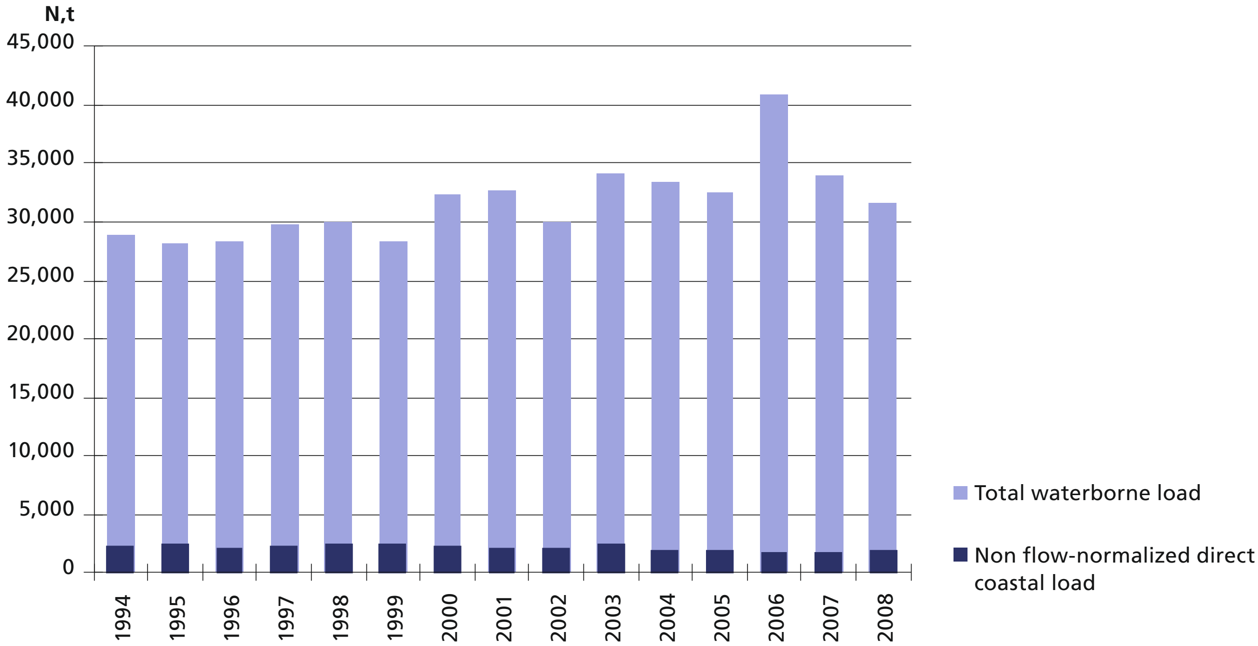
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
2,500
2,000
1,500
1,000
500
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.60
4.50
4.40
4.30
4.20
4.10
4.00
LOG{TN (tonnes)]
3.50
3.00
2.50
.00
1.50
1.00
0.50
0.00
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.303x + 1.5654
R² = 0.8391
y = 0.8723x + 3.3617
R² = 0.6713

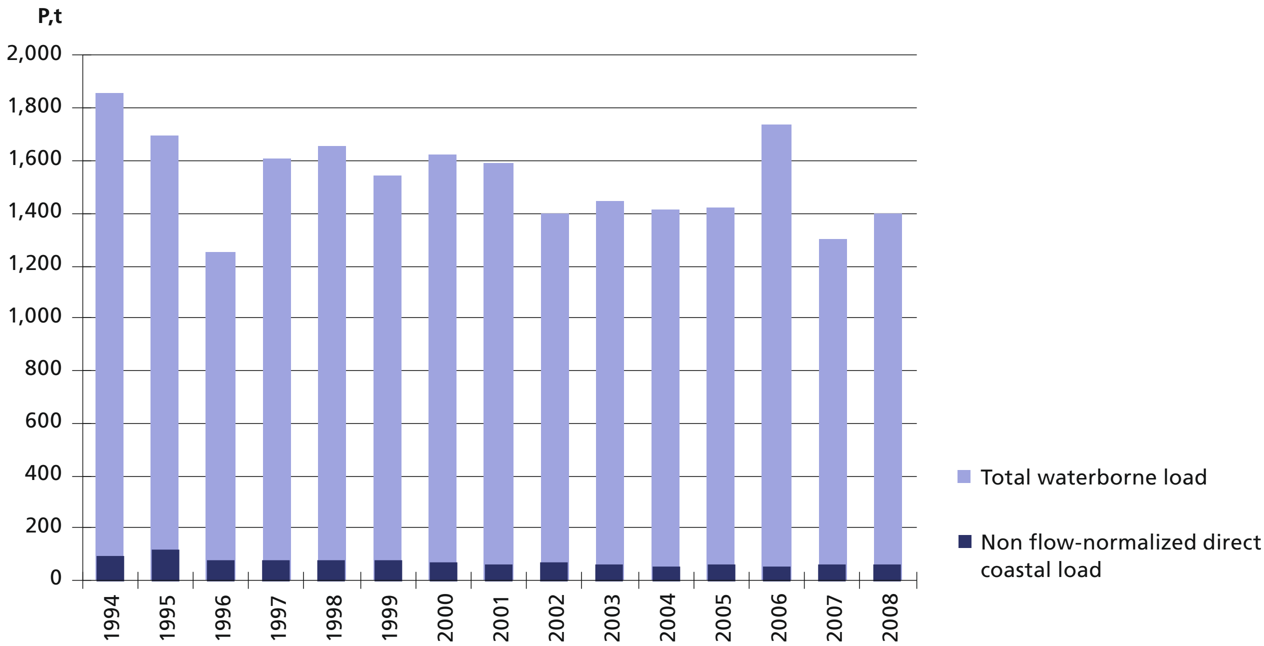
FINLAND: BOTHNIAN BAY

Total flow-normalized waterborne load of nitrogen (in tonnes) from Finland to the Bothnian Bay, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	26,626	25,701	26,259	27,673	27,471	26,034
Non flow-normalized direct coastal loads	2,274	2,419	2,168	2,225	2,469	2,392
Total waterborne loads	28,900	28,120	28,427	29,898	29,940	28,426
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,762	1,575	1,178	1,530	1,581	1,470
Non flow-normalized direct coastal loads	97	120	78	76	78	74
Total waterborne loads	1,859	1,694	1,256	1,606	1,660	1,544

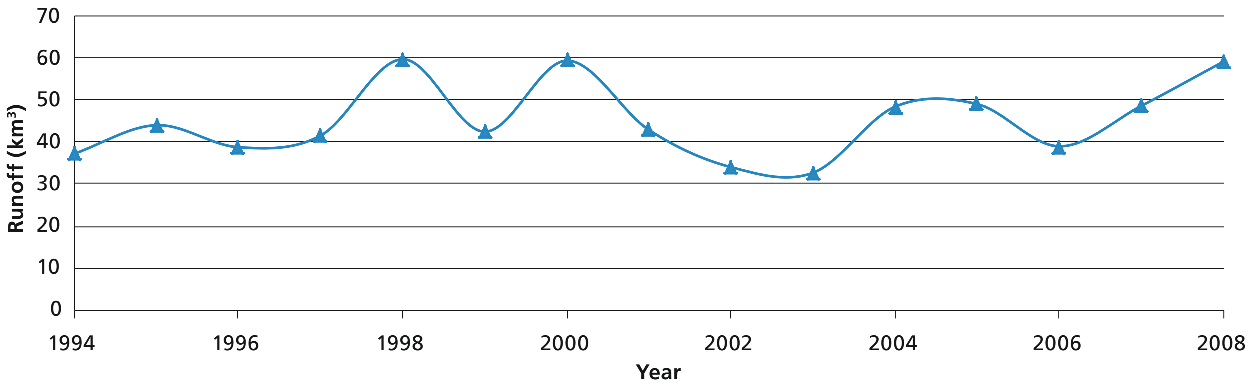
Total flow-normalized waterborne load of phosphorus (in tonnes) from Finland to the Bothnian Bay, 1994-2008

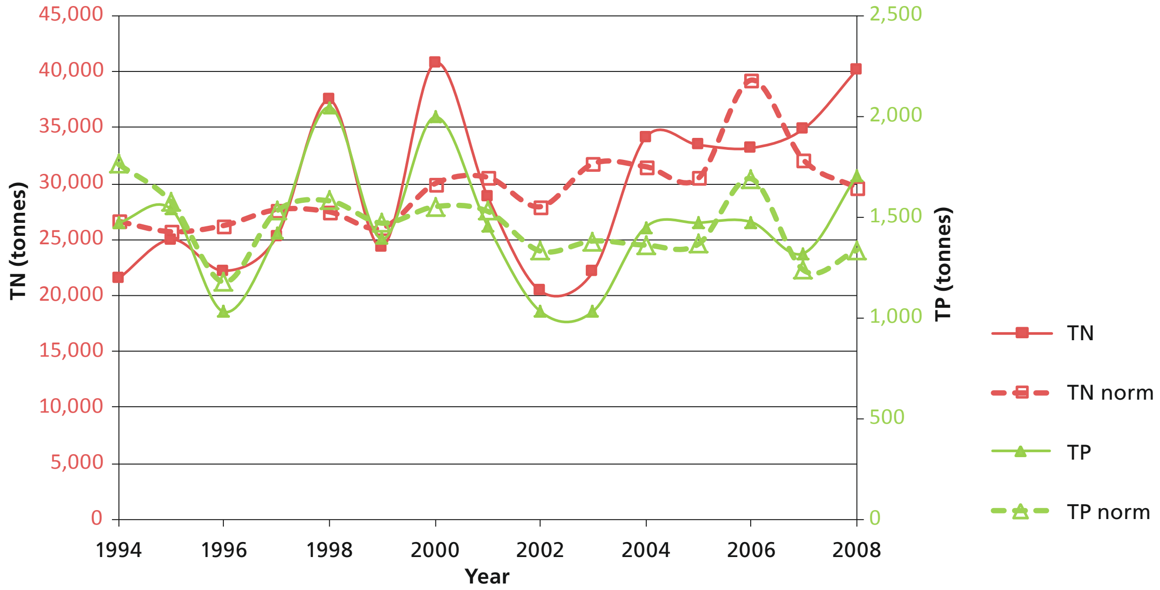


	2000	2001	2002	2003	2004	2005	2006	2007	2008
	29,986	30,563	27,935	31,774	31,510	30,477	39,233	32,082	29,641
	2,351	2,099	2,122	2,388	1,956	2,006	1,745	1,825	1,914
	32,337	32,662	30,058	34,162	33,465	32,483	40,978	33,906	31,555
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
	1,552	1,529	1,332	1,382	1,361	1,366	1,691	1,236	1,335
	72	64	68	62	56	57	50	62	61
	1,624	1,593	1,400	1,444	1,417	1,423	1,741	1,299	1,396

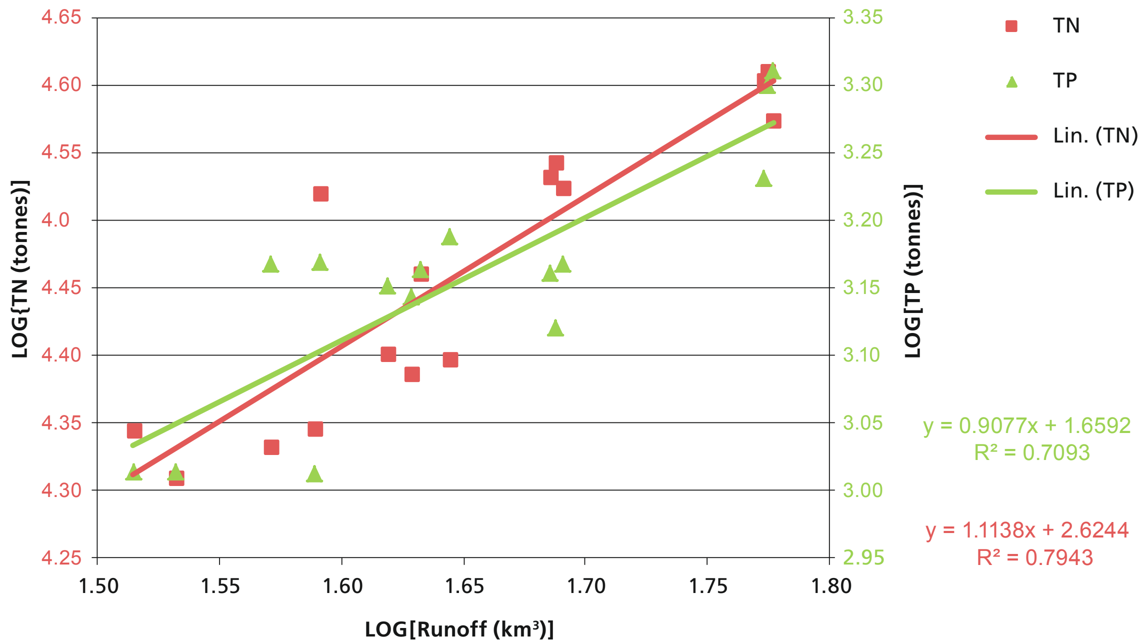
FI_BOTHNIAN BAY	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	37.26	21,520.56	1,472.40	26,625.73	1,762.49	1.57	4.33	3.17
1995	44.07	25,004.92	1,539.01	25,701.47	1,574.73	1.64	4.40	3.19
1996	38.80	22,203.94	1,030.04	26,258.90	1,178.03	1.59	4.35	3.01
1997	41.57	25,233.91	1,417.88	27,673.05	1,530.13	1.62	4.40	3.15
1998	59.81	37,469.00	2,045.60	27,470.86	1,581.03	1.78	4.57	3.31
1999	42.52	24,350.00	1,391.30	26,033.76	1,470.31	1.63	4.39	3.14
2000	59.48	40,753.00	1,996.60	29,986.31	1,552.11	1.77	4.61	3.30
2001	42.93	28,862.00	1,459.20	30,562.89	1,529.15	1.63	4.46	3.16
2002	34.05	20,413.00	1,033.10	27,935.37	1,331.71	1.53	4.31	3.01
2003	32.71	22,108.00	1,032.45	31,774.34	1,381.72	1.51	4.34	3.01
2004	48.49	34,108.00	1,450.70	31,509.52	1,361.34	1.69	4.53	3.16
2005	49.10	33,442.00	1,472.10	30,476.89	1,366.05	1.69	4.52	3.17
2006	39.02	33,168.35	1,475.97	39,233.40	1,690.84	1.59	4.52	3.17
2007	48.69	34,894.00	1,321.10	32,081.54	1,236.22	1.69	4.54	3.12
2008	59.26	40,108.00	1,702.50	29,641.49	1,334.68	1.77	4.60	3.23

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





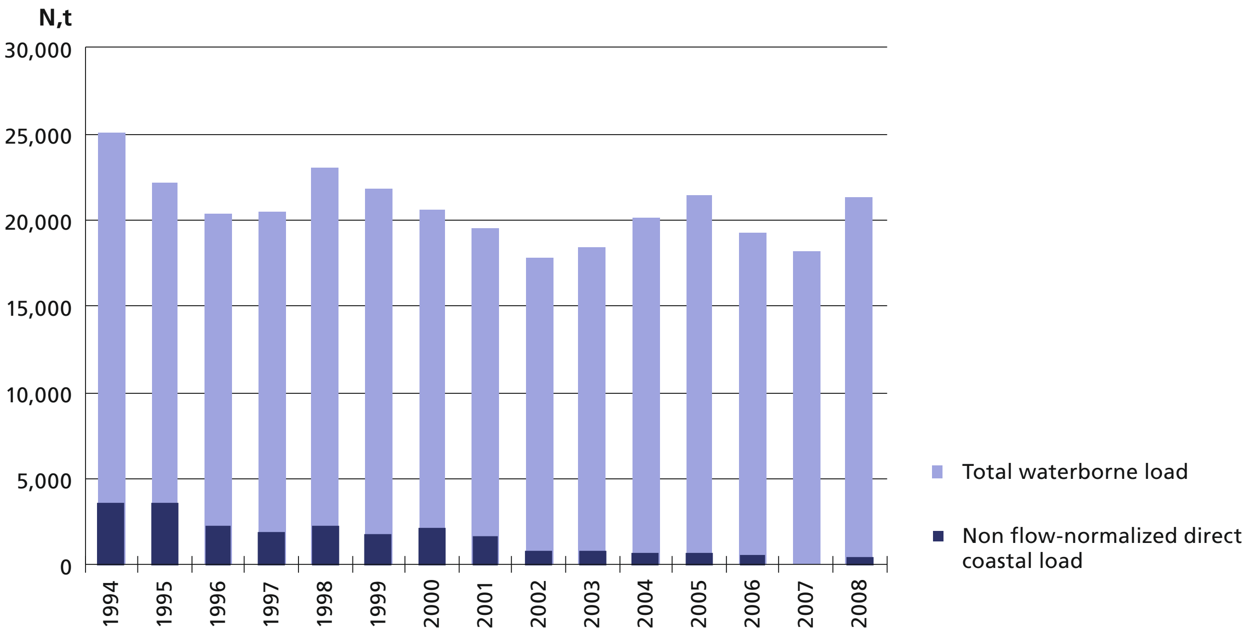
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
2,500
2,000
1,500
1,000
500
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.65
4.60
4.55
4.0
4.45
4.40
4.35
4.30
4.25
LOG[TN (tonnes)]
3.35
3.30
3.25
3.20
3.15
3.10
3.05
3.00
2.95
LOG[TP (tonnes)]
1.50
1.55
1.60
1.65
1.70
1.75
1.80
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.9077x + 1.6592
R² = 0.7093
y = 1.1138x + 2.6244
R² = 0.7943

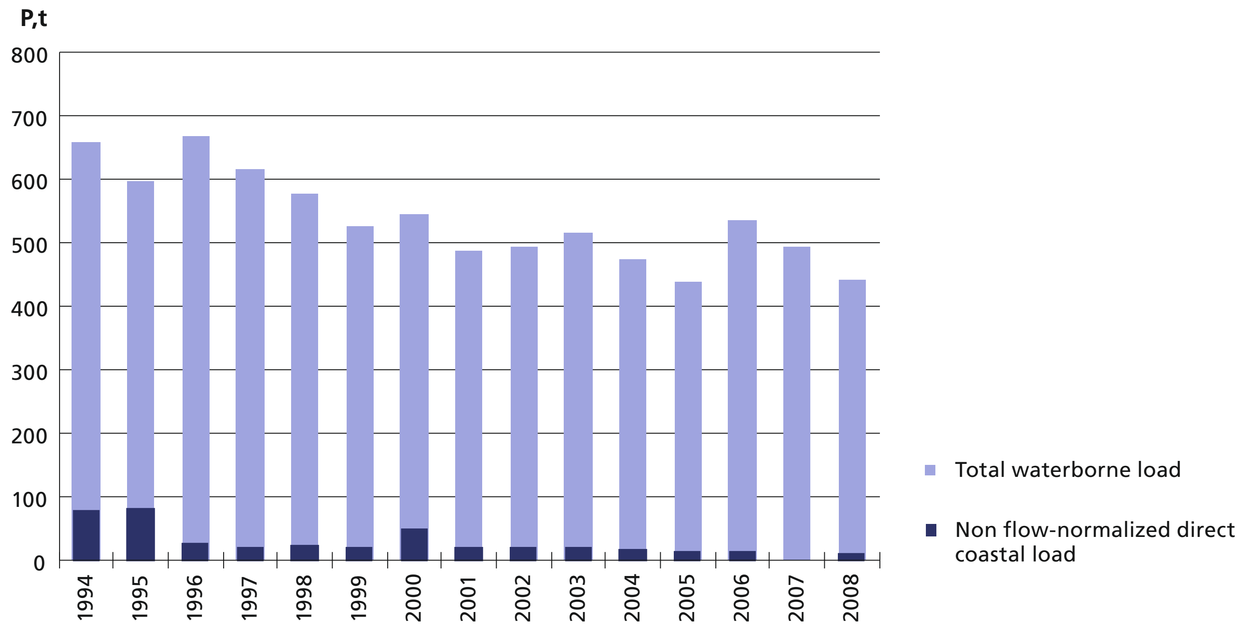
4. GERMANY: TOTAL

Total flow-normalized waterborne load of nitrogen (in tonnes) from Germany to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	21,532	18,566	18,032	18,535	20,736	20,122
Non flow-normalized direct coastal loads	3,580	3,624	2,341	1,977	2,276	1,767
Total waterborne loads	25,113	22,190	20,374	20,512	23,012	21,889
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	580	514	640	595	555	504
Non flow-normalized direct coastal loads	80	84	30	24	25	24
Total waterborne loads	660	598	670	619	580	527

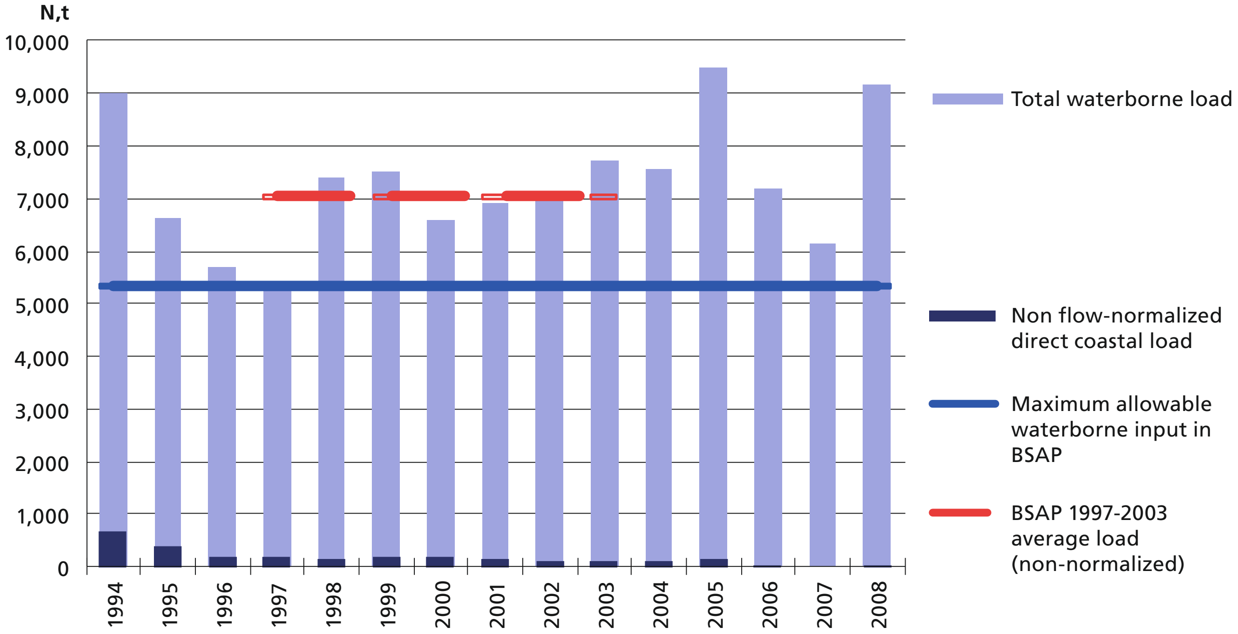
Total flow-normalized waterborne load of phosphorus (in tonnes) from Germany to the Baltic Sea, 1994-2008



2000	2001	2002	2003	2004	2005	2006	2007	2008
18,378	17,850	17,050	17,582	19,321	20,781	18,713	18,186	20,844
2,190	1,628	807	800	759	730	616	0	464
20,568	19,477	17,858	18,382	20,080	21,511	19,329	18,186	21,308
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
495	469	474	496	457	422	521	495	432
50	21	22	21	20	16	14	0	13
546	490	496	517	476	439	535	495	445

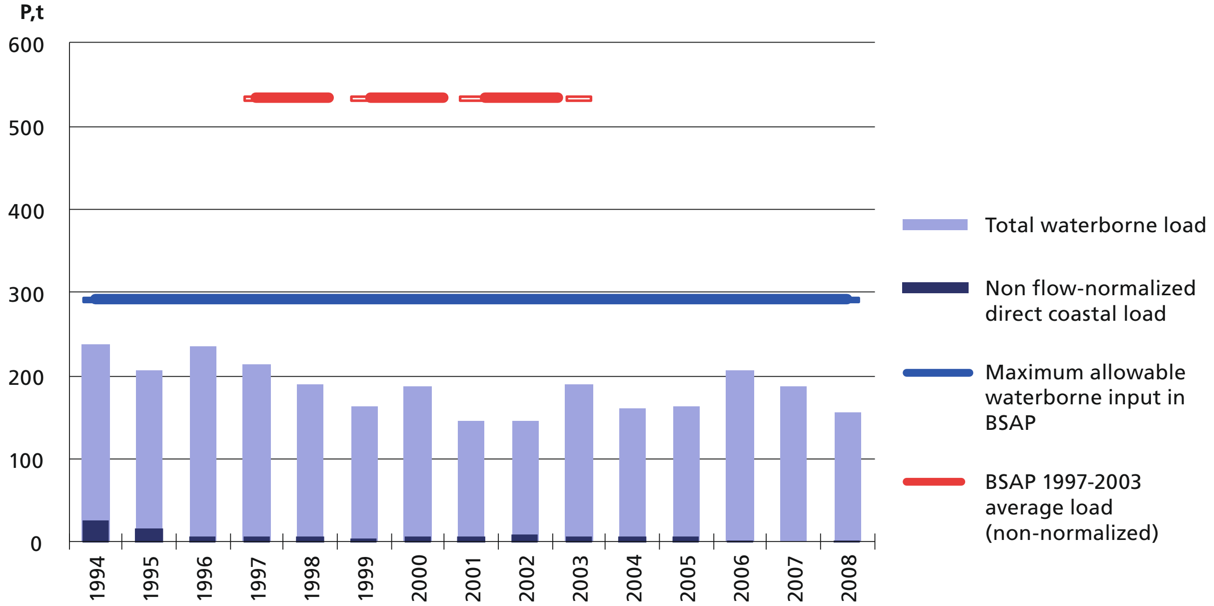
GERMANY: BALTIC PROPER

Total flow-normalized waterborne load of nitrogen (in tonnes) from Germany to the Baltic Proper, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	8,345	6,257	5,506	5,202	7,245	7,355
Non flow-normalized direct coastal loads	654	389	189	186	131	170
Total waterborne loads	8,999	6,646	5,695	5,388	7,376	7,525
Maximum allowable waterborne input in BSAP	5,337	5,337	5,337	5,337	5,337	5,337
BSAP 1997-2003 average load (non-normalized)				7,038	7,038	7,038
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	214	191	229	208	183	157
Non flow-normalized direct coastal loads	25	16	7	5	7	5
Total waterborne loads	239	207	235	213	190	162
Maximum allowable waterborne input in BSAP	292	292	292	292	292	292
BSAP 1997-2003 average load (non-normalized)				534	534	534

Total flow-normalized waterborne load of phosphorus (in tonnes) from Germany to the Baltic Proper, 1994-2008

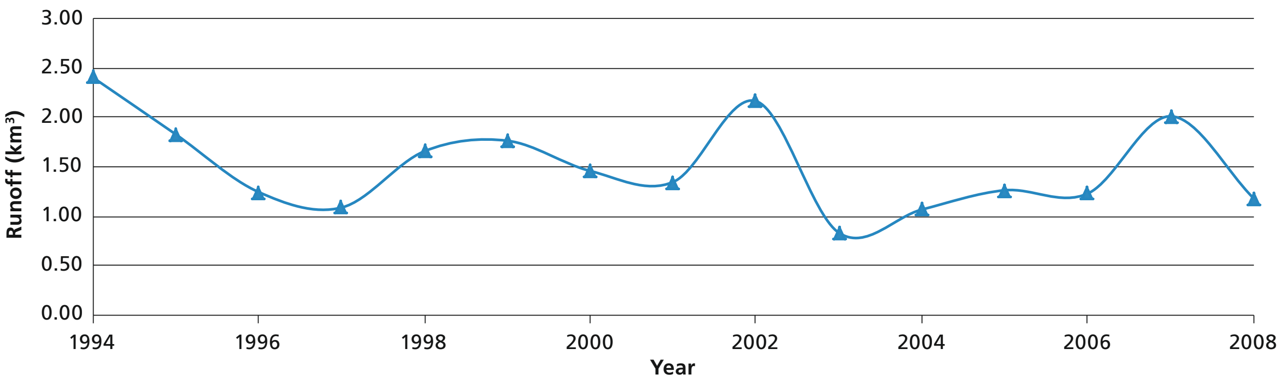


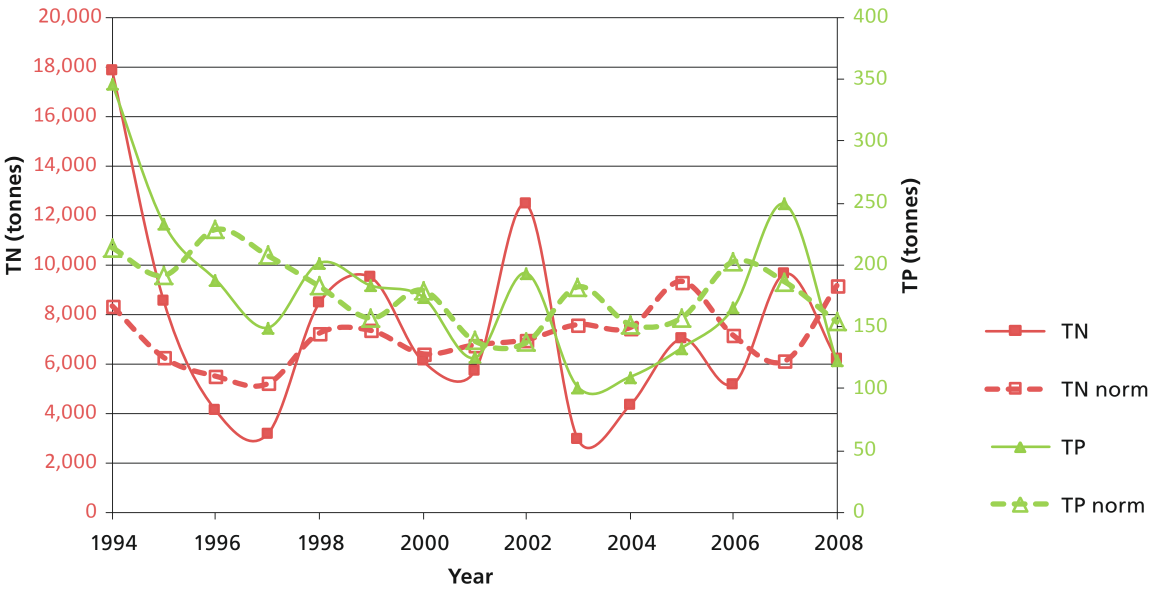
2000	2001	2002	2003	2004	2005	2006	2007	2008
6,413	6,772	6,982	7,594	7,469	9,336	7,155	6,125	9,169
168	126	109	107	92	138	33		16
6,581	6,898	7,091	7,701	7,561	9,474	7,187	6,125	9,185
5,337	5,337	5,337	5,337	5,337	5,337	5,337	5,337	5,337
7,038	7,038	7,038	7,038					

2000	2001	2002	2003	2004	2005	2006	2007	2008
180	139	137	182	152	157	203	186	154
7	7	8	7	7	6	2	0	1
187	146	145	189	159	164	205	186	155
292	292	292	292	292	292	292	292	292
534	534	534	534					

DE_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	2.41	17,842.00	346.30	8,345.25	213.84	0.38	4.25	2.54
1995	1.83	8,512.00	233.30	6,256.84	191.48	0.26	3.93	2.37
1996	1.24	4,120.00	188.10	5,506.46	228.68	0.09	3.61	2.27
1997	1.09	3,167.00	149.23	5,202.36	207.67	0.04	3.50	2.17
1998	1.66	8,464.00	201.51	7,245.08	182.83	0.22	3.93	2.30
1999	1.76	9,492.50	183.30	7,354.93	157.03	0.25	3.98	2.26
2000	1.46	6,116.25	174.33	6,412.52	179.62	0.16	3.79	2.24
2001	1.35	5,692.49	124.93	6,772.35	138.58	0.13	3.76	2.10
2002	2.17	12,441.91	193.40	6,982.09	137.24	0.34	4.09	2.29
2003	0.83	2,945.52	101.18	7,594.08	182.38	-0.08	3.47	2.01
2004	1.07	4,325.54	109.52	7,469.08	152.13	0.03	3.64	2.04
2005	1.26	7,021.54	132.89	9,336.40	157.25	0.10	3.85	2.12
2006	1.23	5,199.45	165.27	7,154.87	202.67	0.09	3.72	2.22
2007	2.01	9,650.00	249.02	6,124.99	186.16	0.30	3.98	2.40
2008	1.18	6,191.96	122.08	9,169.39	153.87	0.07	3.79	2.09

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized




TN (tonnes)
TP (tonnes)
Year
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
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2,000
0
400
350
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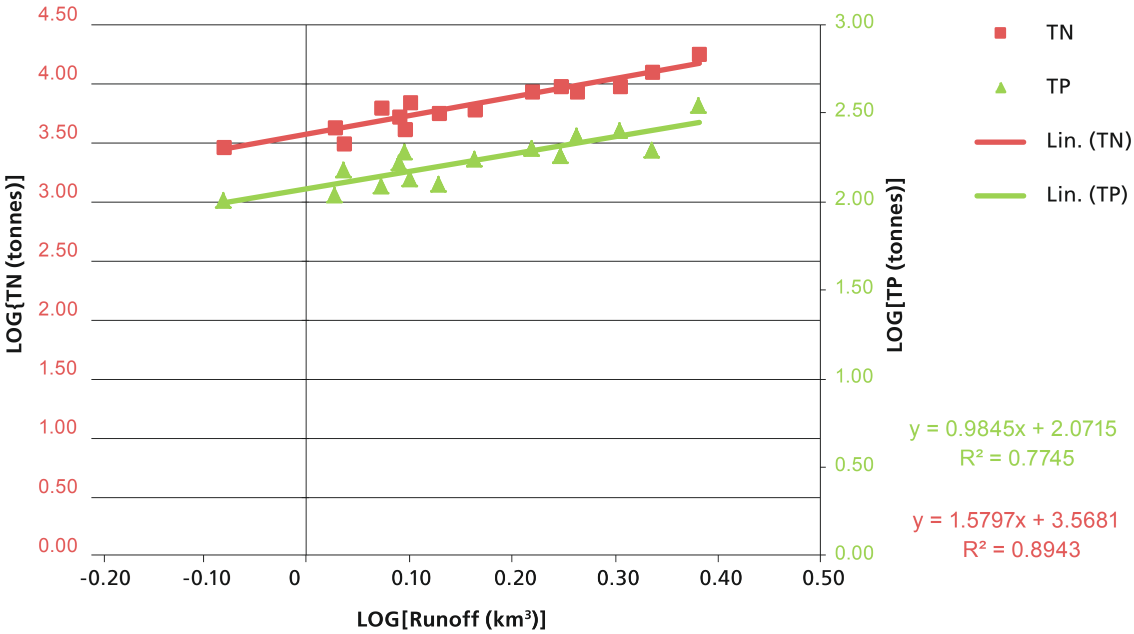
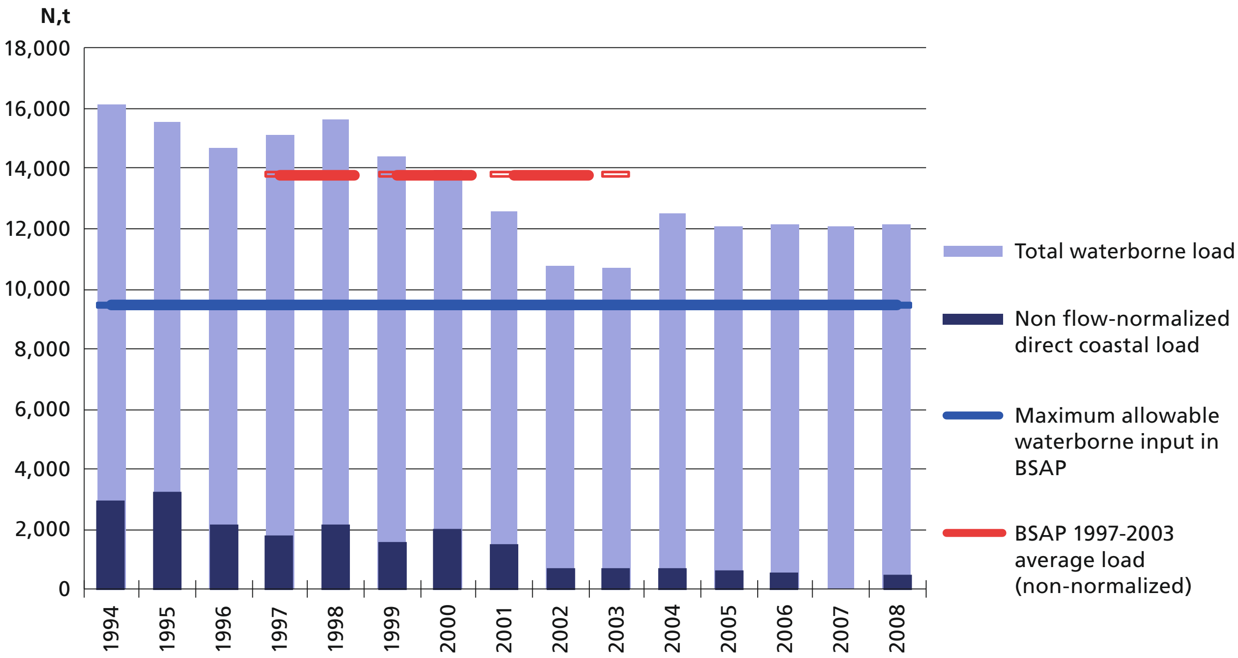
150
100
50
0
1994
1996
1998
2000
2002
2004
2006
2008
TN
TN norm
TP
TP norm


LOG{TN (tonnes)]
LOG[TP (tonnes)]
LOG[Runoff (km³)]
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.20
-0.10
0
0.10
0.20
0.30
0.40
0.50
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.9845x + 2.0715
R² = 0.7745
y = 1.5797x + 3.5681
R² = 0.8943

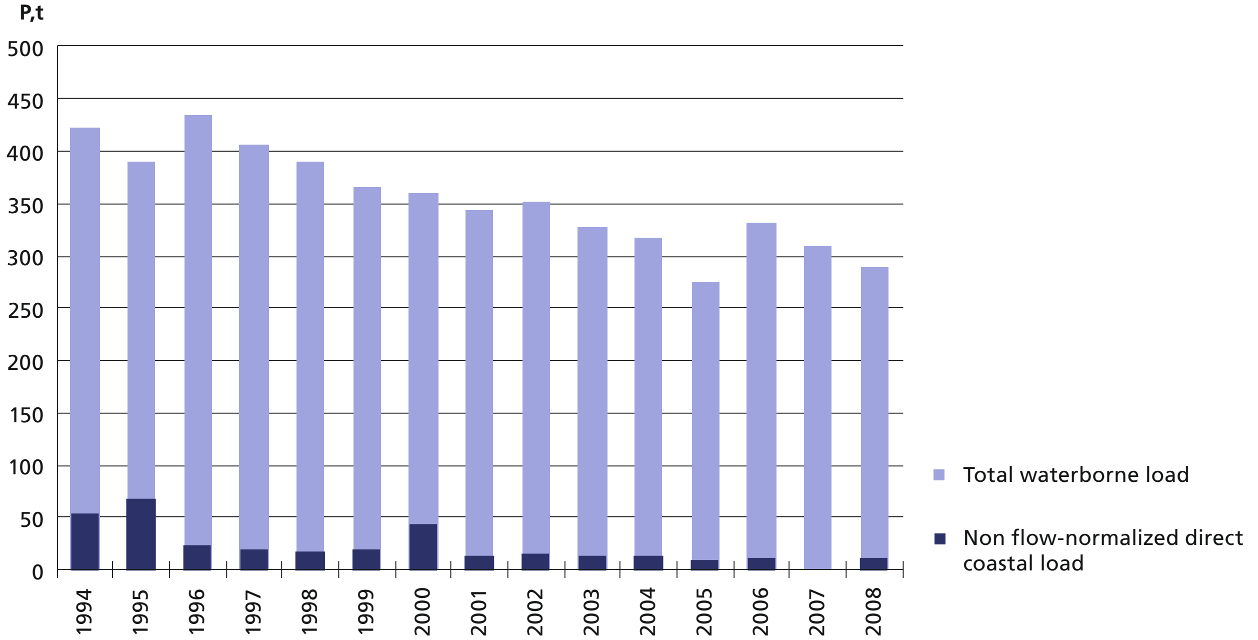
GERMANY: DANISH STRAITS

Total flow-normalized waterborne load of nitrogen (in tonnes) from Germany to the Danish Straits, 1994-2008



NITROGEN	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	13,187	12,309	12,526	13,333	13,491	12,767
Non flow-normalized direct coastal loads	2,926	3,235	2,152	1,791	2,145	1,597
Total waterborne loads	16,113	15,544	14,678	15,123	15,636	14,364
Maximum allowable waterborne input in BSAP	9,463	9,463	9,463	9,463	9,463	9,463
BSAP 1997-2003 average load (non-normalized)				13,811	13,811	13,811
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	367	322	412	387	372	347
Non flow-normalized direct coastal loads	55	68	23	19	18	19
Total waterborne loads	421	390	434	406	390	366

Total flow-normalized waterborne load of nitrogen (in tonnes) from Germany to the Danish Straits, 1994-2008

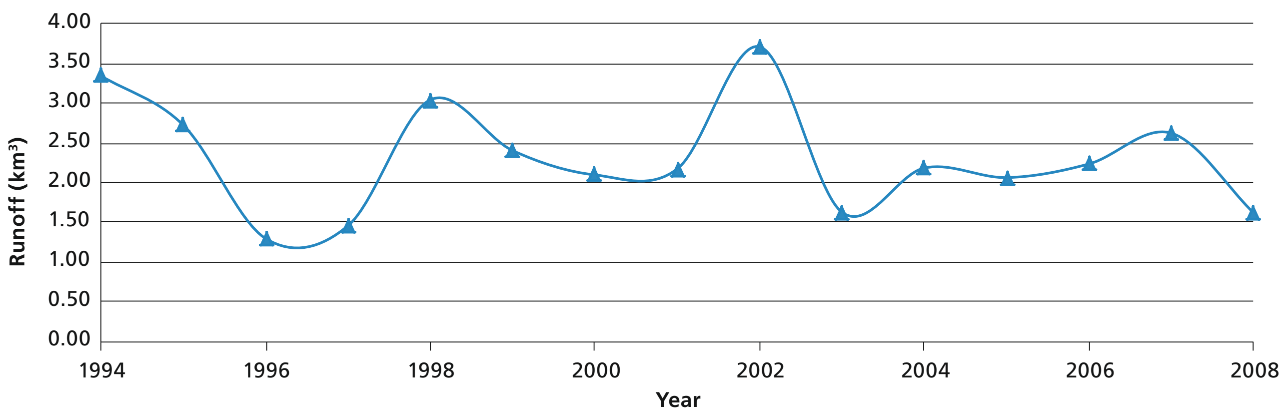


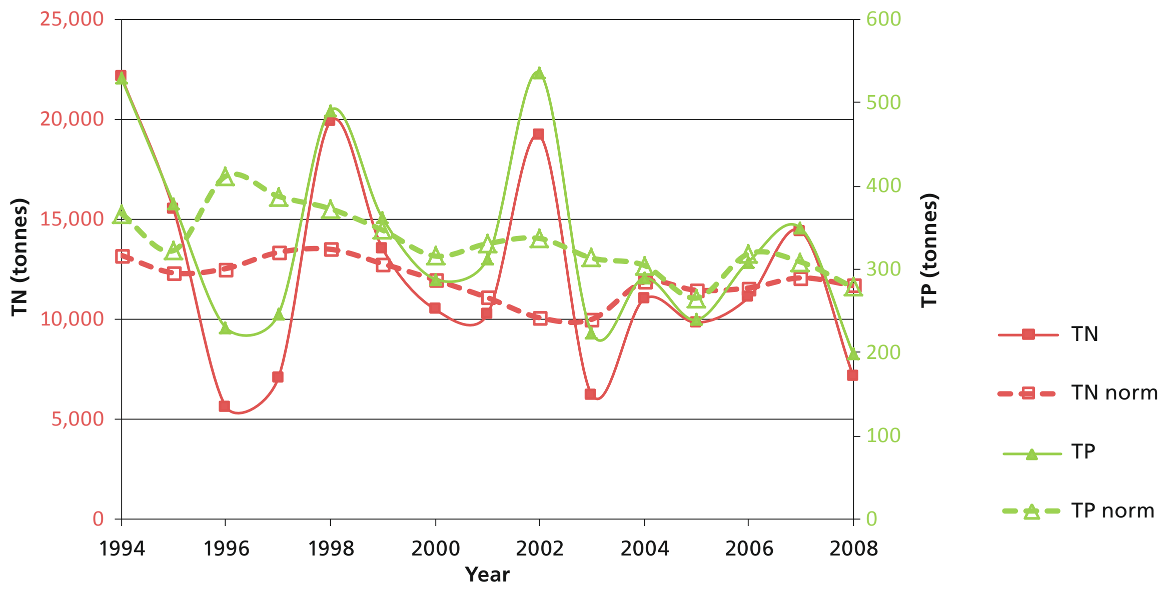
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	11,965	11,077	10,068	9,988	11,852	11,445	11,558	12,061	11,675
	2,022	1,502	698	693	667	593	583	0	448
	13,987	12,579	10,767	10,681	12,519	12,037	12,142	12,061	12,123
	9,463	9,463	9,463	9,463	9,463	9,463	9,463	9,463	9,463
	13,811	13,811	13,811	13,811					

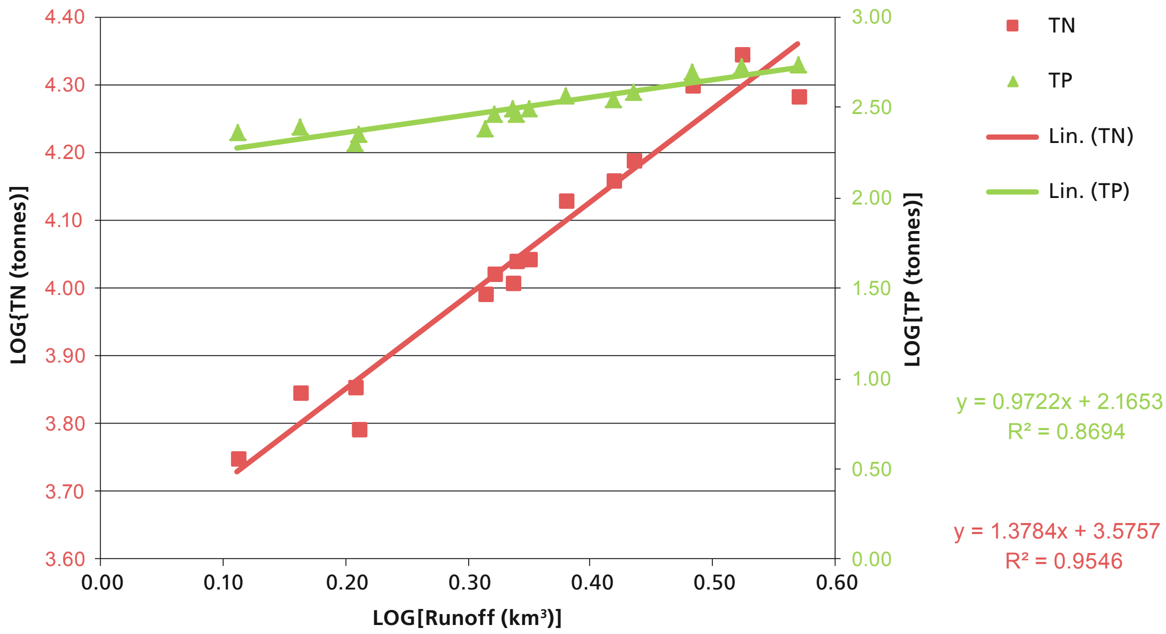
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	316	330	337	313	305	265	318	309	278
	43	14	15	14	13	10	12	0	11
	359	344	351	328	317	275	330	309	289

DE_DANISH STRAITS	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	3.34	22,134.00	529.50	13,187.20	366.50	0.52	4.35	2.72
1995	2.72	15,476.70	378.36	12,309.02	322.31	0.43	4.19	2.58
1996	1.29	5,620.10	229.62	12,525.98	411.66	0.11	3.75	2.36
1997	1.46	7,029.62	244.98	13,332.77	387.49	0.16	3.85	2.39
1998	3.04	19,883.04	490.57	13,491.22	372.39	0.48	4.30	2.69
1999	2.40	13,514.89	360.88	12,767.26	346.66	0.38	4.13	2.56
2000	2.10	10,490.68	287.94	11,965.43	315.70	0.32	4.02	2.46
2001	2.17	10,220.31	312.10	11,077.15	330.49	0.34	4.01	2.49
2002	3.71	19,177.21	535.89	10,068.29	336.80	0.57	4.28	2.73
2003	1.63	6,221.75	223.57	9,987.85	313.23	0.21	3.79	2.35
2004	2.18	10,995.96	289.09	11,852.31	304.58	0.34	4.04	2.46
2005	2.06	9,822.20	238.96	11,444.75	265.21	0.31	3.99	2.38
2006	2.24	11,072.98	308.96	11,558.46	318.43	0.35	4.04	2.49
2007	2.62	14,403.97	349.10	12,061.28	308.51	0.42	4.16	2.54
2008	1.62	7,159.33	198.86	11,674.52	278.13	0.21	3.85	2.30

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

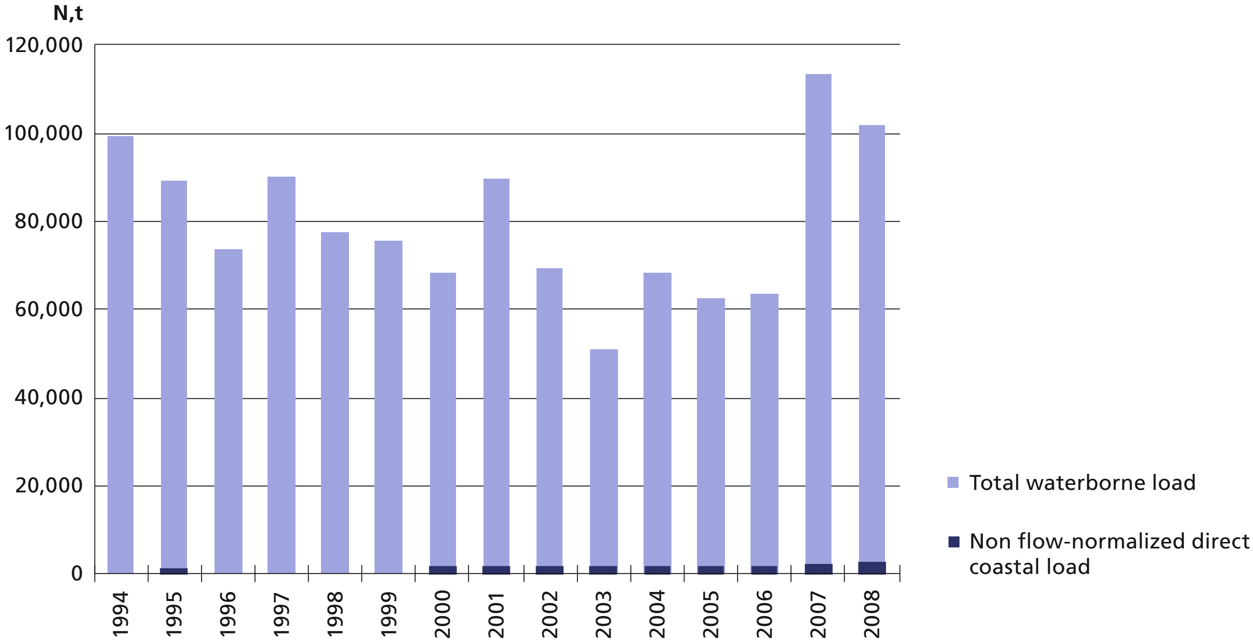



25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
600
500
400
300
200
100
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


4.40
4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
LOG[TN (tonnes)]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
LOG[TP (tonnes)]
0.00
0.10
0.20
0.30
0.40
0.50
0.60
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.9722x + 2.1653
R² = 0.8694
y = 1.3784x + 3.5757
R² = 0.9546

5. LATVIA: TOTAL

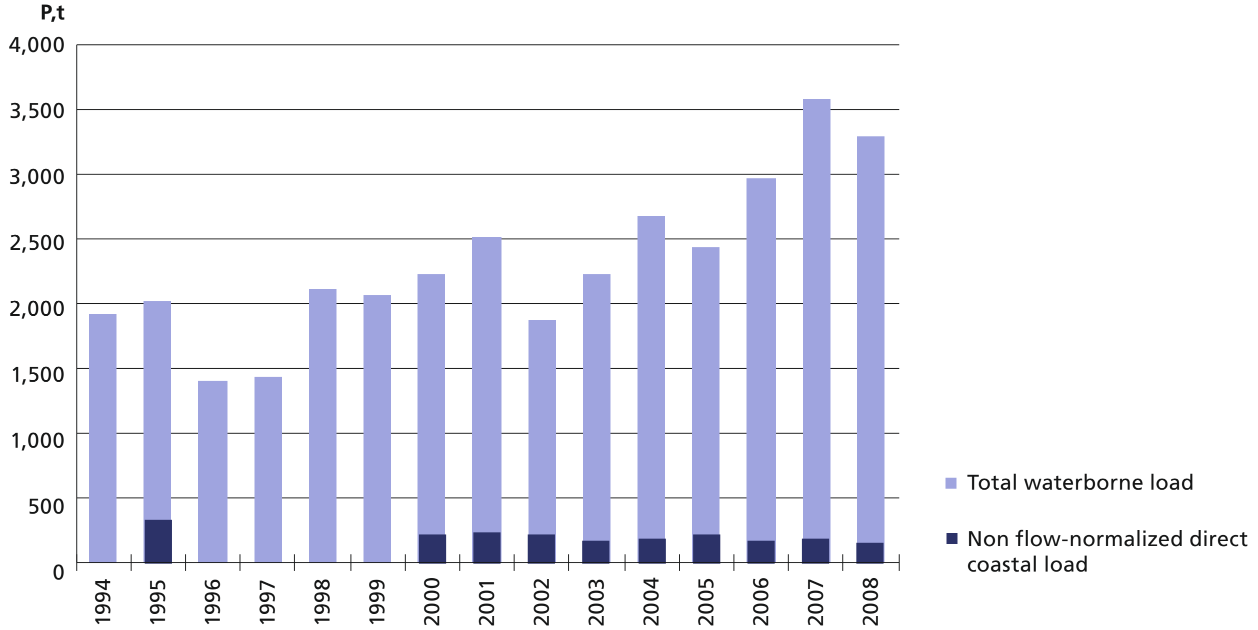
Total flow-normalized waterborne load of nitrogen (in tonnes) from Latvia to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	99,544	88,112	73,731	90,290	77,641	75,866
Non flow-normalized direct coastal loads	0	1,174	0	0	0	0
Total waterborne loads	99,544	89,286	73,731	90,290	77,641	75,866
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,925	1,679	1,407	1,447	2,119	2,076
Non flow-normalized direct coastal loads	0	339	0	0	0	0
Total waterborne loads	1,925	2,018	1,407	1,447	2,119	2,076

NOTE: Riverine loads from Latvia to the Gulf of Riga reported to the PLC-5 database also include transboundary loads from Belarus via the Daugava River catchment. The average load of phosphorus from Belarus to the Gulf of Riga from 1997 to 2003 was estimated at 450 tonnes per year (document 2.1/2 of HELCOM HOD 22/2007).

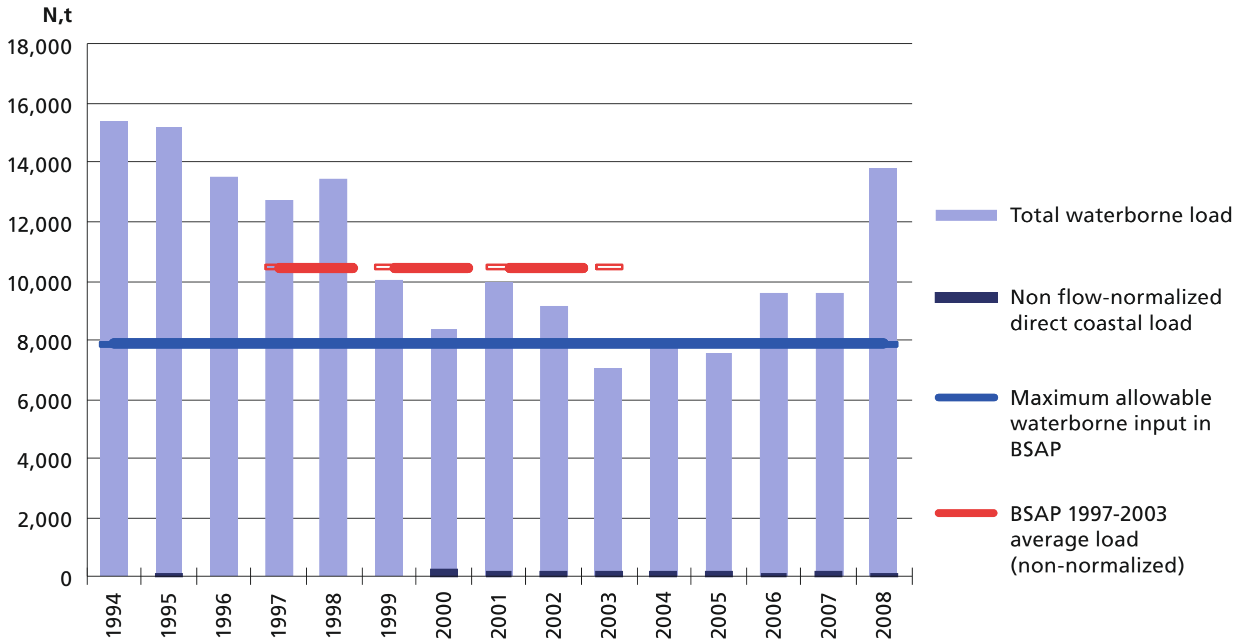
Total flow-normalized waterborne load of phosphorus (in tonnes) from Latvia to the Baltic Sea, 1994-2008



2000	2001	2002	2003	2004	2005	2006	2007	2008
67,024	88,082	67,978	49,144	66,624	60,677	61,523	111,038	99,205
1,551	1,634	1,558	1,926	1,571	1,661	1,800	2,458	2,487
68,575	89,716	69,535	51,070	68,195	62,338	63,324	113,496	101,691
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
2,015	2,277	1,655	2,060	2,490	2,220	2,790	3,404	3,139
213	244	227	177	193	214	177	185	157
2,228	2,520	1,882	2,238	2,683	2,435	2,967	3,589	3,297

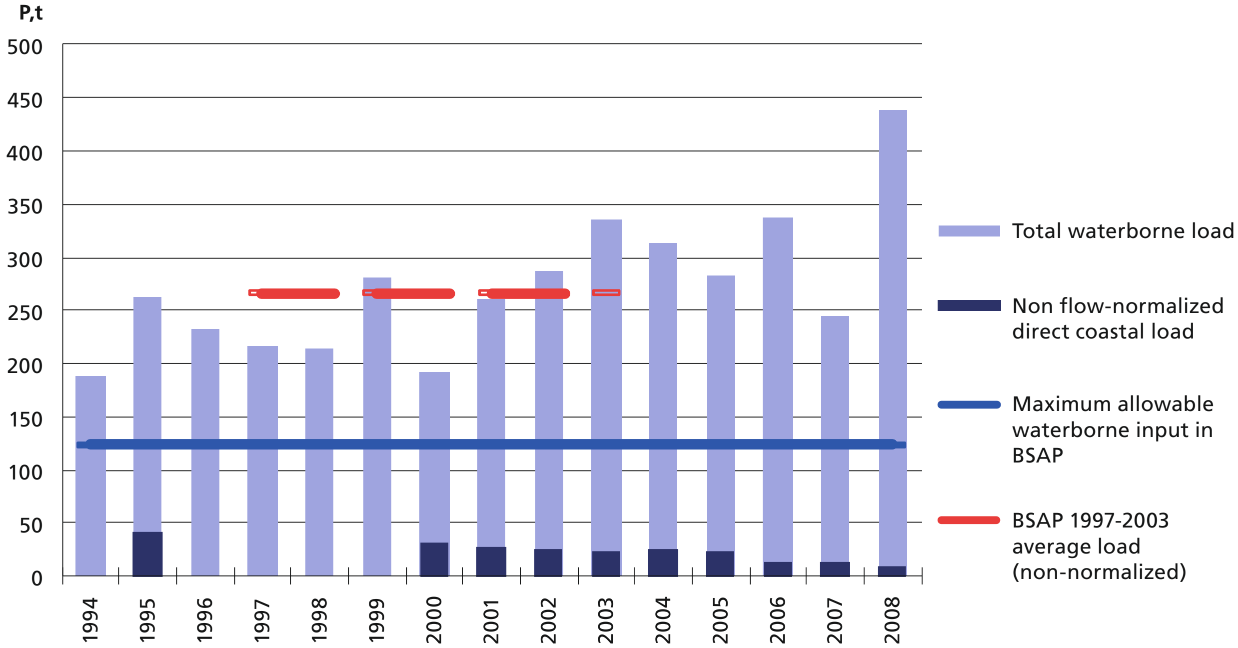
LATVIA: BALTIC PROPER

Total flow-normalized waterborne load of nitrogen (in tonnes) from Latvia to the Baltic Proper, 1994-2008



NITROGEN	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	15,445	15,091	13,546	12,708	13,488	10,073
Non flow-normalized direct coastal loads	0	111	0	0	0	0
Total waterborne loads	15,445	15,202	13,546	12,708	13,488	10,073
Maximum allowable waterborne input in BSAP	7,885	7,885	7,885	7,885	7,885	7,885
BSAP 1997-2003 average load (non-normalized)				10,447	10,447	10,447
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	188	220	233	215	215	280
Non flow-normalized direct coastal loads	0	42	0	0	0	0
Total waterborne loads	188	263	233	215	215	280
Maximum allowable waterborne input in BSAP	124	124	124	124	124	124
BSAP 1997-2003 average load (non-normalized)				266	266	266

Total flow-normalized waterborne load of phosphorus (in tonnes) from Latvia to the Baltic Proper, 1994-2008

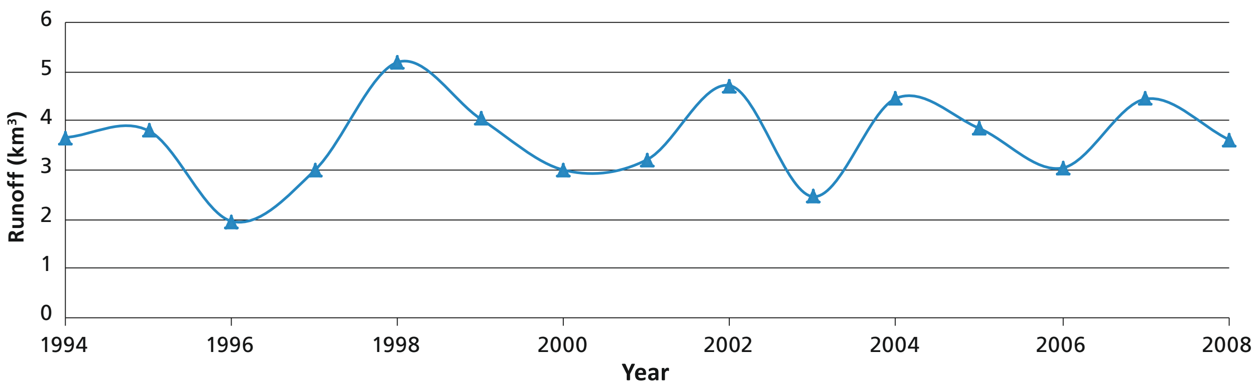


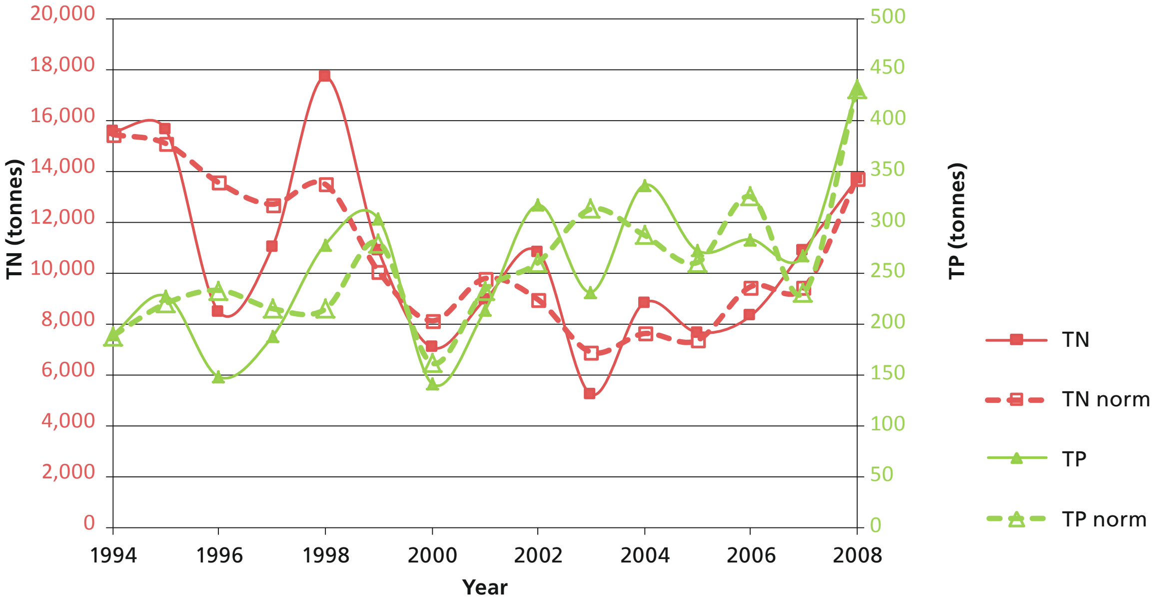
2000	2001	2002	2003	2004	2005	2006	2007	2008
8,129	9,785	8,963	6,892	7,625	7,360	9,465	9,414	13,696
239	196	206	175	197	184	135	165	100
8,368	9,981	9,170	7,068	7,821	7,544	9,600	9,579	13,796
7,885	7,885	7,885	7,885	7,885	7,885	7,885	7,885	7,885
10,447	10,447	10,447	10,447					

2000	2001	2002	2003	2004	2005	2006	2007	2008
162	233	260	313	287	260	325	230	431
31	27	26	23	26	23	13	14	9
193	260	286	336	313	284	338	244	439
124	124	124	124	124	124	124	124	124
266	266	266	266					

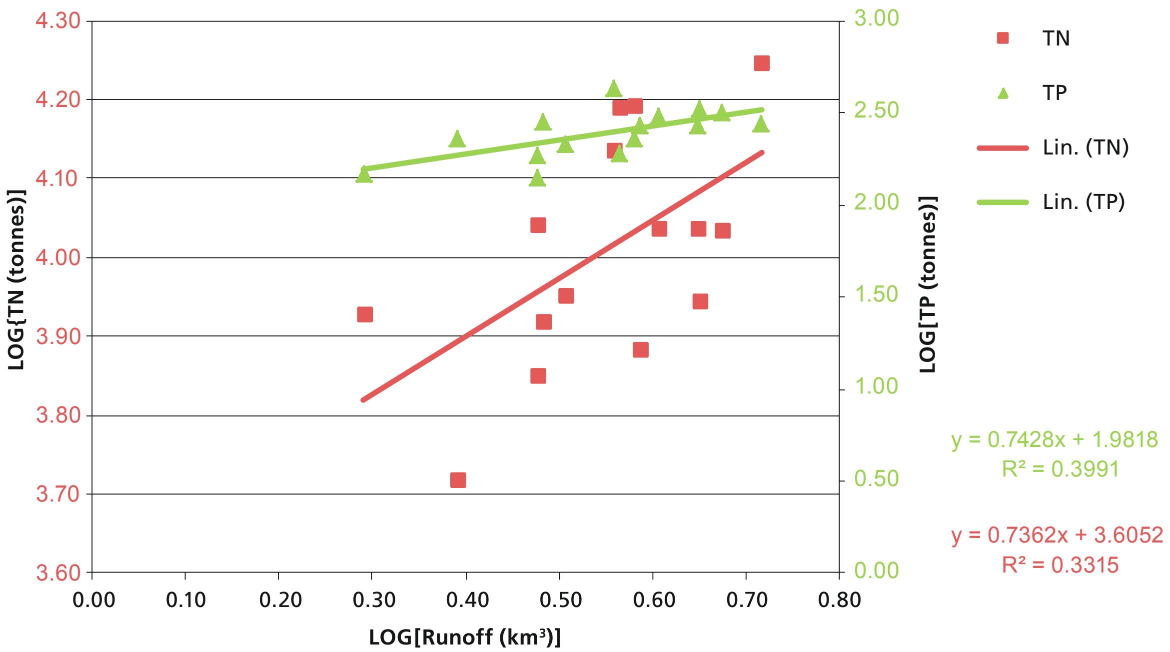
LV_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	3.66	15,554.15	189.62	15,445.45	188.40	0.56	4.19	2.28
1995	3.80	15,619.90	227.52	15,091.17	220.21	0.58	4.19	2.36
1996	1.95	8,470.75	147.93	13,546.19	233.12	0.29	3.93	2.17
1997	3.00	11,002.93	187.39	12,707.52	215.21	0.48	4.04	2.27
1998	5.20	17,705.75	278.24	13,488.16	214.60	0.72	4.25	2.44
1999	4.04	10,887.48	303.35	10,072.57	279.92	0.61	4.04	2.48
2000	3.00	7,085.35	141.84	8,128.85	161.73	0.48	3.85	2.15
2001	3.21	8,944.79	213.06	9,784.88	233.13	0.51	3.95	2.33
2002	4.72	10,839.20	316.70	8,963.36	260.25	0.67	4.03	2.50
2003	2.46	5,235.87	231.29	6,892.46	312.88	0.39	3.72	2.36
2004	4.46	8,831.88	336.36	7,624.83	287.39	0.65	3.95	2.53
2005	3.85	7,671.07	272.05	7,360.25	260.42	0.59	3.88	2.43
2006	3.04	8,315.95	283.17	9,464.51	325.13	0.48	3.92	2.45
2007	4.45	10,912.84	267.13	9,414.30	230.28	0.65	4.04	2.43
2008	3.63	13,680.28	430.08	13,696.42	430.63	0.56	4.14	2.63

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





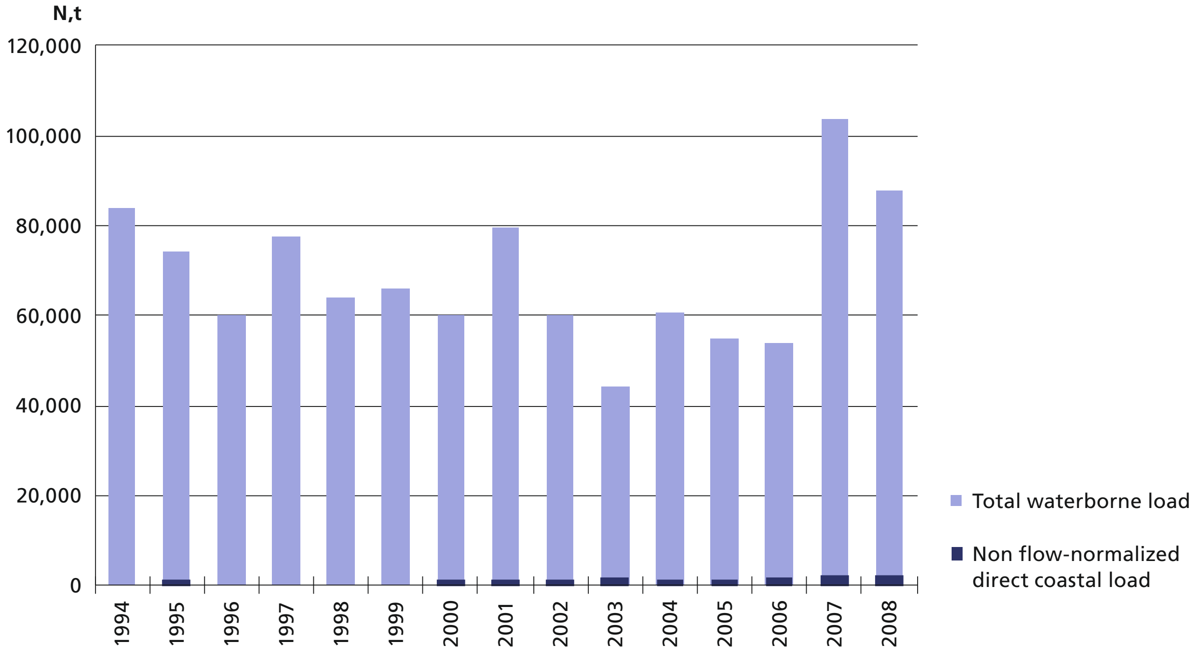
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
TN (tonnes)
500
450
400
350
300
250
200
150
100
50
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
LOG[TN (tonnes)]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
LOG[TP (tonnes)]
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.7428x + 1.9818
R² = 0.3991
y = 0.7362x + 3.6052
R² = 0.3315

LATVIA: GULF OF RIGA

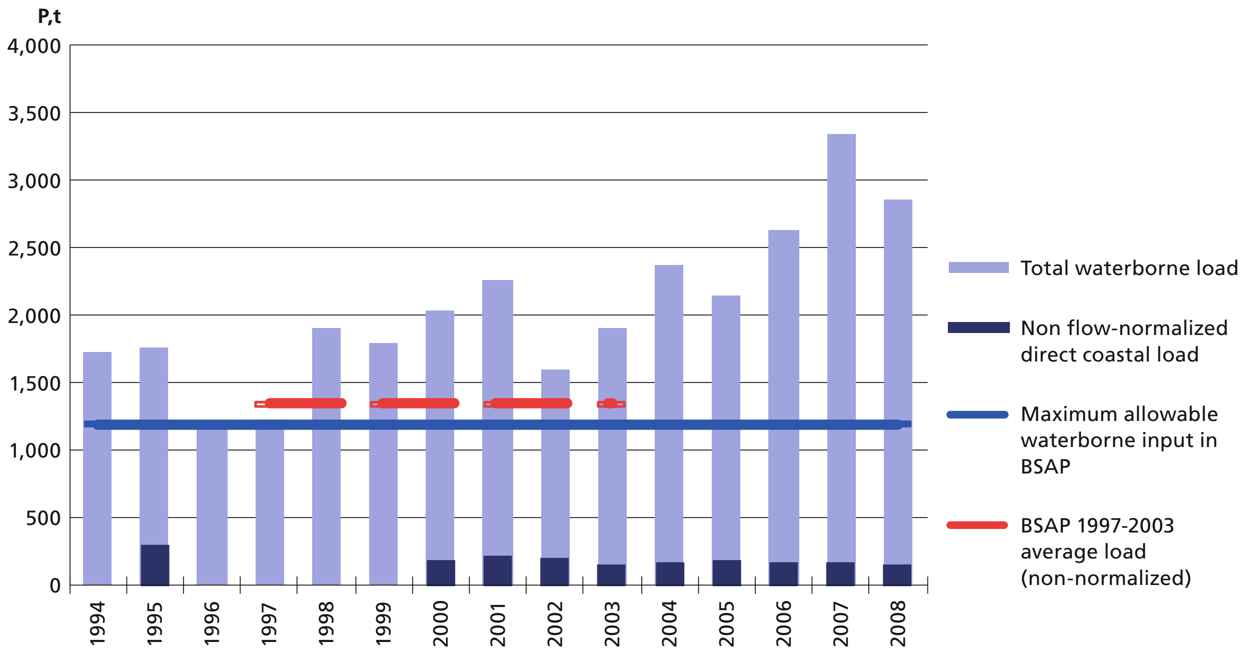
Total flow-normalized waterborne load of nitrogen (in tonnes) from Latvia to the Gulf of Riga, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	84,099	73,020	60,185	77,582	64,153	65,793
Non flow-normalized direct coastal loads	0	1,063	0	0	0	0
Total waterborne loads	84,099	74,084	60,185	77,582	64,153	65,793
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,737	1,459	1,174	1,232	1,905	1,797
Non flow-normalized direct coastal loads	0	297	0	0	0	0
Total waterborne loads	1,737	1,756	1,174	1,232	1,905	1,797
Maximum allowable waterborne input in BSAP	1,191	1,191	1,191	1,191	1,191	1,191
BSAP 1997-2003 average load (non-normalized)				1,347	1,347	1,347

NOTE: Riverine loads from Latvia to the Gulf of Riga reported to the PLC-5 database also include transboundary loads from Belarus via the Daugava River catchment. The average load of phosphorus from Belarus to the Gulf of Riga from 1997 to 2003 was estimated at 450 tonnes per year (document 2.1/2 of HELCOM HOD 22/2007).

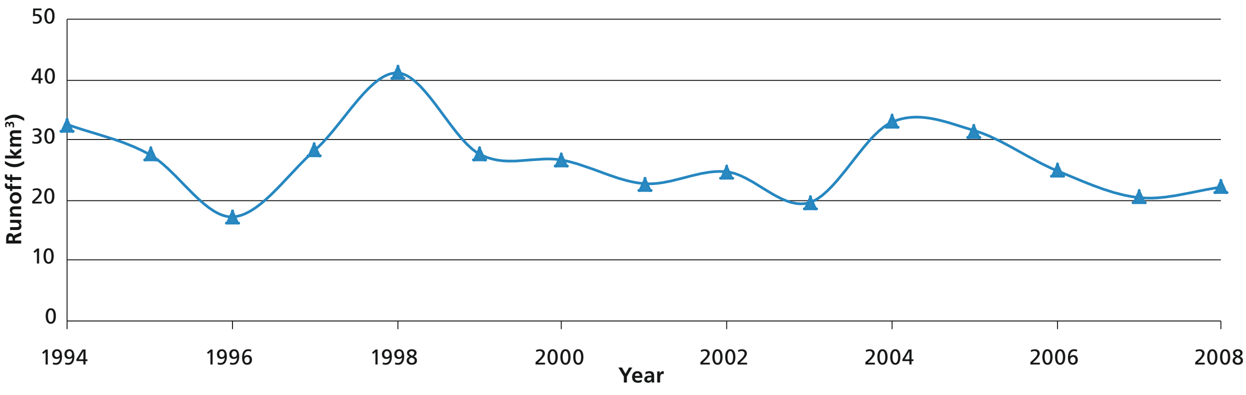
Total flow-normalized waterborne load of phosphorus (in tonnes) from Latvia to the Gulf of Riga, 1994-2008

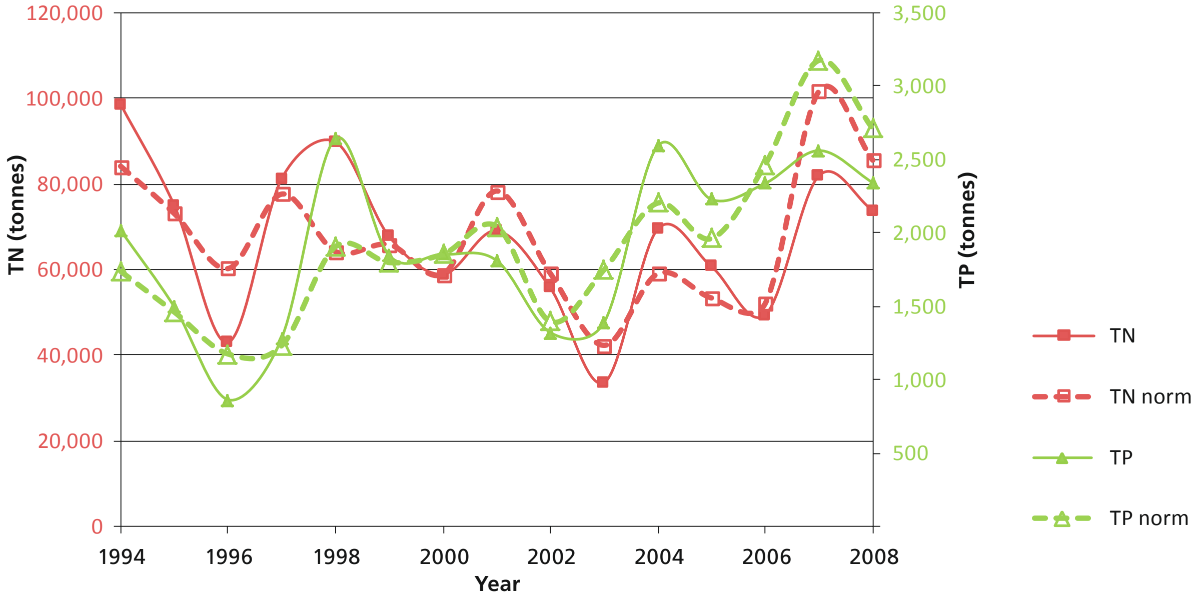


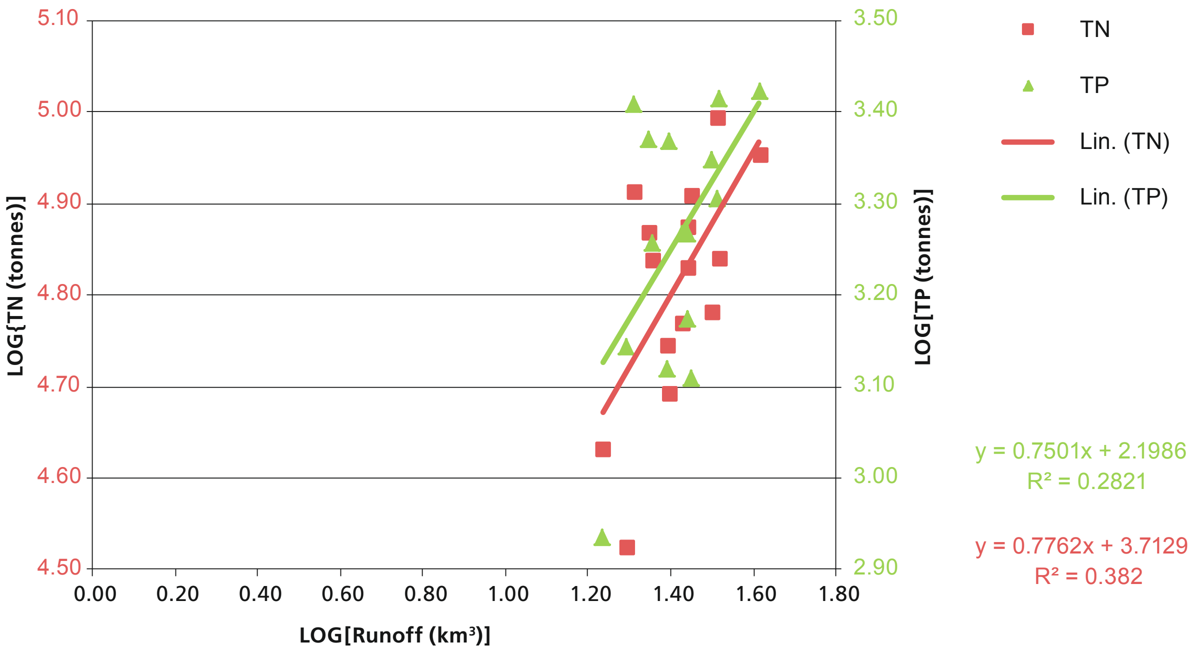
2000	2001	2002	2003	2004	2005	2006	2007	2008
58,895	78,297	59,014	42,252	58,999	53,316	52,059	101,623	85,508
1,312	1,437	1,351	1,751	1,375	1,477	1,665	2,293	2,387
60,207	79,735	60,365	44,002	60,373	54,794	53,724	103,917	87,895
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1,853	2,044	1,395	1,748	2,202	1,960	2,465	3,174	2,709
182	217	201	154	167	191	164	171	149
2,035	2,261	1,596	1,902	2,370	2,151	2,629	3,345	2,858
1,191	1,191	1,191	1,191	1,191	1,191	1,191	1,191	1,191
1,347	1,347	1,347	1,347					

LV_GULF OF RIGA	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	32.59	98,566.54	2,015.55	84,098.78	1,736.85	1.51	4.99	3.30
1995	27.56	74,914.00	1,494.10	73,020.36	1,459.05	1.44	4.87	3.17
1996	17.20	42,942.56	861.66	60,184.68	1,173.56	1.24	4.63	2.94
1997	28.28	81,235.45	1,283.71	77,582.17	1,231.59	1.45	4.91	3.11
1998	41.17	89,765.47	2,640.46	64,152.65	1,904.70	1.61	4.95	3.42
1999	27.65	67,647.51	1,845.29	65,793.26	1,796.58	1.44	4.83	3.27
2000	26.65	58,856.40	1,851.70	58,895.36	1,852.90	1.43	4.77	3.27
2001	22.73	69,031.12	1,809.91	78,297.47	2,043.58	1.36	4.84	3.26
2002	24.70	55,626.80	1,319.20	59,014.23	1,394.52	1.39	4.75	3.12
2003	19.58	33,564.12	1,388.62	42,251.64	1,747.60	1.29	4.53	3.14
2004	32.98	69,439.85	2,591.21	58,998.70	2,202.11	1.52	4.84	3.41
2005	31.56	60,604.51	2,225.79	53,316.31	1,959.98	1.50	4.78	3.35
2006	24.90	49,403.24	2,336.44	52,058.91	2,465.24	1.40	4.69	3.37
2007	20.41	81,883.21	2,559.27	101,623.47	3,173.94	1.31	4.91	3.41
2008	22.16	73,796.18	2,340.55	85,508.49	2,708.79	1.35	4.87	3.37

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

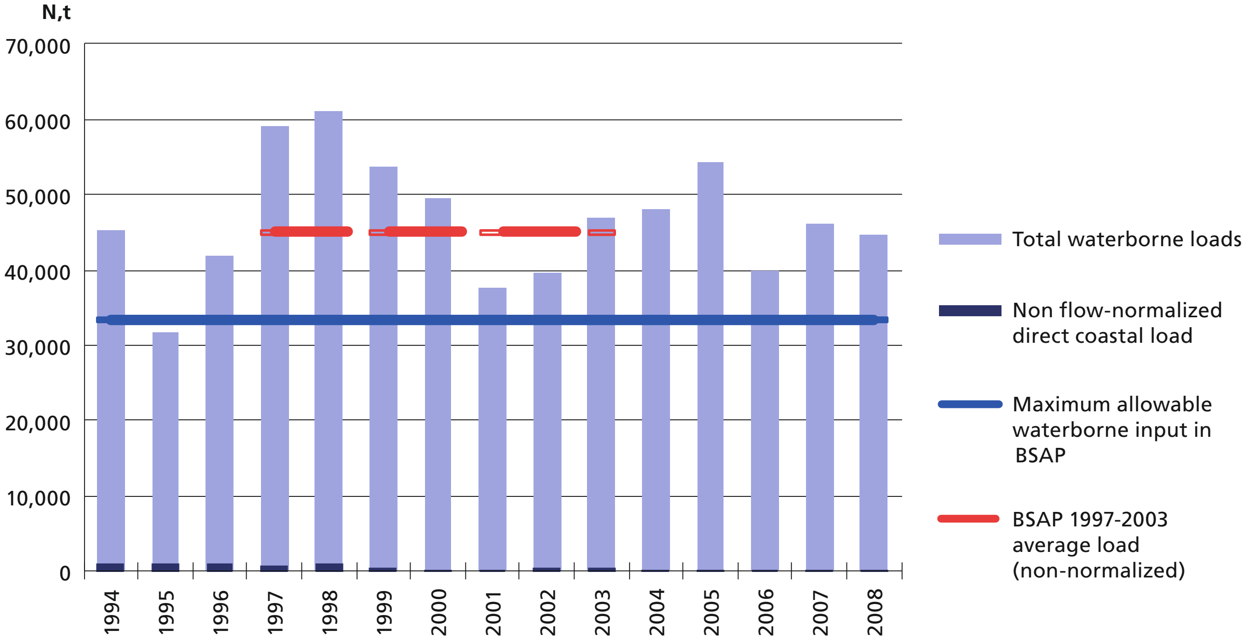



120,000
100,000
80,000
60,000
40,000
20,000
0
TN (tonnes)
3,500
3,000
2,500
2,000
1,500
1,000
500
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


5.10
5.00
4.90
4.80
4.70
4.60
4.50
LOG[TN (tonnes)]
3.50
3.40
3.30
3.20
3.10
3.00
2.90
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.7501x + 2.1986
R² = 0.2821
y = 0.7762x + 3.7129
R² = 0.382

6. LITHUANIA: TOTAL / BALTIC PROPER

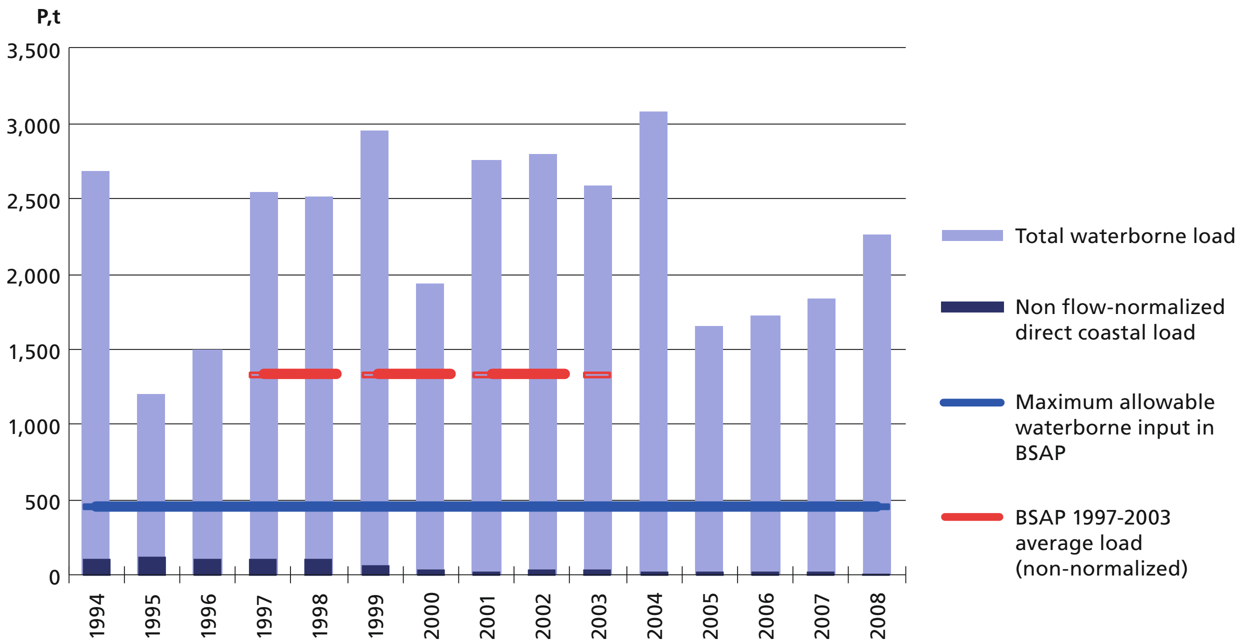
Total flow-normalized waterborne load of nitrogen (in tonnes) from Lithuania to the Baltic Proper, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	44,364	30,747	41,079	58,335	60,100	53,405
Non flow-normalized direct coastal loads	943	902	883	791	887	437
Total waterborne loads	45,307	31,649	41,962	59,125	60,987	53,842
Maximum allowable waterborne input in BSAP	33,363	33,363	33,363	33,363	33,363	33,363
BSAP 1997-2003 average load (non-normalized)				45,109	45,109	45,109
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	2,590	1,077	1,381	2,442	2,411	2,887
Non flow-normalized direct coastal loads	101	119	114	107	106	64
Total waterborne loads	2,691	1,197	1,495	2,549	2,517	2,951
Maximum allowable waterborne input in BSAP	455	455	455	455	455	455
BSAP 1997-2003 average load (non-normalized)				1,336	1,336	1,336

NOTE: Riverine loads from Lithuania to the Baltic Proper reported to the PLC-5 database also include transboundary loads from Belarus via the Nemunas/Neman River catchment. Average loads from Belarus to the Baltic Proper from 1997 to 2003 were estimated at 1206 tonnes P/year and 3763 tonnes N/year (document 2.1/2 of HELCOM HOD 22/2007).

Total flow-normalized waterborne load of phosphorus (in tonnes) from Lithuania to the Baltic Proper, 1994-2008

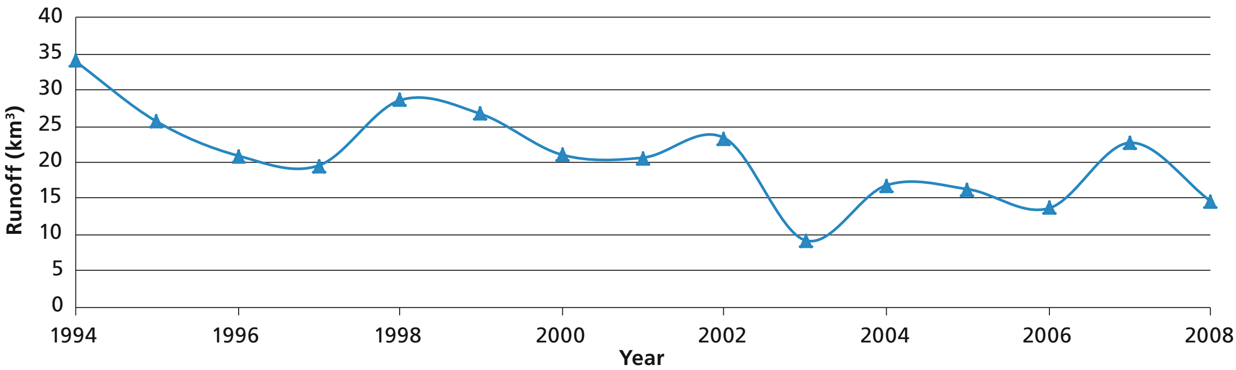


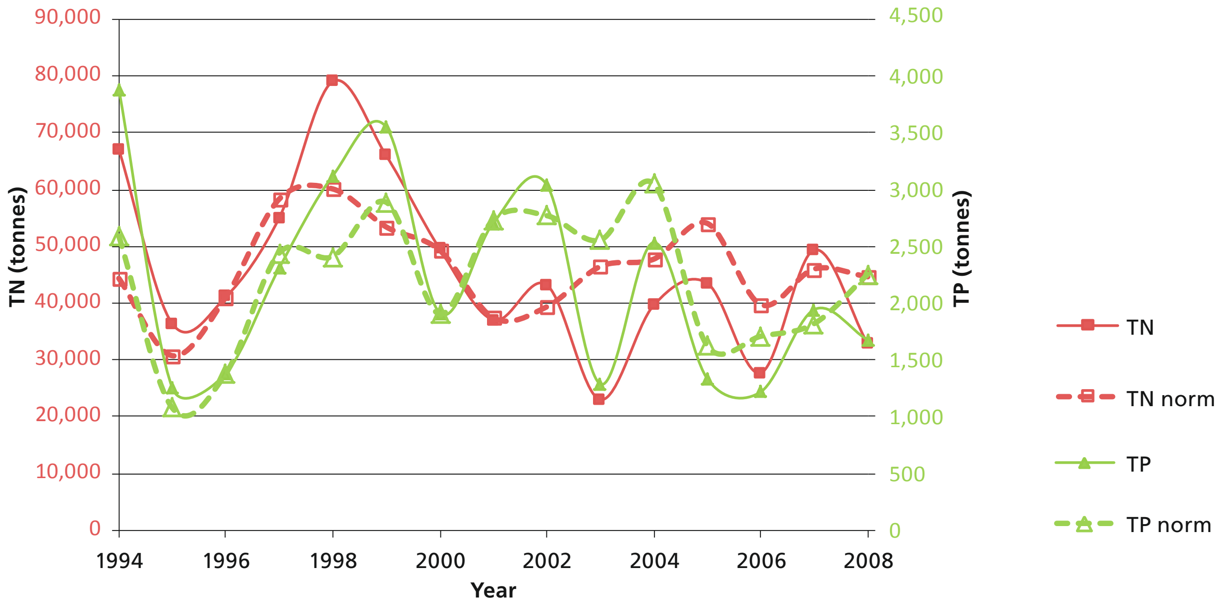
2000	2001	2002	2003	2004	2005	2006	2007	2008
49,277	37,420	39,359	46,462	47,751	54,046	39,745	46,014	44,645
282	307	323	405	262	273	230	125	38
49,558	37,727	39,682	46,868	48,012	54,319	39,976	46,139	44,682
33,363	33,363	33,363	33,363	33,363	33,363	33,363	33,363	33,363
45,109	45,109	45,109	45,109					

2000	2001	2002	2003	2004	2005	2006	2007	2008
1,904	2,734	2,770	2,555	3,049	1,625	1,709	1,820	2,254
37	28	33	35	28	24	22	25	2
1,941	2,762	2,802	2,591	3,077	1,648	1,731	1,845	2,256
455	455	455	455	455	455	455	455	455
1,336	1,336	1,336	1,336					

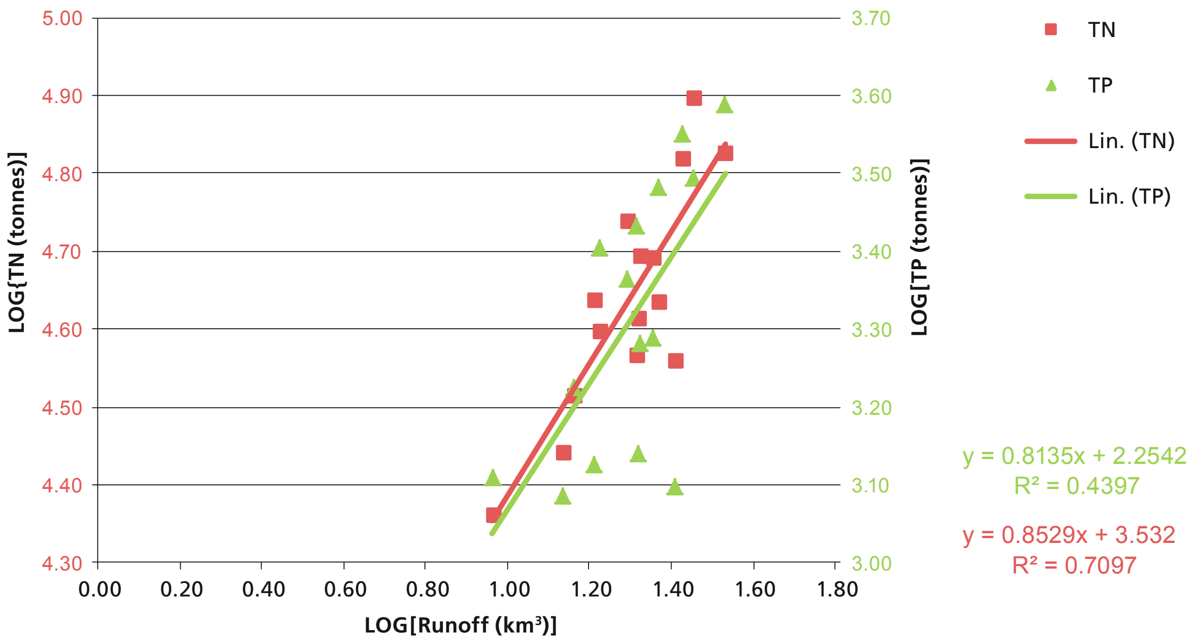
LT_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	33.99	67,073.58	3,884.53	44,363.98	2,590.13	1.53	4.83	3.59
1995	25.65	36,368.44	1,253.45	30,747.03	1,077.30	1.41	4.56	3.10
1996	20.93	41,115.79	1,381.94	41,078.54	1,380.80	1.32	4.61	3.14
1997	19.56	55,044.82	2,311.00	58,334.51	2,441.85	1.29	4.74	3.36
1998	28.58	79,014.70	3,121.86	60,100.46	2,410.75	1.46	4.90	3.49
1999	26.67	65,941.22	3,547.97	53,405.12	2,887.38	1.43	4.82	3.55
2000	21.04	49,536.43	1,913.42	49,276.51	1,904.05	1.32	4.69	3.28
2001	20.65	37,027.38	2,705.55	37,420.19	2,734.34	1.31	4.57	3.43
2002	23.36	43,204.78	3,040.56	39,358.88	2,769.89	1.37	4.64	3.48
2003	9.19	23,015.47	1,288.61	46,462.40	2,555.35	0.96	4.36	3.11
2004	16.83	39,644.15	2,533.88	47,750.52	3,048.59	1.23	4.60	3.40
2005	16.28	43,503.22	1,334.81	54,046.22	1,624.67	1.21	4.64	3.13
2006	13.64	27,734.31	1,219.24	39,745.17	1,708.85	1.13	4.44	3.09
2007	22.70	49,366.72	1,943.72	46,013.61	1,820.22	1.36	4.69	3.29
2008	14.56	32,807.34	1,675.29	44,644.54	2,253.60	1.16	4.52	3.22

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





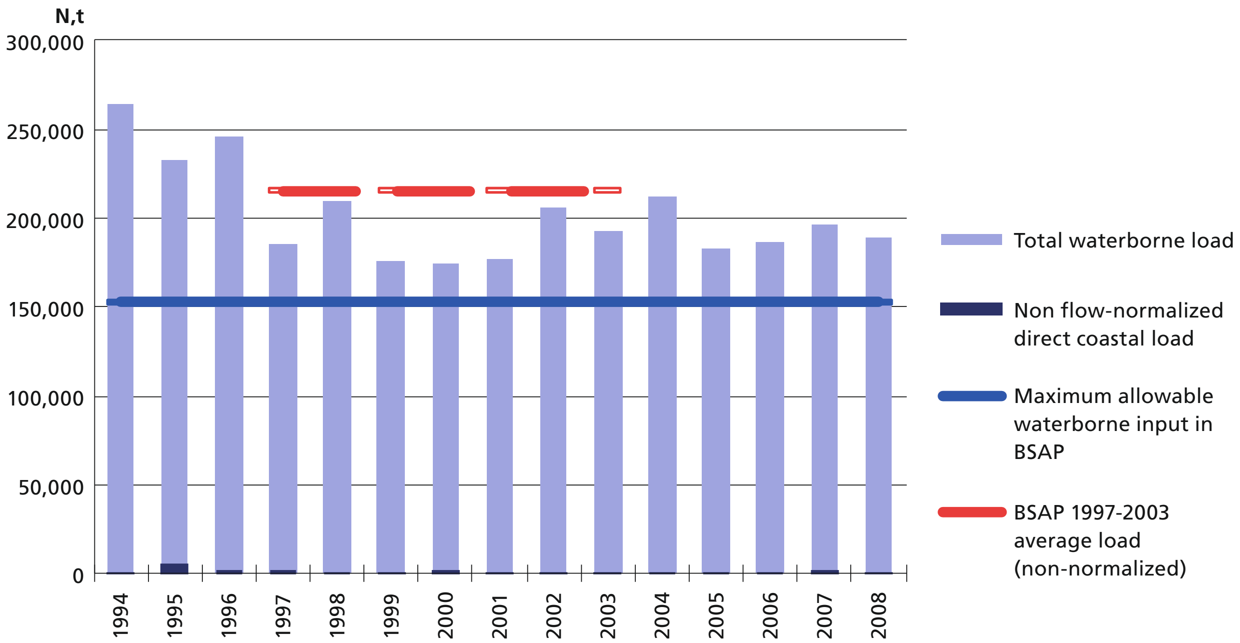
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
TN (tonnes)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



5.00
4.90
4.80
4.70
4.60
4.50
4.40
4.30
LOG{TN (tonnes)]
3.70
3.60
3.50
3.40
3.30
3.20
3.10
3.00
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.8135x + 2.2542
R² = 0.4397
y = 0.8529x + 3.532
R² = 0.7097

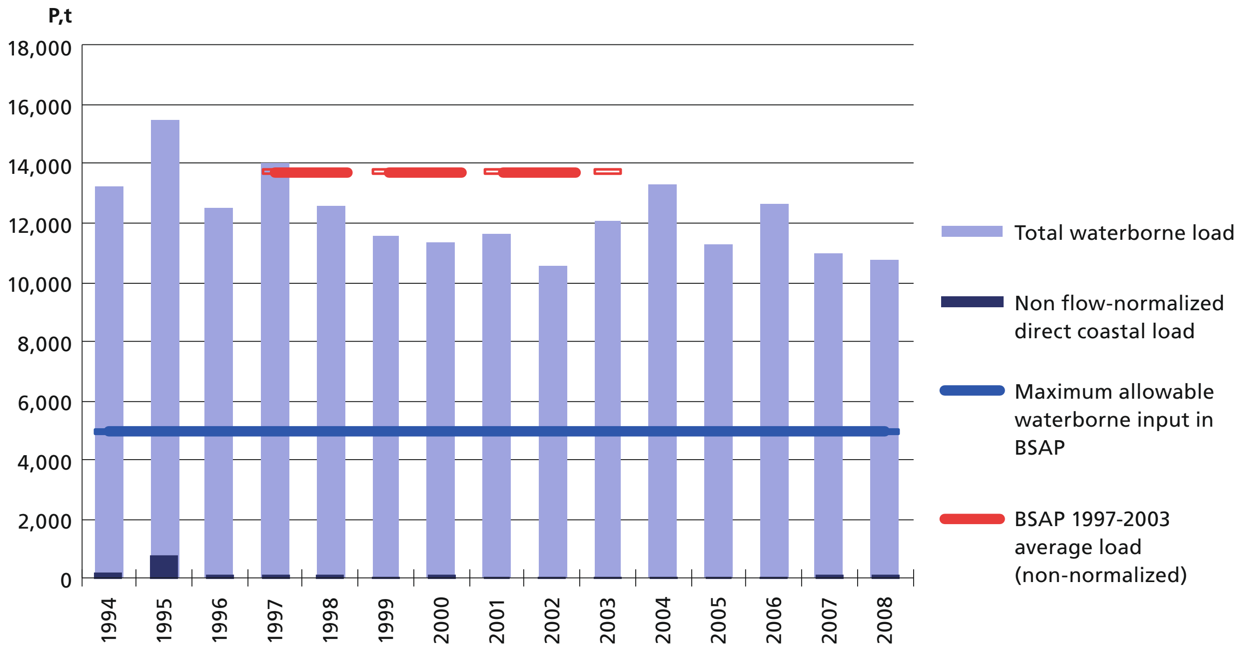
7. POLAND: TOTAL / BALTIC PROPER

Total flow-normalized waterborne load of nitrogen (in tonnes) from Poland to the Baltic Proper, 1994-2008



NITROGEN	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	262,643	227,504	244,898	184,550	208,907	174,875
Non flow-normalized direct coastal loads	1,298	5,206	1,652	1,392	1,103	733
Total waterborne loads	263,941	232,710	246,550	185,943	210,010	175,608
Maximum allowable waterborne input in BSAP	152,955	152,955	152,955	152,955	152,955	152,955
BSAP 1997-2003 average load (non-normalized)				215,350	215,350	215,350
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	13,060	14,709	12,403	13,916	12,431	11,479
Non flow-normalized direct coastal loads	177	779	130	90	139	57
Total waterborne loads	13,237	15,487	12,533	14,006	12,570	11,537
Maximum allowable waterborne input in BSAP	4,962	4,962	4,962	4,962	4,962	4,962
BSAP 1997-2003 average load (non-normalized)				13,717	13,717	13,717

Total flow-normalized waterborne load of phosphorus (in tonnes) from Poland to the Baltic Proper, 1994-2008

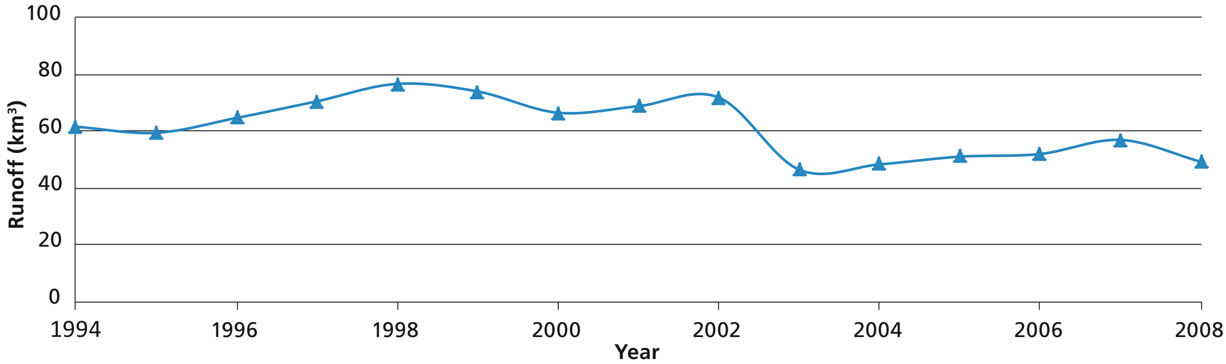


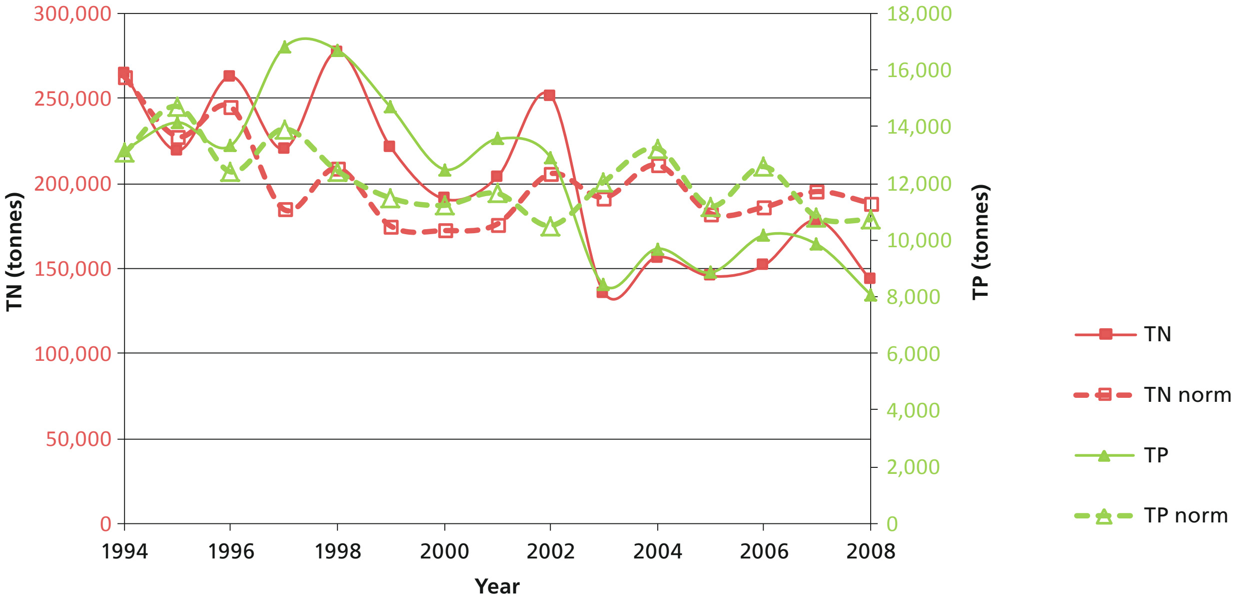
2000	2001	2002	2003	2004	2005	2006	2007	2008
172,204	176,030	205,609	191,675	210,845	182,251	185,908	195,144	188,331
1,809	744	768	1,184	1,029	888	928	1,720	923
174,013	176,774	206,377	192,859	211,874	183,139	186,836	196,864	189,254
152,955	152,955	152,955	152,955	152,955	152,955	152,955	152,955	152,955
215,350	215,350	215,350	215,350					

2000	2001	2002	2003	2004	2005	2006	2007	2008
11,222	11,643	10,505	12,048	13,230	11,194	12,590	10,808	10,709
152	29	43	50	57	61	71	140	91
11,374	11,672	10,549	12,098	13,287	11,255	12,661	10,948	10,800
4,962	4,962	4,962	4,962	4,962	4,962	4,962	4,962	4,962
13,717	13,717	13,717	13,717					

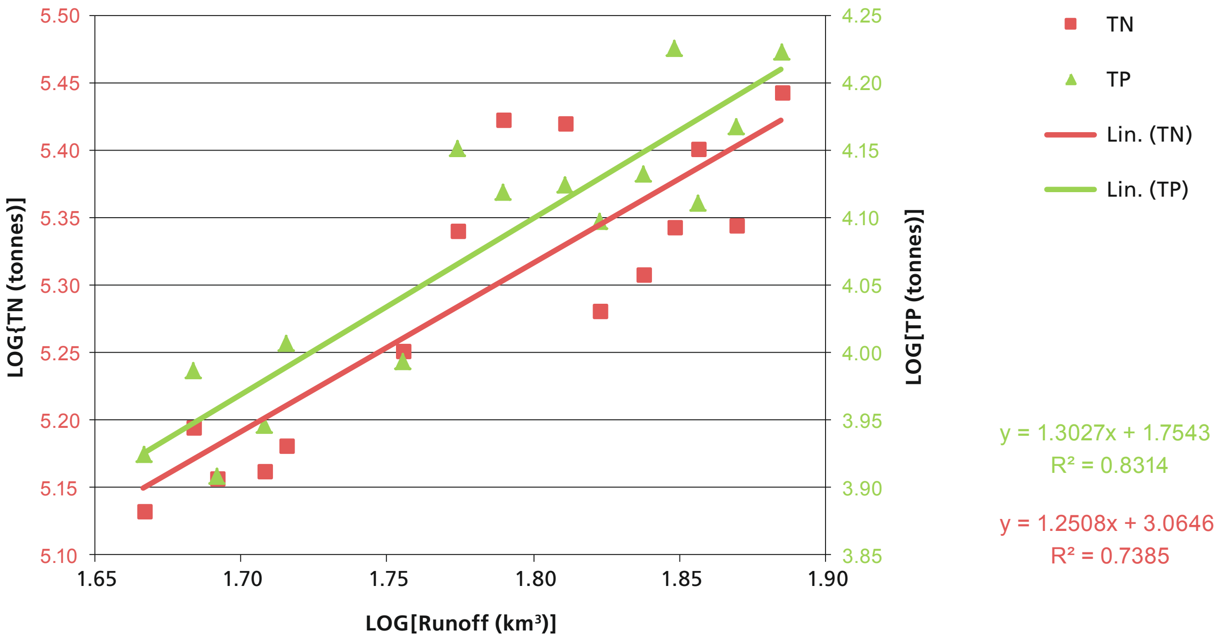
PL_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	61.58	264,762.61	13,168.24	262,642.51	13,059.97	1.79	5.42	4.12
1995	59.42	219,201.56	14,144.68	227,503.59	14,708.76	1.77	5.34	4.15
1996	64.67	262,730.02	13,331.45	244,898.49	12,402.99	1.81	5.42	4.12
1997	70.54	220,206.73	16,792.90	184,550.38	13,915.79	1.85	5.34	4.23
1998	76.69	277,349.61	16,694.92	208,906.56	12,430.89	1.88	5.44	4.22
1999	74.00	221,210.87	14,682.71	174,875.15	11,479.45	1.87	5.34	4.17
2000	66.49	190,811.01	12,493.25	172,203.98	11,222.01	1.82	5.28	4.10
2001	68.83	203,596.92	13,560.73	176,029.89	11,642.84	1.84	5.31	4.13
2002	71.88	251,565.63	12,914.38	205,608.95	10,505.37	1.86	5.40	4.11
2003	46.43	135,844.53	8,408.56	191,674.89	12,047.81	1.67	5.13	3.92
2004	48.29	156,579.45	9,689.25	210,845.43	13,230.10	1.68	5.19	3.99
2005	51.02	145,414.54	8,849.81	182,250.97	11,194.06	1.71	5.16	3.95
2006	51.96	151,683.95	10,163.62	185,907.92	12,589.54	1.72	5.18	4.01
2007	56.92	178,268.64	9,845.81	195,143.90	10,808.07	1.76	5.25	3.99
2008	49.21	143,575.89	8,091.53	188,331.33	10,709.19	1.69	5.16	3.91

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





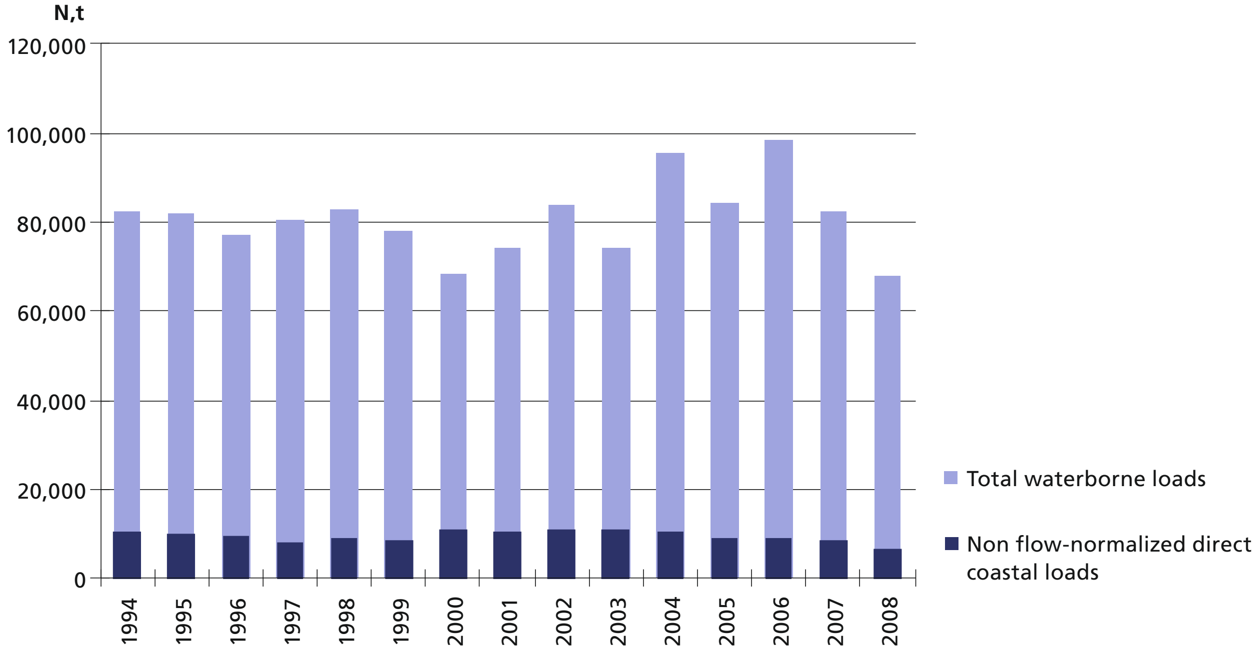
300,000
250,000
200,000
150,000
100,000
50,000
0
TN (tonnes)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



5.50
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
LOG{TN (tonnes)]
4.25
4.20
4.15
4.10
4.05
4.00
3.95
3.90
3.85
LOG[TP (tonnes)]
1.65
1.70
1.75
1.80
1.85
1.90
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.3027x + 1.7543
R² = 0.8314
y = 1.2508x + 3.0646
R² = 0.7385

8. RUSSIA: TOTAL

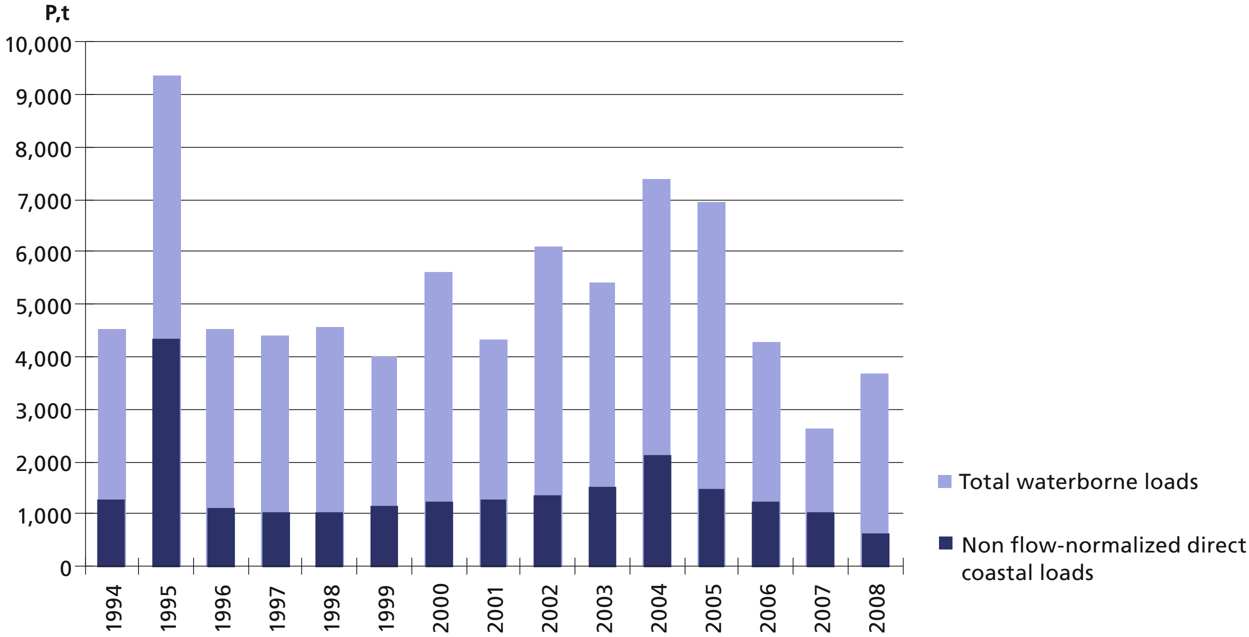
Total flow-normalized waterborne load of nitrogen (in tonnes) from Russia to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	71,961	71,875	67,504	72,197	73,974	69,266
Non flow-normalized direct coastal loads	10,306	10,035	9,412	8,120	9,016	8,651
Total waterborne loads	82,267	81,910	76,916	80,317	82,990	77,916
Maximum allowable waterborne input in BSAP	71,411	71,411	71,411	71,411	71,411	71,411
BSAP 1997-2003 average load (non-normalized)				78,381	78,381	78,381
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	3,276	5,034	3,378	3,390	3,522	2,857
Non flow-normalized direct coastal loads	1,256	4,337	1,130	1,027	1,048	1,162
Total waterborne loads	4,532	9,371	4,508	4,416	4,569	4,019
Maximum allowable waterborne input in BSAP	3,782	3,782	3,782	3,782	3,782	3,782
BSAP 1997-2003 average load (non-normalized)				6,282	6,282	6,282

NOTE: Riverine loads to the Baltic Proper (from the Kaliningrad Region) in 1995-1999 and 2007-2008 for nitrogen and for the whole period of 1995-2008 for phosphorus were not reported to the PLC-5 database and therefore are not included in the assessment of the progress towards BSAP nutrient reduction targets. Accordingly, it is not possible to assess the progress in reaching the BSAP nutrient reduction targets.

Total flow-normalized waterborne load of phosphorus (in tonnes) from Russia to the Baltic Sea, 1994-2008

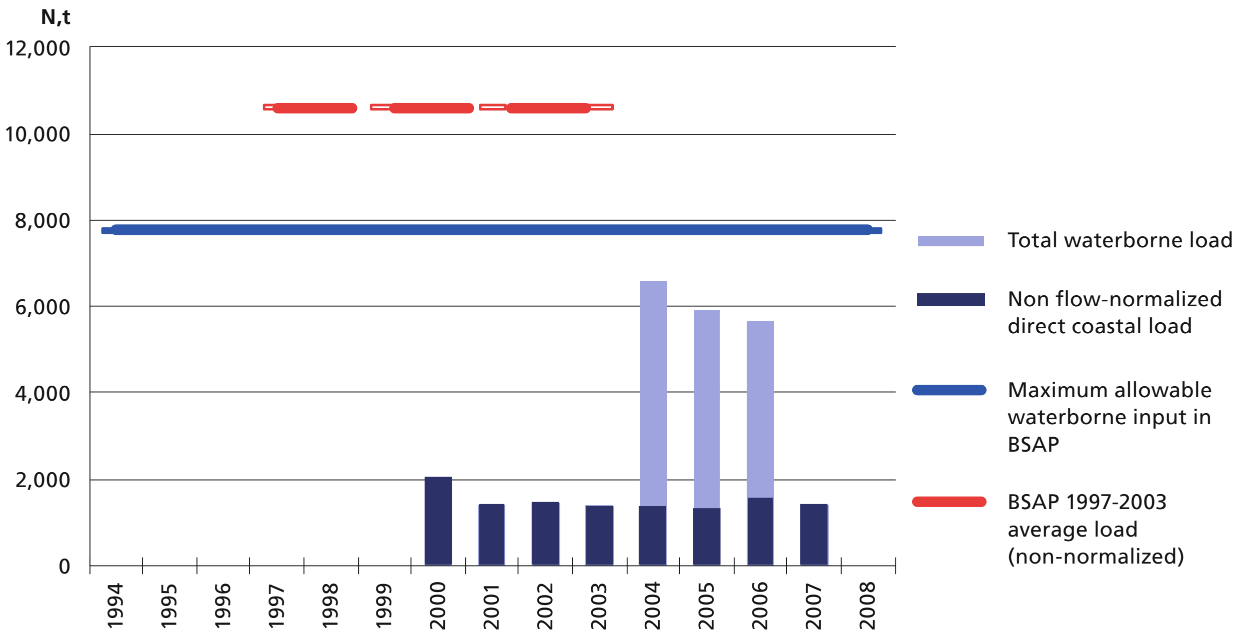


2000	2001	2002	2003	2004	2005	2006	2007	2008
57,345	64,060	73,128	63,536	85,075	75,011	89,492	73,590	61,206
11,020	10,262	10,736	10,765	10,484	9,176	8,866	8,670	6,617
68,365	74,322	83,865	74,301	95,558	84,187	98,358	82,259	67,823
71,411	71,411	71,411	71,411	71,411	71,411	71,411	71,411	71,411
78,381	78,381	78,381	78,381					

2000	2001	2002	2003	2004	2005	2006	2007	2008
4,360	3,050	4,781	3,898	5,255	5,449	3,047	1,625	3,030
1,238	1,267	1,338	1,511	2,125	1,491	1,233	1,015	633
5,598	4,317	6,119	5,409	7,380	6,941	4,280	2,641	3,663
3,782	3,782	3,782	3,782	3,782	3,782	3,782	3,782	3,782
6,282	6,282	6,282	6,282					

RUSSIA: BALTIC PROPER

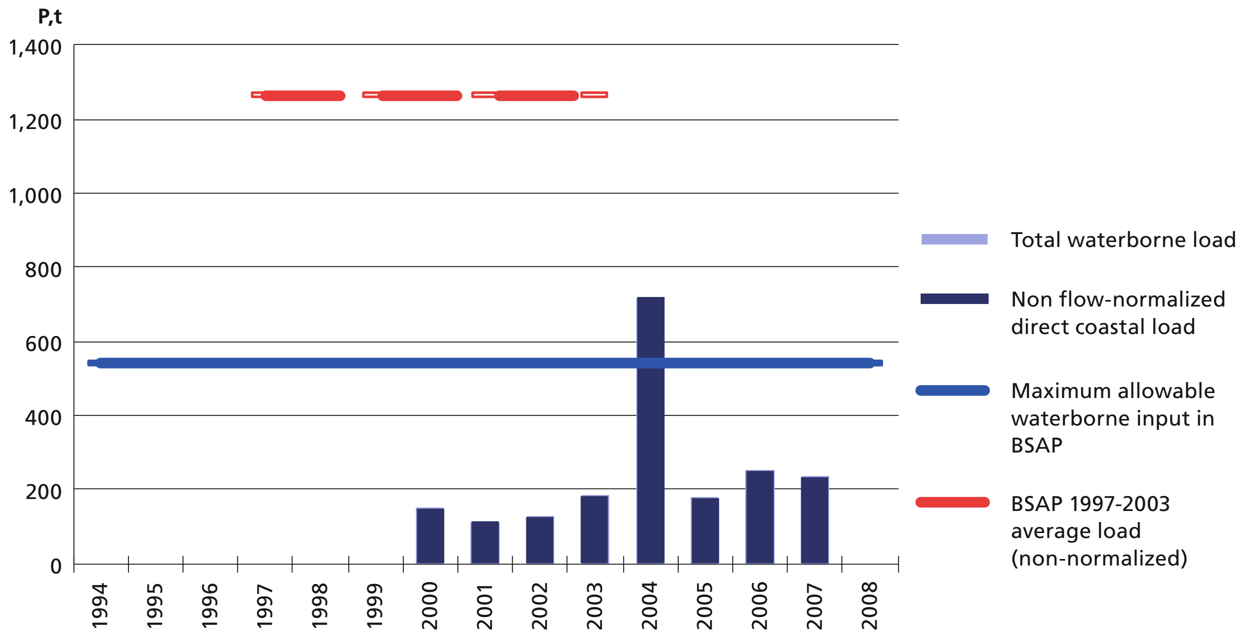
Total flow-normalized waterborne load of nitrogen (in tonnes) from Russia to the Baltic Proper, 1994-2008



NITROGEN	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	0	0	0	0	0	0
Non flow-normalized direct coastal loads	0	0	0	0	0	0
Total waterborne loads	0	0	0	0	0	0
Maximum allowable waterborne input in BSAP	7,773	7,773	7,773	7,773	7,773	7,773
BSAP 1997-2003 average load (non-normalized)				10,594	10,594	10,594
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	0	0	0	0	0	0
Non flow-normalized direct coastal loads	0	0	0	0	0	0
Total waterborne loads	0	0	0	0	0	0
Maximum allowable waterborne input in BSAP	542	542	542	542	542	542
BSAP 1997-2003 average load (non-normalized)				1,266	1,266	1,266

NOTE: Riverine loads to the Baltic Proper (from the Kaliningrad Region) in 1995-1999 and 2007-2008 for nitrogen and for the whole period of 1995-2008 for phosphorus were not reported to the PLC-5 database and therefore are not included in the assessment of the progress towards BSAP nutrient reduction targets. Accordingly, it is not possible to assess the progress in reaching the BSAP nutrient reduction targets.

Total flow-normalized waterborne load of phosphorus (in tonnes) from Russia to the Baltic Proper, 1994-2008

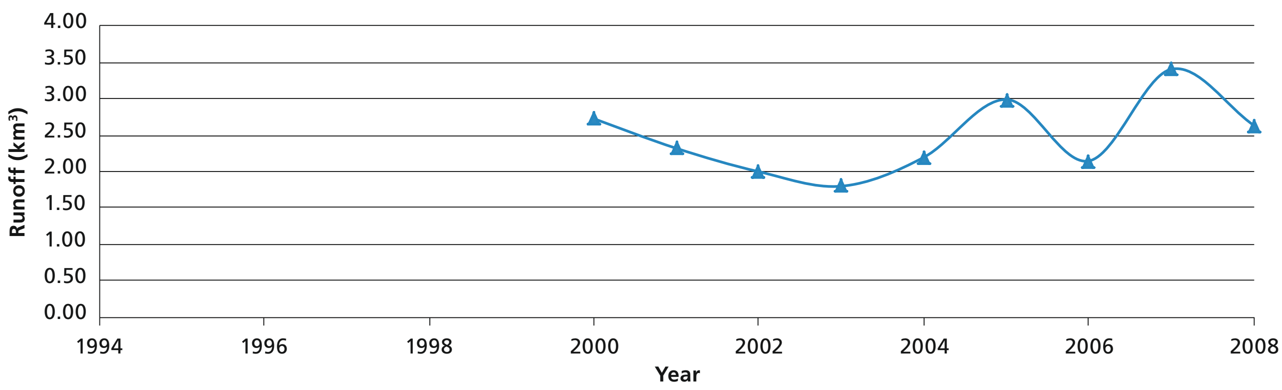


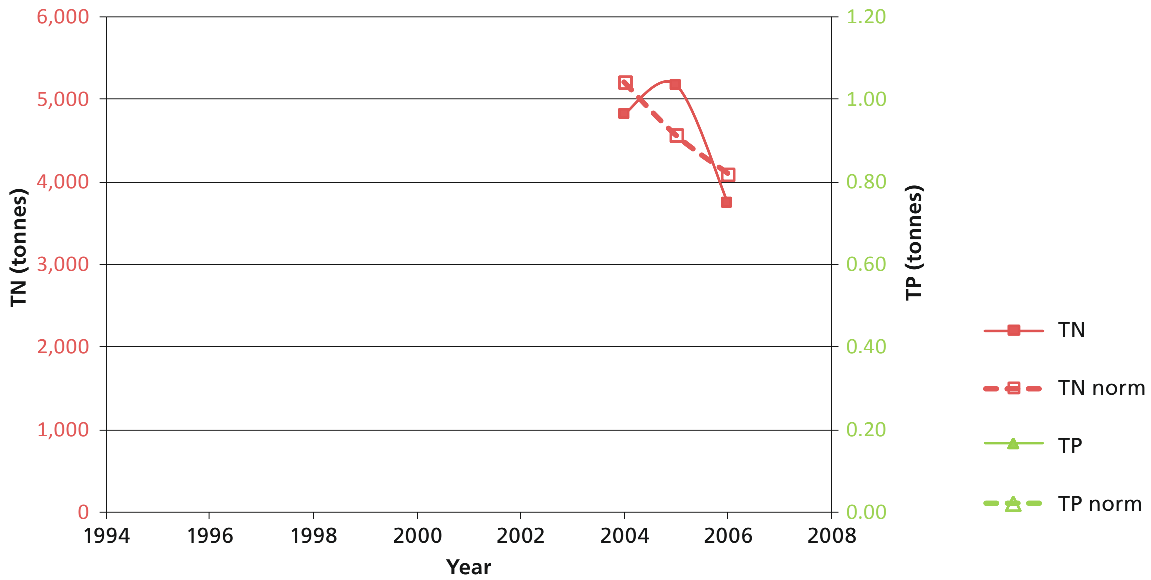
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	0	0	0	0	5,207	4,565	4,103	0	0
	2,033	1,419	1,446	1,393	1,390	1,335	1,548	1,415	0
	2,033	1,419	1,446	1,393	6,597	5,900	5,651	1,415	0
	7,773	7,773	7,773	7,773	7,773	7,773	7,773	7,773	7,773
	10,594	10,594	10,594	10,594					

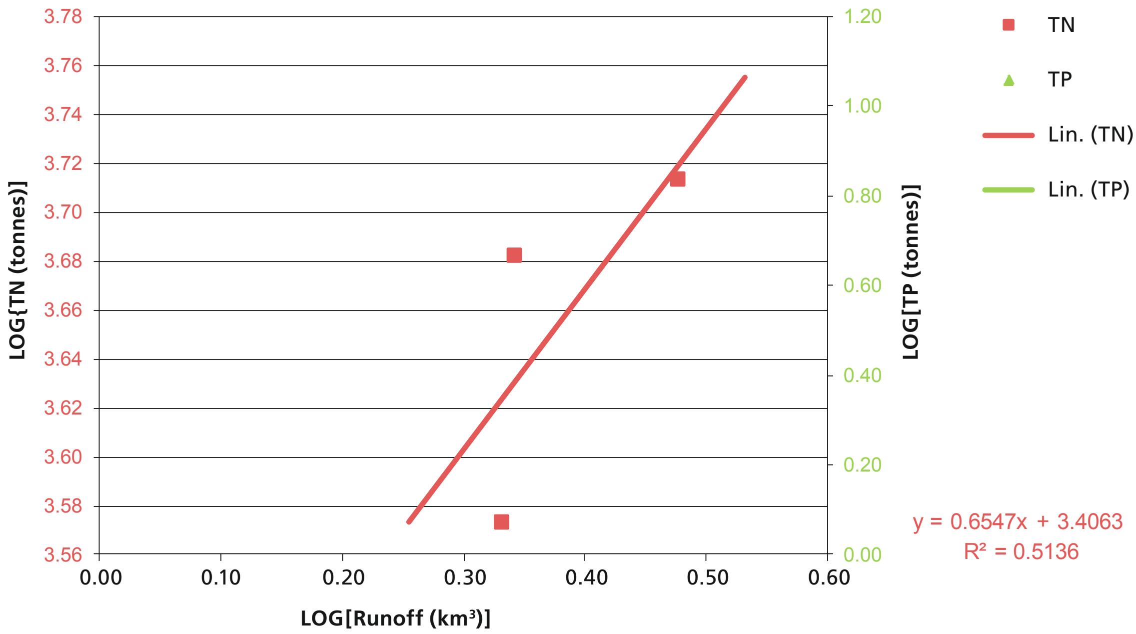
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	0	0	0	0	0	0	0	0	0
	150	115	129	186	719	178	251	235	0
	150	115	129	186	719	178	251	235	0
	542	542	542	542	542	542	542	542	542
	1,266	1,266	1,266	1,266					

RU_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994								
1995								
1996								
1997								
1998								
1999								
2000	2.73					0.44		
2001	2.32					0.37		
2002	2.00					0.30		
2003	1.80					0.25		
2004	2.19	4,817.50		5,207.44		0.34	3.68	
2005	2.99	5,175.50		4,564.86		0.48	3.71	
2006	2.14	3,748.00		4,103.39		0.33	3.57	
2007	3.41					0.53		
2008	2.63					0.42		

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

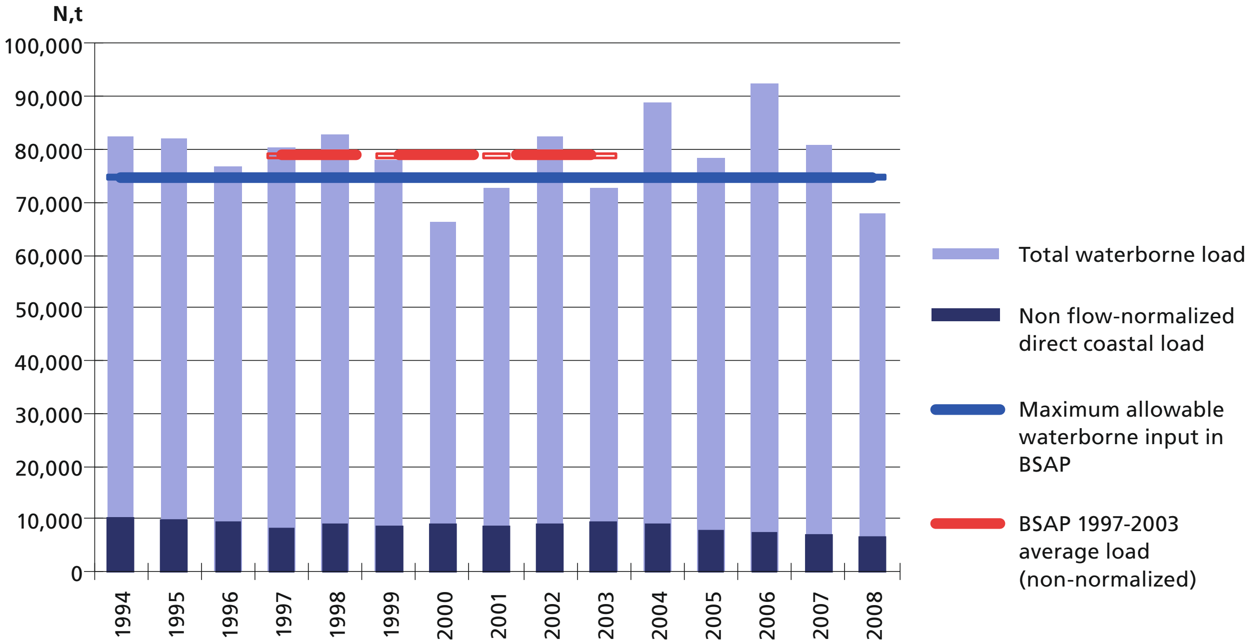



6,000
5,000
4,000
3,000
2,000
1,000
0
TN (tonnes)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


3.78
3.76
3.74
3.72
3.70
3.68
3.66
3.64
3.62
3.60
3.58
3.56
LOG[TN (tonnes)]
1.20
1.00
0.80
0.60
0.40
0.20
0.00
LOG[TP (tonnes)]
0.00
0.10
0.20
0.30
0.40
0.50
0.60
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.6547x + 3.4063
R² = 0.5136

RUSSIA: GULF OF FINLAND

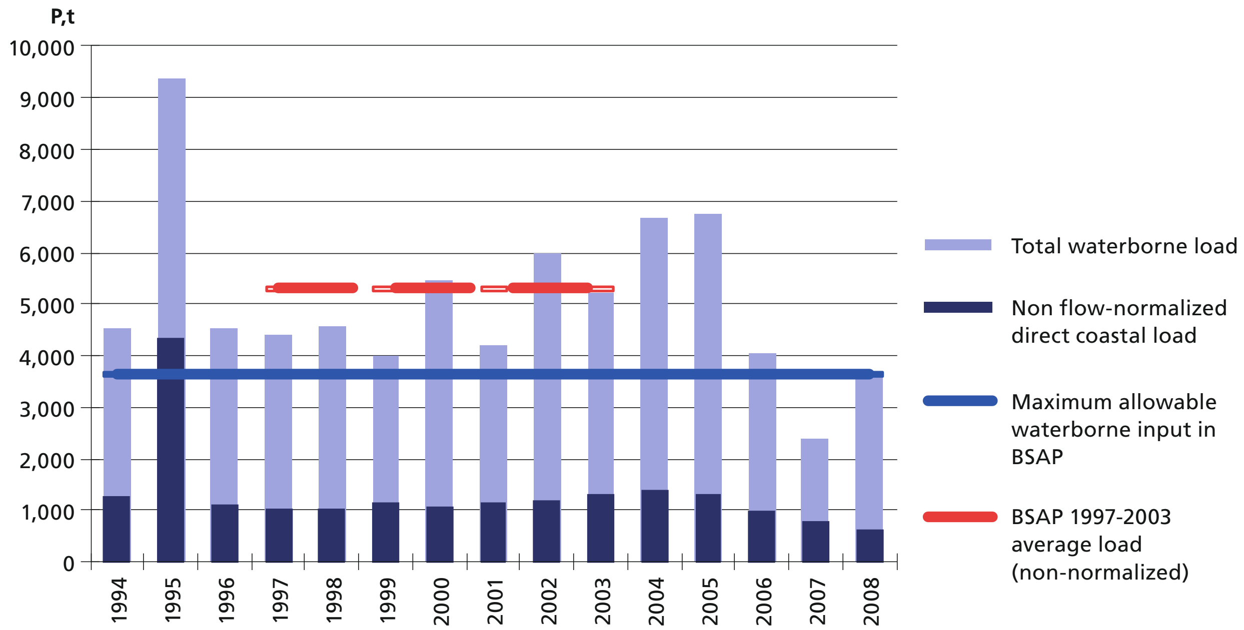
Total flow-normalized waterborne load of nitrogen (in tonnes) from Russia to the Gulf of Finland, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	71,961	71,875	67,504	72,197	73,974	69,266
Non flow-normalized direct coastal loads	10,306	10,035	9,412	8,120	9,016	8,651
Total waterborne loads	82,267	81,910	76,916	80,317	82,990	77,916
Maximum allowable waterborne input in BSAP	74,647	74,647	74,647	74,647	74,647	74,647
BSAP 1997-2003 average load (non-normalized)				78,792	78,792	78,792
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	3,276	5,034	3,378	3,390	3,522	2,857
Non flow-normalized direct coastal loads	1,256	4,337	1,130	1,027	1,048	1,162
Total waterborne loads	4,532	9,371	4,508	4,416	4,569	4,019
Maximum allowable waterborne input in BSAP	3,641	3,641	3,641	3,641	3,641	3,641
BSAP 1997-2003 average load (non-normalized)				5,302	5,302	5,302

NOTE: Riverine loads to the Gulf of Finland in 1995-1999 and 2005 for total nitrogen from riverine sources were not reported to the PLC-5 database and therefore are not included in the assessment of the progress towards BSAP nutrient reduction targets. Accordingly, it is not possible to assess the progress in reaching the BSAP nutrient reduction targets. Yellow background of cells in the table on page 186 stand for data gaps in the original non-normalized dataset which have been filled in retrospectively using the regression equation used in flow-normalization.

Total flow-normalized waterborne load of phosphorus (in tonnes) from Russia to the Gulf of Finland, 1994-2008

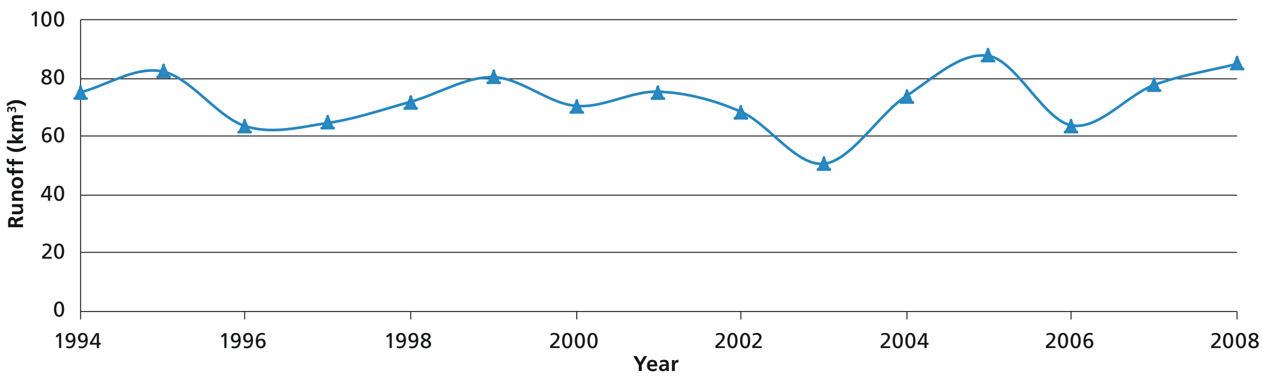


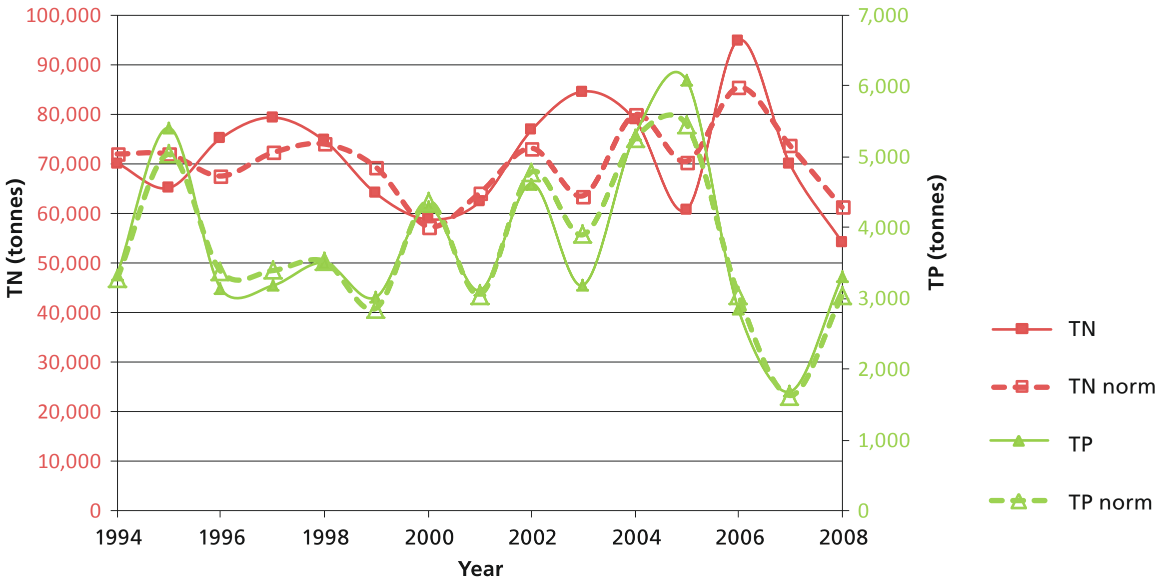
2000	2001	2002	2003	2004	2005	2006	2007	2008
57,345	64,060	73,128	63,536	79,867	70,446	85,389	73,590	61,206
8,987	8,843	9,290	9,371	9,094	7,842	7,318	7,255	6,617
66,332	72,903	82,419	72,908	88,961	78,288	92,706	80,844	67,823
74,647	74,647	74,647	74,647	74,647	74,647	74,647	74,647	74,647
78,792	78,792	78,792	78,792					

2000	2001	2002	2003	2004	2005	2006	2007	2008
4,360	3,050	4,781	3,898	5,255	5,449	3,047	1,625	3,030
1,088	1,152	1,209	1,326	1,407	1,313	982	780	633
5,448	4,202	5,990	5,224	6,662	6,763	4,028	2,406	3,663
3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641
5,302	5,302	5,302	5,302					

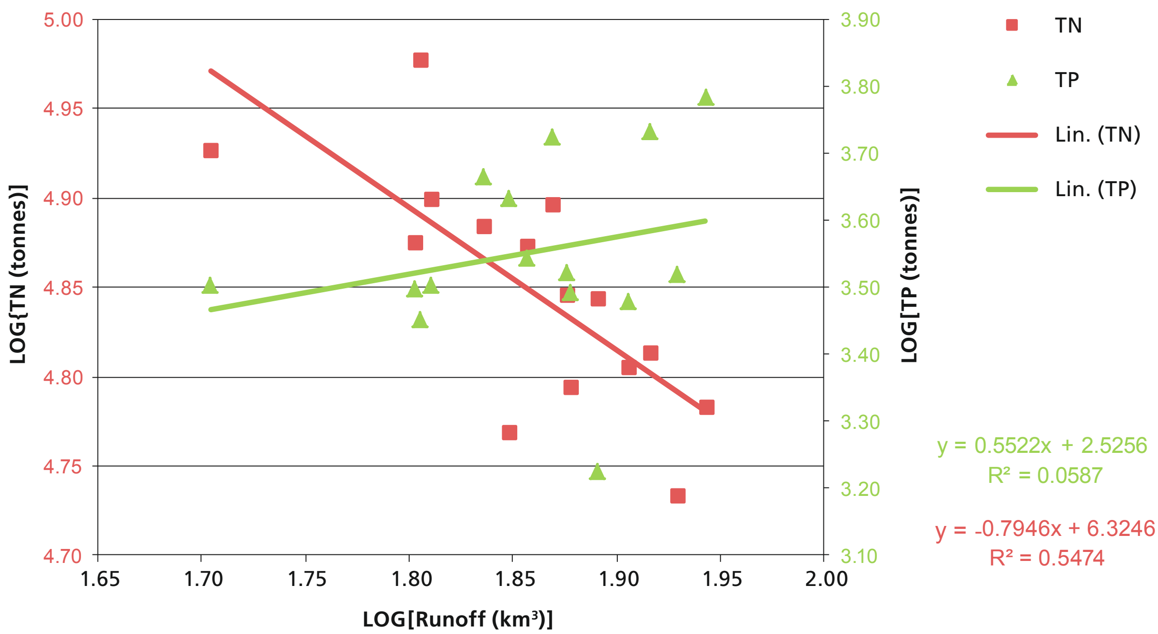
RU_GULF OF FINLAND	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	75.18	70,107.82	3,335.18	71,961.14	3,276.03	1.88	4.85	3.52
1995	82.38	65,102.68	5,407.13	71,875.11	5,034.13	1.92	4.81	3.73
1996	63.55	75,137.32	3,136.46	67,503.91	3,377.94	1.80	4.88	3.50
1997	64.65	79,318.20	3,177.33	72,197.40	3,389.90	1.81	4.90	3.50
1998	71.93	74,649.19	3,499.68	73,973.95	3,521.69	1.86	4.87	3.54
1999	80.42	63,970.77	3,015.39	69,265.68	2,857.45	1.91	4.81	3.48
2000	70.52	58,756.90	4,283.77	57,345.10	4,359.94	1.85	4.77	3.63
2001	75.41	62,277.00	3,110.00	64,059.53	3,050.30	1.88	4.79	3.49
2002	68.50	76,729.00	4,619.00	73,128.43	4,780.90	1.84	4.88	3.66
2003	50.61	84,566.00	3,183.00	63,536.48	3,897.62	1.70	4.93	3.50
2004	73.94	78,840.00	5,304.00	79,867.27	5,254.85	1.87	4.90	3.72
2005	87.71	60,719.49	6,074.00	70,446.25	5,449.41	1.94	4.78	3.78
2006	63.82	94,936.00	2,838.00	85,388.85	3,046.66	1.80	4.98	3.45
2007	77.74	69,798.40	1,680.00	73,589.61	1,625.36	1.89	4.84	3.23
2008	84.97	54,185.00	3,295.77	61,206.41	3,030.32	1.93	4.73	3.52

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





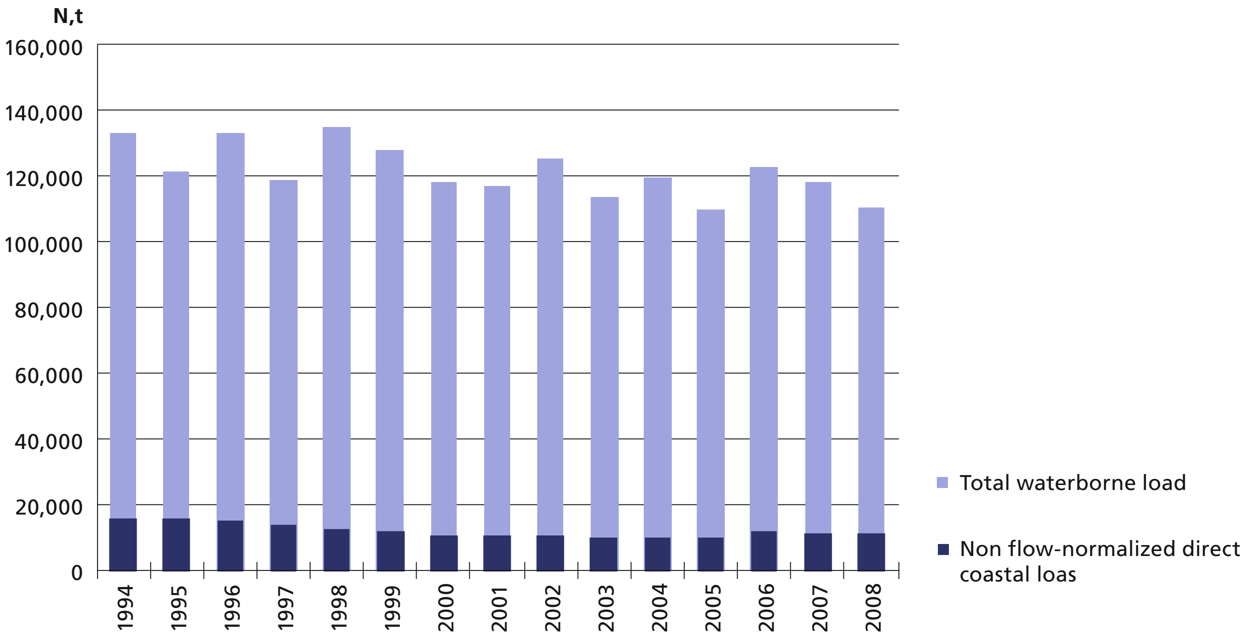
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
TN (tonnes)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



5.00
4.95
4.90
4.85
4.80
4.75
4.70
LOG[TN (tonnes)]
3.90
3.80
3.70
3.60
3.50
3.40
3.30
3.20
3.10
LOG[TP (tonnes)]
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.5522x + 2.5256
R² = 0.0587
y = -0.7946x + 6.3246
R² = 0.5474

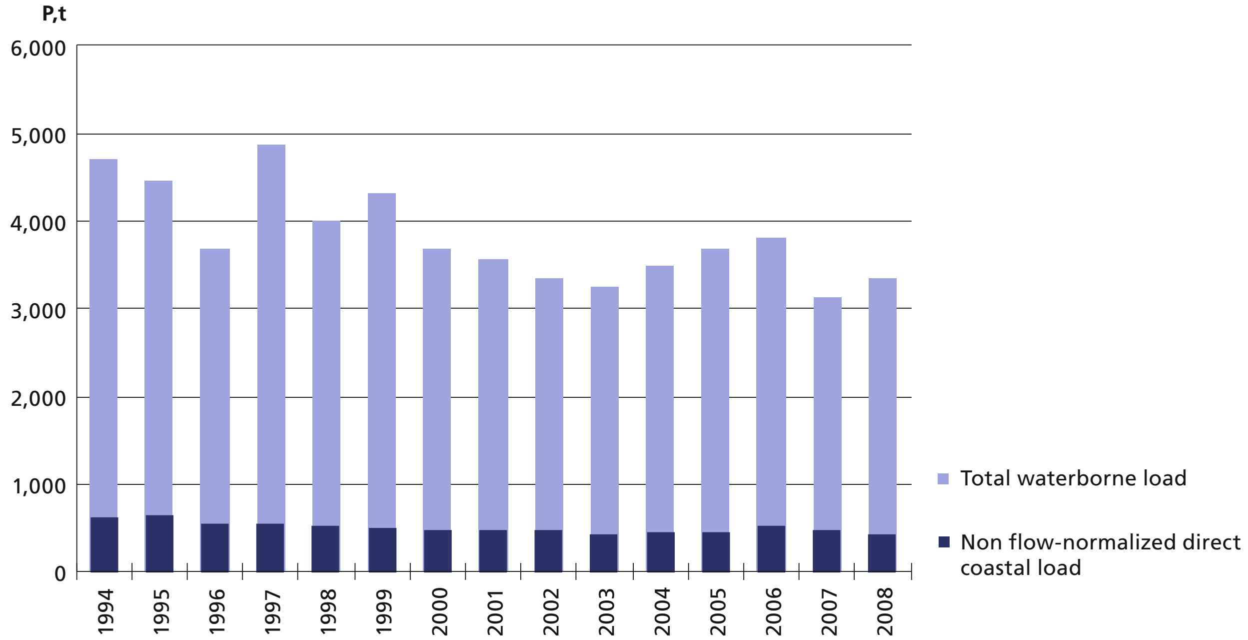
9. SWEDEN: TOTAL

Total flow-normalized waterborne load of nitrogen (in tonnes) from Sweden to the Baltic Sea, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	117,430	105,615	118,182	105,362	122,605	116,217
Non flow-normalized direct coastal loads	16,034	15,879	15,083	13,832	12,602	11,800
Total waterborne loads	133,464	121,494	133,265	119,194	135,207	128,017
Maximum allowable waterborne input in BSAP	105,959	105,959	105,959	105,959	105,959	105,959
BSAP 1997-2003 average load (non-normalized)				126,739	126,739	126,739
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	4,081	3,817	3,140	4,330	3,467	3,802
Non flow-normalized direct coastal loads	632	639	555	538	523	505
Total waterborne loads	4,713	4,457	3,695	4,868	3,990	4,307
Maximum allowable waterborne input in BSAP	3,745	3,745	3,745	3,745	3,745	3,745
BSAP 1997-2003 average load (non-normalized)				4,035	4,035	4,035

Total flow-normalized waterborne load of phosphorus (in tonnes) from Sweden to the Baltic Sea, 1994-2008

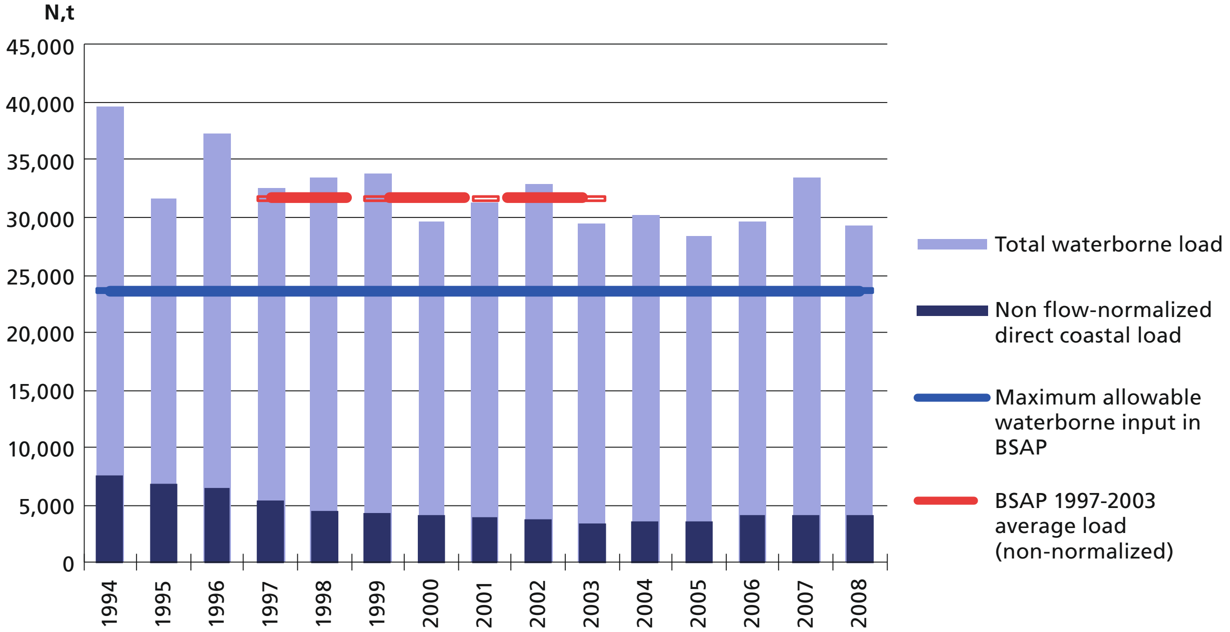


2000	2001	2002	2003	2004	2005	2006	2007	2008
107,353	106,458	114,435	103,756	109,515	99,621	110,469	107,133	99,032
10,882	10,608	10,649	9,890	10,196	10,297	12,024	11,279	11,369
118,235	117,066	125,084	113,645	119,711	109,918	122,493	118,413	110,401
105,959	105,959	105,959	105,959	105,959	105,959	105,959	105,959	105,959
126,739	126,739	126,739	126,739					

2000	2001	2002	2003	2004	2005	2006	2007	2008
3,210	3,083	2,865	2,814	3,028	3,232	3,287	2,653	2,922
483	471	469	429	457	455	528	,467	427
3,693	3,554	3,334	3,243	3,485	3,688	3,815	3,120	3,349
3,745	3,745	3,745	3,745	3,745	3,745	3,745	3,745	3,745
4,035	4,035	4,035	4,035					

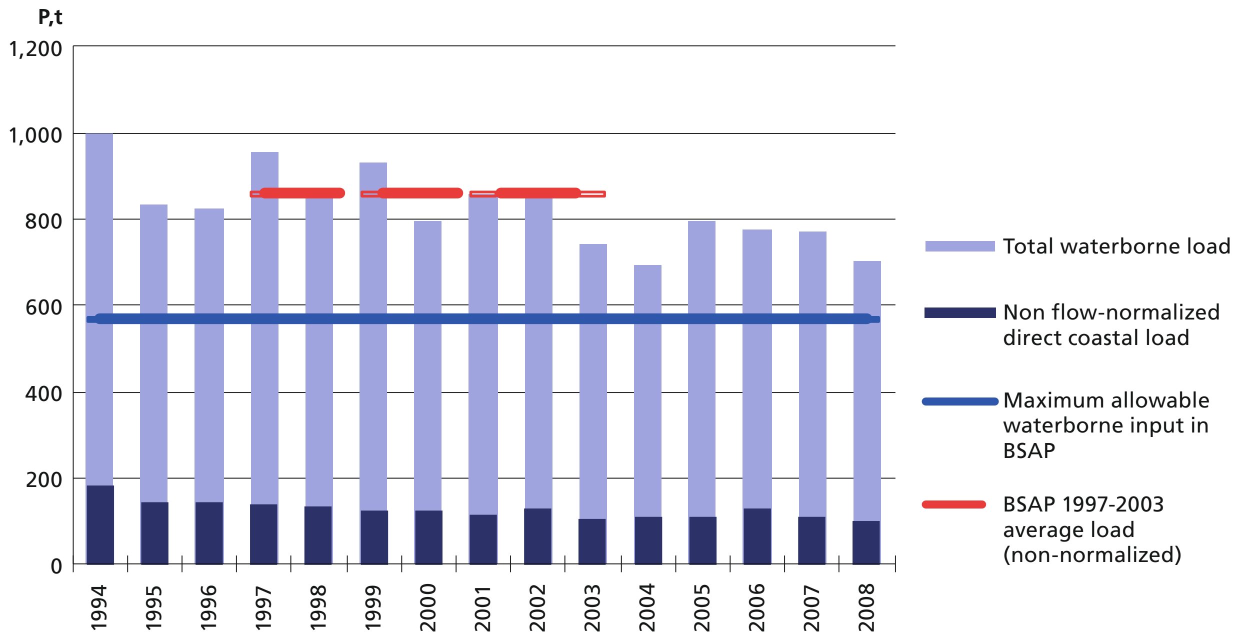
SWEDEN: BALTIC PROPER

Total flow-normalized waterborne load of nitrogen (in tonnes) from Sweden to the Baltic Proper, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	31,923	24,710	30,870	27,217	29,004	29,486
Non flow-normalized direct coastal loads	7,641	6,907	6,485	5,404	4,448	4,281
Total waterborne loads	39,564	31,617	37,355	32,621	33,452	33,767
Maximum allowable waterborne input in BSAP	23,580	23,580	23,580	23,580	23,580	23,580
BSAP 1997-2003 average load (non-normalized)				31,667	31,667	31,667
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	814	691	680	818	716	806
Non flow-normalized direct coastal loads	183	142	144	139	133	124
Total waterborne loads	997	833	824	957	849	930
Maximum allowable waterborne input in BSAP	569	569	569	569	569	569
BSAP 1997-2003 average load (non-normalized)				860	860	860

Total flow-normalized waterborne load of phosphorus (in tonnes) from Sweden to the Baltic Proper, 1994-2008

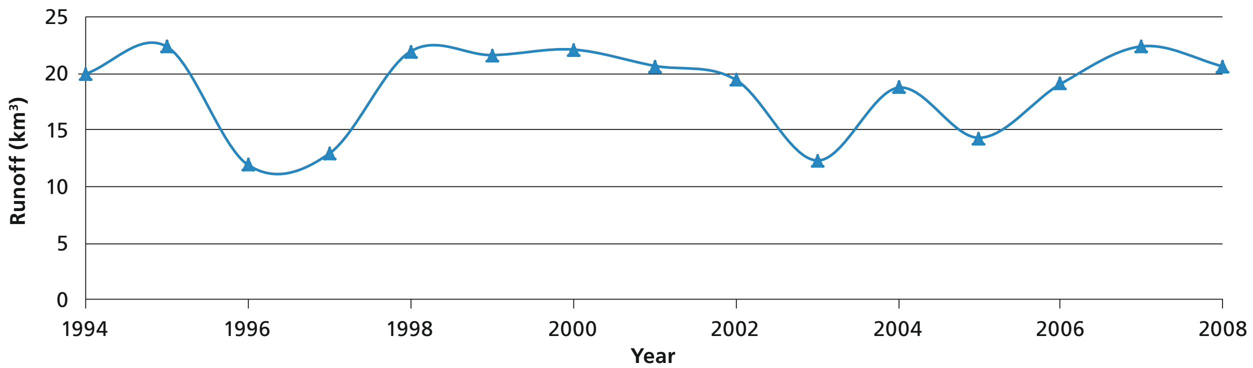


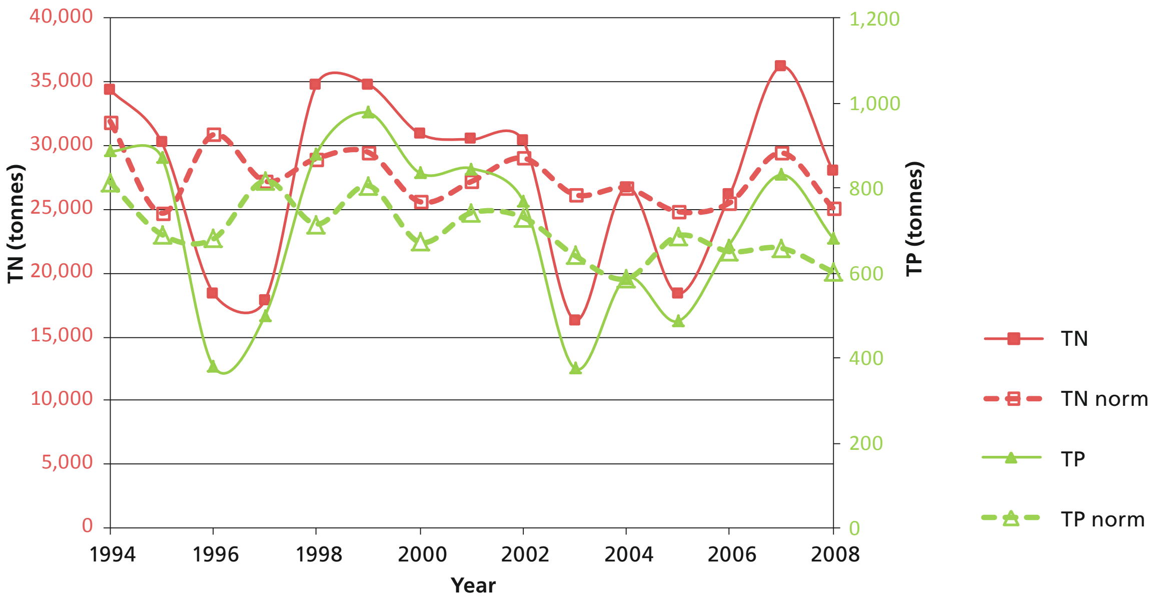
2000	2001	2002	2003	2004	2005	2006	2007	2008
25,607	27,194	29,035	26,161	26,682	24,829	25,518	29,444	25,115
4,022	4,008	3,818	3,311	3,474	3,478	4,099	4,069	4,081
29,628	31,202	32,854	29,472	30,156	28,306	29,617	33,513	29,196
23,580	23,580	23,580	23,580	23,580	23,580	23,580	23,580	23,580
31,667	31,667	31,667	31,667					

2000	2001	2002	2003	2004	2005	2006	2007	2008
673	742	731	642	587	688	651	659	603
123	116	131	102	109	107	127	111	101
795	858	862	744	695	796	778	770	704
569	569	569	569	569	569	569	569	569
860	860	860	860					

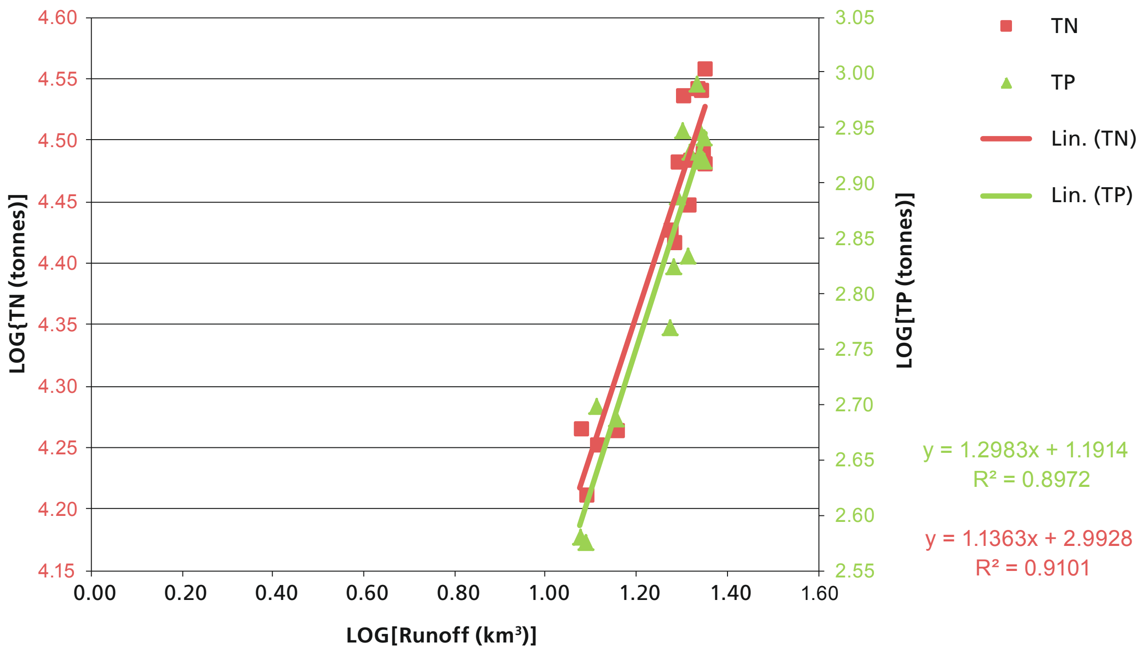
SE_BALTIC PROPER	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	19.96	34,399.00	886.89	31,922.63	813.71	1.30	4.54	2.95
1995	22.40	30,256.00	872.80	24,710.06	691.08	1.35	4.48	2.94
1996	11.94	18,422.90	380.60	30,869.67	680.40	1.08	4.27	2.58
1997	12.92	17,871.70	499.56	27,217.16	817.68	1.11	4.25	2.70
1998	21.95	34,818.00	881.38	29,003.98	715.53	1.34	4.54	2.95
1999	21.64	34,827.00	977.71	29,486.05	806.04	1.34	4.54	2.99
2000	22.13	30,949.00	835.69	25,606.61	672.80	1.34	4.49	2.92
2001	20.69	30,488.00	846.57	27,193.53	741.86	1.32	4.48	2.93
2002	19.47	30,387.00	770.38	29,035.43	731.28	1.29	4.48	2.89
2003	12.32	16,308.80	375.54	26,161.10	641.63	1.09	4.21	2.57
2004	18.75	26,753.00	588.29	26682.37	586.56	1.27	4.43	2.77
2005	14.33	18,386.00	486.81	24,828.69	688.03	1.16	4.26	2.69
2006	19.10	26,111.00	667.79	25,517.57	650.54	1.28	4.42	2.82
2007	22.42	36,209.00	831.36	29,444.03	658.78	1.35	4.56	2.92
2008	20.63	28,035.00	682.72	25,115.33	603.13	1.31	4.45	2.83

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





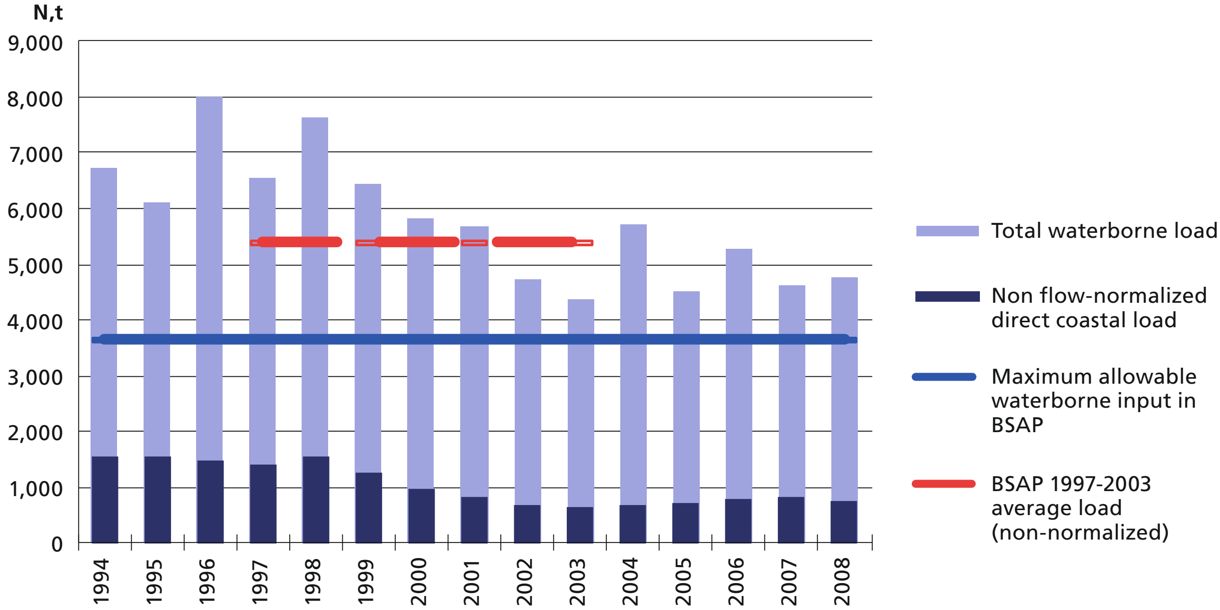
TN (tonnes)
TP (tonnes)
Year
TN
TN norm
TP
TP norm



LOG[TN (tonnes)]
LOG[TP (tonnes)]
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.2983x + 1.1914
R² = 0.8972
y = 1.1363x + 2.9928
R² = 0.9101

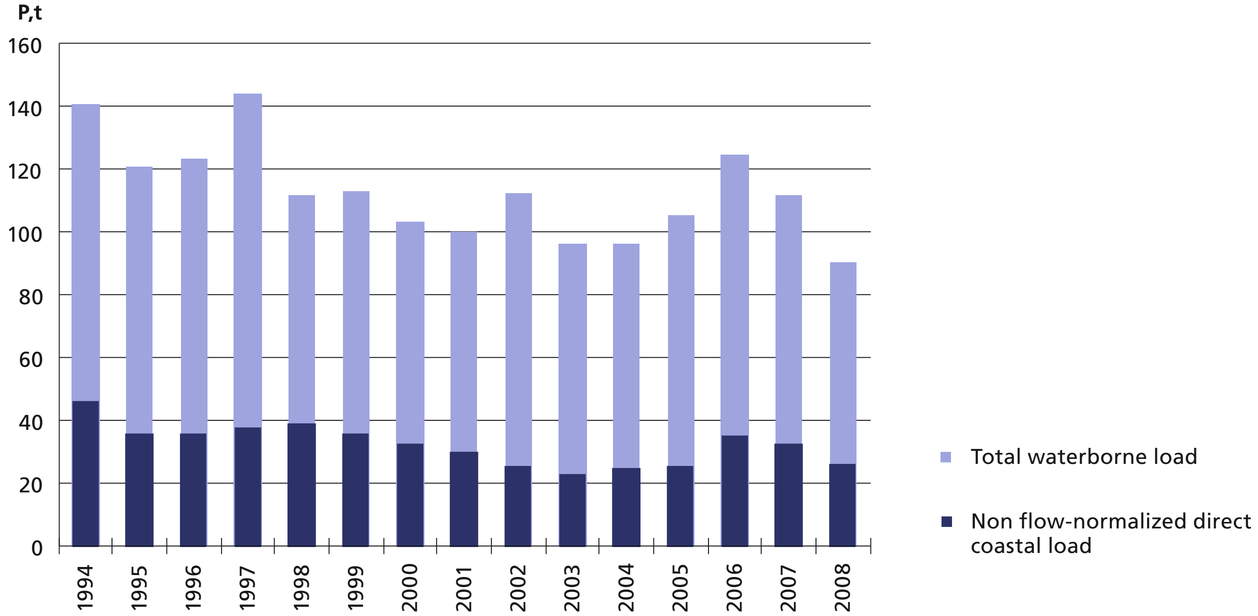
SWEDEN: DANISH STRAITS

Total flow-normalized waterborne load of nitrogen (in tonnes) from Sweden to the Danish Straits, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	5,198	4,574	6,525	5,147	6,082	5,169
Non flow-normalized direct coastal loads	1,536	1,544	1,474	1,404	1,554	1,251
Total waterborne loads	6,734	6,118	7,999	6,551	7,636	6,420
Maximum allowable waterborne input in BSAP	3,653	3,653	3,653	3,653	3,653	3,653
BSAP 1997-2003 average load (non-normalized)				5,386	5,386	5,386
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	95	85	88	106	73	77
Non flow-normalized direct coastal loads	46	36	36	38	39	36
Total waterborne loads	141	121	124	144	112	113
Maximum allowable waterborne input in BSAP	0	0	0	0	0	0
BSAP 1997-2003 average load (non-normalized)				0	0	0

Total flow-normalized waterborne load of phosphorus (in tonnes) from Sweden to the Danish Straits, 1994-2008

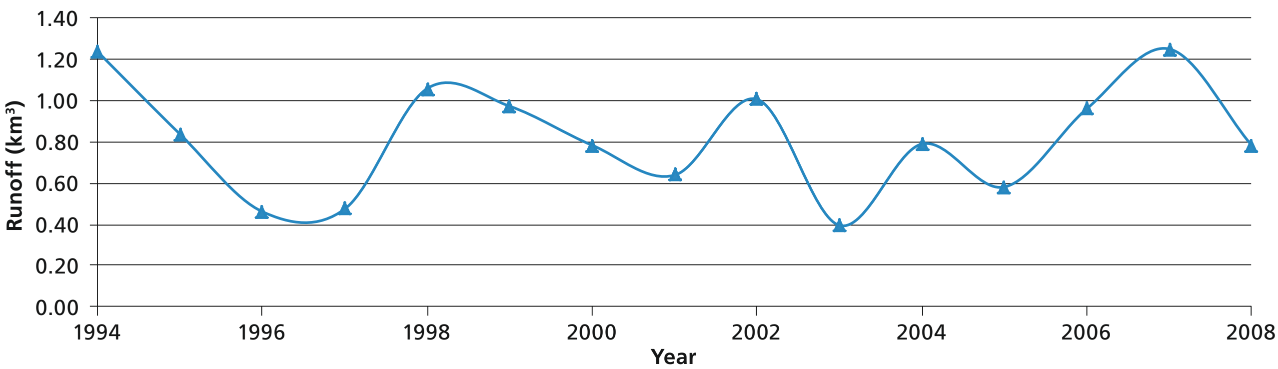


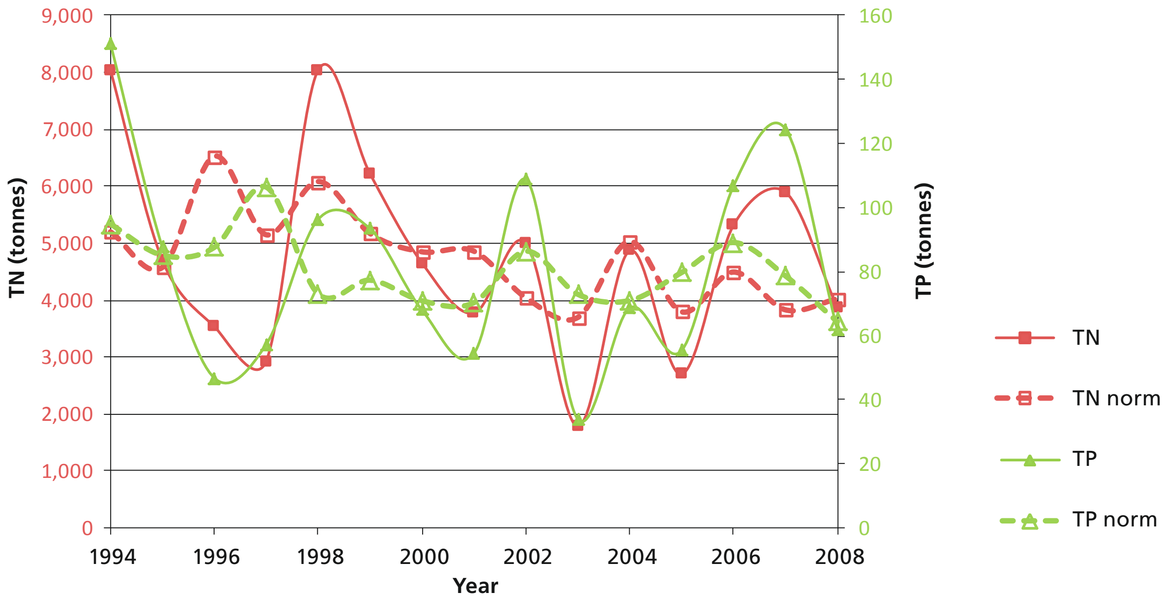
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	4,848	4,858	4,042	3,694	5,031	3,794	4,492	3,829	4,021
	976	820	693	653	692	725	772	805	747
	5,823	5,678	4,734	4,347	5,724	4,518	5,263	4,633	4,768
	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653
	5,386	5,386	5,386	5,386					

	2000	2001	2002	2003	2004	2005	2006	2007	2008
	71	70	86	73	71	80	89	79	64
	33	30	26	23	25	26	35	33	26
	104	100	112	96	96	105	125	112	91
	0	0	0	0	0	0	0	0	0
	0	0	0	0					

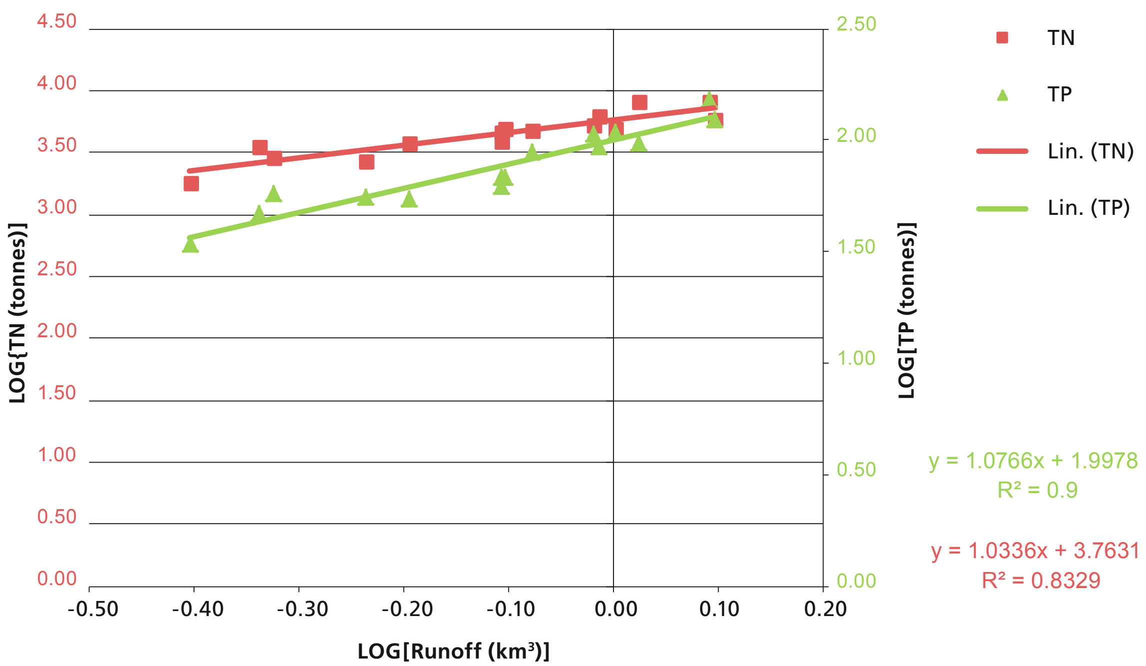
SE_DANISH STRAITS	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	1.24	8,037.00	151.20	5,197.80	94.86	0.09	3.91	2.18
1995	0.84	4,697.00	87.54	4,574.13	85.11	-0.08	3.67	1.94
1996	0.46	3,536.00	46.77	6,525.02	87.57	-0.34	3.55	1.67
1997	0.47	2,928.00	57.26	5,147.15	106.38	-0.32	3.47	1.76
1998	1.06	8,039.00	96.30	6,082.06	73.06	0.02	3.91	1.98
1999	0.97	6,216.00	93.36	5,169.18	77.32	-0.01	3.79	1.97
2000	0.78	4,651.00	67.96	4,847.65	70.86	-0.11	3.67	1.83
2001	0.64	3,770.00	54.45	4,857.85	70.29	-0.20	3.58	1.74
2002	1.01	5,006.00	108.81	4,041.73	86.37	0.00	3.70	2.04
2003	0.39	1,783.00	33.94	3,694.02	72.92	-0.40	3.25	1.53
2004	0.79	4,867.00	68.63	5,031.33	70.96	-0.10	3.69	1.84
2005	0.58	2,697.00	55.36	3,793.64	79.70	-0.24	3.43	1.74
2006	0.96	5,314.00	106.70	4,491.71	89.08	-0.02	3.73	2.03
2007	1.25	5,895.00	124.51	3,828.51	78.67	0.10	3.77	2.10
2008	0.78	3,861.00	61.75	4,020.58	64.33	-0.11	3.59	1.79

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





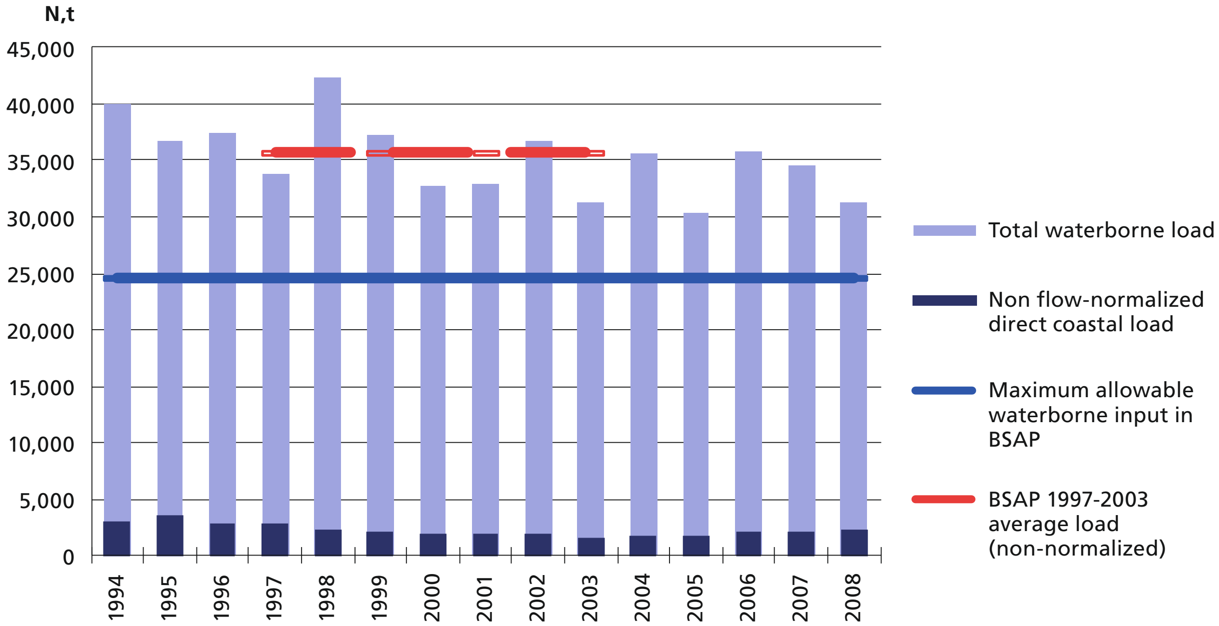
TN (tonnes)
TP (tonnes)
Year
TN
TN norm
TP
TP norm



LOG{TN (tonnes)]
LOG[TP (tonnes)]
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.0766x + 1.9978
R² = 0.9
y = 1.0336x + 3.7631
R² = 0.8329

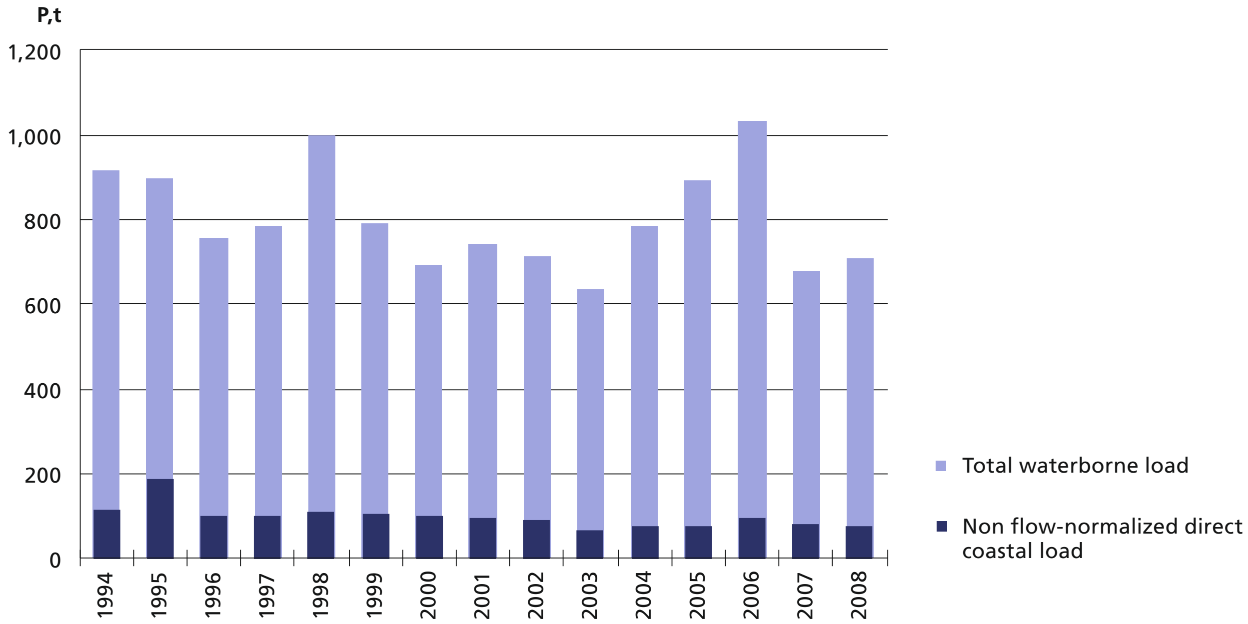
SWEDEN: KATTEGAT

Total flow-normalized waterborne load of nitrogen (in tonnes) from Sweden to the Kattegat, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	36,927	33,099	34,533	30,994	40,016	35,184
Non flow-normalized direct coastal loads	3,070	3,633	2,916	2,800	2,360	2,138
Total waterborne loads	39,997	36,731	37,449	33,794	42,376	37,322
Maximum allowable waterborne input in BSAP	24,582	24,582	24,582	24,582	24,582	24,582
BSAP 1997-2003 average load (non-normalized)				35,710	35,710	35,710
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	801	710	655	682	891	687
Non flow-normalized direct coastal loads	113	186	100	102	108	104
Total waterborne loads	914	896	755	784	999	791

Total flow-normalized waterborne load of phosphorus (in tonnes) from Sweden to the Kattegat, 1994-2008

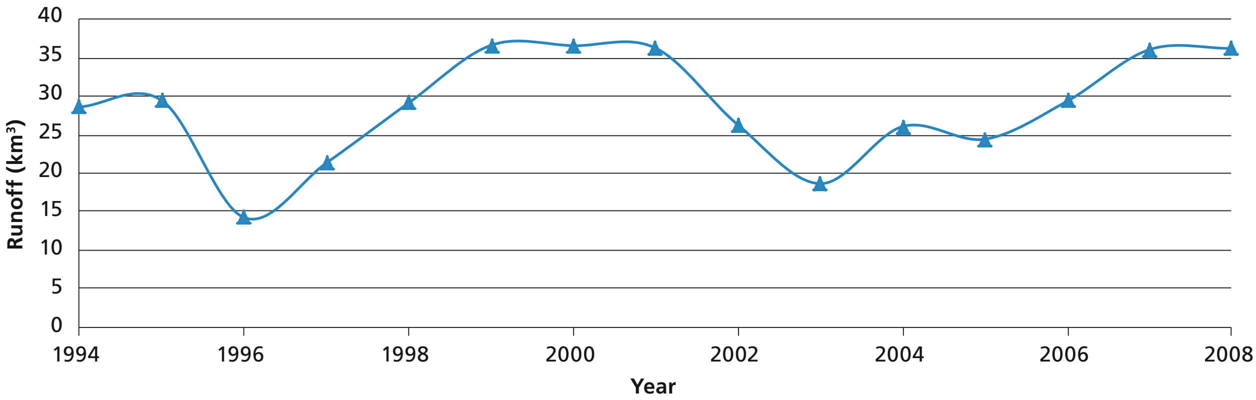


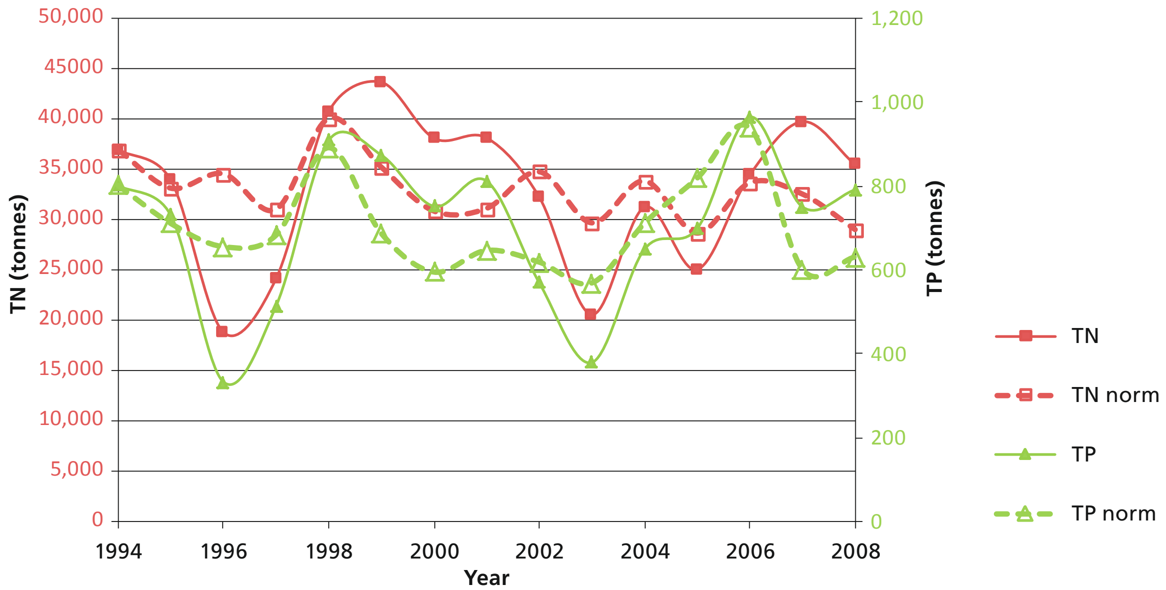
2000	2001	2002	2003	2004	2005	2006	2007	2008
30,826	31,092	34,729	29,655	33,820	28,640	33,642	32,508	28,988
1,877	1,894	1,961	1,631	1,772	1,727	2,090	2,081	2,230
32,703	32,986	36,690	31,287	35,591	30,367	35,732	34,589	31,218
24,582	24,582	24,582	24,582	24,582	24,582	24,582	24,582	24,582
35,710	35,710	35,710	35,710					

2000	2001	2002	2003	2004	2005	2006	2007	2008
594	646	618	568	711	818	938	601	631
100	96	92	68	74	74	93	80	75
694	742	710	637	785	892	1031	681	706

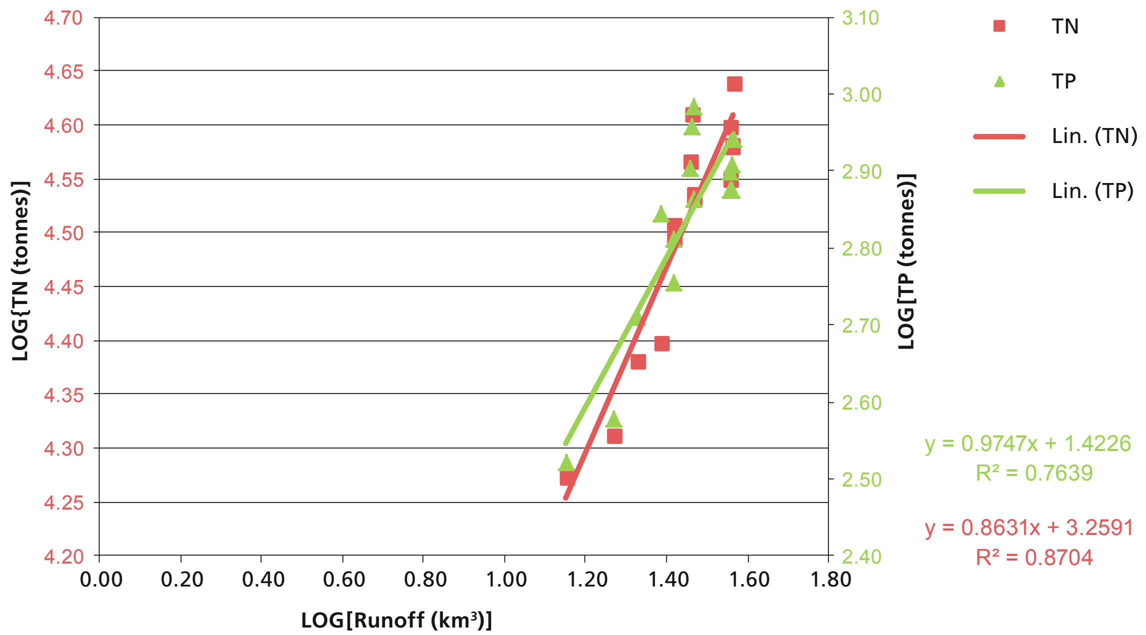
SE_KATTE-GAT	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	28.62	36,910.00	800.60	36,927.01	801.02	1.46	4.57	2.90
1995	29.44	33,907.00	729.98	33,098.97	710.32	1.47	4.53	2.86
1996	14.20	18,795.00	332.68	34,532.89	654.92	1.15	4.27	2.52
1997	21.35	24,093.00	512.90	30,994.01	682.14	1.33	4.38	2.71
1998	29.17	40,679.00	907.83	40,016.22	890.84	1.46	4.61	2.96
1999	36.67	43,619.00	873.24	35,183.88	686.51	1.56	4.64	2.94
2000	36.61	38,057.00	750.84	30,825.63	594.38	1.56	4.58	2.88
2001	36.27	38,091.00	811.28	31,091.61	645.96	1.56	4.58	2.91
2002	26.25	32,212.00	568.90	34,728.92	618.12	1.42	4.51	2.76
2003	18.64	20,545.00	378.92	29,655.35	568.49	1.27	4.31	2.58
2004	26.09	31,200.00	648.89	33,819.69	710.77	1.42	4.49	2.81
2005	24.43	25,018.00	698.25	28,640.39	818.23	1.39	4.40	2.84
2006	29.40	34,420.00	963.87	33,641.70	938.24	1.47	4.54	2.98
2007	36.11	39,708.00	749.60	32,507.50	600.91	1.56	4.60	2.87
2008	36.25	35,442.00	790.70	28,987.67	630.56	1.56	4.55	2.90

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





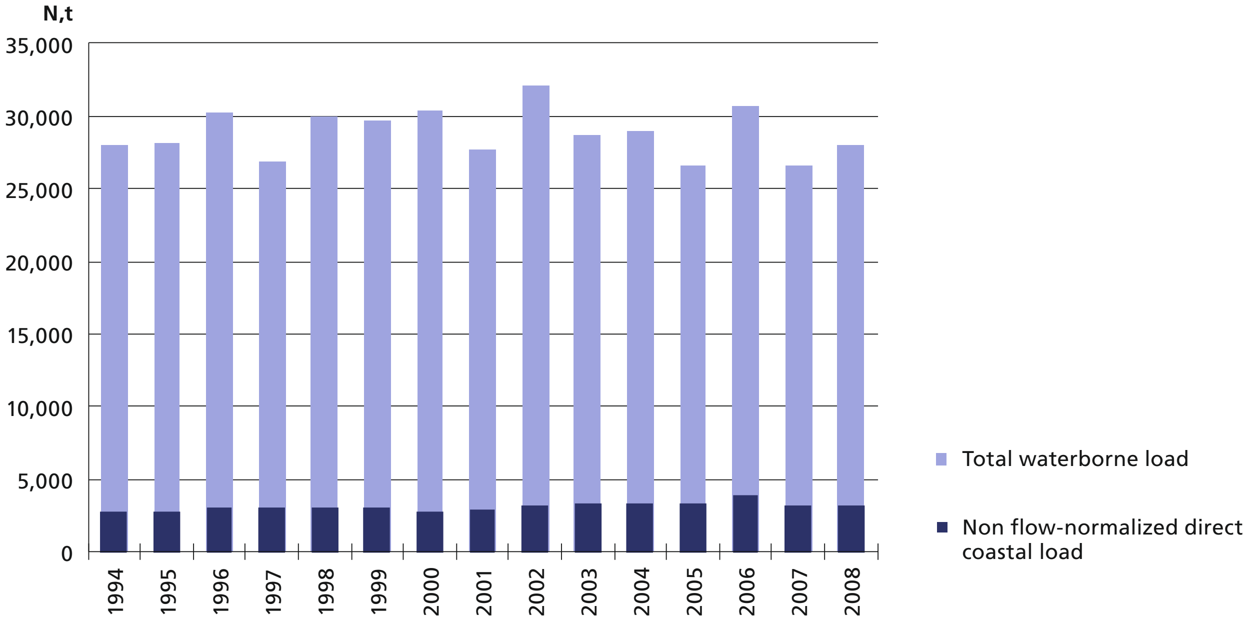
50,000
45000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
1,200
1,000
800
600
400
200
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
LOG{TN (tonnes)]
3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
LOG[TP (tonnes)]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 0.9747x + 1.4226
R² = 0.7639
y = 0.8631x + 3.2591
R² = 0.8704

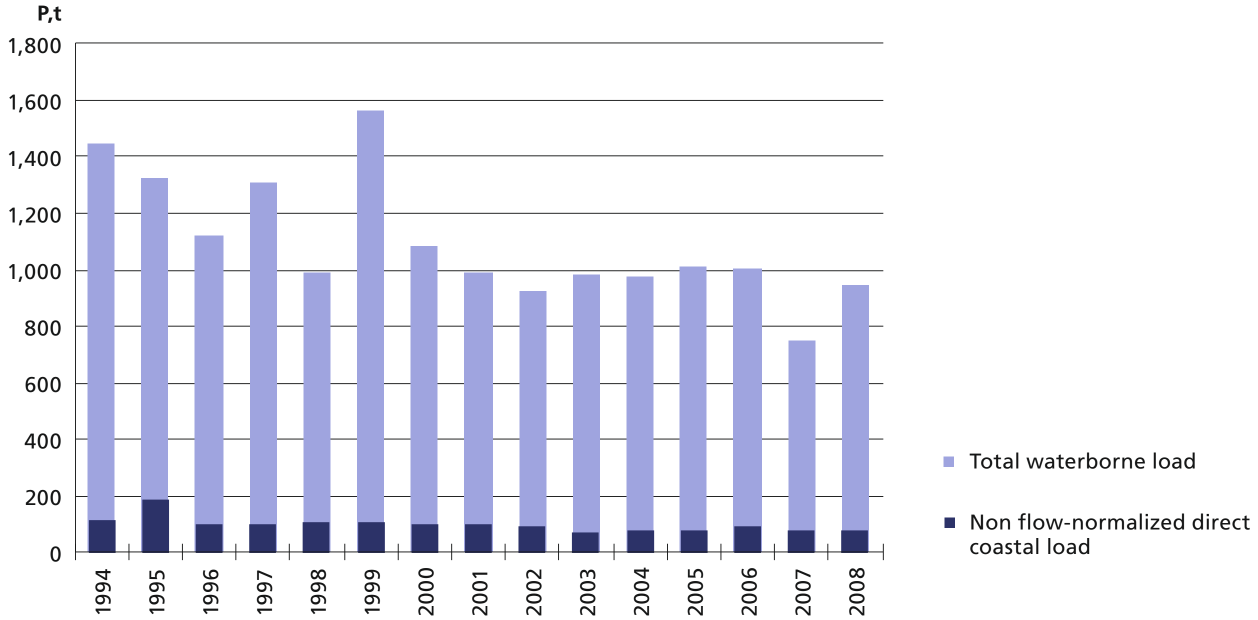
SWEDEN: BOTHNIAN SEA

Total flow-normalized waterborne load of nitrogen (in tonnes) from Sweden to the Bothnian Sea, 1994-2008



NITROGEN	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	25,279	25,353	27,152	23,773	26,877	26,730
Non flow-normalized direct coastal loads	2,754	2,770	3,104	3,106	3,109	3,029
Total waterborne loads	28,033	28,124	30,256	26,879	29,986	29,759
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,209	1,100	895	1,101	790	1,363
Non flow-normalized direct coastal loads	240	222	226	211	197	199
Total waterborne loads	1,449	1,322	1,121	1,312	987	1,562

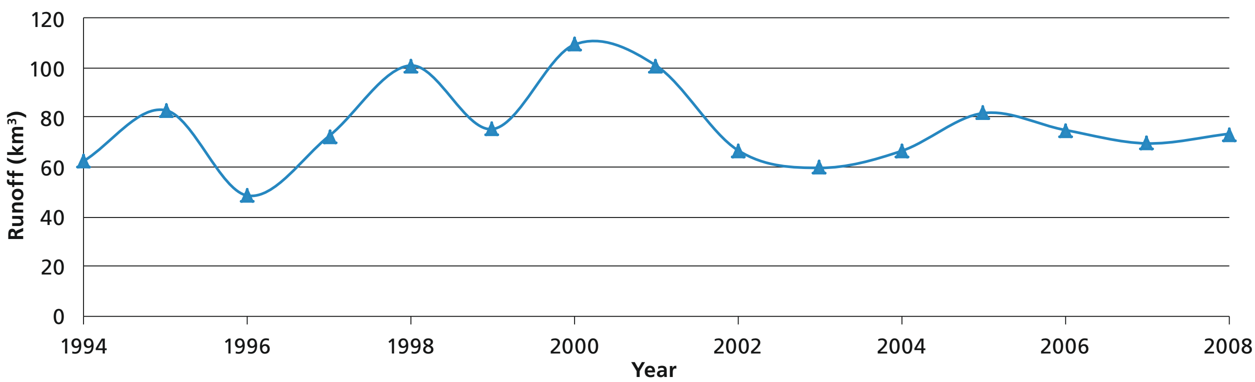
Total flow-normalized waterborne load of phosphorus (in tonnes) from Sweden to the Bothnian Sea 1994-2008

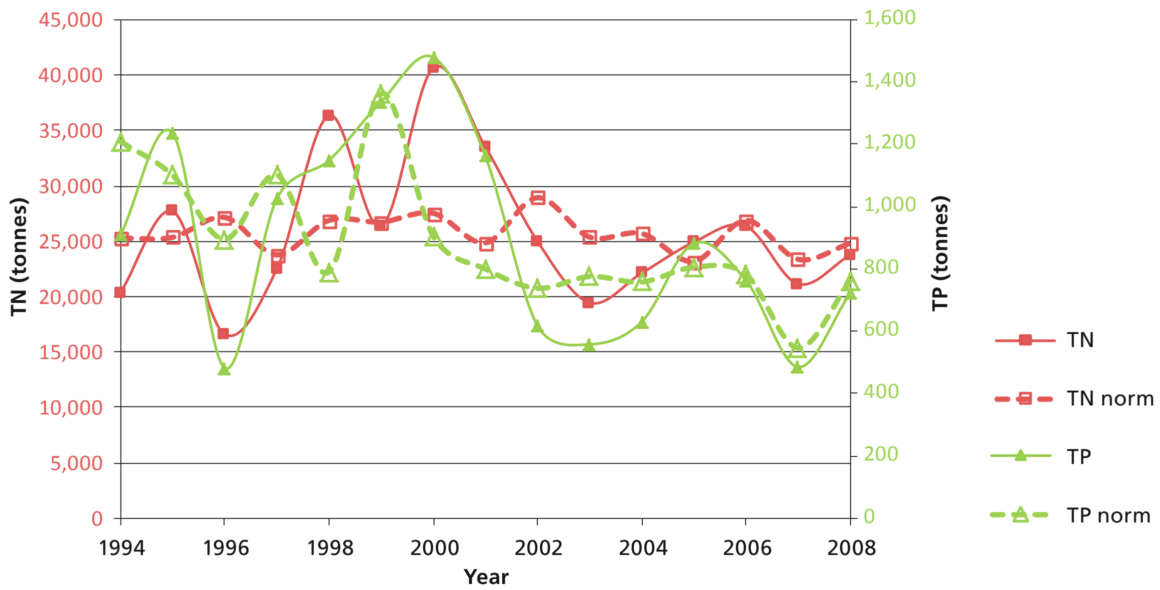


2000	2001	2002	2003	2004	2005	2006	2007	2008
27,521	24,856	28,931	25,375	25,695	23,174	26,884	23,371	24,805
2,830	2,843	3,158	3,317	3,303	3,361	3,855	3,256	3,210
30,351	27,699	32,089	28,692	28,999	26,534	30,738	26,628	28,015
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
906	800	738	776	758	805	783	547	761
175	192	187	208	220	208	222	202	185
1,080	992	926	983	978	1,014	1,005	749	947

SE_BOTH-NIAN SEA	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km³	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	62.47	20,376.90	908.82	25,278.77	1,208.74	1.80	4.31	2.96
1995	82.90	27,696.30	1,234.93	25,353.33	1,100.38	1.92	4.44	3.09
1996	48.44	16,596.60	481.78	27,151.83	894.95	1.69	4.22	2.68
1997	72.56	22,514.50	1,025.46	23,773.05	1,101.41	1.86	4.35	3.01
1998	100.96	36,352.00	1,147.71	26,877.08	790.14	2.00	4.56	3.06
1999	75.31	26,334.00	1,336.18	26,730.20	1,363.15	1.88	4.42	3.13
2000	109.40	40,630.60	1,478.89	27,520.99	905.71	2.04	4.61	3.17
2001	100.90	33,517.00	1,161.78	24,855.89	799.97	2.00	4.53	3.07
2002	66.75	24,993.00	617.86	28,930.70	738.04	1.82	4.40	2.79
2003	59.63	19,455.70	558.04	25,374.92	775.69	1.78	4.29	2.75
2004	66.43	22,120.90	630.19	25,695.46	758.14	1.82	4.34	2.80
2005	81.73	24,916.40	882.35	23,173.68	805.42	1.91	4.40	2.95
2006	74.95	26,349.70	763.53	26,883.72	782.68	1.87	4.42	2.88
2007	69.51	21,144.60	485.56	23,371.41	546.69	1.84	4.33	2.69
2008	73.36	23,762.00	721.75	24,804.78	761.20	1.87	4.38	2.86

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized

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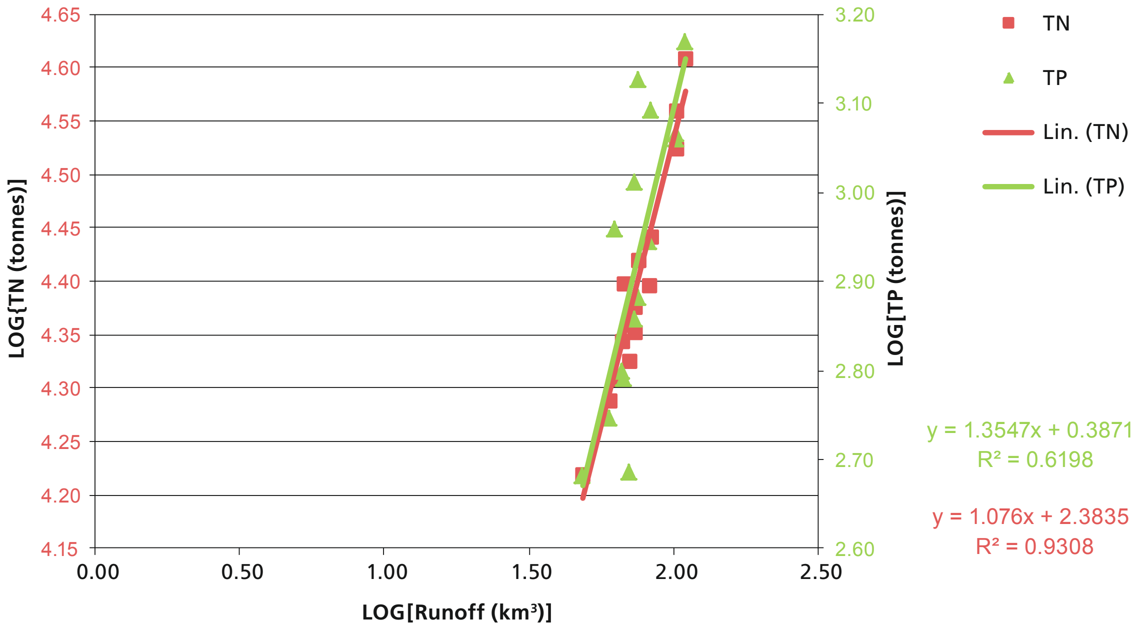
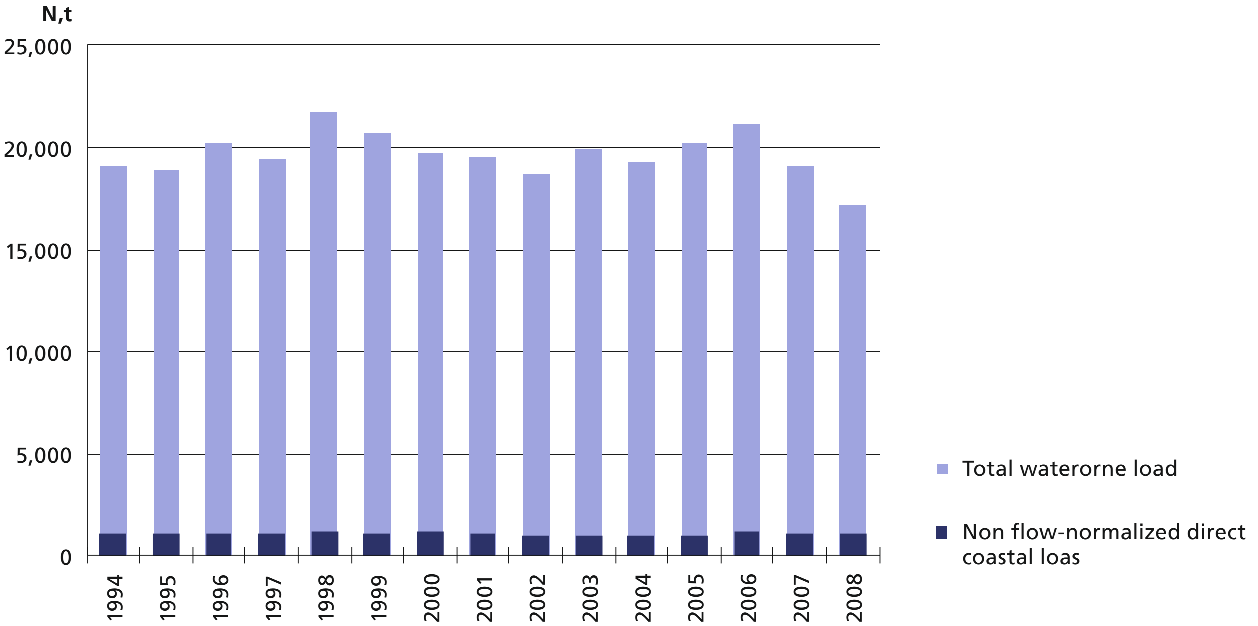
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
TN (tonnes)
1,600
1,400
1,200
1,000
800
600
400
200
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm


4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
4.15
LOG{TN (tonnes)]
3.20
3.10
3.00
2.90
2.80
2.70
2.60
LOG[TP (tonnes)]
0.00
0.50
1.00
1.50
2.00
2.50
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.3547x + 0.3871
R² = 0.6198
y = 1.076x + 2.3835
R² = 0.9308

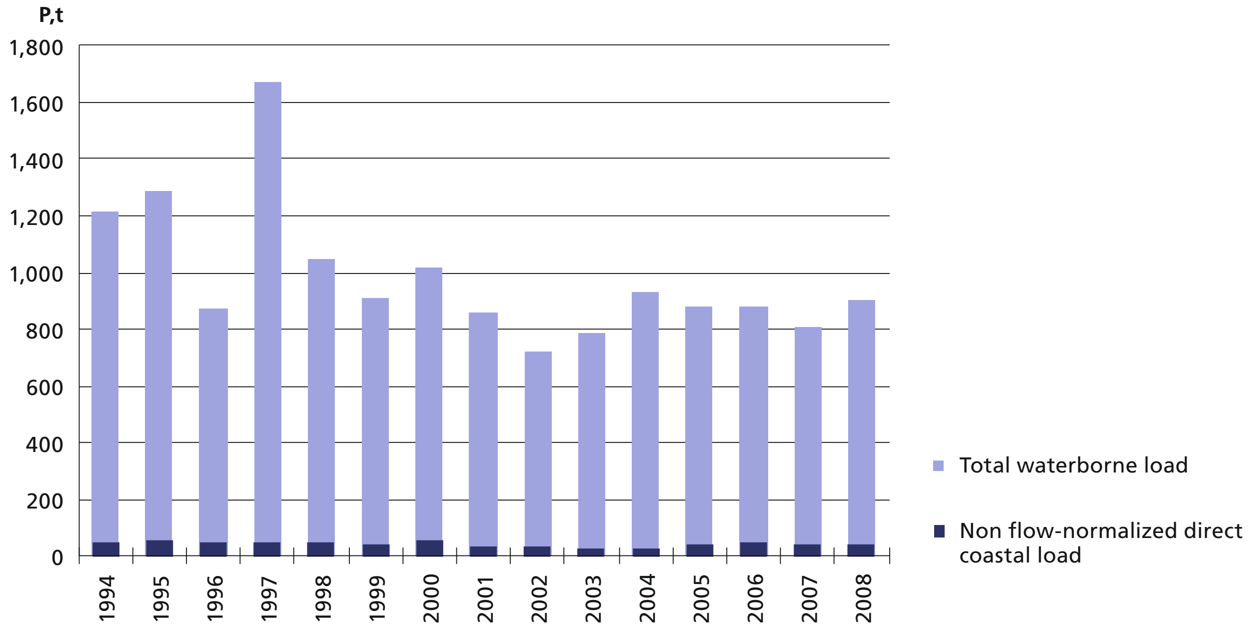
SWEDEN: BOTHNIAN BAY

Total flow-normalized waterborne load of nitrogen (in tonnes) from Sweden to the Bothnian Bay, 1994-2008



NITROGEN	1994	1995	1996	1997	1998	1999
Flow-normalized riverine loads	18,104	17,878	19,103	18,231	20,625	19,647
Non flow-normalized direct coastal loads	1,033	1,027	1,104	1,118	1,131	1,101
Total waterborne loads	19,137	18,905	20,207	19,349	21,756	20,748
PHOSPHORUS	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Flow-normalized riverine loads	1,163	1,231	822	1,622	998	869
Non flow-normalized direct coastal loads	50	55	49	48	46	42
Total waterborne loads	1,213	1,285	871	1,670	1,044	911

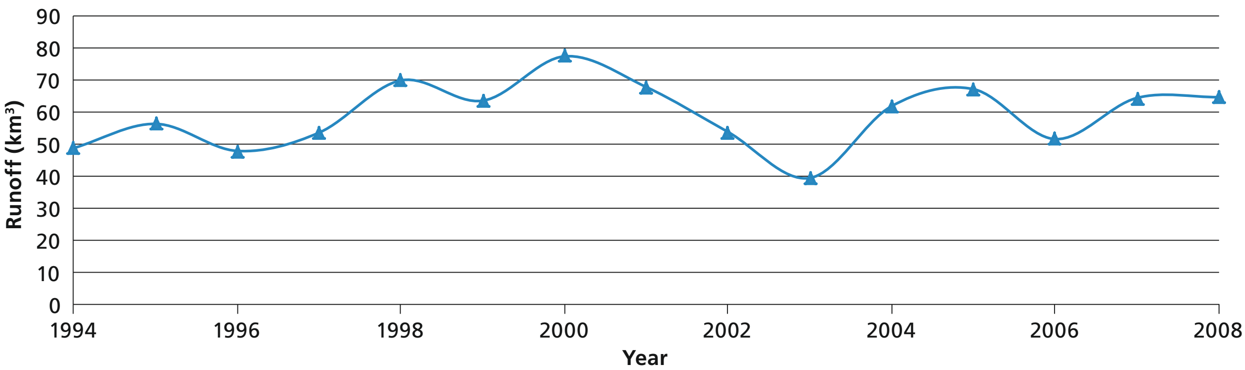
Total flow-normalized waterborne load of phosphorus (in tonnes) from Sweden to the Bothnian Bay, 1994-2008

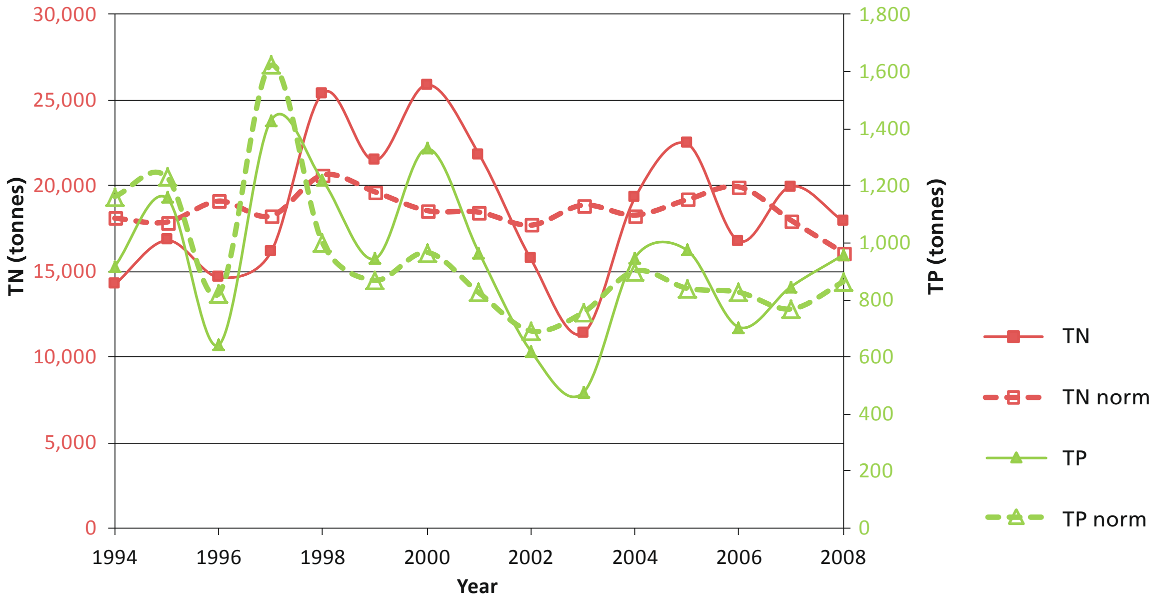


2000	2001	2002	2003	2004	2005	2006	2007	2008
18,552	18,459	17,698	18,870	18,286	19,184	19,934	17,982	16,104
1,177	1,043	1,018	977	955	1,007	1,209	1,069	1,101
19,729	19,502	18,716	19,847	19,241	20,191	21,143	19,051	17,205
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
966	825	691	755	901	841	827	768	863
53	37	32	28	29	40	51	41	39
1,020	862	723	784	930	880	877	809	902

SE_BOTHNIAN BAY	Runoff	TN	TP	TN NORM	TP NORM	Runoff	TN	TP
Year	km^3	tonnes	tonnes	tonnes	tonnes	LOG	LOG	LOG
1994	48.91	14,234.90	917.42	18,104.18	1,162.66	1.69	4.15	2.96
1995	56.44	16,805.00	1,157.07	17,878.42	1,230.55	1.75	4.23	3.06
1996	48.00	14,651.00	641.85	19,102.96	821.86	1.68	4.17	2.81
1997	53.72	16,111.90	1,428.02	18,231.01	1,622.04	1.73	4.21	3.15
1998	69.99	25,415.00	1,217.24	20,625.19	997.94	1.85	4.41	3.09
1999	63.66	21,469.70	943.97	19,647.40	868.71	1.80	4.33	2.97
2000	77.48	25,900.00	1,329.95	18,552.25	966.39	1.89	4.41	3.12
2001	67.91	21,855.10	966.11	18,459.44	824.94	1.83	4.34	2.99
2002	53.91	15,714.90	620.00	17,698.14	691.21	1.73	4.20	2.79
2003	39.57	11,371.90	473.76	18,870.32	755.38	1.60	4.06	2.68
2004	61.95	19,302.20	948.53	18,286.11	901.09	1.79	4.29	2.98
2005	67.27	22,460.00	974.22	19,184.27	840.77	1.83	4.35	2.99
2006	51.70	16,766.90	704.00	19,934.41	826.71	1.71	4.22	2.85
2007	64.51	19,962.00	846.23	17,981.92	768.04	1.81	4.30	2.93
2008	64.77	17,944.50	956.79	16,104.09	862.85	1.81	4.25	2.98

TN=Total nitrogen
TP=Total phosphorus
NORM=Normalized





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25,000
20,000
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5,000
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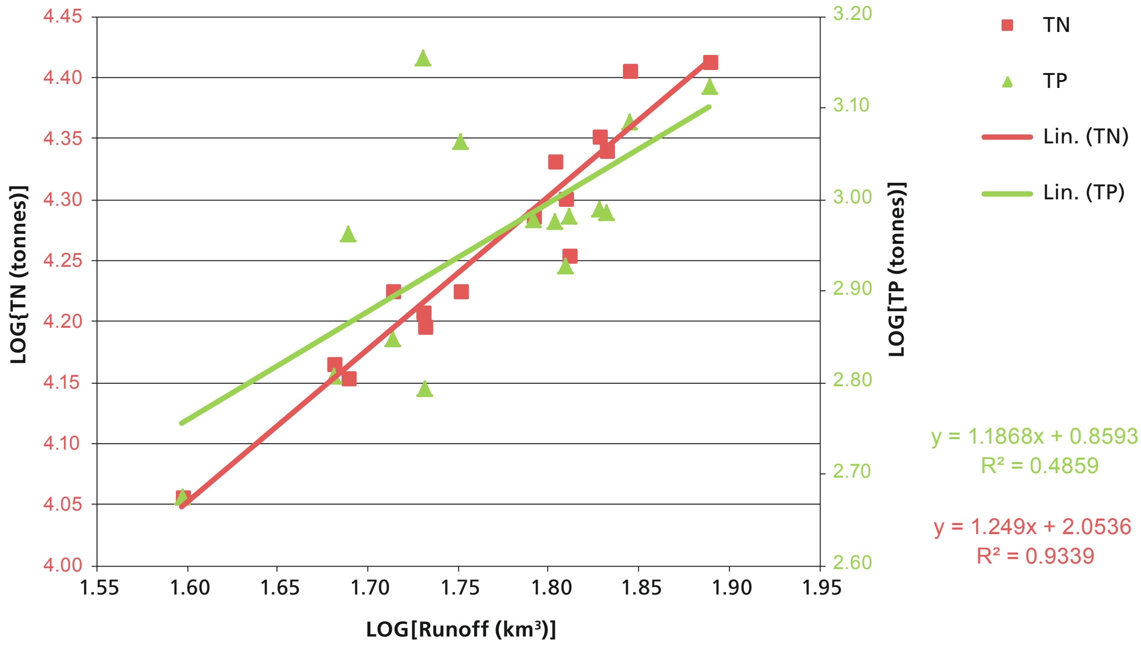
TN (tonnes)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
TP (tonnes)
1994
1996
1998
2000
2002
2004
2006
2008
Year
TN
TN norm
TP
TP norm



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4.15
4.10
4.05
4.00
LOG[TN (tonnes)]
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3.10
3.00
2.90
2.80
2.70
2.60
LOG[TP (tonnes)]
1.55
1.60
1.65
1.70
1.75
1.80
1.85
1.90
1.95
LOG[Runoff (km³)]
TN
TP
Lin. (TN)
Lin. (TP)
y = 1.1868x + 0.8593
R² = 0.4859
y = 1.249x + 2.0536
R² = 0.9339

Annex 3 Methodologies used by HELCOM Contracting Parties for PLC-5

Methodology used in Denmark

Input regarding methodology applied for PLC-5 by Denmark

Overall, Denmark follows the methodology described in the PLC-5 guidelines. Chemical analyses are carried out by accredited laboratories and only three or four are involved. They must follow predefined limits of detection and governmental quality criteria set in a governmental order and mostly follow international standard methods (ISO/EN). All laboratories are obliged to implement a quality assurance system after the requirements of EN ISO/IEC 17025 (EN ISO/IEC, 2005 ISO 17025).

Concerning wastewater sampling frequency and the compilation of annual loads, the description given in PLC-4 report chapter 3 is still valid (HELCOM 2004) and in correspondence with the PLC-5 guidelines. Due to administrative changes in Denmark during 2006 when the counties were terminated, the Danish data (discharges/loads) reported from municipal wastewater treatment plants, industry and fish farms was from 2005, but they differ only slightly from 2006 data which still are not compiled and available. Data from scattered dwellings and storm water constructions/rainwater overflows are from 2004.

Riverine loads are calculated based on time series of daily discharges and daily concentrations. Discharge is monitored at all chemical sampling sites. Daily concentrations are obtained by the linear interpolation method. The diffuse riverine load from unmonitored areas is calculated by multiplying flow-weighted concentrations or area coefficients with a specific discharge and the size of the unmonitored catchment. Flow-weighted concentrations and specific discharges are selected from catchments with similar soil types, land use, geology and climate, and with small inputs from point sources. Furthermore, load from point sources is added to the calculated diffuse riverine load, yielding the total load from unmonitored areas. The load from point sources in unmonitored areas is in fact based on measured values of load from point sources, as the unmonitored areas are only unmonitored with respect to the riverine load.

Source apportionment

Regarding source apportionment, Denmark follows the methodology described in Section 3.5 of the PLC-4 report (HELCOM 2004), whereby the diffuse anthropogenic sources are estimated by subtracting loads from natural background losses, atmospheric deposition on freshwaters in the catchment, point sources, scattered dwellings and storm water constructions from gross loads (monitored load plus retention). The monitored inputs from MWWTPs, industries, the calculated inputs from fish farms, scattered dwellings, storm water constructions, atmospheric deposition and background loads for each catchment together with the estimated diffuse anthropogenic losses estimated as described above comprise the figure used in the source-oriented approach. To estimate sources in the load-oriented approach, the retention is divided proportionally on load/input from natural background losses, atmospheric deposition onto surface waters in the catchment and the diffuse anthropogenic sources in each catchment. No retention is asTotaled on discharges from MWWTPs, industry or fish farms. Natural background loads are calculated from area coefficients obtained from the monitoring of nine small non-agricultural catchments and applied for the unpaved part of the catchment (approximately 94%). The area coefficients used for 2006 were 2.26 kg N ha^{-1} (1.5 mg N l^{-1}) and 0.79 kg P ha^{-1} (0.50 mg P l^{-1}). Atmospheric deposition onto freshwater is calculated from deposition rates of nitrogen, which are modeled for grids based on monitoring results of atmospheric deposition.

Retention was calculated as described in Annex 6.2 of the PLC-5 guidelines based on 2004 data which were the most updated data to use for the PLC-5 assessment.

Methodology used in Finland

Riverine discharges

Altogether 32 monitored rivers were included in the PLC-5 work. These monitored rivers comprise about 90% of the Finnish Baltic Sea catchment area. Water flow was measured continuously in each river and water quality samples were taken flow proportionally, usually 12 to 20 times per year. Load from unmonitored areas was estimated by extrapolating the results of the nearby monitored catchment areas (with same type of land use and soil characteristics). The annual river discharges for nutrients were calculated by multiplying the mean monthly concentration by the monthly flow and Totalming up the monthly loads. Missing monthly concentrations were replaced with seasonal means.

Estimation of loading

Point source load

Nutrient load estimates from municipalities and industrial plants were based on regular measurements made according to the guidelines given by the Finnish environmental authorities. In some cases, it is impossible to separate municipal and industrial discharges, because especially wastewaters from food production plants are usually treated in municipal wastewater treatment plants. Nutrient load estimation for fish farms was based on production statistics, amount of feed and nutrient content of the feed, using the equations in the PLC-4 guidelines.

Non-point loading

Small drainage basins and small experimental areas are used in Finland in the estimations of non-point source loading. The network of drainage basins for water quality monitoring consists altogether of 45 basins with different types of land use in different parts of the country. Water flow was measured continuously and water quality samples were taken flow proportionally 35 to 55 times per year.

Estimation of the losses of phosphorus and nitrogen from agricultural land to surface waters in Finland is based on the monitoring of N and P fluxes from 11 small agricultural drainage basins and from four agriculturally loaded river basins in south and southwestern Finland (Rekolainen et al. 1995, Vuorenmaa et al. 2001). The size of the small basins varies from 0.12 to 15 km^2, and the river basins from 870 km^2 to 1,300 km^2. The agricultural land use of the basins varies from 23% to 100%. The monitoring schemes are based on continuous water flow measurement and flow-weighted water quality sampling. Using these data, annual N and P flux estimates are calculated by subtracting possible point source loads and estimated losses from forested areas and the natural background. The up scaling of the losses of phosphorus to cover the whole Finnish arable land area is based on the ICECREAM model, which takes into account the topography, the structure of soil and agricultural production in different river basins (Tattari et al. 2001). The hydrology of the original model has been modified for Finnish conditions. The most notable change in the model is the inclusion of snow accumulation, snow melt and soil frost processes. For nitrogen, the SOILN-N model was used (Johnsson et al. 1987).

The effects of forestry activities (ditching, clear cut felling, ploughing, hummocking, fertilization, etc.) were evaluated on the basis of regional forestry statistics. The specific yearly net load from forestry activities was approximated using leaching coefficients obtained from the Finnish and Swedish surveys.

Nutrient inputs from scattered dwellings were estimated on the basis of estimated annual wastewater production per person and the level of equipment in handling of lavatory and sanitary wastes (Table 1). The data concern the year 1992.

Table 1. Waste water production per person from houses with various levels of equipment for sanitary wastes.

Level of equipment	kg P a^{-1}	kg N a^{-1}
High		
- without separate handling	0.43	3.1
- with separate handling	0.25	1.0
Low or modest	0.25	0.3

Atmospheric deposition on lake surfaces was obtained by multiplying specific deposition by the surface area of the lakes. Deposition was measured on 65 stations located in the river catchment areas. Nutrient concentrations were analyzed from the integrated monthly samples of rain water.

The estimation of natural leaching was based on coefficients obtained from the monitoring programmes of small drainage basins (Table 2).

Table 2 Natural leaching coefficents for different parts of Finland.

	kg P km^{-2} a^{-1}	kg N km^{-2} a^{-1}
Southern Finland	6	200
Central Finland	5	120
Northern Finland	5	80
Northern Lapland	2	50

Calculation of retention

The estimation of retention of nutrients in freshwater is based on mass balance calculations. Usually the retention of nitrogen and phosphorus is calculated only for the whole catchment area, but in larger river basins it was also calculated for sub-catchment areas when there were continuous flow measurements and representative concentration measurements (at least 12 times per year). Retention was calculated using data from 1990 to 1999.

The retention was calculated according to the following formula:

$$RET = Q_{IN} + (L_{POINT} + L_{AGRI} + L_{ATM} + L_{FOREST} + L_{SCAT} + L_{BACK}) - Q_{OUT},$$

where

Q_{IN} = incoming riverine load
Q_{OUT} = outflowing riverine load
L_{POINT} = point source load (industry, municipalities, fish farming)
L_{AGRI} = agricultural nutrient load
L_{ATM} = direct atmospheric deposition to the lakes
L_{FOREST} = load from forestry activities
L_{SCAT} = load from scattered dwellings
L_{BACK} = natural leaching

Retention of nutrients in freshwaters in Finland is mainly associated with chemical, physical and biological processes taking place in lakes. Unmonitored river catchments and coastal areas in Finland have only a very small number of lakes, and thus retention in these areas is negligible.

Source apportionment

Source apportionment was based on the measured (point source load) or estimated (non-point loading) load figures and retention calculations.

References

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Methodology used in Sweden

The methods used for PLC-5 were similar to those used for PLC-4, but the collection of input data as well as models have been developed and improved. The methodology is described in more detail in a report from the Swedish Environmental Protection Agency (SEPA, 2009) as well as at www.naturvardsverket.se.

The source apportionment of nitrogen and phosphorus loads to water in the catchments (gross load) was based on calculations in sub-catchments, aggregated to 1,100 'PLC-5 catchments' and 119 main river catchments. Land-use data were compiled using the Geographic Information System (GIS) from the National Land Survey of Sweden, block maps and data on crops from the Integrated Administration and Control System (IACS) from the Swedish Board of Agriculture and data on cleared-felled forest areas from the Swedish Forest Agency. Runoff on a daily basis for 1985–2004 was calculated for the PLC-5 catchments using the HBV hydrological model, and then Totalmarized to obtain annual and monthly averages.

Large point sources, classified as inland or coastal, comprise municipal wastewater treatment plants >2,000 PE and large industrial facilities. Emissions were obtained from the county administrative boards' EMIR database for 2006 and the Swedish Chemicals Emissions Register (EPER/KUR). Emissions from fish farms were calculated by multiplying emission factors by the mass of fish produced.

Emissions from small wastewater treatment plants sized 200 to 2000 person equivalents (PE) were calculated by using standard emission factors, while emission data from local on-site wastewater treatment were based on a questionnaire survey to all municipalities and national registers kept by Statistics Sweden (SCB).

Land-use leaching was calculated by multiplying the area (in km^2) devoted to a particular land use by leaching coefficients (mg l^{-1}) and by runoff (l s^{-1} per km^2). Leaching coefficients for nitrogen leaching from agriculture produced by the SOILNDB simulation tool, and phosphorus leaching from agricultural land were estimated using the ICECREAMDB model. Other land-use concentrations were derived from Totalmaries of measured data in small homogeneous catchments. Atmospheric deposition of nitrogen on water (lakes) was calculated by the MATCH model, and phosphorus deposition was obtained from measurements. Loads with storm water in urban areas were estimated using detailed land use data combined with leaching coefficients. Leaching from mountain areas, mires, forested land, unforested land, and atmospheric deposition of phosphorus on lakes were considered natural background load. The load from agricultural land and cleared forest areas comprises both natural background and an anthropogenic part. Retention in lakes and rivers was modelled with the HBV-NP model calibrated and validated with monitoring data from recipients. Retention of nitrogen and phosphorus was simulated for the transport from the sub-catchment in question to the sea.

The total load to the sea was calculated as the Total of direct discharges from coastal point sources and riverine loads. The riverine input of nitrogen and phosphorus to the sea was estimated by subtracting the calculated retention from source to sea for each main catchment, accumulated to sea basin level and then compared with loads calculated from the national monitoring programme for river mouths. In this latter programme, runoff and chemical analyses of nutrients and metals are measured at 47 stations, covering about 82% of the total Swedish catchment area. Loads from unmonitored river catchments and coastal areas were estimated by scaling from the specific load (load per km^2) of neighbouring reference areas.

Reference:

SEPA (2009) Nutrient loads to the Swedish marine environment in 2006. Swedish Environmental Protection Agency, Report 5995.

Methodology used in Poland

Nutrient balance from diffuse sources for Poland (PLC-5, year 2006)

The balance of nutrients from diffuse sources for the area of Poland located in the Baltic Sea catchment has been determined for the following sources of pollution:

– Agricultural land and background (forest and semi-natural areas)
– Built-up areas not connected to sewer system
– Direct deposition to water from precipitation

To perform calculations, the area of Poland has been divided into 133 computational sub-catchments, and the calculated loads of pollution have been used to balance diffuse pollution for the catchments of 12 rivers discharging waters to the Baltic Sea, taking into consideration both monitored and unmonitored areas.

Loads of nutrients from agricultural land and background

The calculations of losses for the background load of nutrients, originating from forest and semi-natural and agricultural land were based, similarly as in PLC-4, on experimental data obtained from small agricultural and forest catchments, free from impacts of relevant point sources; data came from field work conducted from 1979 to 1989, adjusted for field studies from small catchments conducted from 1993 to 2003.

Based on the experimental data from small catchments, mean nitrogen/phosphorus discharge-weighted concentrations were calculated in water outflow from the forest and semi-natural areas (Cwb) and from the agricultural areas (Cwa).

The values of Cw coffeicients depend on the class of soil permeability and topographical configuration of the surface of the catchment, resulting from the catchments' affiliation to four designated hydro-geographical regions in the country. For each of the above-mentioned regions, separate coefficients (Cw) were used for agricultural areas with drainage and without drainage.

The unit background load was calculated as:

$$Lb = 0.31536 * Cwb * Qc \quad (1)$$

Where:

Lb is a unit outflow load of nitrogen or phosphorus in kg $(ha*a)^{-1}$

Cwb is a discharge-weighted nitrogen or phosphorus concentration in the outflow in mg l^{-1}

Qc is a mean outflow during the study period in the area concerned in l $(s*km^2)^{-1}$

The unit load for nitrogen and phosphorus originating from agricultural areas: without drainage (2) and with drainage (3) is calculated as:

$$Lr = 0.31536 * Cwr * Qc * Ns \quad (2)$$

$$Lrd = 0.31536 * Cwrd * Qc*Ns \quad (3)$$

Where:

La is a unit load of nitrogen or phosphorus from agriculture in kg $(ha*a)^{-1}$

Cwa (Cwad) is a discharge-weighted nitrogen or phosphorus concentration from agriculture in the outflow in mg l^{-1}, specific for areas with or without drainage

Qc is a mean outflow during the study period in the area concerned in l $(s*km^2)^{-1}$

Ns is a correction coefficient, taking into consideration surplus of nitrogen or phosphorus

The calculated unit loads of nitrogen and phosphorus are the basis for estimating the balance of loads (Ltot) originating from agriculture and background, discharged to waters from the area taken into account (4).

$$Ltot = Lb*Sb + (La*Sa + Lad*Sad) \quad (4)$$

Where:

Sb forest and semi-natural areas (ha)

Sa agricultural area without drainage (ha)

Sad agricultural area with drainage (ha)

Nutrient loads from the population not connected to a sanitation system

The nutrient load from built-up areas not connected to a sanitation system (LP) has been calculated individually for each commune, based on statistical data from the Main Statistical Office (GUS) on the population not connected to a sanitation system. AsTotaling an average load of nitrogen and phosphorus per capita (Lc) of 4.4 kg N a^{-1} and 1 kg P a^{-1}, respectively, a total commune burden of the nitrogen and phosphorus load (kg N a^{-1}; kg P a^{-1}) is calculated as the result of the multiplication of the number of people not connected to a sanitation system (Ps) in a commune, a unit index of nitrogen and phosphorus discharge from the population not connected to a sanitation system (Lc), and a coefficient (B), asTotaling the percentage of generated nutrients discharged to water.

$$LP = Ps * Lc * B \quad (5)$$

Taking into consideration an average standard of sanitary infrastructure in households, based on the indices from the HARP guidelines, it was asTotaled that in the communes not connected to wastewater treatment plants, 50% of nitrogen and 10% of phosphorus generated by households are discharged to water (coefficient B equals 0.5 and 0.1 for nitrogen and phosphorus, respectively).

Nitrogen and phosphorus loads deposited onto water from atmospheric precipitation

To balance loads of nitrogen and phosphorus deposited onto surface water from atmospheric precipitation, the results of the State Monitoring of the Chemical Composition of Atmospheric Precipitation (the Main Inspection for Environmental Protection), and CORINE land cover maps were used.

When balancing loads of nitrogen and phosphorus deposited directly onto water from atmospheric precipitation, it is asTotaled that surface waters receive the total load of pollutants present in rain water falling on the water surface in a given area. The Totalmary loads of nitrogen and phosphorus for individual catchments were calculated as follow (6):

$$Lap = Sw * qsw \quad (6)$$

Where:

Lap is the load of nitrogen or phosphorus from atmospheric precipitation directly reaching surface water (t a^{-1})

Sw is the total water surface in a catchment (km^2), estimated based on CORINE land cover maps

qsw is an average unit load of nitrogen or phosphorus falling on a surface area of a catchment in 2006, expressed as (t km^{-2}).

Methodology used in Lithuania

Calculations of diffuse and background loads were made using coeffcients for CORINE land cover types. These coefficients have been developed from the monitoring of small catchments, which are dominated by agricultural or natural areas. Nutrient retention was calculated with one method, the "German approach". Nutrient retention was calculated only for the Nemunas river basin using the following formula:

RETENTION (R) = [(point sources (Dp) + (diffuse losses in the catchment, LOD) + (Natural background losses, LOB)] – L_{river}.

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