PLC-8

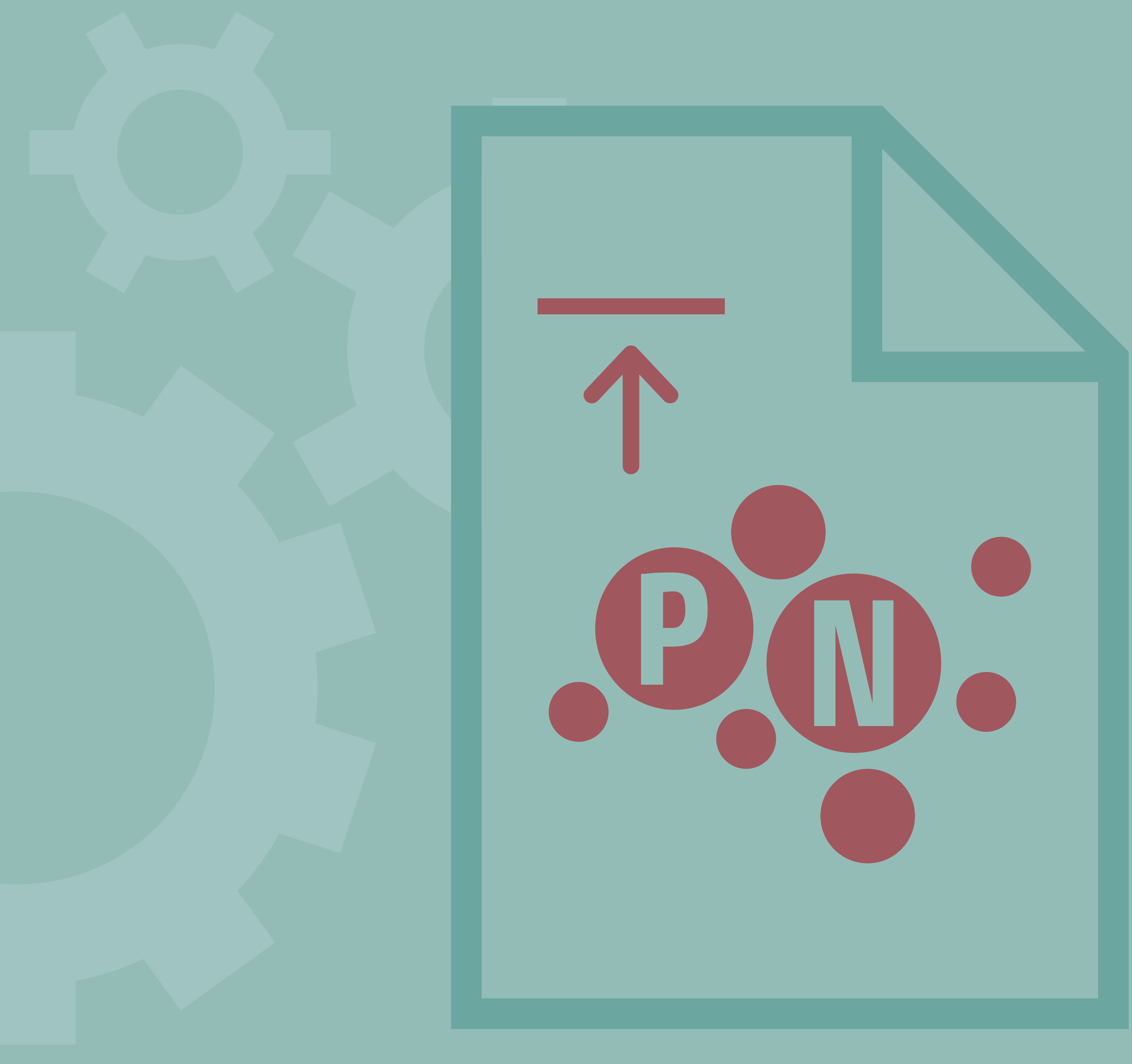
Nutrient Input Ceiling

assessment 1995–2020
Technical report

Baltic Marine Environment Protection Commission

Monitoring & assessment

2023



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Preface

The PLC-8 project has to evaluate the progress towards fulfilling nutrient (nitrogen and phosphorus) input ceilings (NICs) based on 2020 (time series from 1995-2020) and 2022 (time series from 1995-2022) data. The first progress report was made by the end of 2022, approved by the HOD via correspondence in January 2023 and published on the HELCOM website. The progress report is included as chapter 0 in the present technical/scientifical report without any changes. In the end of chapter 0 under the heading "Supplementary findings of NIC-2020 assessment" are main findings added from the present technical/scientifical report that are not included in the first progress report.

This technical/scientifical NIC background report was recommended to be elaborated by PLC-8 IG and welcomed by the Pressure Working Group. Its aim is to be a scientific background report that can be utilized as the basis for discussion on changes needed for showing appropriate messages in future reports. Further the report aims to provide information on all assessment methodologies in relation to evaluating progress towards NIC's. The report includes all the detailed assessment results country by basin and for the nine transboundary rivers with NIC's, and links to the assessment data set behind these tables and plots. There are several extra assessments included in the technical/scientifical report compared with the first progress report. It also included a combination of remaining reductions to fulfil NIC by 2020 and the overall results for the latest source apportionment assessment to indicate what sources are the main contributors of total nitrogen and total phosphorus to the Baltic Sea basin by countries.

Besides two bi-annual assessments of NIC the PLC-8 project conducts an annual assessment of the maximum allowable inputs (MAI) to the Baltic Sea basins. The latest published HELCOM core indicator on maximum allowable inputs of nutrients (MAI) assessment is on 1995-2020 data and published in HELCOM, 2023 online on HELCOM website.

Chapter 1 provides further details om the aims and contents of the present report.

0. Summary

Key Message

National targets for nitrogen and phosphorus inputs have been expressed as nutrient input ceilings for each country by sub-basin. Further nutrient input ceilings have been agreed for 9 transboundary rivers. The evaluation is based on annual air and waterborne nutrient input data from 1995-2020 country per basin and assessing estimated total nitrogen and phosphorus inputs in 2020 with the NIC's from BSAP2021 (results shown in tables 0.1-0.3 and the main findings summarized below the tables).

Table 0.1. Total Nitrogen. Evaluation of input ceilings fulfilment taking into account reallocation of extra reduction. Based on statistically estimated inputs.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	↓	↓	↓	↓	↓	↓	↓
Estonia	↓	↓	↓	↓	↑	↓	↓
Finland	↓	↓	↓	↓	↓	↓	↓
Germany	↓	↓	↓	↓	↓	↓	↓
Latvia	↓	↓	↑	↓		↓	↓
Lithuania			↑		↑		
Poland	↓	↓		↓	↓	↓	↓
Russia	↓	↓	↓		↓	↓	↓
Sweden	↓	↓		↓	↓		↓
Belarus							
Czech Republic			↓				
Ukraine			↑				
Baltic Sea shipping	↓	↓	↓	↓	↓	↓	↓
North Sea Shipping	↓	↓	↓	↓	↓	↓	↓
Other countries	↓	↓	↓	↓	↓	↓	↓

Table 0.2. Total Phosphorus. Evaluation of input ceilings fulfilment taking into account reallocation of extra reduction. Based on statistically estimated inputs.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			↓			↓	↓
Estonia			↓	↓	↓		
Finland	↓			↓			
Germany						↓	
Latvia			↓				
Lithuania			↓		↓		
Poland			↓				
Russia			↓	↓	↓		
Sweden		↓	↓			↓	
Belarus			↓				
Czech Republic			↓				
Ukraine			↑				
Baltic Sea shipping							
North Sea shipping							
Other countries							

Table 0.3. Total Nitrogen and total Phosphorus. Evaluation of input ceilings fulfilment for nine transboundary rivers. Based on statistically estimated inputs.

	Barta	Daugava	Lielupe	Nemunas	Neva	Oder	Pregolya	Venta	Vistula
Total nitrogen	↑		↑	↑				↑	
Total phosphorus	↓		↓	↓	↓	↓		↓	↓

Colour legend

Reduction still left to NIC* is:

- less than 10%
- between 10% and 30%
- between 30% and 50%
- 50% or more

- Within statistical certainty, the fulfilment of NIC cannot be justified
- NIC is with 95 % certainty fulfilled; input ceilings are not exceeded
- Application of extra reduction achieved in neighboring sub-basin

- only airborne inputs to the sub-basin
- only transboundary waterborne inputs to the sub-basin
- application of extra reduction achieved in neighbouring basins changed status

Arrows: statistically significant changes of nutrient inputs from the reference period (1997-2003) to 2020, taking into account 95% confidence interval for both latest inputs and reference values.

↓ significant decrease

↑ significant increase

* Yellow, orange and "red" shades: input ceiling is exceeded. The legend illustrates the percentage which reduction left to the target constitutes in the corresponding input ceiling value.
*Remaining reduction (in %) is calculated as: (remaining reduction in tonnes/ NIC in tonnes) * 100%*

"Other countries" includes sources for atmospheric nitrogen deposition as the EU countries not being HELCOM Contracting Parties, countries outside EU including Belarus, Ukraine etc.

BSS = nitrogen deposition from Baltic Sea Shipping

NOS = nitrogen deposition from North Sea Shipping

Based on estimation of normalized inputs of nitrogen and phosphorus in 2020 (Tables 0.1-0.3) the following conclusions can be made (only statistically significant reductions/increases in inputs since the reference period 1997-2003 to 2020 are mentioned):

Progress towards nitrogen input ceilings

Fulfilment of nitrogen input ceilings by countries:

- **Denmark** is the only country fulfilling nitrogen input ceilings for all HELCOM sub-basins. Denmark reduced total nitrogen inputs to all HELCOM sub-basins since the reference period with between 19% and 49%.
- **Estonia** achieved the national input ceiling for Bothnian Bay, Bothnian Sea, Danish Straits and Kattegat. The remaining reductions for the Gulf of Riga, Baltic Proper and the Gulf of Finland constitute 34%, 13% and 12%, respectively. Accounting for extra reduction in Bothnian Sea only contributes with 2 tonnes TN reduction in Baltic Proper. Inputs since the reference period were reduced statistically significantly to all basins (between 10% and 35%) except to Gulf of Riga which showed a significant increase (23%).
- **Finland** achieved nitrogen input ceilings for five sub-basins except to the Gulf of Finland and Bothnian Bay. The remaining reduction for the Gulf of Finland is 1.6% and for the Bothnian Bay 4.2% and is within statistical uncertainty. Reallocation of the extra reduction from Bothnian Sea to Bothnian Bay reduces the missing reduction to 0.9%, which remains within statistical uncertainty. Finland reduced total nitrogen inputs to all HELCOM sub-basins since the reference period with between 8% and 52%.
- **Germany** achieved nitrogen input ceilings for all sub-basins except to Baltic Proper with a remaining reduction of 4.4%. Reallocation of the extra reduction from the Gulf of Riga, Danish Straits and the Gulf of Finland to Baltic Proper reduces the missing reduction to 2.5%. Germany reduced total nitrogen inputs to all HELCOM sub-basins since the reference period by between 20% and 37%.
- **Latvia** fulfils the input ceilings for Bothnian Bay, Bothnian Sea, Danish Straits and the Kattegat. The remaining reduction for the Gulf of Riga is 3.1% and is within statistical uncertainty. The remaining reductions for Baltic Proper and the Gulf of Finland constitute 105% and 14%, respectively. Accounting for extra reduction in Danish Straits only contributes with 1 tonnes

TN reduction in Baltic Proper. Latvia decreased inputs to five sub-basins between 10% and 14%, but has an 48% increase to Baltic Proper since the reference period, and no change in total nitrogen inputs to Gulf of Riga.

- **Lithuania** exceeded its ceilings to all sub-basins except to Danish Straits. However, remaining reduction to Bothnian Bay, Bothnian Sea and the Kattegat are only between 4.5 and 8.8%. Reallocation of the extra reduction from Danish Straits to the Kattegat reduces the missing reduction from 5.5% to 4.2%. The remaining reductions for Baltic Proper, the Gulf of Riga and the Gulf of Finland constitute 123%, 62 and 22%, respectively. Lithuania increased its input to Baltic Proper (62%) and the Gulf of Riga (55%) since the reference period. Inputs to other sub-basins have not significantly changed since the reference period.
- **Poland** achieved the input ceiling for all sub-basins except for Baltic Proper, where the remaining reduction is 20%. Reallocation of the extra reduction from Danish Straits to the Baltic Proper does not change the missing reduction in percentages. Poland reduced total nitrogen inputs to all HELCOM sub-basins since the reference period by between 11% and 26%.
- **Russia** fulfils input ceiling for Bothnian Sea, the Gulf of Riga, Danish Straits, and the Kattegat. The remaining reductions for the Gulf of Finland, Baltic Proper and Bothnian Bay constitute 28%, 11% and 2.7%, respectively. Reallocation of the extra reduction from the Gulf of Riga and Danish Straits to the Baltic Proper reduced the missing reduction to 9.0%. Russia reduced total nitrogen inputs to all HELCOM sub-basins since the reference period by between 11% and 29%, except for Gulf of Finland where no changes in nitrogen inputs are assessed.
- **Sweden** achieved nitrogen input ceilings for five of the HELCOM sub-basins except for Baltic Proper and Danish Straits. The remaining reduction for the latter is 9.2% but within statistical uncertainty while the reduction requirement for the Baltic Proper remains 32%. The reallocation of the extra reduction achieved in the Kattegat to the Danish Straits change the remaining (statistical uncertain) reduction requirements to 0.9%. The reallocation of the extra reduction achieved in the Gulf of Riga and the Gulf of Finland to Baltic Proper does not change the remaining reduction requirements in percentage. Sweden has reduced total nitrogen inputs to five HELCOM sub-basins by between 20% to 33% since the reference period, but no significant changes in nitrogen inputs have been assessed to Baltic Proper and Danish Straits.

- In general, Baltic Proper, the Gulf of Riga and the Gulf of Finland have the highest remaining reductions to achieve the ceilings for most countries.
- Waterborne transboundary nitrogen inputs from Belarus (31%) and Ukraine (117%) exceed corresponding input ceilings to Baltic Proper, while the exceedance from Czech Republic (20%) is within statistical uncertainty. Waterborne nitrogen inputs from Belarus to the Gulf of Riga fulfil the input ceiling. Ukraine is the only non-HELCOM country which has increased waterborne nitrogen inputs to Baltic Proper since the reference period.
- Atmospheric nitrogen inputs from Baltic Sea shipping exceed their target values to all sub-basins, the remaining reductions are between 43% and 86%. The inputs have been reduced to all sub-basins since the reference period by 23%.
- Atmospheric nitrogen inputs from North Sea shipping exceed their target values to all sub-basins, the remaining reductions are between 61% and 122%. The inputs have been reduced to all sub-basins since the reference period by 27%.
- Other non-HELCOM countries and sources exceed respective target values for atmospheric input of nitrogen to all sub-basins, the remaining reductions are between 26% and 59%. The inputs have been reduced to all sub-basins since the reference period with between 32% and 43%.
- Generally, the highest percentages reductions of total nitrogen inputs from HELCOM Contracting Parties are for the sub-basins where the countries only contribute with airborne inputs.

Fulfilment of nitrogen input ceilings for transboundary rivers:

- Nitrogen nutrient ceilings is only fulfilled for Daugava. The remaining reduction for the remaining eight transboundary rivers with nutrient inputs ceilings are approx. 120% for Barta and Venta, 89% for Nemunas, 77% for Lielupe, 39% for both Pregolya and Vistula, 35% for Neva and 31% for Oder. Waterborne nitrogen inputs increased in Barta, Lielupe, Nemunas and Venta by between 37% and 60% since the reference period. For the remaining five rivers no trend in waterborne inputs is assessed.

Progress towards phosphorus input ceilings

Fulfilment of phosphorus input ceilings by countries:

- None of the HELCOM countries fulfilled the input ceiling for phosphorus to all HELCOM sub-basins without reallocation of extra reduction. In relative terms, higher reduction remains to meet maximum allowable input (MAI) for phosphorus than for nitrogen (10% and 28% of MAI, respectively, HELCOM Core indicator2021).
- All HELCOM and non-HELCOM countries exceeded input ceilings for the Baltic Proper without reallocation of extra reduction.
- No HELCOM Contracting Party increased their input of phosphorus since the reference period, but Ukraine increased its phosphorus inputs to Baltic Proper. All HELCOM Contracting Parties demonstrate either significant decreases or no statistically significant trends in phosphorus inputs.
- **Denmark** achieved reduction requirements for the Kattegat and Danish Straits. The input ceiling for the Baltic Proper is achieved by applying extra reduction from Danish Straits. Denmark reduced total phosphorus inputs to Danish Straits, Baltic Proper and the Kattegat by 29%, 20% and 18%, respectively.
- **Estonia** exceeded input ceilings to Baltic Proper, the Gulf of Finland and the Gulf of Riga. The remaining reductions for these sub-basins are 117%, 39% and 36%, respectively. Estonia reduced total phosphorus inputs to the Gulf of Finland, Baltic Proper, and Gulf of Riga by 45%, 26% and 18%, respectively.
- **Finland** exceeded input ceilings to the Gulf of Finland and Bothnian Sea but achieved it for Bothnian Bay. The remaining reduction for the Gulf of Finland is 107% and for the Bothnian Sea 8.0%. After reallocation of the extra reduction from Bothnian Bay to Bothnian Sea the missing reduction is reduced to 6.8%. Finland reduced total phosphorus inputs to the Bothnian Bay and Gulf of Finland by 18% and 17%, respectively.
- **Germany** meets the input ceiling for Danish Straits but has not achieved it for Baltic Proper where the remaining reduction is 119%. After reallocation of the extra reduction from Danish Straits to Baltic Proper the remaining reduction is reduced to 108%. Germany reduced total phosphorus inputs to the Danish Straits by 14%.
- **Latvia** exceeded input ceilings for both Baltic Proper and the Gulf of Riga where the remaining reduction is 66% and 24%, respectively. Latvia reduced total phosphorus inputs to Baltic Proper by 50%.
- **Lithuania** fulfilled the input ceiling for the Gulf of Riga but exceeded it for Baltic Proper where the remaining reduction is 55%. Reallocation of extra reduction achieved by Lithuania in the Gulf of Riga allowed reducing remaining reduction to the Baltic Proper to 46%. Lithuania reduced total phosphorus inputs to the Gulf of Riga and Baltic Proper by 97% and 45%, respectively.
- **Poland** exceeded the input ceiling for Baltic Proper, and the remaining reduction is 114%. Poland reduced total phosphorus inputs to Baltic Proper by 22%.

- **Russia** exceeded input ceilings for Baltic Proper, the Gulf of Finland and the Gulf of Riga. The remaining reductions for these sub-basins constitute 151%, 35% and 26%, respectively. Russia reduced total phosphorus inputs to the Gulf of Finland, Baltic Proper and the Gulf of Riga by 54%, 36% and 24%, respectively.
- **Sweden** achieved input ceilings for the Bothnian Sea, Danish Straits and the Kattegat. The remaining reduction for Bothnian Bay is 3.8% and within statistical uncertainty. Sweden exceeded input ceilings for the Baltic Proper, where the remaining reduction is 129%. By reallocation of extra reduction from Bothnian Sea to Bothnian Bay the inputs ceilings in Bothnian Sea is fulfilled. Reallocation of extra reduction from Bothnian Bay and Danish Straits to Baltic Proper reduces the remaining reduction to 58%. Sweden reduced total phosphorus inputs to Bothnian Sea, Danish Straits and Baltic Proper by 37%, 20% and 14, respectively.
- Non-HELCOM countries Belarus, Czech Republic, and Ukraine exceeded reduction requirements for the Baltic Proper and the Gulf of Riga.
- All countries fulfilled national ceilings for total phosphorus inputs to Danish Straits and the Kattegat, and further to Bothnian Bay when accounting for extra reductions.

Fulfilment of phosphorus input ceilings for transboundary rivers:

- Phosphorus nutrient ceilings are not fulfilled for eight transboundary rivers with input ceilings. The remaining reduction for Lielupe is 16% but within statistical uncertainty. The remaining reduction is 215% for Pregolya, 128% for Vistula, 108% and 109% for Oder and Venta, respectively, 97% for Neva, 95% for Barta, 82% for Nemunas and 48% for Daugava. Waterborne phosphorus decreased in Barta, Lielupe, Nemunas, Neva, Oder and Vistula by between 22% and 38%. For the remaining three rivers no trend in waterborne inputs is assessed.[1]

[1] Revision of time series and nutrient input ceilings (this paragraph is from the first progress report HELCOM website.):

The time series (1995-2020) of nitrogen and phosphorus inputs have been reviewed and for some countries considerable re-reporting has been performed since the last NIC assessment based on 1995-2017 data. Further, EMEP has recalculated the annual atmospheric nitrogen deposition on sub-basins using improved model and resolution, which led to a remarkably higher deposition compared to former assessments. This has resulted in an overall increase of estimated inputs to the Baltic Sea sub-basins particularly for total nitrogen also in the reference period. Updated NIC's were adopted in the BSAP 2021 update taking into account the updated water and airborne data, improved data (including on retention) from transboundary rivers and the shares of transboundary inputs between countries sharing transboundary catchment. Compared with the NIC-2017, North Sea shipping (NOS) is separated as a source of nitrogen deposition. In the NIC-2017 assessment NOS was included in other countries (OC).

Nutrient Input Ceilings (NICs) agreed in the 2021 BSAP were used for the current assessment but taking into account revised shares of nitrogen and phosphorus inputs for Oder River between Germany and Poland that were agreed in 2022, with changing NIC to Baltic Proper for Germany and Poland compared with the corresponding NICs in the 2021 BSAP.

Supplementary findings of NIC-2020 assessment

Below some main findings from the present technical/scientifical background report are presented that are not included in the first progress report of NIC assessment under the headings “Key message”, “Progress towards nitrogen input ceilings”, “Progress towards phosphorus input ceilings” in this chapter.

Importance of reducing airborne nitrogen inputs of total reduction of nitrogen

For basins with both net total nitrogen air- and waterborne country per basin inputs the reduction of airborne inputs plays an important share in the reduction in total net nitrogen inputs from 1995-2020 in:

- Denmark: For Baltic Proper 90% of total reduction and 27% to both Danish Straits and Kattegat
- Estonia: 100 % of reduction to Baltic Proper – no significant reduction to Gulf of Finland and Guld of Riga
- Finland: 100 % of reduction to Bothnian Bay, Bothnian Sea and 12 % to Gulf of Finland
- Germany: 100 % of reduction to Baltic Proper and 42 % to Danish Straits
- Latvia: 100 % of reduction to Baltic Proper, no significant reduction top Gulf of Riga
- Lithuania: No significant reduction either to Baltic Proper or to Gulf of Riga
- Poland: 23 % of reduction to Baltic Proper
- Russia: 100 % of reduction to Baltic Proper, no (significant) reduction to Gulf of Finland, and increase in atmospheric total nitrogen deposition to Gulf of Riga
- Sweden: 100 % of reduction to Danish Straits, 94% to Baltic Proper, 18% to Bothnian Sea, 9 % to Bothnian Bay and 4 % to Kattegat

The potential reduction share also depends on the proportion of waterborne versus airborne inputs.

Trends in annual net nitrogen inputs

Traditionally changes in net inputs country per basin is based on changes from 1995 to 2020 and change since the reference period (1997-2003) to 2020. Trend analysis is provided on sections of the net nutrient input time series 1995-2020 with breakpoint, estimating changes in the first section 1995 to (first) breakpoint and the last section from last break point to 2020. Further, also changes in percentage per year for these first and last sections and for changes from 1995 to 2020 are calculated to support the visual impression for the plot of the timeseries with some marked changes in trend from the beginning of the timeseries to the last section. For nitrogen it also illustrates the importance to assess not only the sum of water and airborne inputs, but to further analyse airborne and waterborne inputs separately.

Airborne inputs are reduced both in the first and last section of the timeseries to many country basins, but for Baltic Sea and North Sea shipping there are an increase of about 4% per year from 1995-2000. Also Lithuania to all basins, Latvia to Baltic Proper and Gulf of Riga and Estonia to Gulf of Riga have increased airborne nitrogen input in the last section.

For waterborne net total nitrogen inputs the trends in the last section for rather many country basins are increasing, and the percentage change to some basins are very high:

- Denmark to Baltic Proper (5.4 %/yr), Danish Straits (2.4 %/yr)
- Estonia to Gulf of Riga (2.5 %/yr)

- Latvia to Baltic Proper (5.6%/yr)
- Lithuania to Baltic Proper (8.3%/yr)
- Sweden to Baltic Proper (4.2%/yr), Danish Straits (1.7%/yr)
- Belarus to Gulf of Riga (1.7%/yr)

On the other hand, Russia reduced their input to Gulf of Finland with 9.1%/yr in the latest section.

Trends in annual net phosphorus inputs

For phosphorus all country basins have a significant reduction in waterborne total phosphorus inputs besides Ukraine with an increase (31%). Denmark, Germany and Sweden (besides to Bothnian Bay) have the highest reduction in inputs in the first section, and for some countries major reductions in waterborne inputs happened before 1995. There are only few country basins where waterborne phosphorus input are reduced in the last section of the time series:

- Denmark to Danish Straits (2.2 %/yr) and Kattegat (0.5%/yr)
- Germany to Baltic Proper (1.1%/yr) and to Danish Straits (0.9%/yr)
- Russia to Baltic Proper (-8.0%)
- Sweden to Bothnian Bay (1.4%/yr)

Remaining reduction requirements to fulfil NIC compared with the main sources of nitrogen and phosphorus

Combining the remaining reduction (for nitrogen and phosphorus, respectively) country by basin with the input sources reveals that even reduction more or less all inputs from waste water sources (loads from municipal waste water treatment plants, industrial plants, aquaculture plants, scattered dwellings and storm waters) will not be sufficient to fulfil the NIC. There is a need also to reduce inputs from diffuse sources such as agricultural sector and forestry for both nitrogen and also phosphorus, even though waste water constitute a bit higher proportion of total phosphorus inputs than the corresponding share for nitrogen. Particularly to Baltic Proper and Gulf of Riga with the highest remaining reduction and increasing inputs of waterborne nitrogen in the latest c. 10 years the proportion of diffuse sources is rather high.

1. Introduction

1.1 Content and structure of the report

The PLC-8 project is to produce two reports evaluating the progress towards fulfilling nutrient (nitrogen and phosphorus) input ceilings (NICs) based on 2020 (time series from 1995-2020) and 2022 (time series from 1995-2022) data. The first progress report was made by the end of 2022, approved by the HOD via correspondence in January 2023 and published on the HELCOM website.

PLC-8 IG recommended to elaborate also a technical/scientifical background report, and the plan was welcomed by the Pressure Working Group. The aim of this report is to be a scientific background report that can be utilized as the basis for discussion on changes needed for showing appropriate messages in future reports. Further the report aims to provide information on all assessment methodologies in relation to evaluating progress towards NIC's, either by very shortly summarizing on a method and point to a reference with method documentation or have a more detailed description of the method when no easily available document exists.

There are several extra assessments included in the technical/scientifical report compared with the progress report. The report includes all tables and plots elaborated country by basin and for the nine transboundary rivers with NIC's as a part of the assessment of progress towards NIC by 2020, and links to the assessment data set behind these tables and plots. Further, several summary tables with the main results are included in the report. Also included is a combination of remaining reductions to fulfil NIC by 2020 and the overall results for the latest (PLC-7) source apportionment assessment to indicate what sources are the main contributors of total nitrogen and total phosphorus to the Baltic Sea basin by countries (chapter 4).

The report includes in chapter 0 the text from the summary NIC by 2020 report published in January.

The assessment methodologies are described in chapter 2, with more detailed methodology description on how nutrient input ceilings are derived for Archipelago Sea (annex C) and how to take into account extra reduction in neighboring countries (annex D). The current NICs are in annex A and the reference inputs in annex B.

Progress toward NIC by 2020, remaining reductions, changes in nitrogen and phosphorus inputs from 1995 to 2020 and from the reference period (1997-2003) with overview of breakpoints are included in chapter 3 country by basin and for the nine transboundary rivers. The fulfilment of NIC is provided country by basin also with taking into account extra reduction in neighboring basins. Comparison with NIC-2017 assessment is presented in annex E. Chapter 3 includes examples of time series plots for total air + waterborne total nitrogen and total phosphorus inputs, for airborne total nitrogen inputs and waterborne total nitrogen and total phosphorus country by basin, with all plots in annexes C-G. The chapter also evaluates the importance of reduction of the airborne total nitrogen inputs of the total reduction assessed country by basin. Finally, the chapter includes a special NIC assessment where Archipelago Sea has been separated from the remaining Bothnian Sea, and NIC fulfilment evaluation, upon a request from Finland.

Chapter 5 includes a short discussion and conclusions.

Annex J includes an introduction to the file including the assessment dataset and trend line.

The authors want to express their gratitude to the PLC-8 IG and countries for reporting the annual data, and for the assistance by the HELCOM Secretariat.

1.2 List of used abbreviations

Table 1.1 includes abbreviations used in this report.

Table 1.1. List of abbreviations used in the report and/or in the annexes.

Abbreviation	**Explanation**
Countries:	
ALL	Sum of all countries/sources
BSS	Baltic Sea shipping
BY	Belarus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
FI	Finland
LT	Lithuania
LV	Latvia
NOS	North Sea shipping
OC	Other countries – countries (and contributors) outside HELCOM
PL	Poland
RU	Russia
SE	Sweden
UA	Ukraine
Baltic Sea basins:	
ARC	Archipelago Sea
BAP	Baltic Proper
BAS	Baltic Sea
BOB	Bothnian Bay (sum of ARC and remaining BOS)
BOS	Bothnian Sea
DS	Danish Straits (sum of SOU and WEB)
GUF	Gulf of Finland
GUR	Gulf of Riga
KAT	Kattegat
SOU	The Sound
WEB	Western Baltic Sea
Nutrient sources:	
AGL	Agricultural loads
AQL	Aquaculture loads
ATL	Atmospheric deposition on inland surface waters
ATM	Atmospheric deposition on the sea
Diff-other	Sum of diffuse sources not quantified individually
INL	Industrial loads
MFL	Managed forestry loads
MWL	Municipal treatment plants wastewater loads
NBL	Natural background loads
PS	Point source loads (sum of AQL, INL and MWL)
SCL	Scattered dwellings loads
SWL	Stormwater and overflow loads
Others:	

BSAP	HELCOM Baltic Sea Actions Plan
DIR	Direct inputs (inputs entering directly into the sea)
EMEP	European Monitoring and Evaluation Programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) – when referring to EMEP in the report is a EMEP Center, actually MSC-W (Meteorological Synthesizing Center – West at Norwegian Meteorological Institute)
Indir	Indirect inputs (inputs entering the sea via rivers)
MAI	Maximum allowable inputs of TN and TP
NIC	Nutrient input ceiling
TN	Total Nitrogen
TP	Total Phosphorus

Some few definitions to explain terminology used in figures and tables:

- Airborne inputs: atmospheric deposition on the sea
- Direct inputs: inputs from points sources discharging directly into the sea
- Riverine inputs: inputs discharging to the sea via rivers
- Waterborne inputs: sum of riverine and direct inputs
- Total inputs: sum of air- and waterborne inputs
- Net inputs: sum of inputs (water and/or airborne) from a specific country (or sources) where inputs are corrected with inputs from other countries (transboundary inputs that are deducted, see chapter 2.1)

All the assessed total nitrogen and total phosphorus inputs in relation to fulfilment of NIC in the report are annual net inputs country (or source) by basin as described in chapter 2.1.

2. Summary on applied methodology for the NIC assessment

This chapter shortly summarizes applied methodology for the NIC assessment, with reference to publications with more detailed descriptions. For methodology with no publications the detailed description is included in this report, such as for “taking into account extra reduction in neighboring sub-basins” in chapter 2.4 with the details given in annex D.

2.1 Assessment dataset, aggregation and normalization

Calculation of net country-basin wise nutrient inputs

The net nutrient inputs are calculated by summation of the monitored riverine, direct point sources, unmonitored area and, for nitrogen, atmospheric deposition for each country-basin combination. In addition, corrections are made for contributions to transboundary rivers.

In addition to the HELCOM countries, aggregated net nutrient inputs are computed for the waterborne nutrient inputs of the major upstream transboundary countries Belarus, Czech Republic and Ukraine. The atmospheric inputs due to emissions from Baltic and North Sea shipping are separated for further analysis, while the remaining transboundary atmospheric deposition are lumped into one sum. The aggregations are performed on both actual and normalized nutrient inputs, although the further analysis of trends and fulfillments are performed on the normalized nutrient inputs.

Waterborne inputs

The HELCOM PLC-water data was acquired on Sept 7, 2022 and merged into the assessment database (ADB). The ADB contains a small amount of data that was manually corrected and gap filled within PLC-5.5, PLC-6 and PLC-7 projects according to the methodology outlined in HELCOM (2022). There are no corrections/gap filling performed on data after 2014 except for a few missing data in Russian catchments.

The following steps are performed on the riverine data:

1. Some rivers flows and loads are reported separately for the unmonitored and monitored part of the river. In these cases, the flows and loads of the unmonitored part is added to the monitored river sub-catchment.
2. To make the time-series of unmonitored areas as consistent as possible, data from monitored rivers with incomplete time-series are added to the unmonitored areas.
3. Narva river loads are determined by the Estonian time-series. The river is split into Russian and Estonian parts according to agreed percentage (2/3 to Russia and 1/3 to Estonia).
4. Torne river loads are determined by the average of Finnish and Swedish data. The river is split between Finnish and Swedish parts according to agreed percentage (45% to Finland and 55% to Sweden).
5. Nemunas river flow and load is corrected for the portion through Matrosovka channel.
6. The time-series resulting from steps 1-5 are flow normalized as described in Annex 1 in HELCOM (2021) and formula 10.17 in HELCOM (2022).

Data on nutrient inputs at country borders in transboundary rivers is available in the PLC-water data base since 2018 with exception of the loads in Daugava at the Russian-Belarussian border. Older data was compiled based on submissions directly by individual countries (see HELCOM, 2021). The loads at the Russian-Belarussian border are determined as a ratio of the loads at the Belarussian-Latvian border as described in HELCOM (2021). Further, for the contribution of German loads to Oder River fixed percentages are used. Flows at the borders are not available for all rivers and in those cases flow normalization is performed using the flow of the complete river. The contributions from different countries to each river's load to the Baltic Sea are calculated from border loads using retention coefficients as described in HELCOM (2021).

Nutrient inputs from direct point sources are aggregated per country and basin. Flow (waterflow) from coastal point sources is not used, partly because data is incomplete, but also because it is not defined whether the flow is a source of water to the Baltic Sea or, e.g., cooling water.

Atmospheric inputs

For each assessment EMEP provides a complete data set on actual and weather normalized annual atmospheric nitrogen deposition (Gauss & Karlsen, 2022). A complete attribution of the atmospheric deposition on each sub-basin to country emissions or other sources is also provided annually. The contributions from HELCOM countries, and Baltic Sea and North Sea shipping are maintained through the analysis, whereas the rest of sources and country contributions are aggregated into one category.

2.2 Trend analysis and check for break points and estimating changes in inputs

An elaborate scheme for trend analysis have been developed during the past decade (Larsen & Svendsen, 2021). There are dual purposes of the trend analysis: i) to compute a robust estimate of the change in nutrient inputs during the past decades and ii) to obtain robust estimates of the magnitude and uncertainty of current nutrient inputs. Only normalized data are used in the trend analysis. Many of the nutrient input time-series cannot be described accurately by a linear trend. For example: in several cases nutrient inputs decrease faster in the beginning of the time-series than in more recent years, there are also cases with significant jumps due to, e.g., point sources removal, and yet others where there are data quality issues in the early part of the time-series. To accommodate these cases, an elaborate procedure is used to, in effect, split the time-series into segments of at least 5 years length, and perform linear trend regression on the segments. Trends that are not significant are disregarded and the relevant part of the time-series will be described by the mean value. Illustrative examples of results from the analysis in typical cases are shown in Figure 2.1. The methods are described in detail in Larsen & Svendsen (2021) and HELCOM (2022).

Changes in nutrient inputs are substantiated on two time-scales, i) on the full time-series, i.e., 1995-2020 and ii) as change since the reference period (1997-2003). How these changes are defined in relation to the complex trend analysis methodology are indicated in Figure 2.2. In addition, to estimate the magnitude of the change, adequate statistical analysis is performed to assure which changes are significant. This analysis is also described in detail in Larsen & Svendsen (2021) and HELCOM (2022).

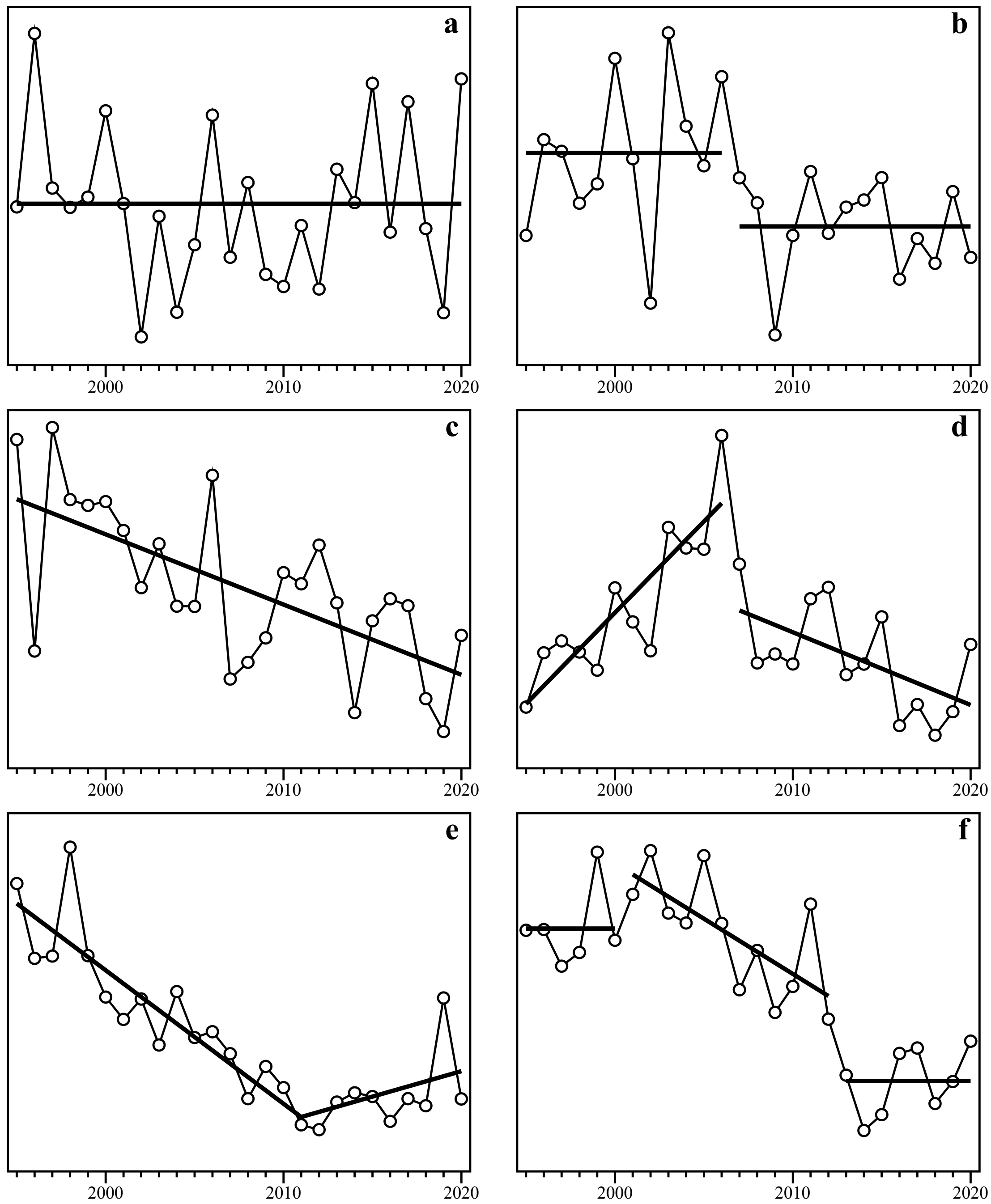


Figure 2.1. Examples of different results from the trend calculation methodology: a) time-series without any significant trend or breakpoints leads to approximation by constant (mean) value throughout, b) time-series with a significant shift in mean but no significant trends is split into parts, each represented by their mean values, c) time-series without breakpoint but with an significant continuous trends, d) time-series with significant shift in both mean and trends are represented by two separate linear regressions (jump between the two trend lines), e) time-series with a trend reversal, but without significant shift, results in two interconnected linear regressions (no jump between the trend lines), and f) mixed cases with break points and significant trends in portions of the time-series.

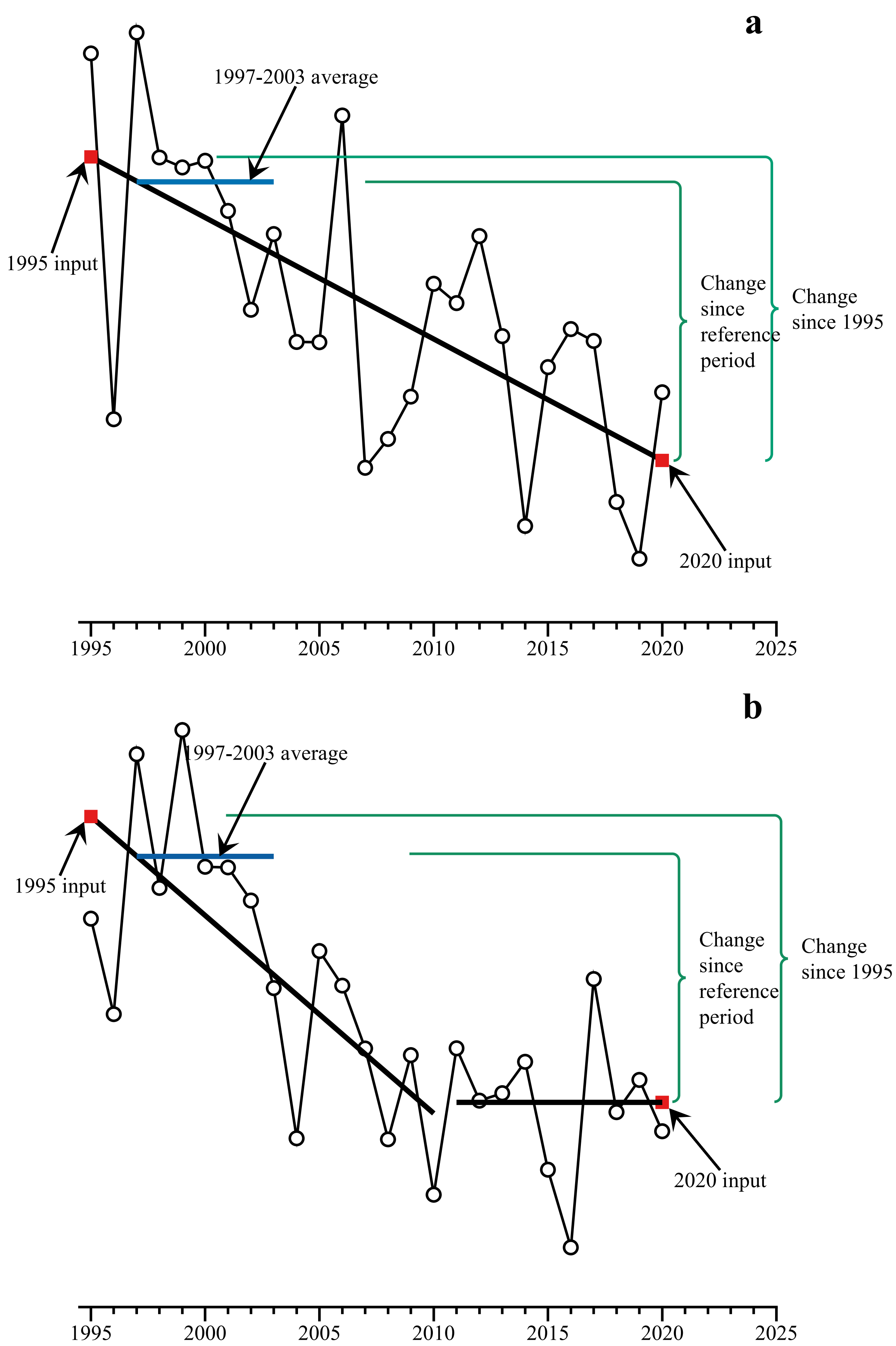


Figure 2.2. Two examples on how changes in inputs and the 2020 inputs used to assess fulfillment of NIC are defined from the trend estimations. NB! that the associated uncertainty and significance are not indicated in the figure.

2.3 Estimation of test value, uncertainties, and evaluations of NIC

The evaluation procedure of fulfillment of NIC is described in detail in particular in Larsen & Svendsen (2021) but also in HELCOM (2022). Therefore, details of the calculations are left out here. The basis for determining the NICs is the basin-wise MAI and a fulfillment of NICs ensure that MAI is reached. The prerequisite for the MAI calculation was if nutrient inputs are equal to MAI (on average), eutrophication status targets in the sea will be eventually reached as a mean value over long time. Following this logic, it would, in principle, be enough if nutrient inputs are on average equal to MAI (or NIC, depending what to evaluate) for fulfillment and in testing fulfillment it would be enough to ensure that present nutrient inputs are not significantly above MAI (or NIC). However, although formally consistent with the MAI calculation basis, there are several principal and practical concerns with such approach, especially for short time-series. The main concern is that limited time-series of variable nutrient inputs with considerable uncertainty would indicate fulfillment according to such criteria although a true long-term average nutrient input are well above MAI (or NIC). A further side effect would be that the more variable and uncertain time-series, the "easier" it would seem to be to fulfill MAI (or NIC). Instead, a different strategy is needed to evaluate fulfillment as the above mentioned approach clearly would violate the precautionary principle. In the adopted methodology, MAI (or NIC) is only judged to be fulfilled when nutrient inputs can be shown to be below MAI (or NIC). This implies that the statistical test rather will be that inputs are significantly below the target. This is indeed stricter, but the difference between the two approaches will become smaller as more time-series become longer and trends weaker.

The assessment of fulfillment includes summaries by a traffic light system (Table 2.1), where also the case were nutrient inputs are below NIC but not significantly below NIC is included. In principle, we could have introduced yet another category (e.g. orange) for the case where nutrient inputs are above NIC but not significantly above. However, instead an indication on how much above NIC the present inputs are is done by gradually darker reds in the summary results (se e.g., table 3.1).

Table 2.1. Summary of the traffic light classification of fulfillment.

Category	Criteria
Red	Input > NIC
Yellow	Input < NIC, Input + uncertainty > NIC
Green	Input + uncertainty < NIC

The nutrient input value for testing fulfillment is the estimated nutrient input the latest year, i.e., the 2020 value of the result from the trend calculation described above (see examples in Figure 2.2). This have been proven to be more accurate measure of current nutrient inputs than averaging a fixed number of years up to most recent year and therefore lower uncertainty. The uncertainty of the 2020 value is estimated in somewhat differently ways depending on the shape of the resulting trend, but in general it is based on the mean square error of the full time-series and including corrections depending on the length and shape of the part of the time-series after the last break point (Larsen & Svendsen, 2021). Examples of 2020 values and related uncertainties compared with NIC in three cases (red, green and yellow) are shown in Figure 2.3.

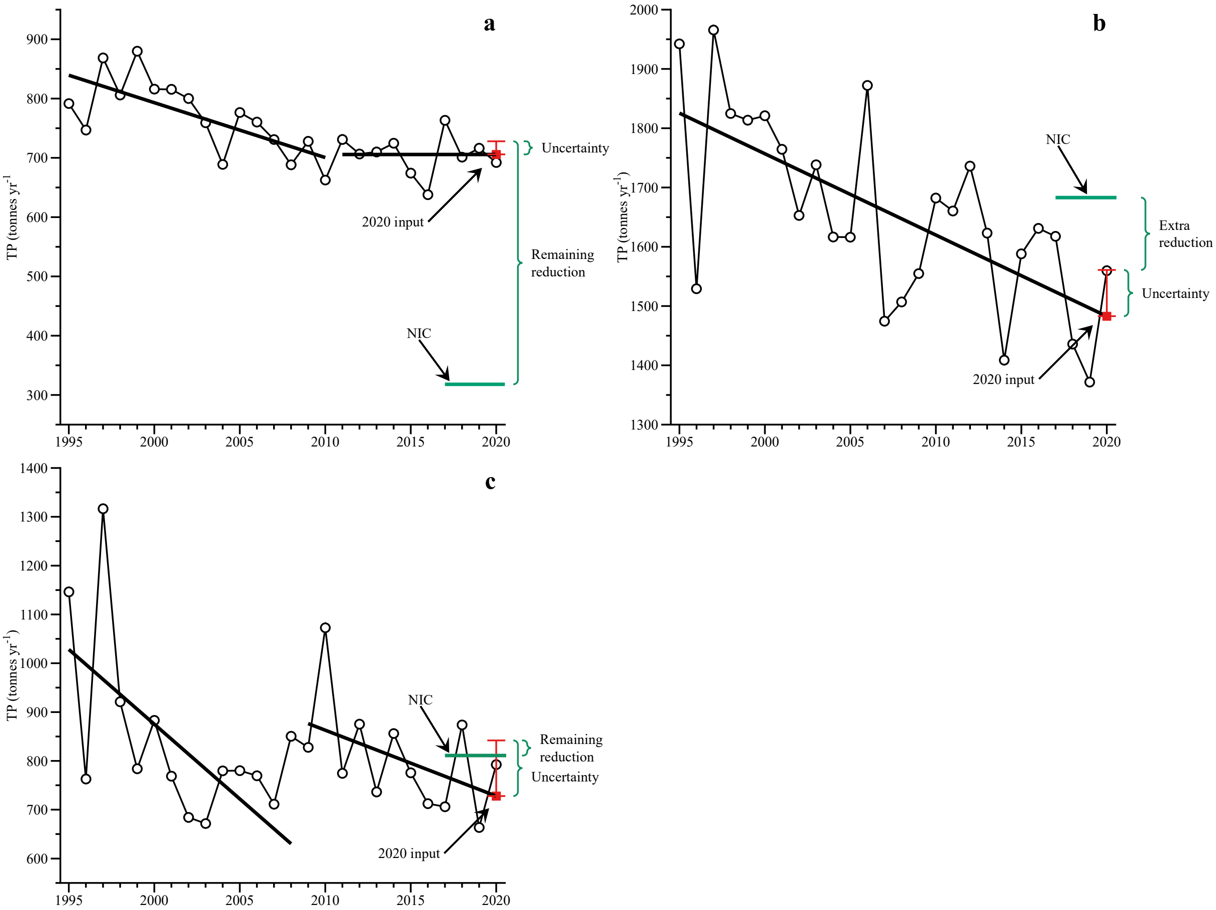


Figure 2.3: Three examples of how NIC fulfillment are estimated from nutrient input time-series. The 2020 nutrient inputs are estimated from the trend calculation as described above. The uncertainty is added to the 2020 value to ensure a robust comparison with NIC. Panel a) shows an example with large remaining reduction resulting in a red classification (SE to BAP for TP), panel b) shows an example where NIC is fulfilled with significant certainty resulting in a green classification (DE to DS for TP), and panel c) illustrates the case where the 2020 inputs are below NIC but including the uncertainty the inputs are above NIC resulting in a yellow classification (SE to BOB for TP).

2.4 Taking into account extra reduction in neighboring sub-basins

The Baltic Sea sub-basins are interconnected causing nutrient exchange. Spreading of eutrophication state response to nutrient input changes in different basins was taken into account in the calculation of MAI. However, for various reasons, changes in nutrient inputs are not converging uniformly toward MAI (and NIC) for all country-basin combinations and in some country-basin combinations nutrient inputs considerably undershoot targets. Under a number of preconditions, countries may take a part of this, so called, extra reduction into account in reaching NIC an adjacent basin. Basically, tables of equivalent reductions (Tables 2.2 and 2.3) indicate how much larger a reduction in an adjacent basin needs to be in order to provide the environmental benefit of 1 tonne reduction directly to the basin. A thorough description of the preconditions and calculations are provided in Annex D.

Table 2.2. Equivalent reductions on nitrogen. The table should be read so that each row provides the necessary input reduction to the basins to the left to provide the equivalent environmental effect in the basins in the top row. E.g., 1.3 tonne reduction to GUR gives the same effect in the BAP as 1 tonne reduction directly to BAP. NB! The factors are valid on single basin pairs under condition that all other basins fulfil MAI.

	KAT	DS	BAP	BOS	BOB	GUR	GUF
KAT	1	7.3	–	–	–	–	–
DS	1.7	1	4.6	–	–	–	–
BAP	–	–	1	–	–	–	–
BOS	–	–	–	1	7.8	–	–
BOB	–	–	–	1.1	1	–	–
GUR	–	–	1.3	–	–	1	–
GUF	–	–	4.0	–	–	–	1

Table 2.3. Equivalent reductions on phosphorus. The table should be read so that each row provides the necessary input reduction to the basins to the left to provide the equivalent environmental effect in the basins in the top row. E.g., 1.5 tonne reduction to BOS gives the same effect in the BAP as 1 tonne reduction directly to BAP. NB! The factors are valid on single basin pairs under condition that all other basins fulfil MAI.

	KAT	DS	BAP	BOS	BOB	GUR	GUF
KAT	1	4.0	–	–	–	–	–
DS	0.8	1	3.2	–	–	–	–
BAP	2.4	2.8	1	3.3	7.7	–	3.8
BOS	3.8	4.6	1.5	1	2.6	–	5.8
BOB	–	–	9.0	8.3	1	–	–
GUR	3.6	4.3	1.6	4.8	–	1	6.5
GUF	3.6	4.2	1.3	4.1	–	–	1

3. Assessment results

This chapter includes NIC-2020 assessment results provided country by basin. Information is provided with overview tables, and tables with detailed results from the NIC assessment. NIC assessment results taking into account extra reduction in neighboring sub-basins are in chapter 3.2. In annexes E and F the detailed results from the NIC-2020 assessment are compared with corresponding assessment results from the NIC-2017 assessment.

Tables with assessment results for nine big rivers with NICs and plots with the nutrient time series are included in chapter 3.3.

Examples with information on the assessment dataset as time series country by basin with nutrient input data are included in chapter 3.4. There are time series plots for every country basin with inputs to the Baltic Sea including for Baltic and North Sea shipping and from transboundary sources in annexes F to J.

Overview of breakpoints in time series are available in chapter 3.5.

The importance of reduction in airborne nitrogen inputs of the total assessed reduction in nitrogen inputs country by basin are included in chapter 3.6.

Changes by 2020 in total nitrogen and total phosphorus inputs country by basin since the reference periods 1997-2003 are summarized in chapter 3.7.

Data from Archipelago Sea have been separated from Bothnian Bay for assessing progress towards NIC for Archipelago and the remaining part of Bothnian Sea, separately in chapter 3.8.

All the total nitrogen and total phosphorus inputs in the report are annual net inputs country (or source) by basin as described in chapter 2.1.

Used abbreviations are explained in chapter 1.2.

3.1 Status country by basin in 2020

This sub-chapter provides detailed results on assessing fulfilment of the NICs from the 2021 BSAP based on annual air- and waterborne total nitrogen (TN) and total phosphorus (TP) inputs to the Baltic Sea 1995-2020 by evaluating the estimated nutrient inputs in 2020. The methodology behind the assessment results is summarized in chapters 2.1 to 2.3.

Table 3.1 provides an overview of the progress towards nutrient inputs ceilings achieved by 2020 for total nitrogen assessed country by Baltic Sea basin. The main findings are summarized in chapter 0. Green indicates fulfilment of NIC as is the case for Denmark for all seven basins. Reddish colors indicate for which basins NIC are not fulfilled by 2020, as for Baltic Sea and North Sea shipping and other countries for all basins and for Baltic Proper besides for Denmark and Finland. The graduated red color indicates how far from NIC (in percentages) are the inputs in 2020 (se legend below table 3.1). For some few basins it is not possible to judge if NIC is fulfilled by 2020 (marked with yellow in table 3.1) because even though the estimated input is lower than the NIC when adding uncertainty on the estimated inputs, it is not the case, e.g., as for Sweden to Danish Straits.

Table 3.1. Overall results on progress towards fulfilling NIC for total nitrogen inputs by 2020. The legend below the tables explains the contents.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	↓	↓	↓	↓	↓	↓	↓
Estonia	↓	↓	↓	↓	↑	↓	↓
Finland	↓	↓	↓	↓	↓	↓	↓
Germany	↓	↓	↓	↓	↓	↓	↓
Latvia	↓	↓	↑	↓		↓	↓
Lithuania			↑		↑		
Poland	↓	↓		↓	↓	↓	↓
Russia	↓	↓	↓		↓	↓	↓
Sweden	↓	↓		↓	↓		↓
Belarus							
Czech Republic			↓				
Ukraine			↑				
Baltic Sea shipping	↓	↓	↓	↓	↓	↓	↓
North Sea Shipping	↓	↓	↓	↓	↓	↓	↓
Other countries	↓	↓	↓	↓	↓	↓	↓

↑	Significant increase (95 % confidence) from reference period (1997-2003) to 2020
↓	Significant decrease (95 % confidence) from reference period (1997-2003) to 2020
	Only airborne inputs to the sub-basin
	Only transboundary waterborne inputs to the sub-basin
	NIC are not fulfilled
	Within statistical certainty, the fulfilment of NIC cannot be justified
	NIC is with 95 % certainty fulfilled; input ceiling are not exceed
	Application of extra reduction achieved in neighboring sub-basin

	less than 10%
	between 10% and 30%
	between 30% and 50%
	50% or more

The remaining reduction requirements are mainly to Baltic Proper, Gulf of Finland and Gulf of Riga. Tables 3.2 and 3.3 summarize the remaining reduction country by basin expressed in percentages of NIC (table 3.2) and in tonnes (table 3.3). Information on remaining reduction in percentages and in tonnes are important because a remaining small reduction requirement in percentages can cover that many tonnes reduction is needed, while a high remaining reduction requirement in percentages might cover rather few tonnes of remaining reduction needed (e.g. Germany 4 % remaining to BAP equals 1,507 tonnes TN, while 117 % remaining reduction for Check Republic to BAP equals 708 tonnes TN).

Table 3.2. Remaining nitrogen reduction country by basin in percentages of NIC by 2020. "-" = no remaining reduction.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	-	-	-	-	-	-	-
Estonia	-	-	13	12	34	-	-
Finland	1.6	-	-	4.2	-	-	-
Germany	-	-	4	-	-	-	-
Latvia	-	-	105	14	3	-	-
Lithuania	8.8	4.5	123	22	62	-	5.5
Poland	-	-	20	-	-	-	-
Russia	3	-	11	28	-	-	-
Sweden	-	-	32	-	-	9	-
Belarus			31		-		
Czech Republic			20				
Ukraine			117				
Baltic Sea shipping	77	74	66	63	86	59	43
North Sea Shipping			104				
Other countries	36	35	30	26	27	27	35

Table 3.3. Remaining nitrogen reduction country by basin in tonnes by 2020. "-" = no remaining reduction.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	-	-	-	-	-	-	-
Estonia	-	-	193	1392	4473	-	-
Finland	555	-	-	858	-	-	-
Germany	-	-	1507	-	-	-	-
Latvia	-	-	6780	35	1328	-	-
Lithuania	9.5	22	31807	68	5476	-	4
Poland	-	-	30578	-	-	-	-
Russia	22	-	1120	16960	-	-	-
Sweden	-	-	9910	-	-	559	-
Belarus			4173		-		
Czech Republic			708				
Ukraine			1977				
Baltic Sea shipping	218	841	3408	427	296	381	305
North Sea Shipping	160	498	2522	212	162	553	543
Other countries	491	1755	8065	786	587	1316	1559

More detailed results on the assessment of progress towards NIC by 2020 for total nitrogen is included in table 3.4. The results are compared with the corresponding results from the NIC2017 assessment (based on 1995-2017 data) where the former NICs were assessed (results from the original NIC2017 assessment (Svendsen et al., 2022).

The tables include the NIC from the 2021 BSAP, the estimated inputs in 2020 (according to PLC guidelines 2022 and Larsen and Svendsen 2022, see chapters 2.2 and 2.3), the test values 2020 (estimated input + estimated uncertainty on these inputs), extra reduction by 2020 (colored green) or remaining reduction by 2020 (colored yellow or red), if there is a remaining reduction by 2020 the percentages of remaining reduction in % of the ceiling (NIC), the results by 2020 if we take into account extra reduction in a neighboring basin and how the extra reduction is applied. If changes are statistically significant, further changes in percentage in inputs since the reference period to 2020 are presented at the last row in each country per basin table.

Table 3.4 includes one table per country with results per basin. Basins without any input from the country (or source) are left empty.

Table 3.4. Assessment of progress towards total nitrogen NIC by 2020 presented country by basin – see text above. All numbers in the table are in tonnes besides the row with "remaining in % of ceilings", "remaining in % of ceilings taking into account extra reduction", and "significant changes since the reference period to 2020", that are in percentages. Only significant percentages changes since the reference period are shown. In chapter 3.2 is explained about the rows related to accounting for extra reduction which occurs for some countries. Colors are used as defined for table 3.1.

Denmark TN	**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
A : Input ceiling (NIC BSAP2021 update)	280	1148	9025	421	462	28067	28538
B: Estimated input 2020	155	628	8026	272	254	23597	25280
C: Inputs 2020 including uncertainty (test value)	165	662	8339	287	266	25527	26112
Extra reduction by 2020 (A-C)	115	486	686	134	196	2540	2426
Remaining reduction to fulfill NIC by 2020							
Remaining in % of ceiling							
Accounting for extra reduction							
Remaining taking into account extra reduction							
Significant changes since reference period (%) to 2020	-49	-47	-34	-48	-46	-19	-22

Estonia TN	**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
A : Input ceiling (NIC BSAP2021 update)	113	404	1478	11334	13099	22	24
B: Estimated input 2020	82	288	1518	12219	16047	14	17
C: Inputs 2020 including uncertainty (test value)	87	304	1671	12726	17572	15	18
Extra reduction by 2020 (A-C)	26	100				7	6
Remaining reduction to fulfill NIC by 2020			193	1392	4473		
Remaining in % of ceiling			*13*	*12*	*34*		
Accounting for extra reduction			-2				
Remaining taking into account extra reduction			191				
Remaining in % of ceiling taking into account extra reduction			*13*				
Extra reduction in DS is used to reduced the remaining reduction requirements in BAP with 2 tons TN							
Significant changes since reference period (%) to 2020	-33	-29	-19	-10	23	-35	-33

Finland TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	35087	28700	1827	20457	295	76	89
B: Estimated input 2020	34298	25581	1237	20293	159	35	46
C: Inputs 2020 including uncertainty (test value)	35642	26917	1284	21315	165	37	48
Extra reduction by 2020 (A-C)		1783	543		130	39	41
Remaining reduction to fulfill NIC by 2020	555			858			
Remaining in % of ceiling	*2*			*4*			
Accounting for extra reduction	-229						
Remaining taking into account extra reduction	326						
Remaining in % of ceiling taking into account extra reduction	*0,9*						
Extra reduction in BOS is used to reduced the remaining reduction requirements in BOB with 229 tons TN							
Significant changes since reference period (%) to 2020	-8	-12	-48	-20	-48	-52	-51

Germany TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	947	3920	34105	1645	1747	23647	4661
B: Estimated input 2020	628	2502	34778	1263	1112	18134	3487
C: Inputs 2020 including uncertainty (test value)	641	2553	35612	1288	1133	19314	3543
Extra reduction by 2020 (A-C)	306	1367		357	614	4333	1118
Remaining reduction to fulfill NIC by 2020			1507				
Remaining in % of ceiling			*4*				
Accounting for extra reduction			-660				
Remaining taking into account extra reduction			847				
Remaining in % of ceiling taking into account extra reduction			*2*				
Extra reduction in DS, GUF and GUR is used to reduced the remaining reduction requirements in BAP with 660 tons TN							
Significant changes since reference period (%) to 2020	-37	-36	-20	-36	-35	-21	-31

Latvia TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	73	330	6457	246	43074	31	34
B: Estimated input 2020	71	308	11955	277	41735	27	32
C: Inputs 2020 including uncertainty (test value)	73	313	13237	281	44402	27	33
Extra reduction by 2020 (A-C)	0	17				4	1
Remaining reduction to fulfill NIC by 2020			6780	35	1328		
Remaining in % of ceiling			*105*	*14*	*3*		
Accounting for extra reduction			-1				
Remaining taking into account extra reduction			6779				
Remaining in % of ceiling taking into account extra reduction			*105*				
Extra reduction in DS is used to compensated for the remaining reduction requirement with 1 tons TN in BAP							
Significant changes since reference period (%) to 2020	-14	-12	48	-10		-14	-13

Lithuania TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	108	495	25878	305	8820	66	80
B: Estimated input 2020	114	503	51857	363	12868	62	82
C: Inputs 2020 including uncertainty (test value)	117	517	57685	373	14296	64	84
Extra reduction by 2020 (A-C)						2	
Remaining reduction to fulfill NIC by 2020	9	22	31807	68	5476		4
Remaining in % of ceiling	*9*	*4*	*123*	*22*	*62*		*5*
Accounting for extra reduction							-1
Remaining taking into account extra reduction							3
Remaining in % of ceiling taking into account extra reduction							*4*
Extra reduction in DS is used to reduced the remaining reduction requirements in KAT with 1 tons TN							
Significant changes since reference period (%) to 2020			62		55		

Poland TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	668	3125	151969	1407	1596	1480	1443
B: Estimated input 2020	556	2468	170361	1317	1248	1125	1210
C: Inputs 2020 including uncertainty (test value)	570	2529	182547	1349	1278	1153	1240
Extra reduction by 2020 (A-C)	98	596		58	318	327	203
Remaining reduction to fulfill NIC by 2020			30578				
Remaining in % of ceiling			*20*				
Accounting for extra reduction			-333				
Remaining taking into account extra reduction			30245				
Remaining in % of ceiling taking into account extra reduction			*20*				
Extra reduction in DS, GUF and GUR is used to reduced the remaining reduction requirements in BAP with 33 tons TN							
Significant changes since reference period (%) to 2020	-25	-25	-11	-25	-25	-26	-25

Russia TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	839	1993	10317	61503	3296	238	245
B: Estimated input 2020	854	1918	9712	72640	2775	210	238
C: Inputs 2020 including uncertainty (test value)	861	1935	11437	78463	3063	212	240
Extra reduction by 2020 (A-C)		58			233	26	5
Remaining reduction to fulfill NIC by 2020	22		1120	16960			
Remaining in % of ceiling	*3*		*11*	*28*			
Accounting for extra reduction			-187				
Remaining taking into account extra reduction			933				
Remaining in % of ceiling taking into account extra reduction			*9*				
Extra reduction in DS and GUR is used to reduced the remaining reduction requirements in BAP with 187 tons TN							
Significant changes since reference period (%) to 2020	-11	-11	-29		-14	-12	-11

Sweden TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	17718	32633	30690	626	525	6056	32799
B: Estimated input 2020	13859	25800	38523	509	366	6053	28257
C: Inputs 2020 including uncertainty (test value)	14499	26843	40600	515	370	6615	29043
Extra reduction by 2020 (A-C)	3219	5790		111	155		3756
Remaining reduction to fulfill NIC by 2020			9910			559	
Remaining in % of ceiling							
Accounting for extra reduction			-148			-516	
Remaining taking into account extra reduction			9762			43	
Remaining in % of ceiling taking into account extra reduction			32			1	
Extra reduction in DS and GUR is used to reduced the remaining reduction requirements in BAP with 148 tons TN, and extra reduction i							
Significant changes since reference period (%) to 2020	-26	-22		-33	-30		-20

Belarus TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			13456		12820		
B: Estimated input 2020			16935		10917		
C: Inputs 2020 including uncertainty (test value)			17629		12546		
Extra reduction by 2020 (A-C)					274		
Remaining reduction to fulfill NIC by 2020			4173				
Remaining in % of ceiling			*31*				
Significant changes since reference period (%) to 2020							

Czeck Republic TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			3551				
B: Estimated input 2020			3524				
C: Inputs 2020 including uncertainty (test value)			4259				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2017			708				
Remaining in % of ceiling			*20*				
Significant changes since reference period (%) to 2020			-26				

Ukraine TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			1693				
B: Estimated input 2020			3261				
C: Inputs 2020 including uncertainty (test value)			3670				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			1977				
Remaining in % of ceiling			*117*				
Significant changes since reference period (%) to 2020			49				

Baltic Sea shipping TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	284	1141	5180	675	345	651	701
B: Estimated input 2020	487	1924	8335	1069	622	1002	976
C: Inputs 2020 including uncertainty (test value)	502	1982	8588	1102	641	1032	1006
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020	218	841	3408	427	296	381	305
Remaining in % of ceiling	*77*	*74*	*66*	*63*	*86*	*59*	*43*
Significant changes since reference period (%) to 2020	-23	-23	-23	-23	-23	-23	-23

North Sea shipping TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	131	475	2427	196	150	729	884
B: Estimated input 2020	285	951	4838	399	305	1253	1395
C: Inputs 2020 including uncertainty (test value)	291	973	4949	408	312	1282	1427
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020	160	498	2522	212	162	553	543
Remaining in % of ceiling	*122*	*105*	*104*	*108*	*108*	*76*	*61*
Significant changes since reference period (%) to 2020	-27	-27	-27	-27	-27	-27	-27

OC TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	1375	5008	26947	2986	2188	4933	4502
B: Estimated input 2020	1837	6657	34429	3715	2731	6137	5954
C: Inputs 2020 including uncertainty (test value)	1866	6763	35012	3772	2775	6249	6061
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020	491	1755	8065	786	587	1316	1559
Remaining in % of ceiling	*36*	*35*	*30*	*26*	*27*	*27*	*35*
Significant changes since reference period (%) to 2020	-38	-37	-39	-35	-35	-43	-43

For total phosphorus the information corresponding to tables 3.1 to 3.4 are presented in tables 3.5 to 3.8.

The overall results of progress towards phosphorus NICs by 2020 are given in chapter 0, showing that without taking into account extra reduction in neighboring basin NICs are not fulfilled for Baltic Proper and only fulfilled for Kattegat (table 3.5). No country fulfills all their NICs. In percentages of NIC the needed reduction is more than 100% for several countries to Baltic proper (table 3.5), but in tonnes Poland with nearly 4,800 tonnes needs to reduce more than double of the sum of required reduction by all other countries having phosphorus input to Baltic Proper (table 3.6).

Table 3.5. Overall results on progress towards fulfilling NIC for total phosphorus inputs by 2020. Legend below the tables explains the contents.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			↓			↓	↓
Estonia			↓	↓	↓		
Finland	↓			↓			
Germany						↓	
Latvia			↓				
Lithuania			↓		↓		
Poland			↓				
Russia			↓	↓	↓		
Sweden		↓	↓			↓	
Belarus			↓				
Czech Republic			↓				
Ukraine			↑				

↑	Significant increase (95 % confidence) from reference period (1997-2003) to 2020
↓	Significant decrease (95 % confidence) from reference period (1997-2003) to 2020
	Only airborne inputs to the sub-basin
	Only transboundary waterborne inputs to the sub-basin
	NIC are not fulfilled
	Within statistical certainty, the fulfilment of NIC cannot be justified
	NIC is with 95 % certainty fulfilled; input ceiling are not exceed
	Application of extra reduction achieved in neighboring sub-basin

	less than 10%
	between 10% and 30%
	between 30% and 50%
	50% or more

Table 3.6. Remaining phosphorus reduction country by basin in percentages of NIC by 2020. "-" = no remaining reduction.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			125			-	-
Estonia			117	39	36		
Finland	-	8,0		107			
Germany			119			-	
Latvia			66		24		
Lithuania			55		-		
Poland			114				
Russia			151	35	26		
Sweden	3,8	-	129			-	-
Belarus			148		61		
Czech Republic			114				
Ukraine			279				

Table 3.7. Remaining phosphorus reduction country by basin in tonnes by 2020. "-" = no remaining reduction.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			26			-	-
Estonia			11	88	67	-	-
Finland	-	100	-	338			
Germany			241			-	
Latvia			111		255		
Lithuania			388		-		
Poland			4766				
Russia			365	1010	25	-	-
Sweden	31	-	410			-	-
Belarus			518		248		
Czech Republic			65				
Ukraine			131				

Details behind the tables 3.5 to 3.7 are in table 3.8 organized by country for total phosphorus inputs.

Table 3.8. Assessment of progress towards total phosphorus NIC by 2020 presented country by basin – see text above. All numbers in the table are in tonnes beside row with "remaining in % of ceilings", "remaining in % of ceilings taking into account extra reduction", and "significant changes since the reference period to 2020", that are in percentages. Only significant percentages changes since the reference period are shown. The rows related to accounting for extra reduction which occurs for some countries are explained in chapter 3.2. Colors are used as defined in table 3.5.

Denmark TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			21			979	815
B: Estimated input 2020			44			643	683
C: Inputs 2020 including uncertainty (test value)			48			694	704
Extra reduction by 2020 (A-C)						285	111
Remaining reduction to fulfill NIC by 2020			26				
Remaining in % of ceiling			*125*				
Accounting for extra reduction			-90				
Remaining taking into account extra reduction			0				
Remaining in % of ceiling taking into account extra reduction			*0*				
Extra reduction in DS is used to compensated for the remaining reduction requirement of 26 tons TP in BAP							
Significant changes since reference period (%) to 2020			-20			-29	-18

Estonia TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			9	225	185		
B: Estimated input 2020			17	281	233		
C: Inputs 2020 including uncertainty (test value)			20	313	252		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			11	88	67		
Remaining in % of ceiling			*117*	*39*	*36*		
Significant changes since reference period (%) to 2020			-26	-45	-18		

Finland TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	1683	1246		315			
B: Estimated input 2020	1483	1283		610			
C: Inputs 2020 including uncertainty (test value)	1561	1346		653			
Extra reduction by 2020 (A-C)	122						
Remaining reduction to fulfill NIC by 2020		100		338			
Remaining in % of ceiling		*8*		*107*			
Accounting for extra reduction		-15					
Remaining taking into account extra reduction		85					
Remaining in % of ceiling taking into account extra reduction		*7*					
Extra reduction in BOB is used to reduced the remaining reduction requirements in BOS with 15 tons TP							
Significant changes since reference period (%) to 2020	-18			-17			

Germany TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			203			401	
B: Estimated input 2020			414			302	
C: Inputs 2020 including uncertainty (test value)			444			332	
Extra reduction by 2020 (A-C)						69	
Remaining reduction to fulfill NIC by 2020			241				
Remaining in % of ceiling			*119*				
Accounting for extra reduction			-22				
Remaining taking into account extra reduction			219				
Remaining in % of ceiling taking into account extra reduction			*108*				
Extra reduction in DS is used to reduced the remaining reduction requirements in BAP with 22 tons TP							
Significant changes since reference period (%) to 2020						-14	

Latvia TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			167		1061		
B: Estimated input 2020			214		1198		
C: Inputs 2020 including uncertainty (test value)			278		1316		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			111		255		
Remaining in % of ceiling			*66*		*24*		
Significant changes since reference period (%) to 2020			-50				

Lithuania TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			703		175		
B: Estimated input 2020			991		7		
C: Inputs 2020 including uncertainty (test value)			1091		74		
Extra reduction by 2020 (A-C)					101		
Remaining reduction to fulfill NIC by 2020			388				
Remaining in % of ceiling			*55*				
Accounting for extra reduction			-66				
Remaining taking into account extra reduction			322				
Remaining in % of ceiling taking into account extra reduction			*46*				
Extra reduction in GUR is used to reduced the remaining reduction requirements in BAP with 45 tons TP							
Significant changes since reference period (%) to 2020			-45		-97		

Poland TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			4198				
B: Estimated input 2020			8167				
C: Inputs 2020 including uncertainty (test value)			8964				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			4766				
Remaining in % of ceiling			*114*				
Significant changes since reference period (%) to 2020			-22				

Russia TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			242	2909	99		
B: Estimated input 2020			410	3092	106		
C: Inputs 2020 including uncertainty (test value)			607	3919	124		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			365	1010	25		
Remaining in % of ceiling			*151*	*35*	*26*		
Significant changes since reference period (%) to 2020			-36	-54	-24		

Sweden TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	811	1133	318			116	753
B: Estimated input 2020	728	729	706			84	679
C: Inputs 2020 including uncertainty (test value)	842	809	728			89	718
Extra reduction by 2020 (A-C)		324				27	35
Remaining reduction to fulfill NIC by 2020	31		410				
Remaining in % of ceiling	*4*		*129*				
Accounting for extra reduction	-101		-224				
Remaining taking into account extra reduction	0		186				
Remaining in % of ceiling taking into account extra reduction	*0*		*58*				
A proportion of extra reduction in BOS is used to compensated for the remaining reduction requirement of 31 tons TP in BOB							
Significant changes since reference period (%) to 2020		-37	-14			-20	

Belarus TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			349		407		
B: Estimated input 2020			801		614		
C: Inputs 2020 including uncertainty (test value)			867		655		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			518		248		
Remaining in % of ceiling			*148*		*61*		
Significant changes since reference period (%) to 2020			-13				

Czeck Republic TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			57				
B: Estimated input 2020			89				
C: Inputs 2020 including uncertainty (test value)			122				
Extra reduction by 2020 (A-C)							
0			65				
Remaining in % of ceiling			*114*				
Significant changes since reference period (%) to 2020			-41				

Ukraine TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			47				
B: Estimated input 2020			159				
C: Inputs 2020 including uncertainty (test value)			178				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			131				
Remaining in % of ceiling			*279*				
Significant changes since reference period (%) to 2020			29				

3.2 Status country by basin in 2020 taking into account extra reduction

In this chapter extra reductions in a neighboring basin are taken into account when evaluating progress towards total nitrogen (table 3.9) and total phosphorus (table 3.10) NIC by 2020. The corresponding tables that are not taking into account extra reduction are tables 3.1 (total nitrogen) and 3.5 (total phosphorus). Chapter 2.4 and annex D explain how extra reductions in neighboring basins are taken into account. Table 3.4 (for total nitrogen) and 3.8 (for total phosphorus), respectively, include extra lines in the country tables when extra reduction is relevant. The equivalent reduction in calculated as e.g. for Germany and Baltic Proper for total nitrogen (table 3.4): The extra reduction in Danish Straits (1,367 tonnes), Gulf of Finland (357 tonnes) and Gulf of Riga (617 tonnes) provides an equivalent reduction of 660 tonnes nitrogen in Baltic Proper for Germany by using table 2.2, reducing remaining reduction requirement from 1,507 tonnes to 847 tonnes (1,507- 660).

Taking into account extra reductions the only changes in the assessment of fulfilling NIC in 2020 are:

- Denmark: Red to green for total phosphorus to Baltic Proper
- Sweden: Yellow to green for total phosphorus to Bothnian Bay

In all other situations taking into account extra reduction in neighboring basin only reduces the remaining reduction requirement.

Table 3.9. Overall results on progress towards fulfilling NIC for total nitrogen inputs by 2020 taking into account extra reduction in neighboring basins. Legend below the table 3.10 explains the contents.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	↓	↓	↓	↓	↓	↓	↓
Estonia	↓	↓	↓	↓	↑	↓	↓
Finland	↓	↓	↓	↓	↓	↓	↓
Germany	↓	↓	↓	↓	↓	↓	↓
Latvia	↓	↓	↑	↓		↓	↓
Lithuania			↑		↑		
Poland	↓	↓		↓	↓	↓	↓
Russia	↓	↓	↓		↓	↓	↓
Sweden	↓	↓		↓	↓		↓
Belarus							
Czech Republic			↓				
Ukraine			↑				
Baltic Sea shipping	↓	↓	↓	↓	↓	↓	↓
North Sea Shipping	↓	↓	↓	↓	↓	↓	↓
Other countries	↓	↓	↓	↓	↓	↓	↓

Table 3.10. Overall results on progress towards fulfilling NIC for total phosphorus inputs by 2020 taking into account extra reduction in neighboring basins. Legends below the tables explains the contents.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			↓			↓	↓
Estonia			↓	↓	↓		
Finland	↓			↓			
Germany						↓	
Latvia			↓				
Lithuania			↓		↓		
Poland			↓				
Russia			↓	↓	↓		
Sweden		↓	↓			↓	
Belarus			↓				
Czech Republic			↓				
Ukraine			↑				

↑	Significant increase (95 % confidence) from reference period (1997-2003) to 2020
↓	Significant decrease (95 % confidence) from reference period (1997-2003) to 2020
(dotted)	Only airborne inputs to the sub-basin
(lined)	Only transboundary waterborne inputs to the sub-basin
(red)	NIC are not fulfilled
(yellow)	Within statistical certainty, the fulfilment of NIC cannot be justified
(green)	NIC is with 95 % certainty fulfilled; input ceiling are not exceed
(bold frame)	Application of extra reduction achieved in neighboring sub-basin

(orange)	less than 10%
(light pink)	between 10% and 30%
(red)	between 30% and 50%
(dark red)	50% or more

3.3 Assessment of progress towards NIC's for nine transboundary rivers

The 2021 BSAP update includes total nitrogen and total phosphorus NICs for nine transboundary rivers. These NICs are included in table 3.11 (total nitrogen) and 3.12 (total phosphorus). The progress towards NICs for the nine transboundary rivers are assessed as for the country by basins (chapter 3.1 and 3.2), and the results are summarized in tables 3.11 and 3.12, and in chapter 0. The NICs are only fulfilled for Daugava (nitrogen) and for Lielupe (phosphorus) fulfilment cannot be judged when taking into account uncertainty on the estimated 2020 total phosphorus input. The remaining reduction requirements on both total nitrogen and total phosphorus are quite high for most of the transboundary rivers.

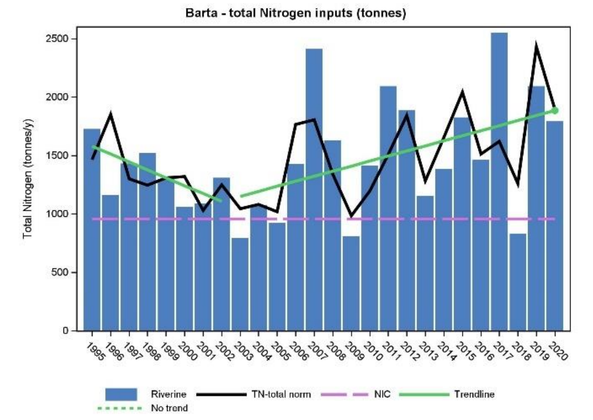
Table 3.11. Assessment of progress towards fulfilling total nitrogen NICs by 2020 for nine big rivers with reduction requirements (units in tonnes). Colors are explained in the legend below table 3.10.

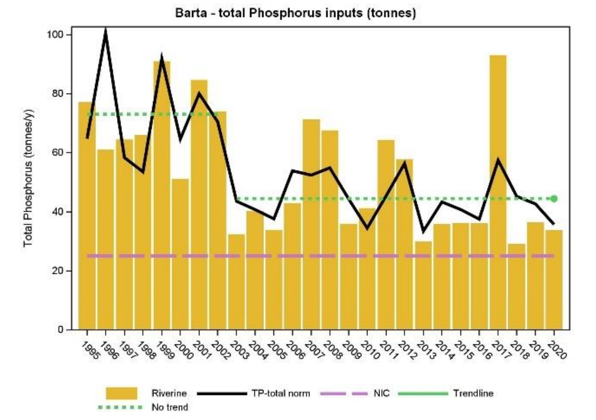
TN		Barta	Daugava	Lielupe	Nemunas	Neva	Oder	Pregolya	Venta	Vistula
A : Input ceiling (NIC)		957	38800	15863	29338	43476	49298	5493	6033	74807
B: Estimated input 2020		1887	32910	23980	50152	49409	61949	7189	11932	92218
C: Inputs 2020 including uncertainty (test value)		2110	35129	28050	55323	58503	64381	7640	13266	104221
Extra reduction by 2020 (A-C)			3671							
Remaining reduction to fulfill NIC by 2020		1153		12187	25985	15027	15083	2147	7233	29414
Remaining in % of ceiling		*121*		*77*	*89*	*35*	*31*	*39*	*120*	*39*
Significant changes since reference period (%) to 202		55		56	37				60	

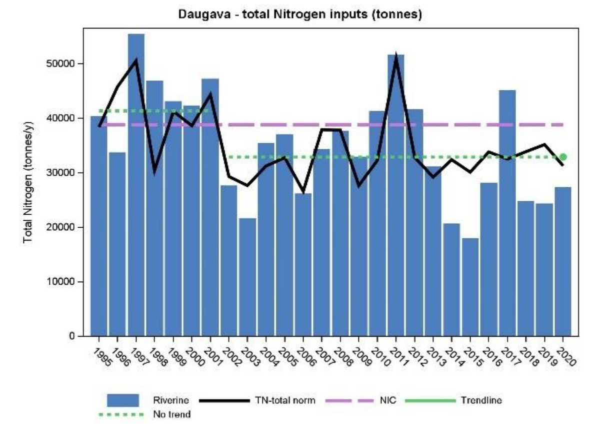
Table 3.12. Assessment of progress towards fulfilling total phosphorus NICs by 2020 for nine big rivers with reduction requirements (units in tonnes). Colors are explained in the legend below table 3.10.

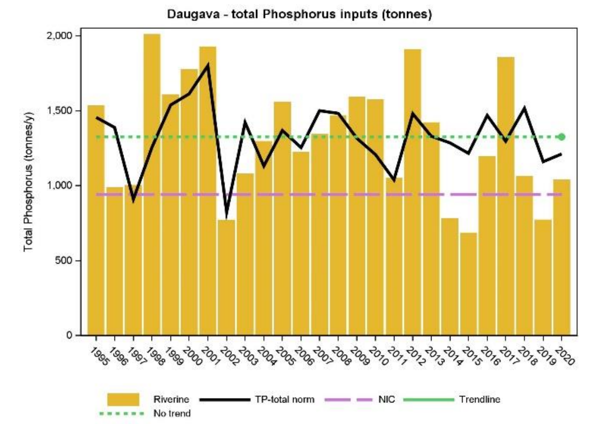
TP		Barta	Daugava	Lielupe	Nemunas	Neva	Oder	Pregolya	Venta	Vistula
A : Input ceiling (NIC)		25	941	302	914	1398	1554	147	106	2350
B: Estimated input 2020		44	1326	255	1540	2204	2995	420	182	4223
C: Inputs 2020 including uncertainty (test value)		49	1397	352	1663	2759	3226	463	221	5352
Extra reduction by 2020 (A-C)										
Remaining reduction to fulfill NIC by 2020		24	456	50	749	1361	1672	316	115	3002
Remaining in % of ceiling		*95*	*48*	*16*	*82*	*97*	*108*	*215*	*109*	*128*
Significant changes since reference period (%) to 202(		-33	-	-38	-35	-31	-22		-33	-

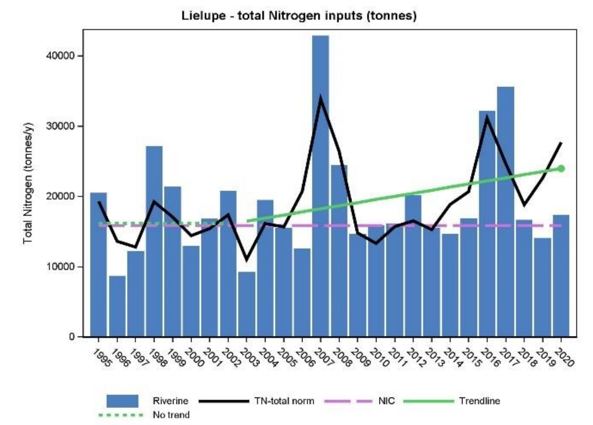
Statistical analysis on time series with annual waterborne total nitrogen and total phosphorus inputs during 1995-2020 (figure 3.1) indicates significant increase in total nitrogen inputs since the reference period (1997-2003) for four rivers (table 3.11 and figure 3.1): Barta (55%), Lielupe (56%), Nemunas (37%) and Vistula (60%), and no trend for the remaining five rivers. For total phosphorus there is a significant decrease since the reference period for 6 rivers (table 3.12 and figure 3.1): Barta (33%), Lielupe (38%), Nemunas (35%), Neva (31%), Oder (22%) and Venta (33%), and no trend for the remaining three rivers.

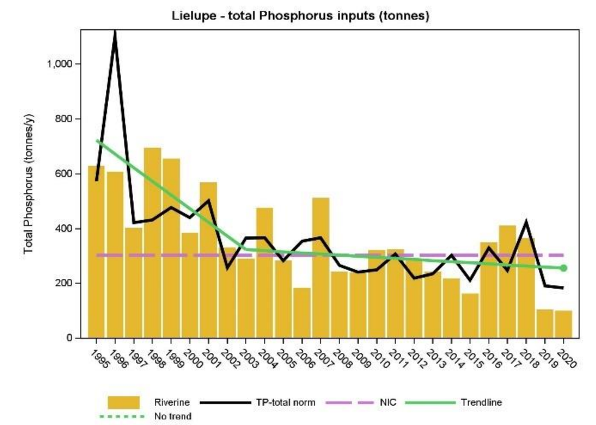

Barta - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend

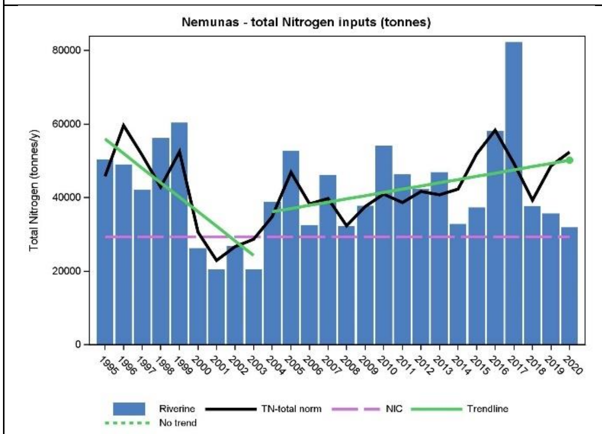

Barta - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend

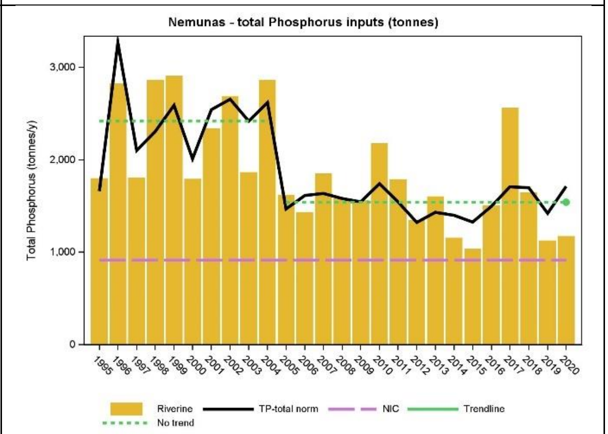

Daugava - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend

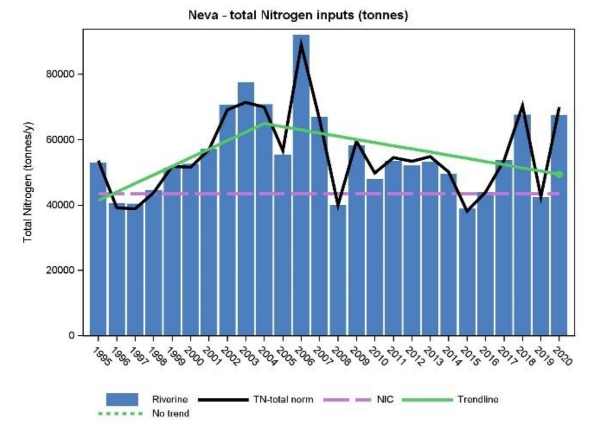

Daugava - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend

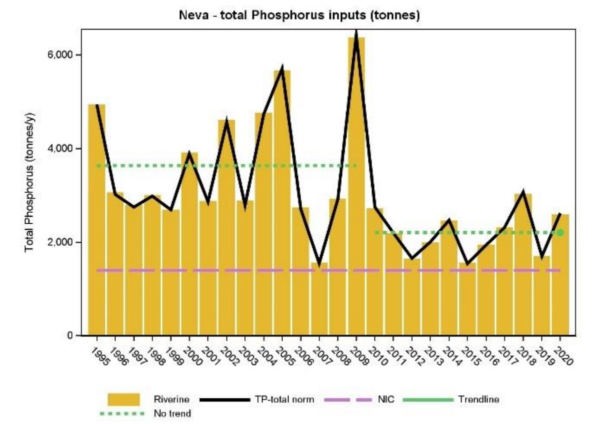

Lielupe - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend

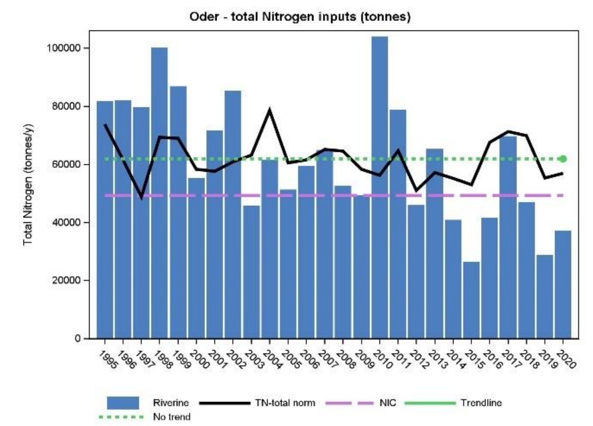

Lielupe - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend

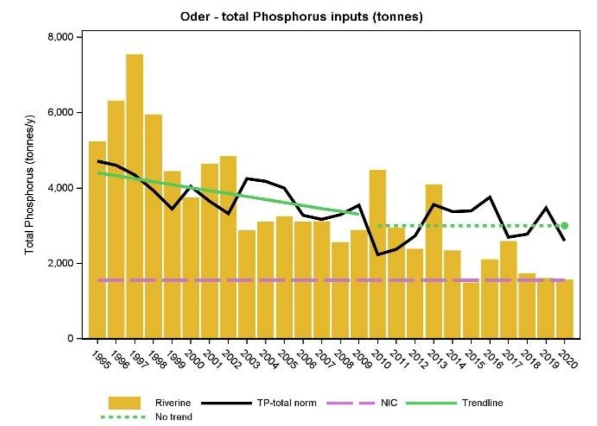

Nemunas - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend

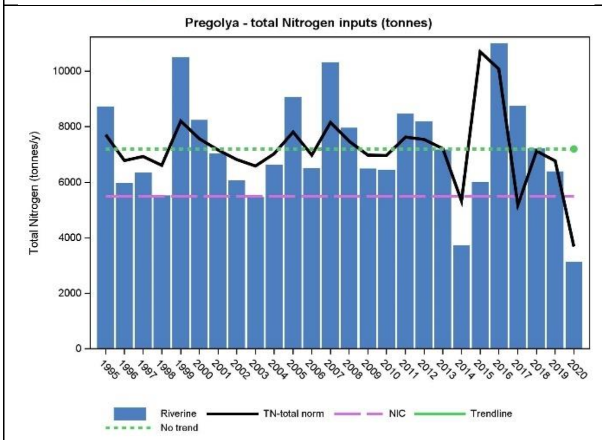

Nemunas - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend

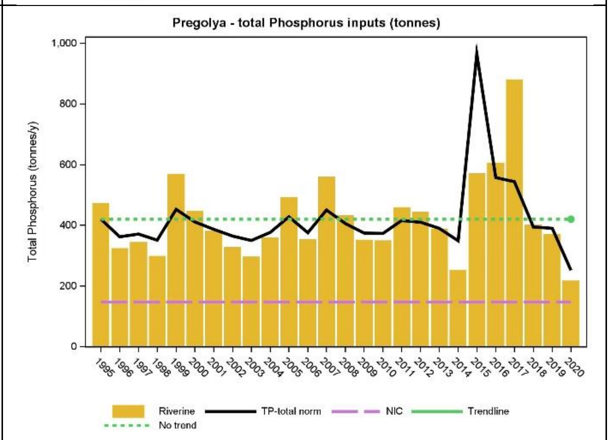

Neva - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend

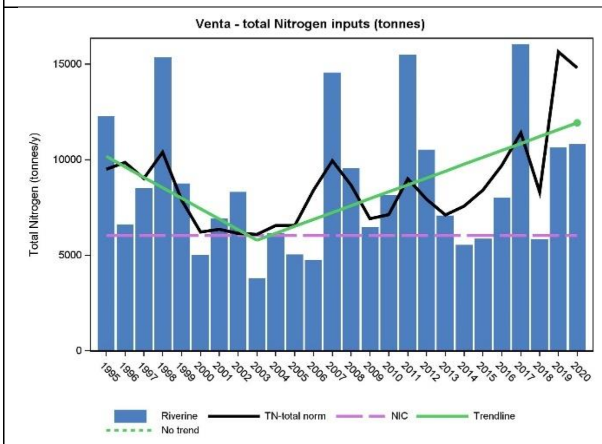

Neva - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend

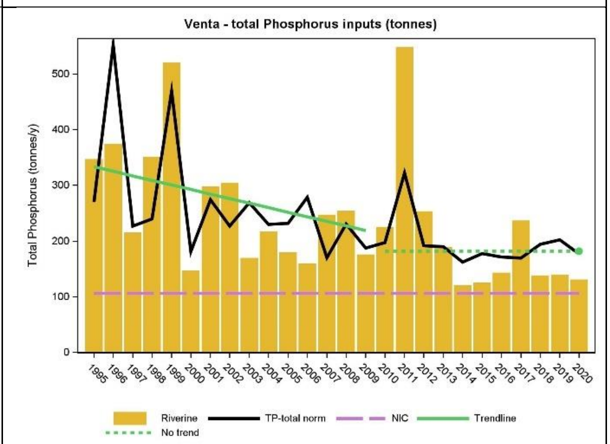

Oder - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend


Oder - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend


Pregolya - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend


Pregolya - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend


Venta - total Nitrogen inputs (tonnes)
Total Nitrogen (tonnes/y)
Riverine
TN-total norm
NIC
Trendline
No trend


Venta - total Phosphorus inputs (tonnes)
Total Phosphorus (tonnes/y)
Riverine
TP-total norm
NIC
Trendline
No trend

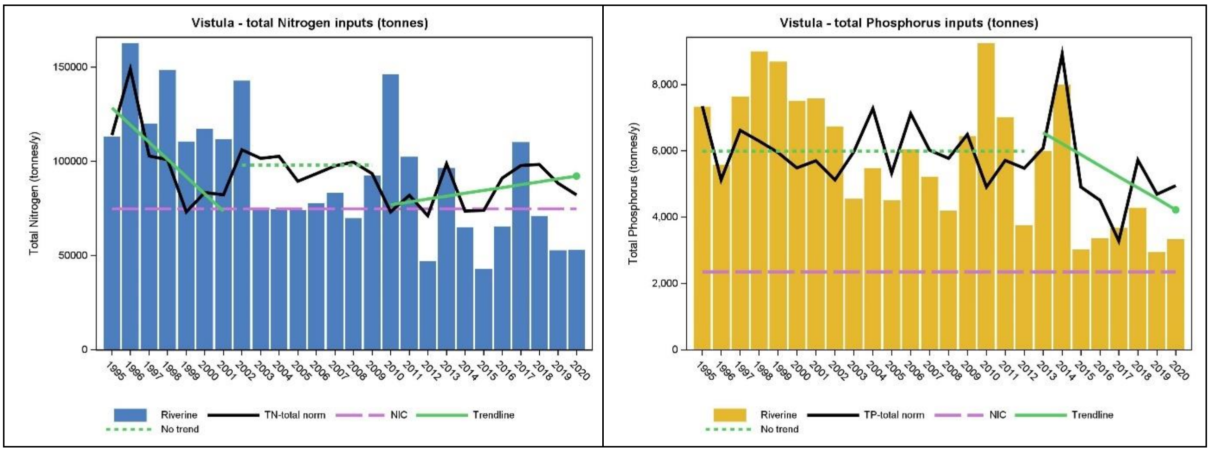


Figure 3.1. For the nine Baltic Sea transboundary rivers with NICs: Timeseries of actual waterborne annual total nitrogen (left columns) and total phosphorus (right column) inputs during 1995-2020, the corresponding normalized waterborne inputs, the NIC from 2021 BSAP, and trend lines including identified break points and the estimated input in 2020 used for evaluation progress towards NIC (as given in tables 3.11 and 3.12).

3.4 Time series plots country per basin

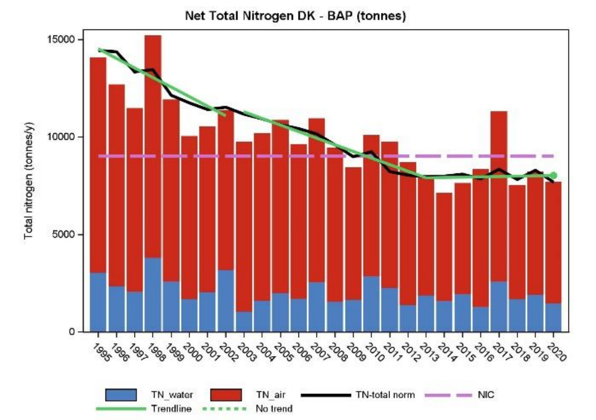
Timeseries plots are made for country per basin with water and/or airborne inputs from each HELCOM country, countries with transboundary waterborne inputs (Belarus, Czech Republic and Ukraine), for countries and other sources with transboundary airborne inputs (called OC = other countries), as well as Baltic Sea and North Sea shipping for airborne nitrogen inputs. There are sets of plots for:

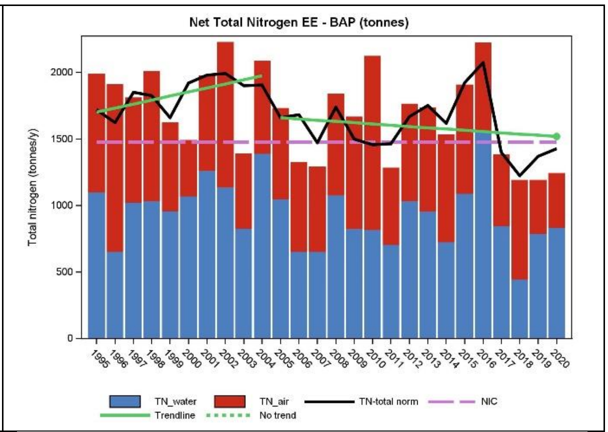
- Total nitrogen (waterborne, airborne, total normalized, trend lines with break points, NICs) – annex F;
- Total phosphorus (waterborne, total normalized, trend lines with break points, NICs) – annex G;
- Airborne total nitrogen (actual, normalized and trend lines with break points) – annex H;
- Waterborne total nitrogen (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend lines with break points) – annex I;
- Waterborne total phosphorus (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend lines with break points) – annex J.

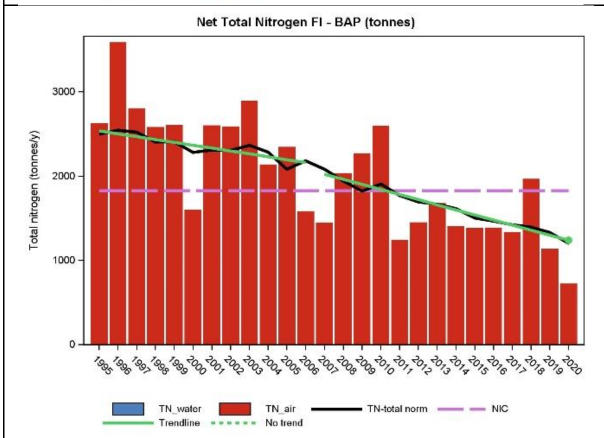
All plots are included in annexes F to J. In figures 3.2 to 3.6 there are examples of the plots for each HELCOM country to a basin (to Baltic Proper where possible) for airborne (only for total nitrogen), waterborne and total inputs of nitrogen and phosphorus, and for Belarus, Czech Republic and Ukraine for waterborne nitrogen and phosphorus inputs, and for Baltic Sea and North Sea shipping and other countries for atmospheric deposition of total nitrogen.

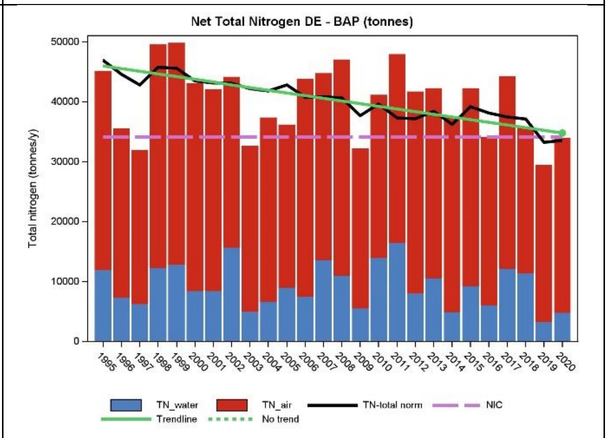
The time series plots include actual and normalized inputs (airborne, waterborne of total inputs respectively), the NIC from 2021 BSAP, trendline with breakpoints (if some are identified) and indication of significant trends for (sections of) time series. The plots in the annexes F to J provide the complete assessment dataset and visualize how far estimated inputs in 2020 are from NIC – and the estimated inputs in 2020 correspond to the numbers given in tables 3.4 and 3.8.

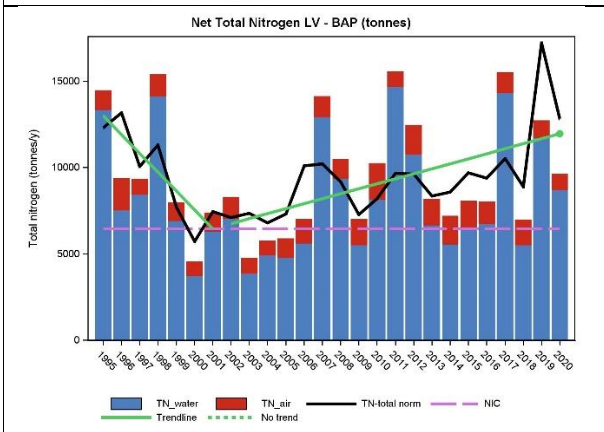
The data behind plots in figures 3.2-3.6 and annexes F-J are introduced in annex K, and the annex K includes a link to the assessment dataset.

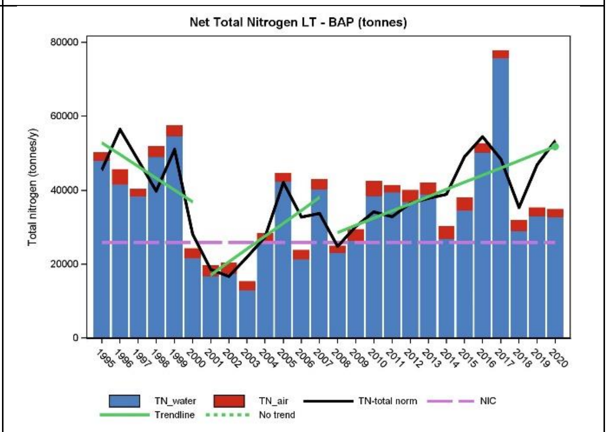

Net Total Nitrogen DK - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend

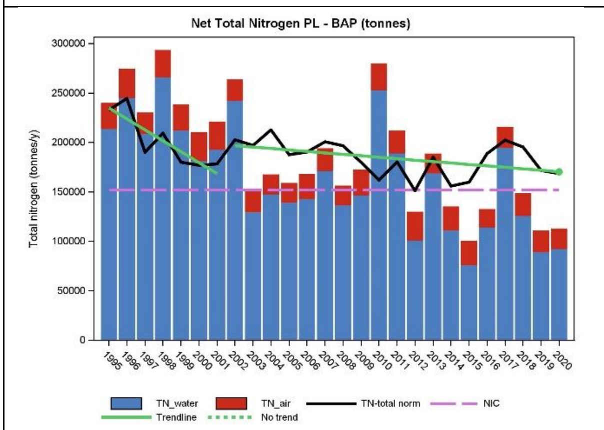

Net Total Nitrogen EE - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend

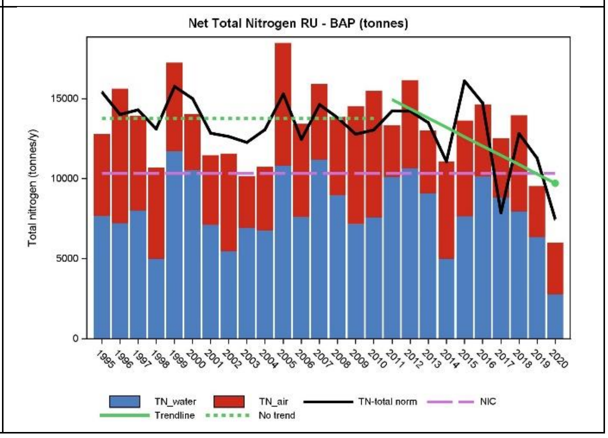

Net Total Nitrogen FI - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend


Net Total Nitrogen DE - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend


Net Total Nitrogen LV - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend


Net Total Nitrogen LT - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend


Net Total Nitrogen PL - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend


Net Total Nitrogen RU - BAP (tonnes)
Total nitrogen (tonnes/y)
TN_water
TN_air
TN-total norm
NIC
Trendline
No trend

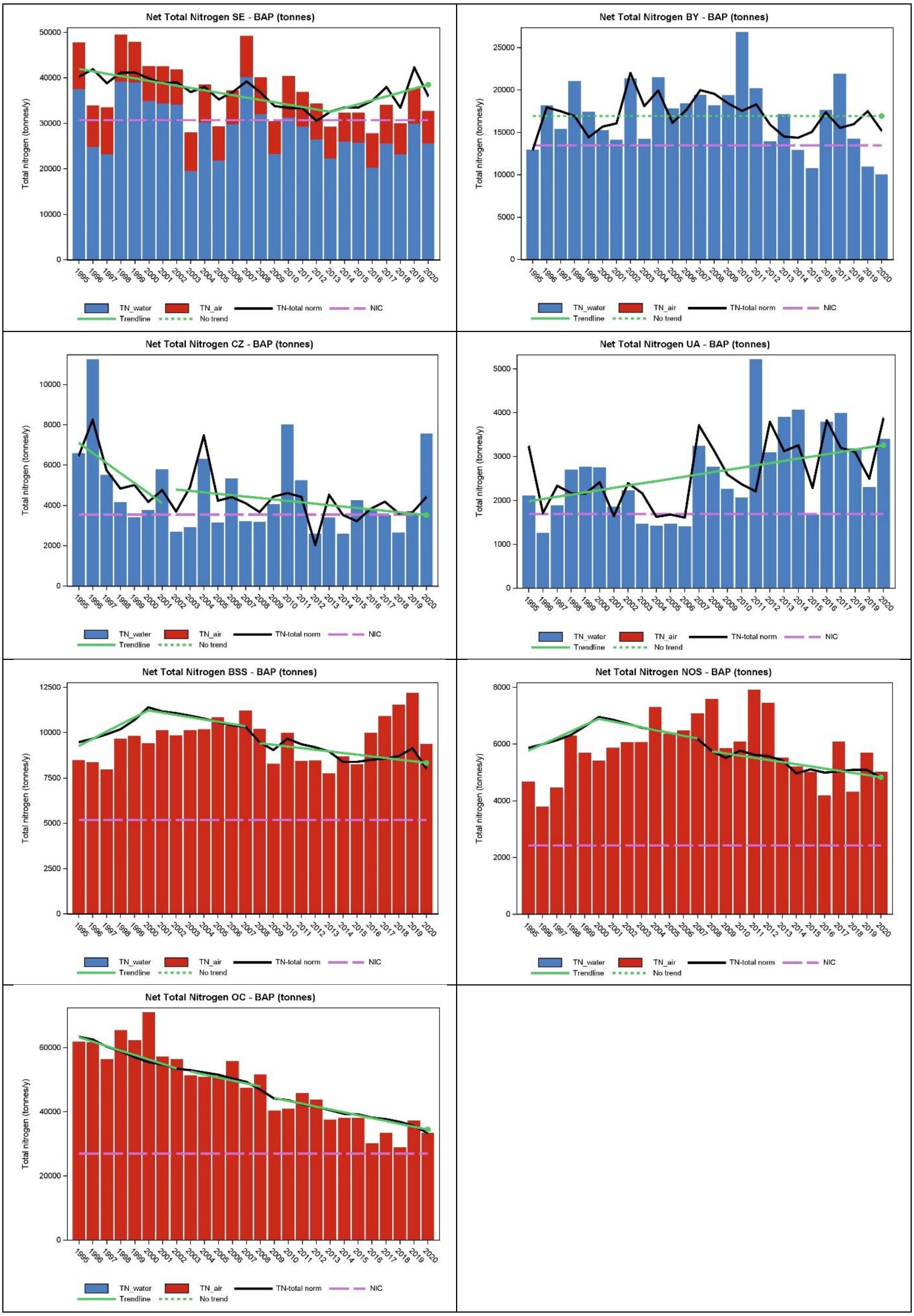
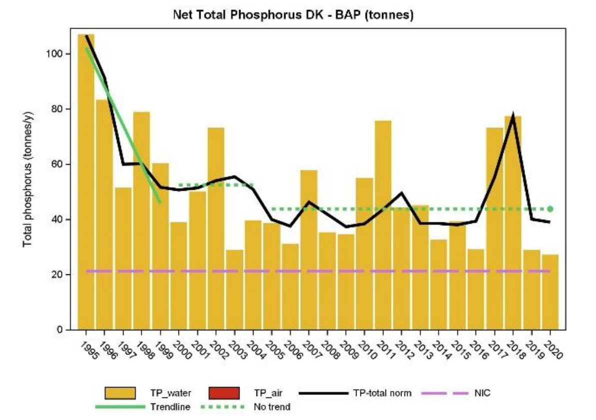
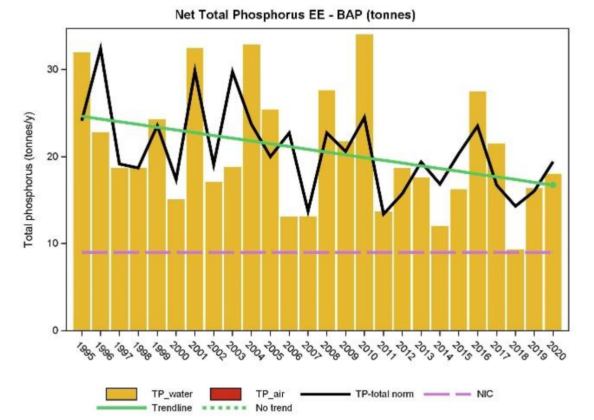


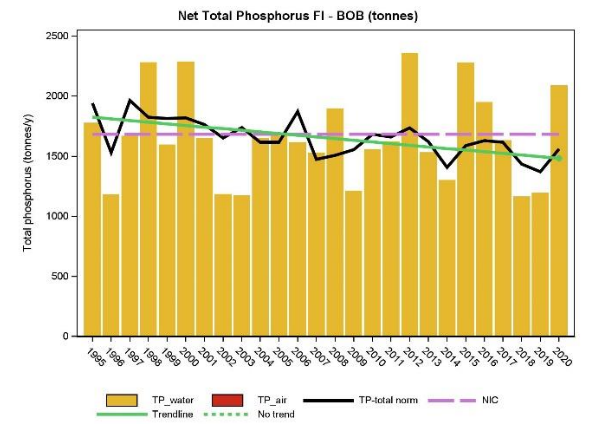
Figure 3.2. Timeseries country per basin (BAP) on annual actual water and airborne total nitrogen inputs, total normalized net nitrogen inputs, NIC for the country basin, and trend lines. Trend lines are in sections (if there are detected break points), where full line indicates a significant trend and dotted type when it is not significant. The green dot in 2020 are the estimated inputs for 2020. Examples for Baltic Proper. Finland has no waterborne nitrogen inputs to the Baltic Proper. Atmospheric inputs from Belarus, Czech Republic and Ukraine are included under Other Countries (OC). All plots are in annex F.



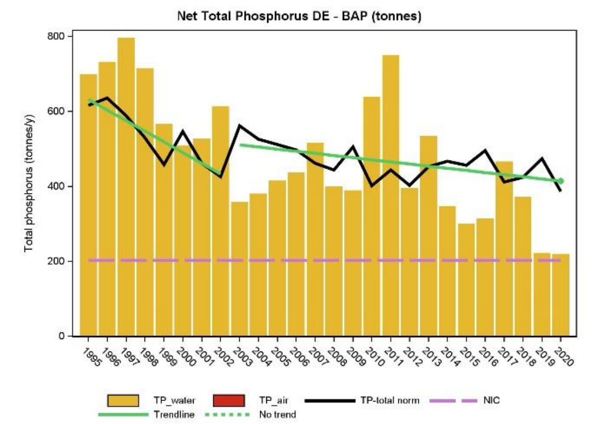
Net Total Phosphorus DK - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



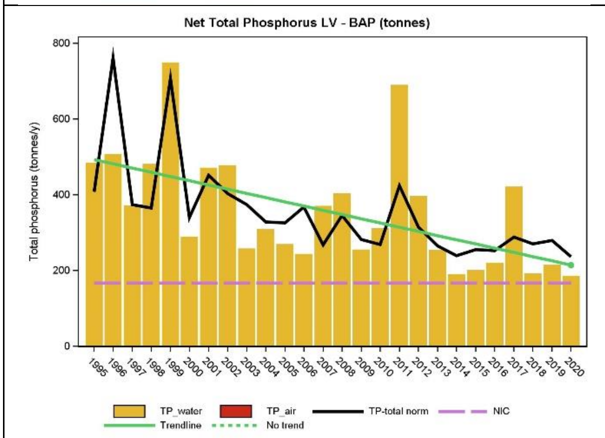
Net Total Phosphorus EE - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



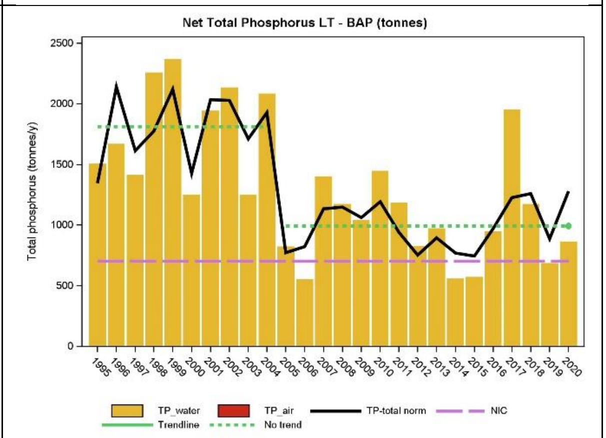
Net Total Phosphorus FI - BOB (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



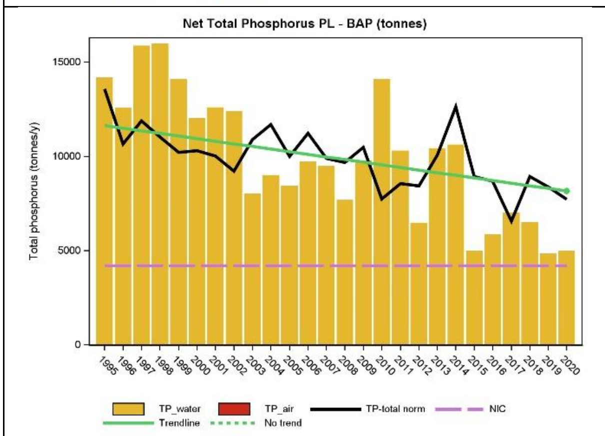
Net Total Phosphorus DE - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



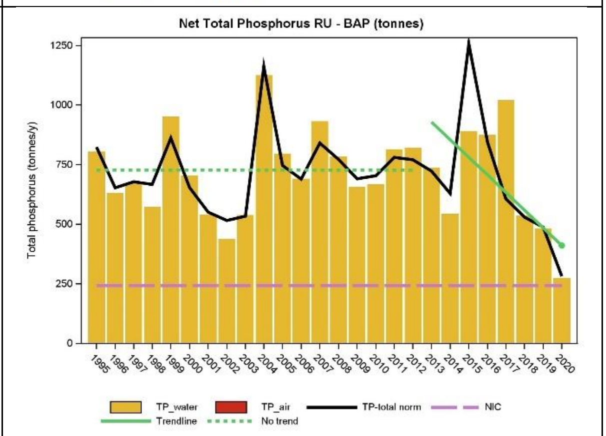
Net Total Phosphorus LV - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



Net Total Phosphorus LT - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



Net Total Phosphorus PL - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend



Net Total Phosphorus RU - BAP (tonnes)
Total phosphorus (tonnes/y)
TP_water
TP_air
TP-total norm
NIC
Trendline
No trend

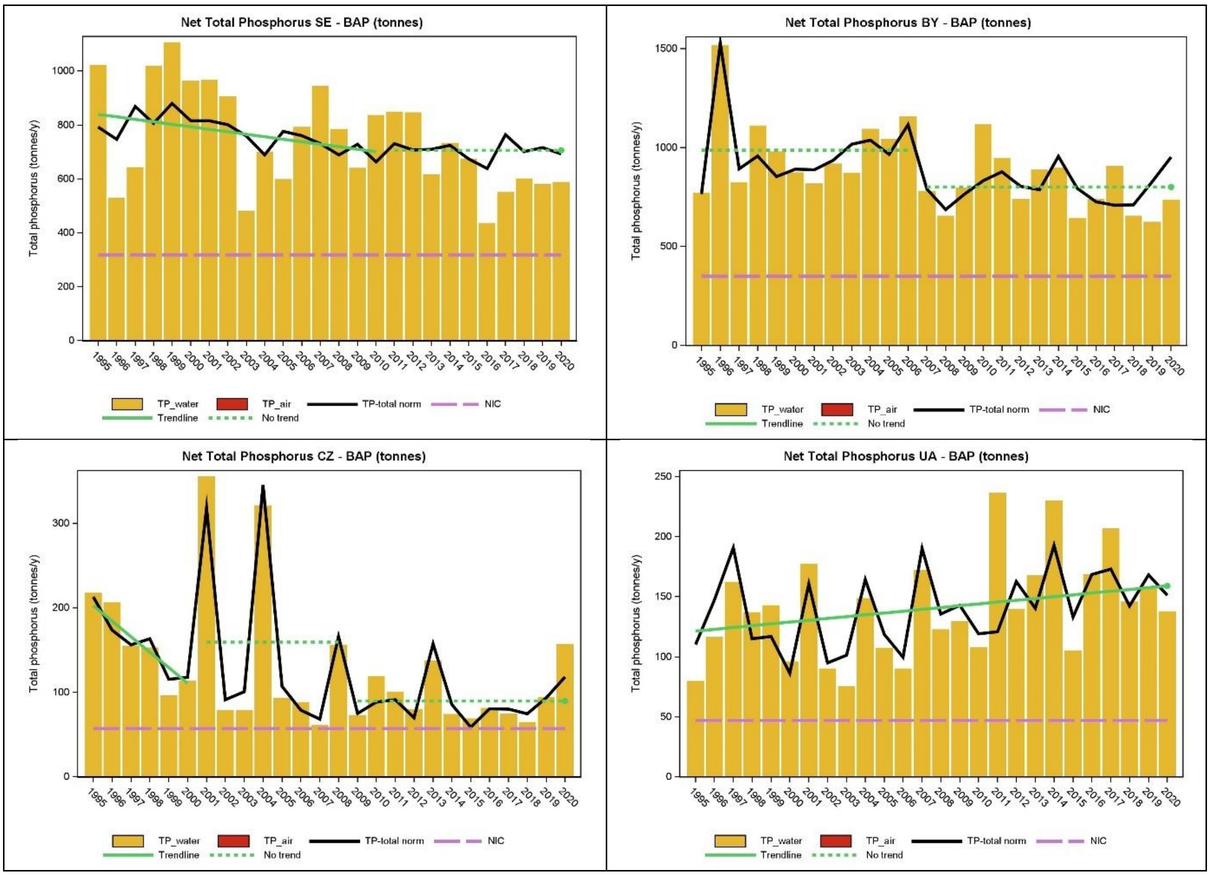
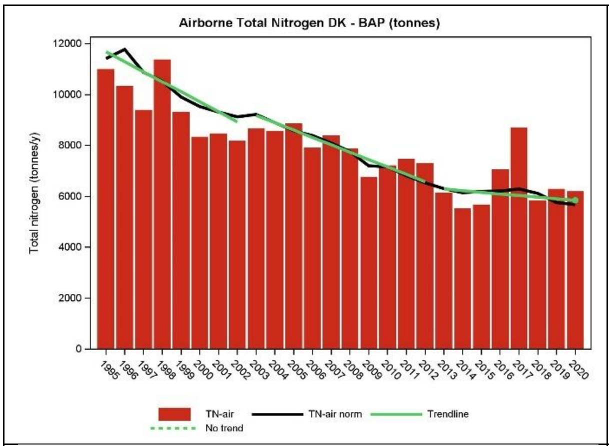
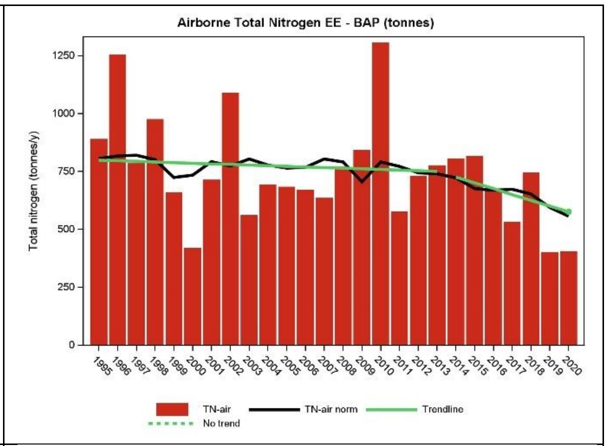
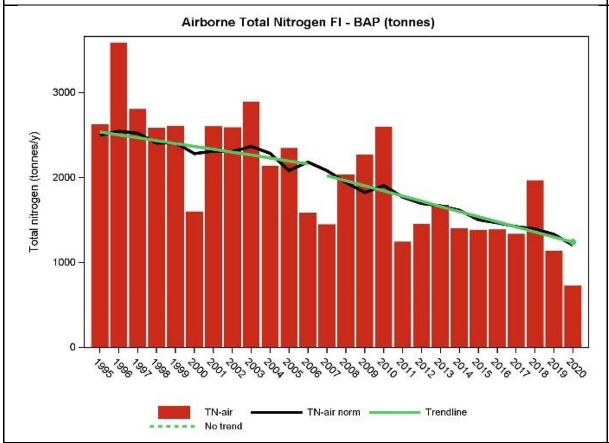
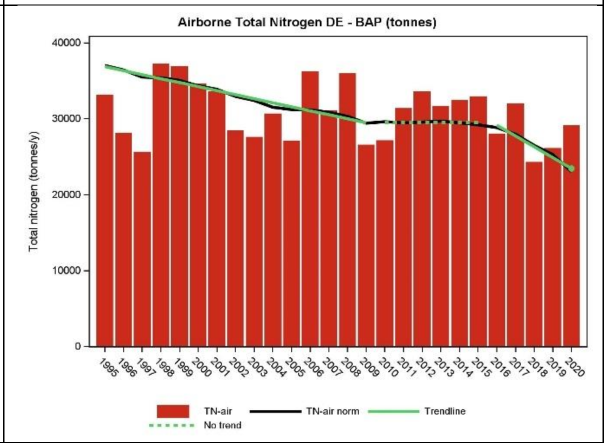


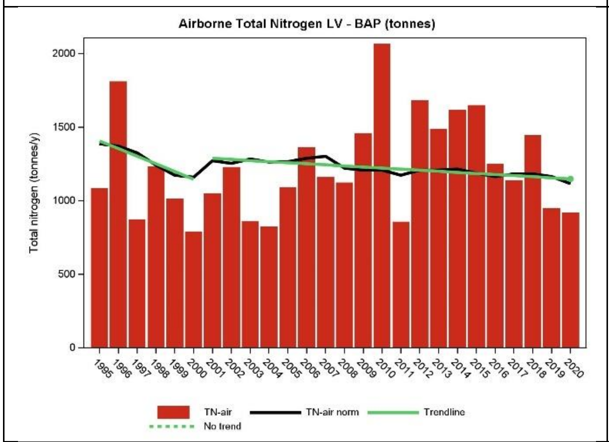
Figure 3.3. Timeseries country per basin (mostly BAP) on annual actual waterborne total phosphorus inputs, total normalized net waterborne phosphorus inputs, NIC, and trend lines. Trend lines are in sections (if there are detected break points), where full line indicates a significant trend and dotted type when it is not significant. The green dots in 2020 are the estimated inputs for 2020. Examples for Baltic Proper, but for Finland to Gulf of Finland as Finland has no waterborne inputs to the Baltic Proper. It is not possible to allocate atmospheric inputs of phosphorus per country, but only as total input per basin from all countries and sources, and therefore not shown on the country per basin plots. All plots are in annex G.

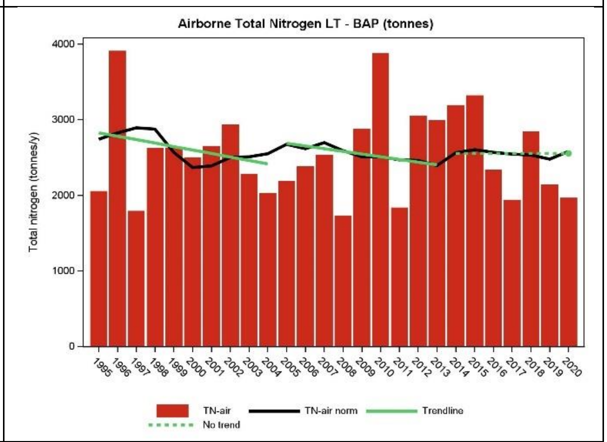

Airborne Total Nitrogen DK - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend

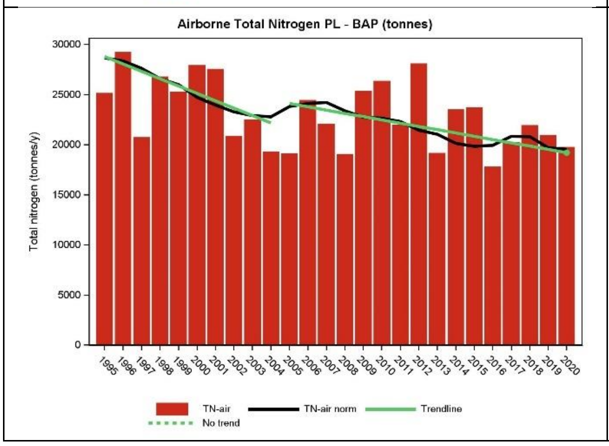

Airborne Total Nitrogen EE - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend

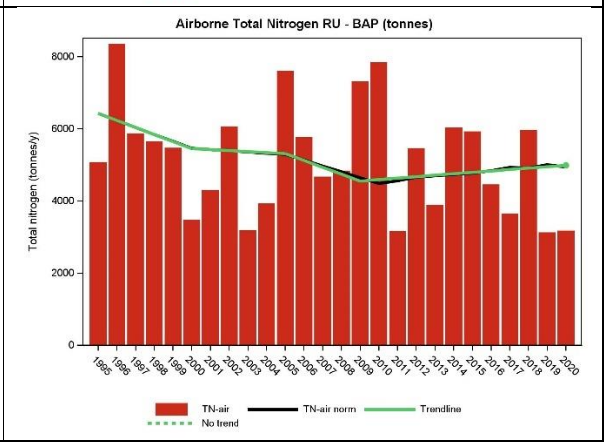

Airborne Total Nitrogen FI - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend


Airborne Total Nitrogen DE - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend


Airborne Total Nitrogen LV - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend


Airborne Total Nitrogen LT - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend


Airborne Total Nitrogen PL - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend


Airborne Total Nitrogen RU - BAP (tonnes)
Total nitrogen (tonnes/y)
TN-air
TN-air norm
Trendline
No trend

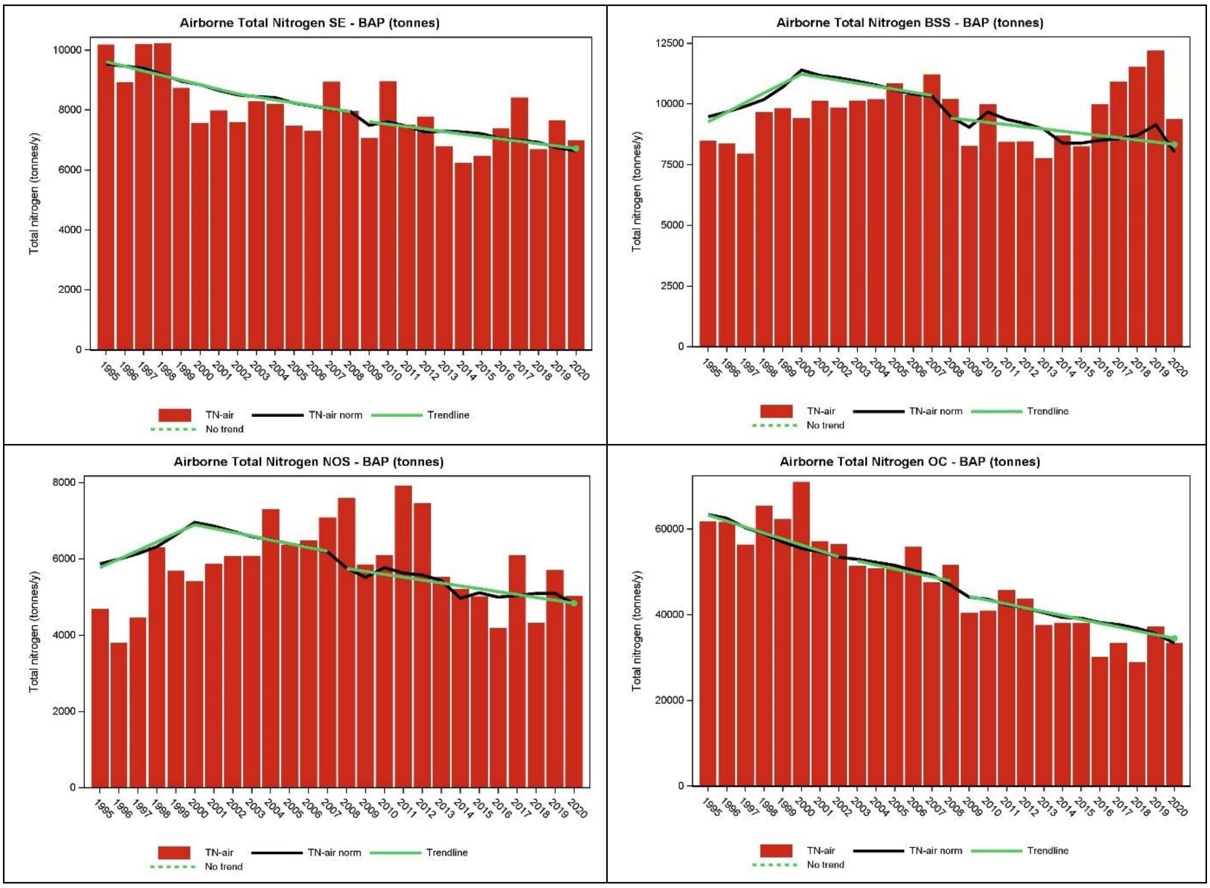
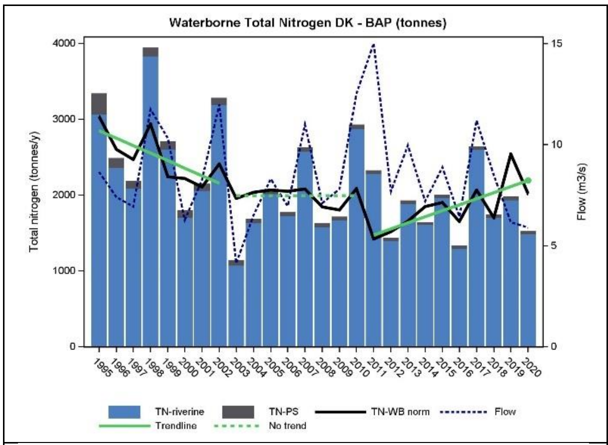
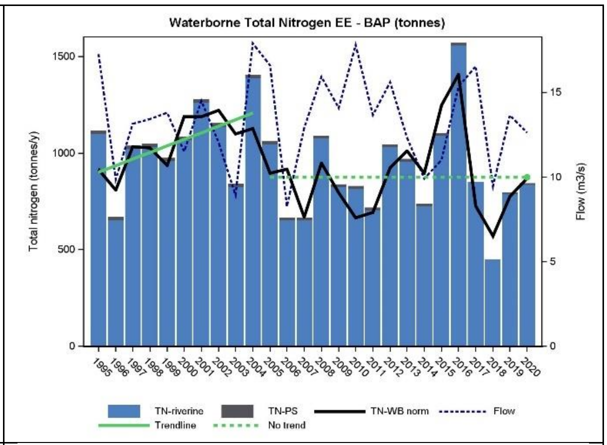
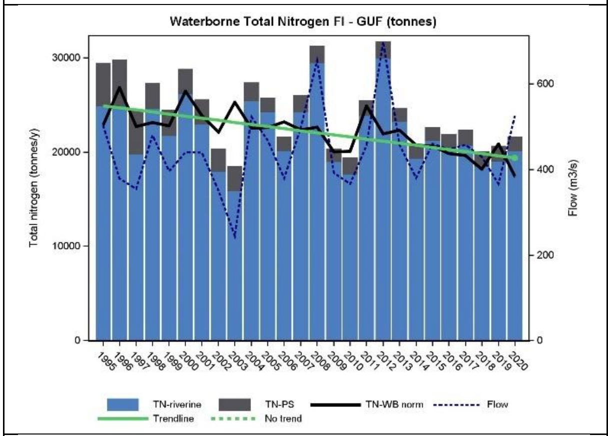
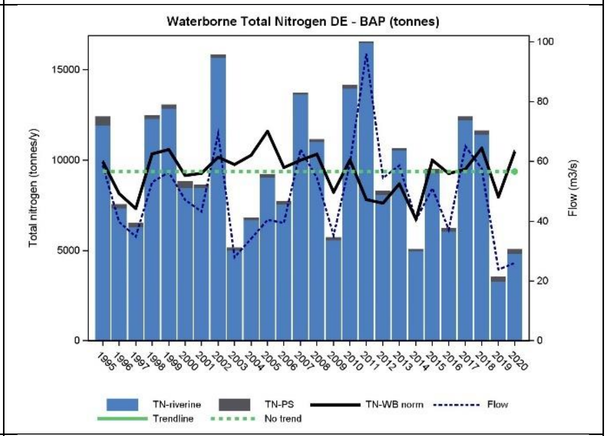


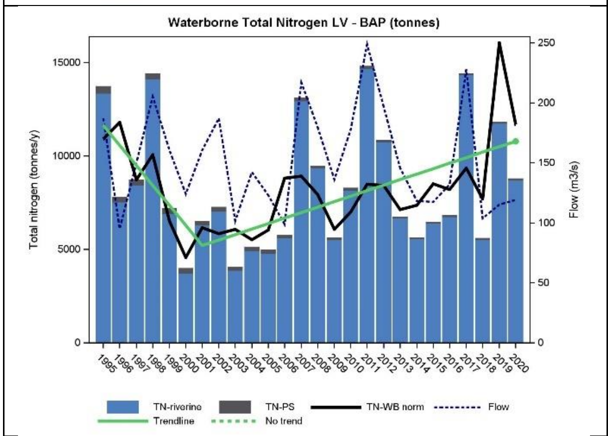
Figure 3.4. Timeseries country per basin (BAP) on annual actual airborne total nitrogen inputs, total normalized net nitrogen inputs, and trend lines. Trend lines are in sections (if there are detected break points), where full line indicates a significant trend and dotted type when it is not significant. The green dots in 2020 are the estimated inputs for 2020. Examples for Baltic Proper. All plots are in annex H.

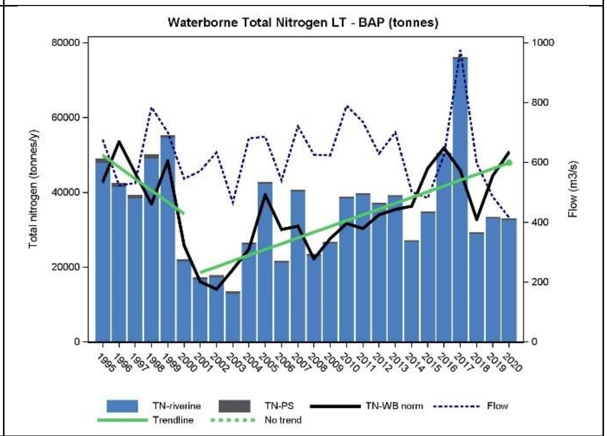

Waterborne Total Nitrogen DK - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend

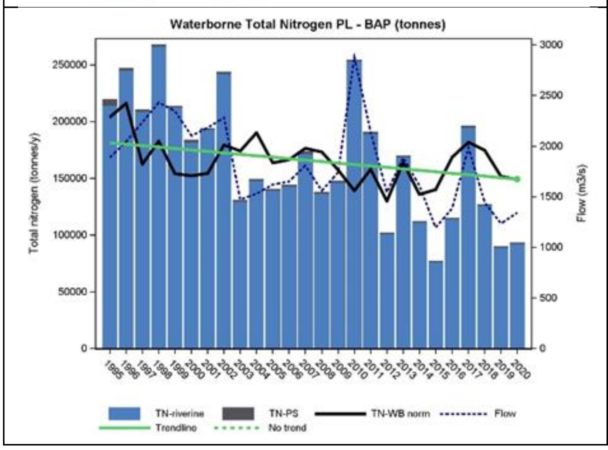

Waterborne Total Nitrogen EE - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend

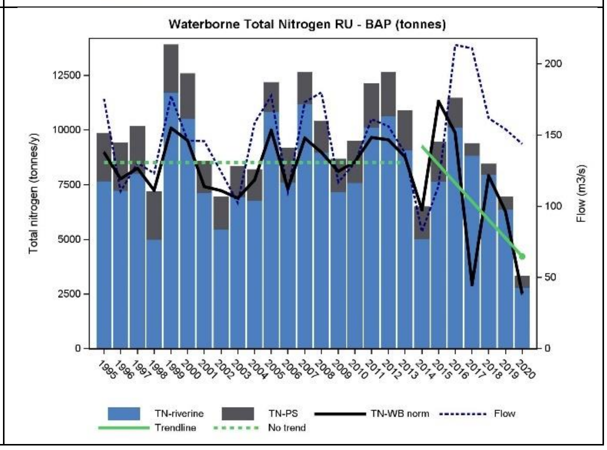

Waterborne Total Nitrogen FI - GUF (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend


Waterborne Total Nitrogen DE - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend


Waterborne Total Nitrogen LV - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend


Waterborne Total Nitrogen LT - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend


Waterborne Total Nitrogen PL - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend


Waterborne Total Nitrogen RU - BAP (tonnes)
Total nitrogen (tonnes/y)
Flow (m3/s)
TN-riverine
TN-PS
TN-WB norm
Flow
Trendline
No trend

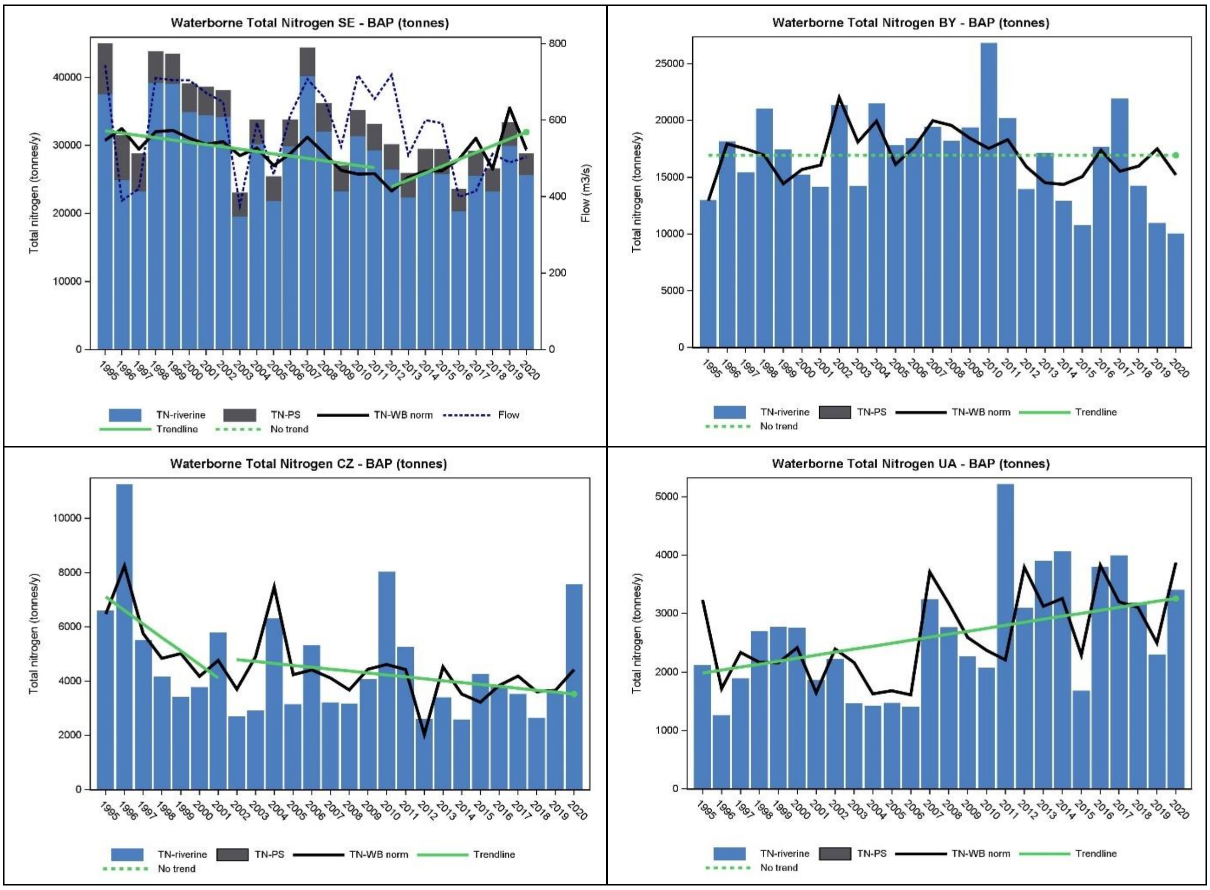
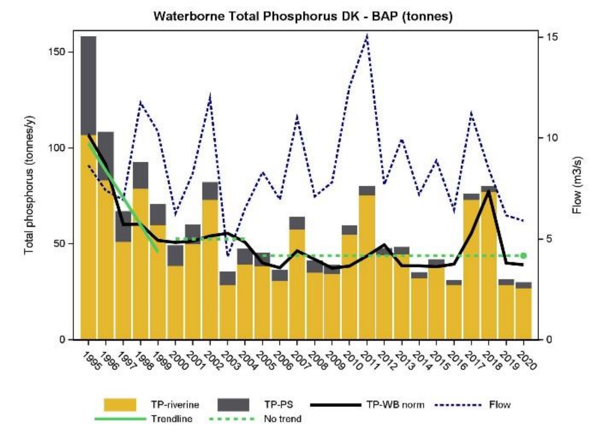
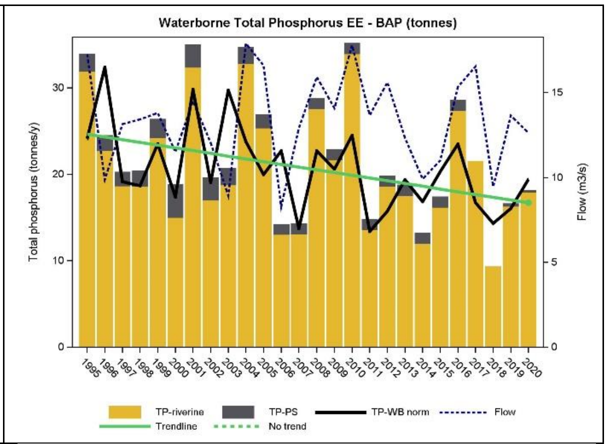
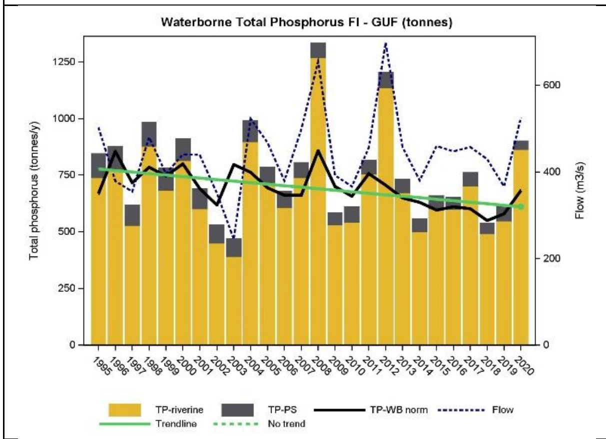
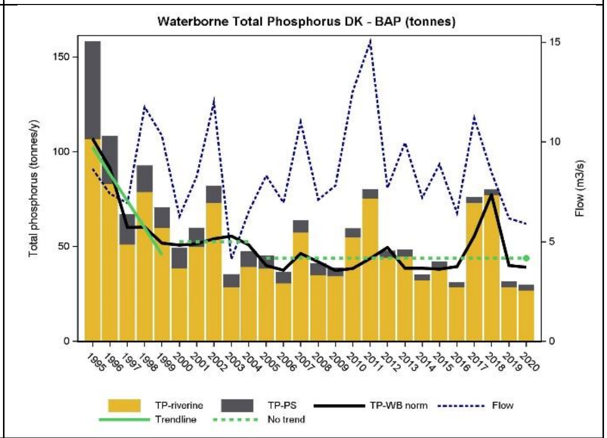


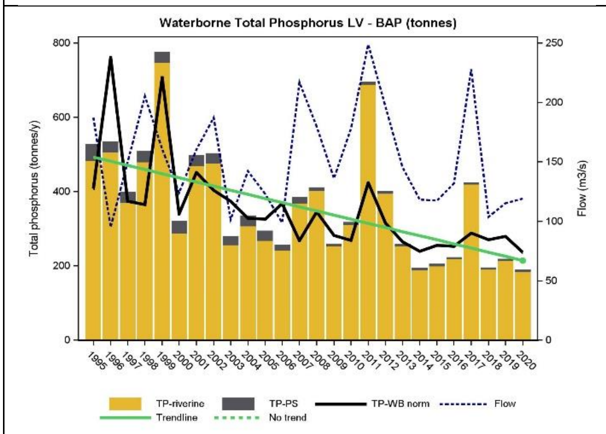
Figure 3.5. Timeseries country per basin (mostly BAP) on annual actual riverine nitrogen inputs, direct nitrogen point source inputs, flow, normalized net waterborne inputs, and trend lines. Trend lines are in sections (if there are detected break points), where full line indicates a significant trend and dotted type when it is not significant. The green dots in 2020 are the estimated inputs for 2020. Examples for Baltic Proper, but for Finland to Gulf of Finland. Flow not reported for Belarus, Czech Republic and Ukraine. All plots are in annex I.

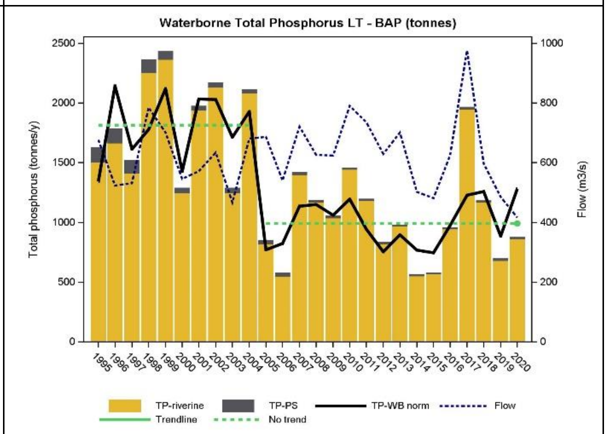

Waterborne Total Phosphorus DK - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend

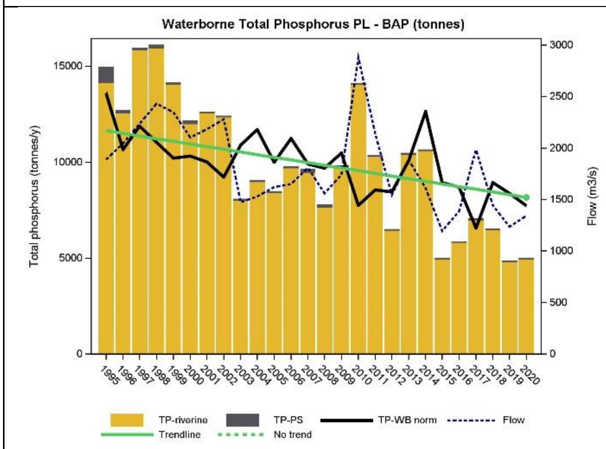

Waterborne Total Phosphorus EE - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend

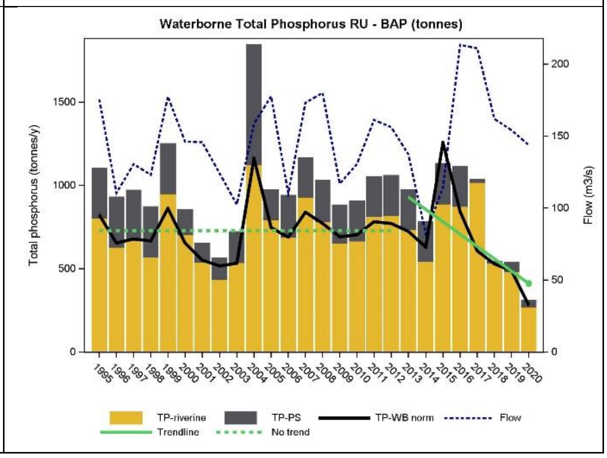

Waterborne Total Phosphorus FI - GUF (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend


Waterborne Total Phosphorus DK - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend


Waterborne Total Phosphorus LV - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend


Waterborne Total Phosphorus LT - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend


Waterborne Total Phosphorus PL - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend


Waterborne Total Phosphorus RU - BAP (tonnes)
Total phosphorus (tonnes/y)
Flow (m3/s)
TP-riverine
TP-PS
TP-WB norm
Flow
Trendline
No trend

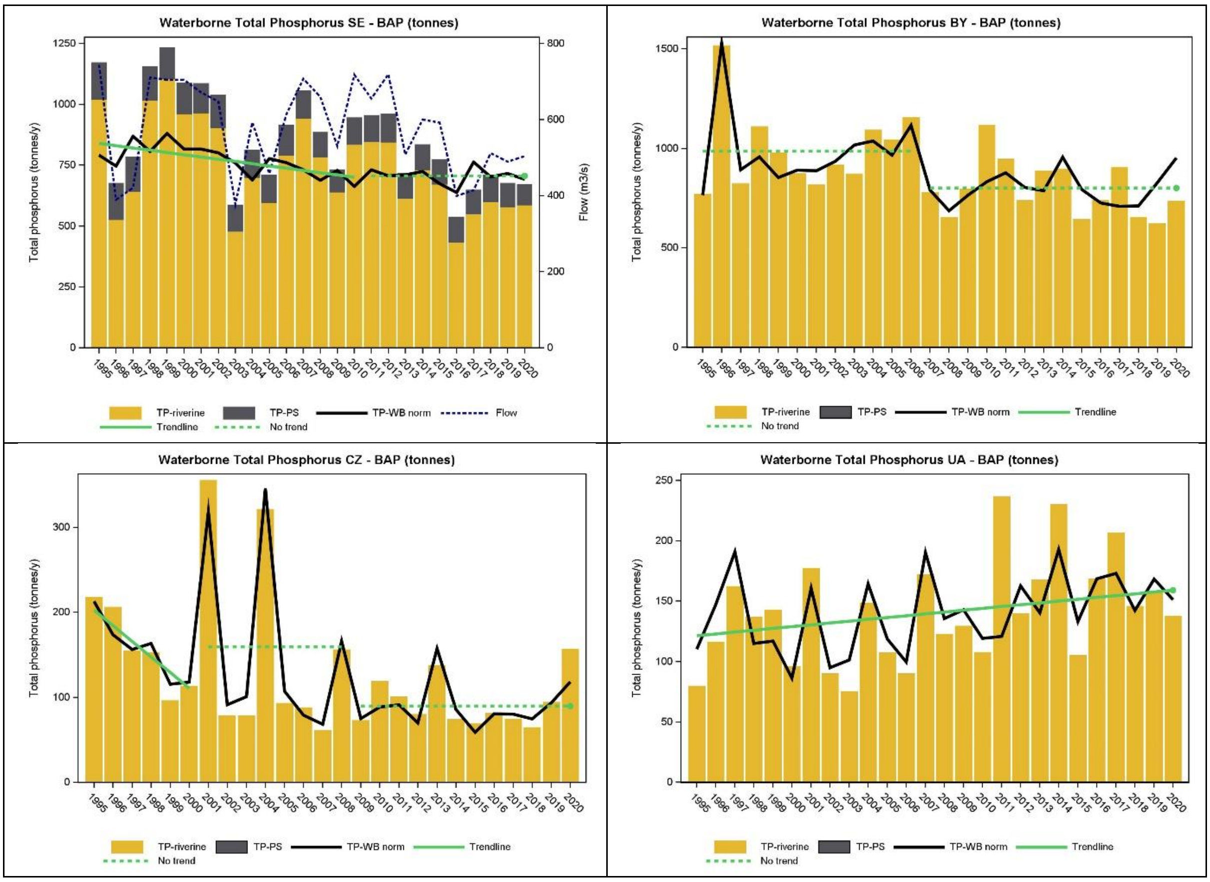


Figure 3.6. Timeseries country per basin (mostly BAP) on annual actual riverine phosphorus inputs, direct phosphorus point source inputs, flow, normalized net waterborne inputs and trend lines. Trend lines are in sections (if there are detected break points), where full line indicates a significant trend and dotted type when it is not significant. The green dots in 2020 are the estimated inputs for 2020. Examples for Baltic Proper, but for Finland to Gulf of Finland. Flow not reported for Belarus, Czech Republic, and Ukraine. All plots are in annex J.

3.5 Break points

As a step towards estimating inputs in 2020 from the regression line of the normalized inputs (chapter 2.2) the time series 1995-2020 with normalized annual net inputs of total nitrogen (airborne, waterborne and total nitrogen inputs) and total phosphorus (waterborne and total phosphorus inputs) country per basins are tested for break points. Significant break points are summarized in tables 3.13-3.16. Even if these break points are deducted with statistical tools, they reflect that implementation of measures such as building wastewater treatment plants and/or improving existing plants, changed agricultural practices and management as well as changes in weather accumulated induce breaks in the nitrogen and/or phosphorus inputs entering in inland surface waters (the riverine inputs), and in direct inputs from points sources to the sea or in the atmospheric depositions.

From table 3.13 it is remarkable that for atmospheric nitrogen inputs (shipping on both Baltic Sea and North Sea) there is a breakpoint in the times series to all Baltic Sea basins in 2000 and 2008 and from "Other countries" in 2002 and 2009. There are breakpoints for every time series with airborne deposition (table 3.14).

Year of the break point is often the same year for HELCOM countries with only atmospheric inputs to a specific basin, e.g., Denmark to Bothnian Bay, Bothnian Sea, Gulf of Finland and Gulf of Riga with break points in 2003 and 2013 (table 3.13).

There are less break points for waterborne nitrogen and phosphorus inputs (tables 3.15 and 3.16) as compared with the time series of atmospheric nitrogen deposition.

Table 3.13. Overview of break points for total (water and airborne) net nitrogen inputs country per basin. E.g. for Denmark there are two break points in the time series to BAP, one in 2003 and one in 2013, but to DS only one (in 2011). '-' no breakpoint.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	2003	2003	2003	2003	2003	2011	2011
Denmark	2013	2013	2013	2013	2013	-	-
Estonia	2013	2013	2005	2010	2009	2013	2013
Finland	2007	2007	2007	-	2007	2007	2007
Germany	2010	2010	-	2010	2010	-	2010
Germany	2016	2016	-	2016	2016	-	2016
Latvia	2001	2001	2001	2001	-	2001	2001
Lithuania	2005	2005	2001	2005	-	2005	2005
Lithuania	2014	2014	2008	2014	-	2014	2014
Poland	2005	2005	2002	2005	2005	2005	2005
Russia	2000	2000	2011	2004	2004	2000	2000
Russia	2005	2005	-	2009	-	2005	2005
Russia	2009	2009	-	-	-	2009	2009
Sweden	2007	2007	2013	2002	2002	2007	2009
Sweden	-	-	-	2009	2009	-	-
Belarus	-	-	-	-	2010	-	-
Czech Republic	-	-	2002	-	-	-	-
Ukraine	-	-	-	-	-	-	-
Baltic Sea shipping	2000	2000	2000	2000	2000	2000	2000
Baltic Sea shipping	2008	2008	2008	2008	2008	2008	2008
North Sea shipping	2000	2000	2000	2000	2000	2000	2000
North Sea shipping	2008	2008	2008	2008	2008	2008	2008
Other countries	2002	2002	2002	2002	2002	2002	2002
Other countries	2009	2009	2009	2009	2009	2009	2009

Table 3.14. Overview of break points for airborne nitrogen inputs country per basin. E.g. for Germany there are two break points in the time series to BAP, one in 2010 and one in 2016. '-' no breakpoint.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark	2003	2003	2003	2003	2003	2003	2003
Denmark	2013	2013	2013	2013	2013	2013	2013
Estonia	2013	2013	2013	2013	2013	2013	2013
Finland	2007	2007	2007	2007	2007	2007	2007
Germany	2010	2010	2010	2010	2010	2010	2010
Germany	2016	2016	2016	2016	2016	2016	2016
Latvia	2001	2001	2001	2001	2001	2001	2001
Lithuania	2005	2005	2005	2005	2005	2005	2005
Lithuania	2014	2014	2014	2014	2014	2014	2014
Poland	2005	2005	2005	2005	2005	2005	2005
Russia	2000	2000	2000	2000	2000	2000	2000
Russia	2005	2005	2005	2005	2005	2005	2005
Russia	2009	2009	2009	2009	2009	2009	2009
Sweden	2002	2002	2002	2002	2002	2002	2002
Sweden	2009	2009	2009	2009	2009	2009	2009
Baltic Sea shipping	2000	2000	2000	2000	2000	2000	2000
Baltic Sea shipping	2008	2008	2008	2008	2008	2008	2008
North Sea shipping	2000	2000	2000	2000	2000	2000	2000
North Sea shipping	2008	2008	2008	2008	2008	2008	2008
Other countries	2002	2002	2002	2002	2002	2002	2002
Other countries	2009	2009	2009	2009	2009	2009	2009

Table 3.15. Overview of break points for net waterborne nitrogen inputs country per basin. E.g. for Denmark there are two break points in the time series to BAP, one in 2003 and one in 2011. '-' no breakpoint.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			2003			2011	2007
Denmark			2011			-	-
Estonia			2005	-	2005		
Finland	2008	2008		-			
Germany			-			2012	
Latvia			2001		2006		
Lithuania			2001		-		
Poland			-				
Russia			2014	2005	2002		
Sweden	2007	2007	2012			2002	2009
Belarus			-		2010		
Czech Republic			2002				
Ukraine			-				

Table 3.16. Overview of break points for total net phosphorus inputs country per basin. E.g. for Estonia there are two break points in the time series to Gulf of Finland, one in 2001 and one in 2013, but to Gulf of Riga only one (in 2005). '-' no breakpoint.

Country/basin	BOB	BOS	BAP	GUF	GUR	DS	KAT
Denmark			2000			2001	2002
Denmark			2005			2008	-
Estonia			-	2001	2005		
Estonia			-	2013	-		
Finland	-	-		-			
Germany			2003			2006	
Latvia			-		2001		
Lithuania			2005		-		
Poland			-				
Russia			2013	2012	-		
Sweden	2008	-	2011			2008	2007
Belarus			2007		-		
Czech Republic			2001				
Czech Republic			2009				
Ukraine			-				

3.6 Importance of reduction in airborne TN inputs for reduction in total inputs

To evaluate the importance of reducing atmospheric nitrogen deposition to the Baltic Sea for the reduction of total nitrogen inputs to Baltic Sea basins, the share of the significant reduction in total nitrogen inputs from 1995 to 2020 that can be explained by reduction in airborne inputs have been assessed (table 3.17).

Estimated changes in inputs from 1995 to 2020 are based on the trend analysis methodology identifying break points as described in chapter 2.2. Significant changes between 1995 and 2020 are calculated from the regression line on the normalized inputs as:

$$((Norm\_regTN_{2020} – Norm\_regTN_{1995}) / Norm\_regTN_{1995}) * 100\%$$

and changes in tonnes as:

$$Norm\_regTN_{2020} – Norm\_regTN_{1995}$$

for time series of air+waterborne, airborne and waterborne, respectively.

$Norm\_regTN_{2020}$ = total net nitrogen inputs in 2020 estimated from the regression line on the time series 1995-2020 (or latest section of the time series if a break point is detected)

$Norm\_regTN_{1995}$ = total net nitrogen inputs in 1995 estimated from the regression line on the time series 1995-2020 (or the first section of the time series if a break point is detected)

If there is no significant reduction in waterborne total nitrogen inputs, then airborne accounts for 100% of the changes in air+waterborne inputs if there is a significant change in the airborne inputs.

As the analysis of significant changes are done separately on the sum of air and waterborne, airborne and waterborne total nitrogen input time series, the changes in percentages of airborne and waterborne inputs will not add up to 100% of changes in the sum of air and waterborne timeseries (it can add up to more or less than 100%). Therefore, when there is significant reduction in both water and airborne inputs time series, respectively, the changes in airborne inputs are weighted together with the changes in waterborne inputs, to ensure the change in percentages add up to 100% of the changes in the sum of air and waterborne time series.

There are several basins where a country contributes only with airborne inputs, and reduction in nitrogen input can only be assigned to reduced atmospheric deposition. But overall reductions in airborne nitrogen inputs are important to many basins that also receive waterborne inputs from a country.

Table 3.17. Importance of significant reduction in airborne nitrogen inputs in percentage of significant reduction in total (sum of air and waterborne) net nitrogen reduction from 1995 to 2020 in percentages. "Total" = change in total (sun of air and waterborne) nitrogen inputs in tonnes, "airborne" = change in airborne nitrogen inputs in tonnes, "waterborne" = change in waterborne inputs in tonnes. Italic numbers indicate when changes are not significant. If changes are not significant, they are not taken into account in the calculation of the share of the total reduction. "Reduction air % of total" indicates the share in percentages of the reduction in airborne inputs of the reduction of the total net nitrogen inputs. "Reduction in total inputs %" indicates the change in total nitrogen inputs from 1995 to 2020 in %. Example: total net nitrogen inputs from Denmark to Baltic Proper were significantly reduced with 6,506 tonnes from 1995 to 2020. Airborne nitrogen inputs were reduced significantly with 5,841 tonnes and waterborne nitrogen inputs significantly with 657 tonnes. The 6,506 tonnes reduction in total nitrogen inputs in 2020 is a 45% reduction in total nitrogen inputs from Denmark to Baltic Proper since 1995. Airborne nitrogen inputs account 90% of the reduction of total net nitrogen inputs.

Denmark		**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
Total		220	835	6506	365	321	9357	10304
Airborne		220	835	5841	365	321	2431	2957
Waterborne		0	0	657	0	0	6555	7863
Reduction air % of total		**100**	**100**	**90**	**100**	**100**	**27**	**27**
Reduction in total inputs %		59	57	45	57	56	28	29

Estonia		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		46	129	183	*1317*	-4963	*8*	9
Airborne		46	129	224	*121*	*14*	8	9
Waterborne		0	0	*25*	*1743*	-4838	0	0
Reduction air % of total		**100**	**100**	**100**	**0**	**0**	**100**	**100**
Reduction in total inputs %		36	31	11	10	-45	38	36

Finland		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		*35*	3489	1299	6297	167	45	55
Airborne		904	1336	1299	738	167	45	55
Waterborne		*-784*	*2818*	0	5527	0	0	0
Reduction air % of total		**100**	**100**	**100**	**12**	**100**	**100**	**100**
Reduction in total inputs %		0	12	51	24	51	56	55

Germany		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		461	1781	11191	890	753	6596	1916
Airborne		461	1781	13407	890	753	2824	1916
Waterborne		0	0	0	0	0	3880	0
Reduction air % of total		**100**	**100**	**100**	**100**	**100**	**42**	**100**
Reduction in total inputs %		42	42	24	41	40	27	35

Latvia		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		23	88	*1039*	70	*0*	9	10
Airborne		23	88	258	70	*63*	9	10
Waterborne		0	0	*859*	0	*6883*	0	0
Reduction air % of total		**100**	**100**	**100**	**100**	**0**	**100**	**100**
Reduction in total inputs %		25	22	8	20	0	25	24

Lithuania		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		22	84	*986*	60	-5051	11	14
Airborne		22	84	*275*	60	*47*	11	14
Waterborne		0	0	*2027*	0	-5084	0	0
Reduction air % of total		**100**	**100**	**0**	**100**	**0**	**100**	**100**
Reduction in total inputs %		16	14	2	14	-65	15	15

Poland		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		316	1374	64360	735	673	641	672
Airborne		316	1374	9607	735	673	641	672
Waterborne		0	0	31989	0	0	0	0
Reduction air % of total		**100**	**100**	**23**	**100**	**100**	**100**	**100**
Reduction in total inputs %		36	36	27	36	35	36	36

Russia		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total (tons)		247	554	4052	*-14056*	1281	61	69
Airborne (tons)		247	554	1437	720	179	61	69
Waterborne (Tons)		0	0	*4295*	-16534	1376	0	0
Reduction air % of total		**100**	**100**	**100**	**0**	**12**	**100**	**100**
Reduction in total inputs %		22	22	29	-24	32	23	22

Sweden		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		4852	7237	3467	343	219	*1149*	8195
Airborne		444	1351	2895	343	219	171	358
Waterborne		4532	6246	174	0	0	*1268*	7902
Reduction air % of total		**9**	**18**	**94**	**100**	**100**	**100**	**4**
Reduction in total inputs %		26	22	8	40	37	16	22

Baltic Sea Shipping		BOB	BOS	BAP	GUF	GUR	DS	KAT
Total		55	216	934	120	70	112	109
Airborne		55	216	934	120	70	112	109
Waterborne		0	0	0	0	0	0	0
Reduction air % of total		**100**	**100**	**100**	**100**	**100**	**100**	**100**
Reduction in total inputs %		10	10	10	10	10	10	10

North Sea Shipping		**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
Total		55	182	928	76	58	240	267
Airborne		55	182	928	76	58	240	267
Waterborne		0	0	0	0	0	0	0
Reduction air % of total		**100**	**100**	**100**	**100**	**100**	**100**	**100**
Reduction in total inputs %		16	16	16	16	16	16	16

Other countries		**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
Total		1482	5256	28810	2735	2032	6058	5772
Airborne		1482	5256	28810	2735	2032	6058	5772
Waterborne		0	0	0	0	0	0	0
Reduction air % of total		**100**	**100**	**100**	**100**	**100**	**100**	**100**
Reduction in total inputs %		45	44	46	42	43	50	49

Belarus		**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
Total		0	0	*0*	0	3773	0	0
Airborne		0	0	0	0	0	0	0
Waterborne		0	0	*0*	0	3773	0	0
Reduction air % of total		**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reduction in total inputs %		0	0	0	0	26	0	0

Czeck Republic		**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
Total		0	0	3583	0	0	0	0
Airborne		0	0	0	0	0	0	0
Waterborne		0	0	3583	0	0	0	0
Reduction air % of total		**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reduction in total inputs %		0	0	50	0	0	0	0

Ukraine		**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**DS**	**KAT**
Total		0	0	-1280	0	0	0	0
Airborne		0	0	0	0	0	0	0
Waterborne		0	0	-1280	0	0	0	0
Reduction air % of total		**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reduction in total inputs %		0	0	-65	0	0	0	0

3.7 Changes in TN and TP inputs since the reference period and since 1995

This sub-chapter provides and overview of significant changes since the reference period (1997-2003) to 2020 and since 1995 to 2020, respectively, given country by basin for:

- Total annual normalized net nitrogen inputs (table 3.18 and 3.18a);
- Airborne normalized annual nitrogen inputs (table 3.19 and 3.19a);
- Normalized waterborne annual net nitrogen inputs (table 3.20 and 3.20a);
- Total annual normalized net phosphorus inputs (table 3.21 and 3.21a).

The methods applied are summarized in chapter 2.2 – see figure 2.2.

Changes are calculated as percentage change for the period (e.g., from 1995 to 2020) in tables 3.18-3.21, and as annual changes (percentage per year) for the period (e.g., annual change in percentages from 1995 to 2020) in tables 3.18a-3.21a. The changes as percentages per year are calculated by e.g. dividing the changes from 1995 to 2020 with 25 years (from 1995 to 2020) and with 10 years, since reference period to 2020 as reference period is covering 1997 to 2003 the average is year 2000.

Many countries have higher reduction in net total nitrogen (sum of air and waterborne) inputs from 1995 to 2020 as compared to reduction since reference period, indicating a reduction in nitrogen inputs also before the reference period (table 3.18). In many cases net total nitrogen inputs are reduced since the reference period, but there are some cases as e.g., Estonia and Lithuania to Gulf of Riga with significant increase in TN inputs after the reference period. For shipping (both on the Baltic Sea and the North Sea) the decrease in total net nitrogen inputs (which is only airborne) from the reference period to 2020 is higher than the decrease since 1995, indicating a higher annual decrease since the reference period, than in the beginning of the time series where there is an increase in airborne inputs from 1995 to around year 2000 (see e.g. figure 3.4).

The annual reduction (percentage per year) since the reference period to 2020 is higher (steeper decrease) than the corresponding changes since 1995 for atmospheric inputs, as for Baltic Sea and North Sea shipping and from “other countries”, but also for many HELCOM countries where they only contribute with atmospheric deposition, see table 3.18a. For basins with both airborne and waterborne nitrogen inputs there might occur opposite trends, and in tables 3.19-3.19a, 3.20-3.20a airborne nitrogen and waterborne input are analyzed for changes separately.

Table 3.18. Changes in percentages in normalized total (air+waterborne) annual net nitrogen inputs country by basin from the reference period to 2020 and from 1995 to 2020, respectively. "– "no significant changes**.**

Total TN	**Since ref. period BOB**	**Since 1995 BOB**	**Since ref. period BOS**	**Since 1995 BOS**	**Since ref. period BAP**	**Since 1995 BAP**	**Since ref. period GUF**	**Since 1995 GUF**	**Since ref. period GUR**	**Since 1995 GUR**	**Since ref. period DS**	**Since 1995 DS**	**Since ref. period KAT**	**Since 1995 KAT**
Denmark	-49	-59	-47	-57	-34	-45	-48	-57	-46	-56	-19	-28	-22	-29
Estonia	-33	-36	-29	-31	-19	-11	-	-10	23	45	-35	-38	-33	-36
Finland	-8.1	-	-12	-12	-48	-51	-20	-24	-48	-51	-52	-56	-51	-55
Germany	-37	-42	-36	-42	-20	-24	-36	-41	-35	-40	-21	-27	-31	-35
Latvia	-14	-25	-12	-22	48	-	-10	-20	-	-	-14	-25	-13	-24
Lithuania	-	-16	-	-14	62	-	-	-14	55	65	-	-15	-	-15
Poland	-25	-36	-25	-36	-11	-27	-25	-36	-25	-35	-26	-36	-25	-36
Russia	-11	-22	-11	-22	-29	-29	-	-	-14	-32	-12	-23	-11	-22
Sweden	-26	-26	-22	-22	-	-8.3	-33	-40	-30	-37	-	-	-20	-22
Belarus					-	-			-	-26				
Czech Republic					-26	-50								
Ukraine					49	65								
Baltic Sea shipping	-23	-10	-23	-10	-23	-10	-23	-10	-23	-10	-23	-10	-23	-10
North Sea Shipping	-27	-16	-27	-16	-27	-16	-27	-16	-27	-16	-27	-16	-27	-16
Other countries	-38	-45	-37	-44	-39	-46	-35	-42	-35	-43	-43	-50	-43	-49

Table 3.18a. As table 3.18 but changes expressed as percentages per year in the period.

Total TN	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark	-4.9	-2.3	-4.7	-2.3	-3.4	-1.8	-4.8	-2.3	-4.6	-2.2	-1.9	-1.1	-2.2	-1.2
Estonia	-3.3	-1.4	-2.9	-1.2	-1.9	-0.4	-	-0.4	2.3	1.8	-3.5	-1.5	-3.3	-1.4
Finland	-0.8	-	-1.2	-0.5	-4.8	-2.0	-2.0	-0.9	-4.8	-2.0	-5.2	-2.2	-5.1	-2.2
Germany	-3.7	-1.7	-3.6	-1.7	-2.0	-1.0	-3.6	-1.7	-3.5	-1.6	-2.1	-1.1	-3.1	-1.4
Latvia	-1.4	-1.0	-1.2	-0.9	4.8	-	-1.0	-0.8	-	-	-1.4	-1.0	-1.3	-0.9
Lithuania	-	-0.6	-	-0.6	6.2	-	-	-0.6	5.5	2.6	-	-0.6	-	-0.6
Poland	-2.5	-1.5	-2.5	-1.4	-1.1	-1.1	-2.5	-1.4	-2.5	-1.4	-2.6	-1.5	-2.5	-1.4
Russia	-1.1	-0.9	-1.1	-0.9	-2.9	-1.2	-	-	-1.4	-1.3	-1.2	-0.9	-1.1	-0.9
Sweden	-2.6	-1.0	-2.2	-0.9	-	-0.3	-3.3	-1.6	-3.0	-1.5	-	-	-2.0	-0.9
Belarus					-	-			-	-1.0				
Czech Republic					-2.6	-2.0								
Ukraine					4.9	2.6								
Baltic Sea shipping	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4
North Sea Shipping	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6
Other countries	-3.8	-1.8	-3.7	-1.8	-3.9	-1.8	-3.5	-1.7	-3.5	-1.7	-4.3	-2.0	-4.3	-2.0

Reductions in airborne inputs are for most country basins higher from 1995 to 2020 compared with the changes from the reference period to 2020, besides for shipping (table 3.19). But in terms of annual changes in percentages we get the opposite picture, as for almost all changes the annual changes are highest since the referecne period (table 3.19a), the only exceptions being for Lithuania (all basins) and Latvia (to Baltic Proper and Gulf of Riga).

Table 3.19. Changes in percentages in normalized total annual net nitrogen airborne inputs country by basin from the reference period to 2020 and from 1995 to 2020, respectively. "– "no significant changes**.**

Airborne TN	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark	-49	-59	-47	-57	-40	-50	-48	-57	-46	-56	-30	-39	-31	-40
Estonia	-33	-36	-29	-31	-26	-28	-13	-	-6	-	-35	-38	-33	-36
Finland	-37	-39	-39	-42	-48	-51	-43	-46	-48	-51	-52	-56	-51	-55
Germany	-37	-42	-36	-42	-31	-36	-36	-41	-35	-40	-24	-27	-31	-35
Latvia	-14	-25	-12	-22	-	-18	-10	-	-	-11	-14	-25	-13	-24
Lithuania	-	-16	-	-14	-	-10	-	-14	-	-	-	-15	-	-15
Poland	-25	-36	-25	-36	-23	-33	-25	-36	-25	-35	-26	-36	-25	-36
Russia	-11	-22	-11	-22	-11	-22	-10	-22	-11	-22	-12	-23	-11	-22
Sweden	-33	-40	-30	-37	-24	-30	-33	-40	-30	-37	-27	-34	-23	-29
Belarus														
Czech Republic														
Ukraine														
Baltic Sea shipping	-23	-10	-23	-10	-23	-10	-23	-10	-23	-10	-23	-10	-23	-10
North Sea Shipping	-27	-16	-27	-16	-27	-16	-27	-16	-27	-16	-27	-16	-27	-16
Other countries	-38	-45	-37	-44	-39	-46	-35	-42	-35	-43	-43	-50	-43	-49

Table 3.19a. As table 3.19 but changes expressed as percentages per year in the period.

Airborne TN	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark	-4.9	-2.3	-4.7	-2.3	-4.0	-2.0	-4.8	-2.3	-4.6	-2.2	-3.0	-1.6	-3.1	-1.6
Estonia	-3.3	-1.4	-2.9	-1.2	-2.6	-1.1	-1.3	-	-0.6	-	-3.5	-1.5	-3.3	-1.4
Finland	-3.7	-1.6	-3.9	-1.7	-4.8	-2.0	-4.3	-1.9	-4.8	-2.0	-5.2	-2.2	-5.1	-2.2
Germany	-3.7	-1.7	-3.6	-1.7	-3.1	-1.5	-3.6	-1.7	-3.5	-1.6	-2.4	-1.1	-3.1	-1.4
Latvia	-1.4	-1.0	-1.2	-0.9	-	-0.7	-1.0	-	-	-0.4	-1.4	-1.0	-1.3	-0.9
Lithuania	-	-0.6	-	-0.6	-	-0.4	-	-0.6	-	-	-	-0.6	-	-0.6
Poland	-2.5	-1.5	-2.5	-1.4	-2.3	-1.3	-2.5	-1.4	-2.5	-1.4	-2.6	-1.5	-2.5	-1.4
Russia	-1.1	-0.9	-1.1	-0.9	-1.1	-0.9	-1.0	-0.9	-1.1	-0.9	-1.2	-0.9	-1.1	-0.9
Sweden	-3.3	-1.6	-3.0	-1.5	-2.4	-1.2	-3.3	-1.6	-3.0	-1.5	-2.7	-1.3	-2.3	-1.2
Belarus														
Czech Republic														
Ukraine														
Baltic Sea shipping	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4	-2.3	-0.4
North Sea Shipping	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6	-2.7	-0.6
Other countries	-3.8	-1.8	-3.7	-1.8	-3.9	-1.8	-3.5	-1.7	-3.5	-1.7	-4.3	-2.0	-4.3	-2.0

Waterborne net total nitrogen input has only decreased significantly since the reference period to 2020 from Czech Republic to Baltic Proper (26 %), of the remaining country basins there are either no significant changes or significant increases as e.g., Estonia (15%) and Lithuania (59%) to Gulf of Riga and Latvia (57%) and Lithuania (63%) to Baltic Proper (table 3.20). The annual increases per year since the reference period are very high amounting about 5 to 6 % per year to Baltic Proper for Latvia, Lithuania, and Ukraine and Lithuania to Gulf of Riga (table 3.20a and figures in Annex I).

Table 3.20 Changes in percentages in total annual normalized waterborne net nitrogen inputs country by basin from the reference period to 2020 and from 1995 to 2020, respectively. "– "no significant changes.

Waterborne TN	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark					-	-23					-	-25	-	-28
Estonia					-	-	-	-	15	49				
Finland	-	-	-	-	-		-	-22						
Germany					-	-					-	-27		
Latvia					57	-			-	-				
Lithuania					63	-			59	69				
Poland					-	-18								
Russia					-	-	-	-	-	-39				
Sweden	-	-26	-	-21	5	-					-	-	-	-22
Belarus					-	-			-	-26				
Czech Republic					-26	-50								
Ukraine					49	65								
Baltic Sea shipping														
North Sea Shipping														
Other countries														

Table 3.20a. As table 3.20 but changes expressed as percentages per year in the period.

Waterborne TN	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark					-	-0.9					-	-1.0	-	-1.1
Estonia					-	-	-	-	1.5	2.0				
Finland	-	-	-	-	-		-	-0.9						
Germany					-	-					-	-1.1		
Latvia					5.7	-			-	-				
Lithuania					6.3	-			5.9	2.8				
Poland					-	-0.7								
Russia					-	-	-	-	-	-1.6				
Sweden	-	-1.0	-	-0.8	0.5	-					-	-	-	-0.9
Belarus					-	-			-	-1.0				
Czech Republic					-2.6	-2.0								
Ukraine					4.9	2.6								
Baltic Sea shipping														
North Sea Shipping														
Other countries														

Waterborne net phosphorus inputs decreased significantly for most country basins both from 1995 to 2020 and since the reference period (table 3.21). Only for Ukraine there is an increase. For most countries to basins the reduction from 1995 to 2020 are higher (in percentages) than from since the reference period to 2020. But based on the annual changes in percentages we get the highest annual reductions in net waterborne total phosphorus inputs from since the reference period to 2020 (table 3.21a). There are some very high annual reductions since the reference period, higher than 4 % per year to Baltic Proper from Latvia, Lithuania, and Czech Republic, to Gulf of Finland from Estonia and Russia and to Gulf of Riga from Lithuania (as high as 9.7 % per year).

Table 3.21 Changes in percentages in normalized total annual net phosphorus inputs country by basin from the reference period to 2020 and from 1995 to 2020, respectively. "– "no significant changes.

Total TP	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark					-20	-57					-29	-54	-18	-24
Estonia					-26	-32	-45	-42	-18	-20				
Finland	-18	-19	-	-			-17	-21						
Germany					-	-35					-14	-26		
Latvia					-50	-57			-	-30				
Lithuania					-45	-45			-97	-97				
Poland					-22	-30								
Russia					-36	-	-54	-55	-24	-31				
Sweden	-	-	-37	-42	-14	-16					-20	-22	-	-14
Belarus					-13	-19			-	-				
Czech Republic					-41	-56								
Ukraine					29	31								

Table 3.21a. As table 3.18 but changes expressed as percentages per year in the period.

Total TP	Since ref. period BOB	Since 1995 BOB	Since ref. period BOS	Since 1995 BOS	Since ref. period BAP	Since 1995 BAP	Since ref. period GUF	Since 1995 GUF	Since ref. period GUR	Since 1995 GUR	Since ref. period DS	Since 1995 DS	Since ref. period KAT	Since 1995 KAT
Denmark					-2.0	-2.3					-2.9	-2.2	-1.8	-1.0
Estonia					-2.6	-1.3	-4.5	-1.7	-1.8	-0.8				
Finland	-1.8	-0.8	-	-			-1.7	-0.9						
Germany					-	-1.4					-1.4	-1.0		
Latvia					-5.0	-2.3			-	-1.2				
Lithuania					-4.5	-1.8			-9.7					
Poland					-2.2	-1.2								
Russia					-3.6	-	-5.4	-2.2	-2.4	-1.2				
Sweden	-	-	-3.7	-1.7	-1.4	-0.6					-2.0	-0.9	-	-0.6
Belarus					-1.3	-0.8			-	-				
Czech Republic					-4.1	-2.2								
Ukraine					2.9	1.2								

Sections of the timeseries pointing out recent changes

The significant changes in inputs of nitrogen and phosphorus, respectively, are also calculated for sections of the time series if they are significant. In tables 3.22, 3.23 and 3.24 these changes are shown for the first section and the last section of the time series, and in tables 3.22a, 3.23a and 3.24a as annual changes in percentages in the sections (overview of breakpoint years are in tables 3.13 and 3.15 (nitrogen) and 3.16 (phosphorus). If there is one break point e.g., in 2005 then the change in the first section is the change in annual net inputs from 1995 to 2005 estimated from the regression line from the trends analysis, and the last section is the changes from 2005 to 2020. In tables 3.22a, 3.23a and 3.24a the change is calculated as percentages per year in the section. If there are two break points e.g., in 2003 and in 2011, the first section represents then changes from 1995 to 2003 and last section changes from 2011 to 2020. Significant changes from 1995 to 2020 are also shown. In cases where there is a break point but there is no change in the first section, the changes are indicated with a zero. In cases with a break point and a jump in the trend, but no change either in the section before or after the breakpoint (as shown in example b in figure 2.1) then changes in the period are indicated with zero in the two sections, but with a change different from zero in the "since 1995" column as e.g., for Estonia to Gulf of Finland and Finland to BOS (table 3.22 and corresponding plots in Annex F). When comparing changes between section and change in the "Since 1995" column, it is important that in some time series there are more than one breakpoint, and in many time series there is a jump in the trend line between section and the time series. Therefore it is recommended to look at the plots of the time series in Annexes F, G and I to understand the changes country by basin. The number of years in the different sections varies from at least 5 years up to nearly 20 years. Using the changes calculated as percentage change per year in each section and from 1995 to 2020 (tables 3.22a and 3.23a) facilitates the comparison between the sections of how fast inputs are changing.

Table 3.22. Significant changes (in percentage) in normalized total annual net nitrogen (water+airborne) inputs for the first and the last section of the time series 1995-2020, where one or more breakpoints have been identified, and significant changes from 1995 to 2020. “0” indicates no significant changes in inputs in that specific section of the time series. If there is no breakpoint in the time series from 1995 to 2020 columns “first section” and “last section” are empty, and only the column “1995-2020” includes a number for significant change. Further explanation to the table in the text above table 3.22.

Country /basin	BOB First section	BOB Last Section	BOB 1995-2020	BOS First section	BOS Last Section	BOS 1995-2020	BAP First section	BAP Last Section	BAP 1995-2020	GUF First section	GUF Last Section	GUF 1995-2020	GUR First section	GUR Last Section	GUR 1995-2020	DS First section	DS Last Section	DS 1995-2020	KAT First section	KAT Last Section	KAT 1995-2020
Denmark	-28	-12	-59	-27	-11	-57	-24	1,4	-45	-27	-12	-57	-26	-11	-56	-36	12	-28	-29	0	-29
Estonia	-13	-27	-36	-8.5	-25	-31	16	-8.6	-11	0	0	-10	27	61	45	-14	-28	-38	-12	-26	-36
Finland	21	-9	0	0	0	-12	-15	-39	-51			-24	-15	-39	-51	-17	-42	-56	-17	-42	-55
Germany	-25	-21	-42	-24	-21	-42			-24	-24	-21	-41	-24	-21	-40			-27	-19	-19	-35
Latvia	-19	-17	-25	-19	-15	-22	-50	85	-8	-19	-13	-20			0	-19	-18	-25	-19	-16	-24
Lithuania	-18	0	-16	-17	0	-14	-30	82	-2	-17	0	-14			65	-18	0	-15	-7.2	0	-15
Poland	-25	-23	-36	-25	-23	-36	-28	-13	-27	-25	-23	-36	-24	-22	-35	-25	-23	-36	-25	-23	-36
Russia	-15	9.0	-22	-15	9.0	-22	0	-35	-29	64	0	24	-29	-10	-32	-14	8.5	-23	-15	9	-22
Sweden	0	-19	-26	0	-18	-22	-22	18	-8	-15	-19	-40	-14	-17	-37	-38	35	-16	-7.3	0	-22
Belarus									0				-25	32	-26						
Czech Republic							-42	-26	-50												
Ukraine									65												
Baltic Sea shipping	21	-12	-10	21	-12	-10	21	-12	-10	21	-12	-10	21	-12	-10	21	-12	-10	21	-12	-10
North Sea Shipping	20	-16	-16	20	-16	-16	20	-16	-16	20	-16	-16	20	-16	-16	20	-16	-16	20	-16	-16
Other countries	-15	-22	-45	-16	-21	-44	-15	-22	-46	-16	-20	-42	-16	-20	-43	-16	-25	-50	-15	-25	-49

For normalized total annual net nitrogen (water+airborne) inputs we get some extra and more specific information from tables 3.22 and 3.22a as compared with tables 3.18 and 3.18a when assessing changes for e.g., Baltic Sea and North Sea shipping where there is an *increase* in nitrogen (atmospheric) inputs in the *first* section (which for all basins covers the period 1995 to 2000) where information on the total change since 1995 to 2020 or since reference period to 2020 indicate a decrease. Further, there are some high annual increases (percentages per year) in the *last* section to Baltic Proper for Latvia (4.5 % per year) and Lithuania (6.8 % per year) and for Estonia to Gulf of Riga (5.6 % per year) (table 3.22a). There are further some countries with annual increases in last section in the range of 1 to 3% e.g., Denmark and Sweden to Danish Straits.

Table 3.22a. As table 3.22 but changes expressed as percentages per year in the period.

Country/ basin	BOB First section	BOB Last Section	BOB 1995-2020	BOS First section	BOS Last Section	BOS 1995-2020	BAP First section	BAP Last Section	BAP 1995-2020	GUF First section	GUF Last Section	GUF 1995-2020	GUR First section	GUR Last Section	GUR 1995-2020	DS First section	DS Last Section	DS 1995-2020	KAT First section	KAT Last Section	KAT 1995-2020
Denmark	-3.4	-1.8	-2.3	-3.4	-1.6	-2.3	-3.0	0.2	-1.8	-3.4	-1.7	-2.3	-3.3	-1.5	-2.2	-2.3	1.4	-1.1	-1.8	0.0	-1.2
Estonia	-0.7	-3.8	-1.4	-0.5	-3.5	-1.2	1.6	-0.6	-0.4	0.0	0.0	-0.4	2.0	5.6	1.8	-0.8	-3.9	-1.5	-0.7	-3.8	-1.4
Finland	1.8	-0.7	0.0	0.0	0.0	-0.5	-1.2	-3.0	-2.0			-0.9	-1.2	-3.0	-2.0	-1.5	-3.3	-2.2	-1.4	-3.2	-2.2
Germany	-1.7	-5.3	-1.7	-1.6	-5.2	-1.7			-1.0	-1.6	-5.2	-1.7	-1.6	-5.2	-1.6			-1.1	-1.3	-4.8	-1.4
Latvia	-3.2	-0.9	-1.0	-3.1	-0.8	-0.9	-8.4	4.5	-0.3	-3.1	-0.7	-0.8			0.0	-3.2	-0.9	-1.0	-3.1	-0.9	-0.9
Lithuania	-1.8	0.0	-0.6	-1.7	0.0	-0.6	-5.0	6.8	-0.1	-1.7	0.0	-0.6			2.6	-1.8	0.0	-0.6	-0.7	0.0	-0.6
Poland	-2.5	-1.6	-1.5	-2.5	-1.5	-1.4	-4.0	-0.7	-1.1	-2.5	-1.5	-1.4	-2.4	-1.5	-1.4	-2.5	-1.6	-1.5	-2.5	-1.5	-1.4
Russia	-2.9	0.8	-0.9	-3.0	0.8	-0.9	0.0	-3.9	-1.2	7.1	0.0	1.0	-3.2	-0.6	-1.3	-2.9	0.8	-0.9	-2.9	0.8	-0.9
Sweden	0.0	-1.4	-1.0	0.0	-1.4	-0.9	-1.2	2.6	-0.3	-2.2	-1.7	-1.6	-2.0	-1.5	-1.5	-3.1	2.7	-0.6	-0.5	0.0	-0.9
Belarus									0.0				-1.7	3.2	-1.0						
Czech Republic							-6.0	-1.5	-2.0												
Ukraine									2.6												
Baltic Sea shipping	4.2	-1.0	-0.4	4.2	-1.0	-0.4	4.2	-1.0	-0.4	4.2	-1.0	-0.4	4.2	-1.0	-0.4	4.2	-1.0	-0.4	4.2	-1.0	-0.4
North Sea Shipping	3.9	-1.3	-0.6	3.9	-1.3	-0.6	3.9	-1.3	-0.6	3.9	-1.3	-0.6	3.9	-1.3	-0.6	3.9	-1.3	-0.6	3.9	-1.3	-0.6
Other countries	-2.2	-2.0	-1.8	-2.2	-2.0	-1.8	-2.2	-2.0	-1.8	-2.4	-1.8	-1.7	-2.3	-1.8	-1.7	-2.3	-2.2	-2.0	-2.2	-2.2	-2.0

Table 3.23. Significant changes (in percentage) in normalized annual net waterborne total nitrogen inputs for the first and the last section of the time series 1995-2020, where one or more breakpoints have been identified, and significant changes from 1995 to 2020. “0” indicates no significant changes in inputs in that specific section of the time series. If there is no breakpoint in the time series from 1995 to 2020 columns “first section” and “last section” are empty, and only the column “1995-2020” includes a number for significant change. Further explanation to the table in the text above table 3.22.

Country/ basin	BOB First section	BOB Last section	BOB 1995-2020	BOS First section	BOS Last section	BOS 1995-2020	BAP First section	BAP Last section	BAP 1995-2020	GUF First section	GUF Last section	GUF 1995-2020	GUR First section	GUR Last section	GUR 1995-2020	DS First section	DS Last section	DS 1995-2020	KAT First section	KAT Last section	KAT 1995-2020
Denmark							-24	49	-23							-32	22	-25	-19	-5	-28
Estonia							34	0	-3			-13	50	38	49						
Finland	22	-5	2	0	0	-11						-22									
Germany									0							-13	0	-27			
Latvia							-55	107	-7				-27	0	-14						
Lithuania							-31	158	-4						69						
Poland									-18												
Russia							0	-54	-50	64	0	30	-42	-17	-39						
Sweden	0	-18	-26	0	-17	-21	-17	34	-1							-17	30	-19	-7.0	0	-22
Belarus									0				-25	32	-26						
Czech Republic							-42	-26	-50												
Ukraine									65												
Baltic Sea shipping																					
North Sea Shipping																					
Other countries																					

The increased nitrogen inputs in the last section of the time series becomes even more obvious considering the net waterborne nitrogen inputs (tables 3.23 and 3.23a). There is a significant increase in normalized annual net waterborne total nitrogen inputs to Baltic Proper from Denmark, Latvia, Lithuania, Sweden, to Gulf of Riga from Estonia and Belarus, and to Danish Straits from Denmark and Sweden. Ukraine has a steady increase since 1995 with 65 % in their total nitrogen inputs to the Baltic Proper. The annual percentages increase is very high to Baltic Proper from Lithuania (8.3% per year since 2001), Latvia (5.6% per year since 2001) and Denmark (5.4% per year since 2011), while the corresponding inputs from Russia decreased markedly (9.1% per year since 2014).

Table 3.23a. As table 3.23 but changes expressed as percentages per year in the period.

Country/ basin	BOB First section	BOB Last section	BOB 1995-2020	BOS First section	BOS Last section	BOS 1995-2020	BAP First section	BAP Last section	BAP 1995-2020	GUF First section	GUF Last section	GUF 1995-2020	GUR First section	GUR Last section	GUR 1995-2020	DS First section	DS Last section	DS 1995-2020	KAT First section	KAT Last section	KAT 1995-2020
Denmark							-3.0	5.4	-0.9							-2.0	2.4	-1.0	-1.6	-0.4	-1.1
Estonia							3.4	0.0	-0.1			-0.5	5.0	2.5	2.0						
Finland	1.7	-0.4	0.1	0.0	0.0	-0.4						-0.9									
Germany									0.0							-0.8	0.0	-1.1			
Latvia							-9.2	5.6	-0.3				-2.5	0.0	-0.6						
Lithuania							-5.2	8.3	-0.2						2.8						
Poland									-0.7												
Russia							0.0	-9.1	-2.0	6.4	0.0	1.2	-6.0	-0.9	-1.6						
Sweden	0.0	-1.4	-1.0	0.0	-1.3	-0.8	-1.0	4.2	0.0							-2.5	1.7	-0.8	-0.5	0.0	-0.9
Belarus									0.0				-1.7	3.2	-1.0						
Czech Republic							-6.0	-1.5	-2.0												
Ukraine									2.6												
Baltic Sea shipping																					
North Sea Shipping																					
Other countries																					

Normalized annual net waterborne total phosphorus inputs decreased significantly since 1995 to 2020 for all country basins besides Ukraine to Baltic Proper (increase with 31%) (table 3.24). For time series with breakpoints no significant increases are assessed in the last section but on the other hand for rather many country basins there are no trends in the last section: to Baltic Proper for Denmark, Lithuania, Sweden, Belarus and Czech Republic; to Gulf of Finland from Estonia and Russia; to Gulf of Riga from Estonia; to Danish Straits from Sweden and to Kattegat from Sweden, indicating that the reduction of waterborne phosphorus inputs have ceased in recent years from many countries to some of the basins. As for waterborne nitrogen there is a marked reduction in the last section in waterborne phosphorus inputs from Russia to the Gulf of Finland. The percentage change per year (table 3.24a) is very high (8.0% per year since 2012) from Russia to Baltic Proper. The highest percentage changes per year are in most cases in the first section, indicating that many countries had their measures implemented in the early part of the 1995-2020 time series, e.g., major investments in wastewater treatment plants. For some countries these efforts took place before 1995.

Table 3.24. Significant changes (in percentage) in normalized annual net waterborne total phosphorus inputs for the first and the last section of the time series 1995-2020, where one or more breakpoints have been identified, and significant changes from 1995 to 2020. "0" indicates no significant changes in inputs in that specific section of the time series. If there is no breakpoint in the time series from 1995 to 2020 columns, "first section" and "last section" are empty, and only the column "1995-2020" includes a number for significant change. Further explanation to the table in the text above table 3.22.

Country/ basin	BOB First section	BOB Last Section	BOB 1995-2020	BOS First section	BOS Last Section	BOS 1995-2020	BAP First section	BAP Last Section	BAP 1995-2020	GUF First section	GUF Last Section	GUF 1995-2020	GUR First section	GUR Last Section	GUR 1995-2020	DS First section	DS Last Section	DS 1995-2020	KAT First section	KAT Last Section	KAT 1995-2020
Denmark							-55	0	-57							-42	-26	-54	-15	-8.3	-24
Estonia									-32	0	0	-42	0	0	-20						
Finland			-19			0						-21									
Germany							-32	-19	-35							-28	-13	-26			
Latvia									-57						-30						
Lithuania							0	0	-45						-97						
Poland									-30												
Russia							0	-56	-44	0	0	-55			-31						
Sweden	-15	-17	-29			-42	-17	0	-16							-22	0	-22	0	0	-14
Belarus							0	0	-19						0						
Czech Republic							-21	0	-56												
Ukraine									31												

Table 3.24a. As table 3.24 but changes expressed as percentages per year in the period.

Country/ basin	BOB First section	BOB Last section	BOB 1995-2020	BOS First section	BOS Last section	BOS 1995-2020	BAP First section	BAP Last section	BAP 1995-2020	GUF First section	GUF Last section	GUF 1995-2020	GUR First section	GUR Last section	GUR 1995-2020	DS First section	DS Last section	DS 1995-2020	KAT First section	KAT Last section	KAT 1995-2020
Denmark							-11.0	0.0	-2.3							-7.1	-2.2	-2.2	-2.1	-0.5	-1.0
Estonia									-1.3	0.0	0.0	-1.7	0.0	0.0	-0.8						
Finland			-0.8			0.0						-0.9									
Germany							-3.9	-1.1	-1.4							-2.6	-0.9	-1.0			
Latvia									-2.3						-1.2						
Lithuania							0.0	0.0	-1.8						-3.9						
Poland									-1.2												
Russia							0.0	-8.0	-1.7	0.0	0.0	-2.2			-1.2						
Sweden	-1.1	-1.4	-1.2			-1.7	-1.0	0.0	-0.6							-1.7	0.0	-0.9	0.0	0.0	-0.6
Belarus							0.0	0.0	-0.8						0.0						
Czech Republic							-3.6	0.0	-2.2												
Ukraine									1.2												

3.8 Special case: Assessing NIC for Archipelago Sea

Finland has requested an assessment of NIC for the Archipelago Sea (ARC) separately. Data reported to PLC-water are assigned to 9 sub-basins and EMEP calculates deposition to these 9 sub-basins and among those is the Archipelago Sea, while assessments including the one for MAI and NIC aggregate to 7 basins[2]. Thus, Bothnian Sea (BOS) MAI and NIC in the BSAP includes the Archipelago Sea. In annex C we describe how NIC and reference inputs are established for Archipelago Sea and the rest of Bothnian Sea. In this sub-chapter we provide assessment result for ARC and the remaining part of BOS.

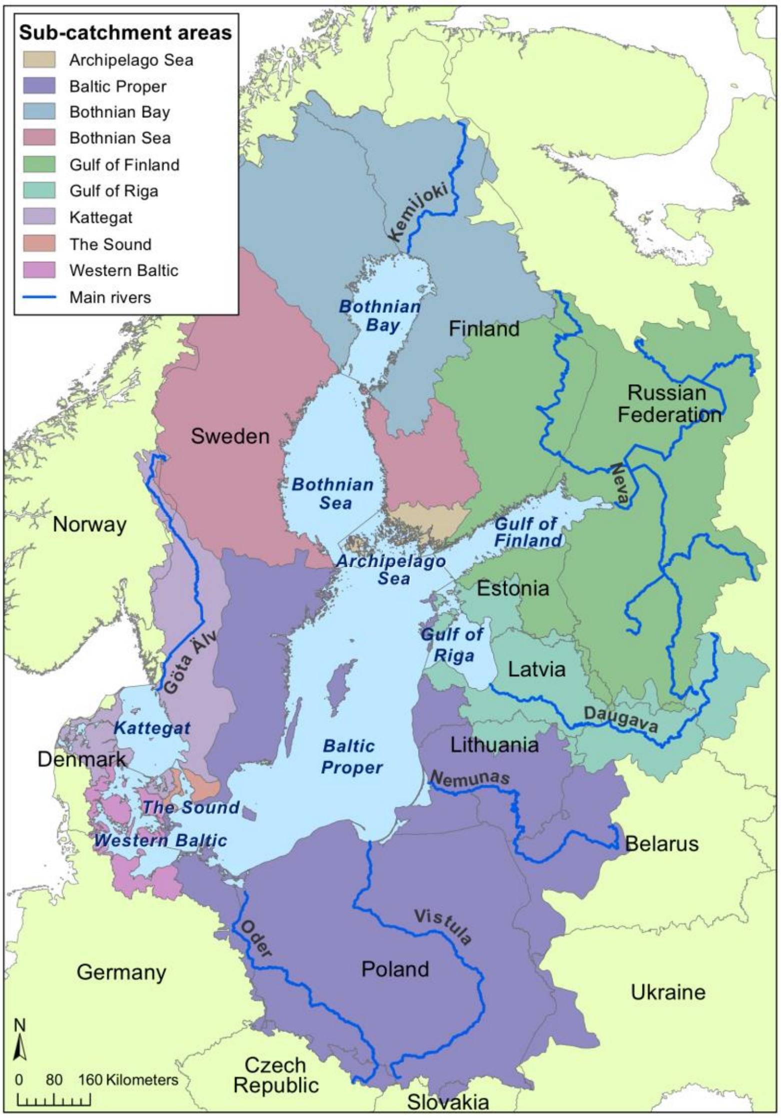


Figure 3.7. Sub-basin definitions of the PLC-water data base showing the borders of the Archipelago Sea sub-basin.

[2] The basins in PLC-water are Bothnian Bay (BOB), Bothnian Sea (BOS), Archipelago Sea (ARC), Baltic Proper (BAP), Gulf of Finland (GUF), Gulf of Riga (GUR), Western Baltic (WEB), the Sound (SOU) and Kattegat (KAT). In assessments, Danish Straits (DS) is the sum of WEB and SOU, and Bothnian Sea (BOS) is the sum of Bothnian Sea (BOS) and Archipelago Sea (ARC). That Bothnian Sea is used with two definitions is utterly confusing, but difficult to change.

The normalized total annual (sum of air and waterborne) nitrogen inputs time series from Finland to ARC (figure 3.8) have a breakpoint in 2008 and the corresponding time series to the remaining part of BOS without ARC in 2007 (as is the case for total BOS). The time series to ARC have no trend before and after the break point in 2008. For the remaining BOS there is a significant increase in total nitrogen inputs from 1995 to 2008 with 24 %, and after the breakpoint no trend and therefore no change in inputs.

The total nitrogen inputs decrease with 15% from 1995 to 2020 to ARC but there is no decrease for the remaining BOS. Total nitrogen inputs decrease from reference period to 2020 with 15% to ARC, but there is no significant decrease for the remaining BOS.

Total normalized annual phosphorus input time series to ARC have a break point in 2011, and the corresponding time series for the remaining part of BOS has no break points (figure 3.8). Total phosphorus inputs to ARC decrease with 27 % from 1995 to 2011, and thereafter constant, while the inputs are constant during 1995-2020 to the remaining BOS.

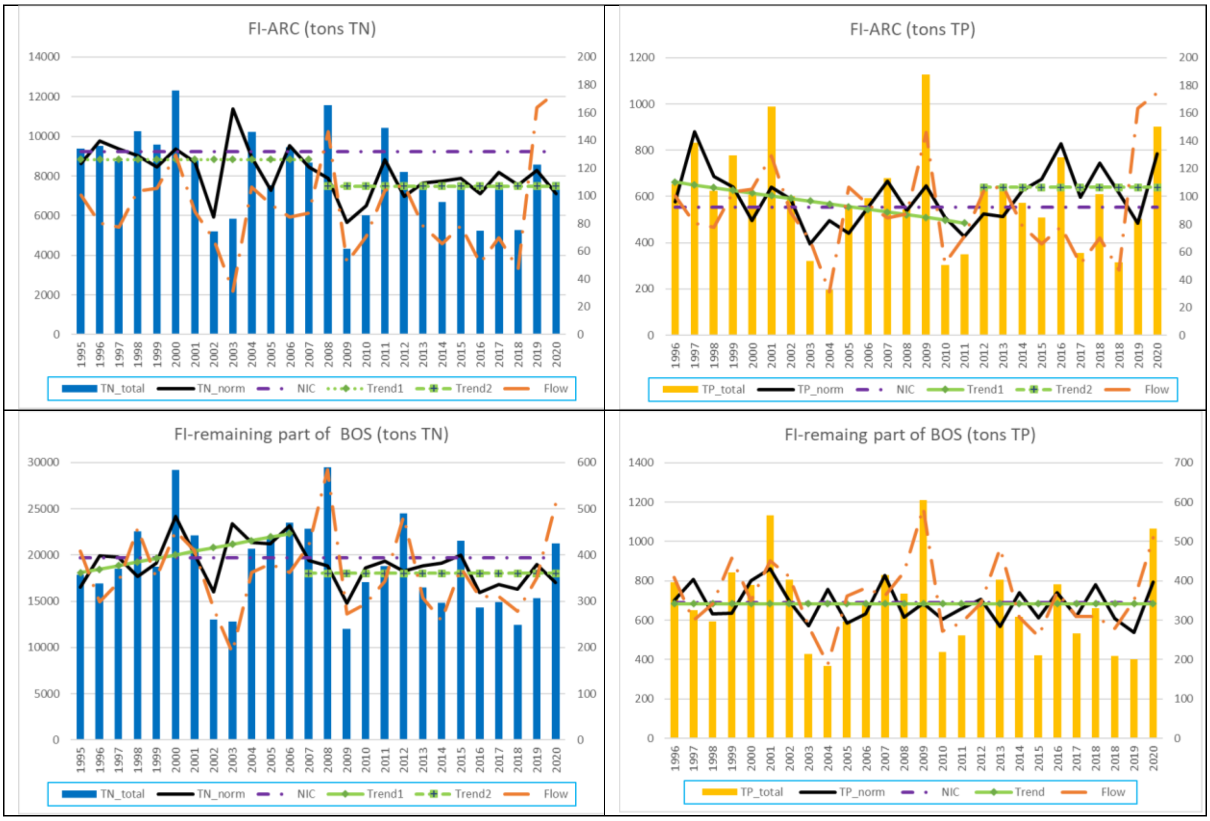


Figure 3.8. Total annual (sum of air and waterborne) nitrogen (left) and total phosphorus inputs (right) to Archipelago Sea – ARC (upper row) and remaining part of Bothnian Sea BOC-ARC (lower row) from Finland. For the corresponding normalized inputs, flow, NIC and trends – see explanation in caption to e.g., figure 3.1. Plots for the undivided Bothnian See are in annexes F to J.

NIC are fulfilled for total nitrogen NIC to ARC and the remaining part of BOS, as it is for the undivided BOS (table 3.25). As input data to the undivided BOS is a sum of independent time series of inputs to ARC and the remaining part of BOS, respectively, and statistical analysis are done separately for ARC, remaining part of BOS and the undivided BOS it is not likely that summing up remaining and/or extra reductions for ARC and the remaining part of BOS equals the remaining and/or extra reductions in the undivided BOS. Extra reduction for ARC plus the remaining part of BOS is 1,221 tonnes + 773 tonnes TN = 1,994 tonnes TN where analysis on the undivided BOS results in 1,783 tonnes TN. The main differences are related to the estimated inputs in 2020, where these inputs are estimated on two individual time series when ARC and remaining part of BOS are assessed separately, but it provides a more certain estimate on the progress towards NIC for ARC than just estimating a proportion of the assessment of an undivided BOS to estimate status for ARC.

For total phosphorus the NIC are not fulfilled for the undivided BOS (remaining 100 tonnes TP), or ARC (remaining 147 tonnes TP) and remaining part of BOS (remaining 23 tonnes TP) (table 3.26). The analysis shows that the main share of the remaining reduction need on total phosphorus is to the Archipelago Sea – and by dividing BOS in ARC and the remaining part of BOS we get at better estimate on the remining reduction requirements in these basins.

Table 3.25. Assessment of fulfilment of total nitrogen NIC to Archipelago (ARC) and remaining part of Bothnian Sea by 2020 for Finland – se caption to table 3.4 for further explanation.

Finland TN	ARC	Remaining part of BOS	Undivided BOS
A : Input ceiling (NIC BSAP2021 update)	9223	19685	28700
B: Estimated input 2020	7490	18023	25581
C: Inputs 2020 including uncertainty (test value)	8002	18912	26917
Extra reduction by 2020 (A-C)	1221	773	1783
Remaining reduction to fulfill NIC by 2020			
Remaining in % of ceiling			

Table 3.25. Assessment of fulfilment of total phosphorus NIC to Archipelago (ARC) and remaining part of Bothnian Sea by 2020 for Finland – se caption to table 3.8 for further explanation.

Finland TP	ARC	Remaining part of BOS	Undivided BOS
A : Input ceiling (NIC BSAP2021 update)	554	691	1246
B: Estimated input 2020	639	684	1283
C: Inputs 2020 including uncertainty (test value)	701	714	1346
Extra reduction by 2020 (A-C)	0	0	
Remaining reduction to fulfill NIC by 2020	147	23	100
Remaining in % of ceiling	26	3	8

4. Fulfilment of NIC and nutrient sources

To facilitate the follow-up on progress towards NIC in 2020 and how to respond on remaining reduction requirements, we combine the status of fulfilling NIC with the results of the latest source apportionment assessment from PLC-7 project (HELCOM, 2022b) to indicate the main sources of nitrogen and phosphorus for each country basin.

All countries provided total air- and waterborne nitrogen and waterborne phosphorus sources on a rather aggregated level, as shown in tables 4.1 and 4.2. Five countries provide more detailed sources for these inputs, as shown in tables 4.3. and 4.4. The remaining reduction in percentages is calculated as the remaining reduction (in tonnes) divided with input in 2020.

To illustrate how the tables can be used: Sweden to Baltic Proper remains to reduce with 9,762 tonnes TN or 25% of the estimated inputs in 2020 (table 4.1). Natural sources constitute more than 1/3 of the inputs and can in principle not be reduced by implementing measures. Point sources (both inland and discharging directly into the sea) constitute 14 % or about 5,000 tonnes TN, so even removing that source is not enough, therefore measures to reduction from diffuse sources and the atmospheric deposition on the Baltic Proper will be necessary to fulfil TN NIC to BAP.

For Germany to Baltic Proper remains 219 tonnes TP or 53% of the estimated input in 2020 (table 4.2). Natural background sources cannot be reduced. Point sources (indirect and direct) constitute about 20% of the load or approx. 80 tonnes TP in 2020, and therefore it is necessary to apply measures reducing diffuse source loads to fulfil TP NIC to BAP.

In tables 4.3 and 4.4 a more detailed source apportionment reveals that besides natural background losses, agriculture (24%) and atmospheric deposition on the Baltic Proper (21%) and direct input for municipal wastewater treatment plants (10%) are the main sources of total nitrogen inputs from Sweden to the Baltic Sea (table 4.3). Much of the atmospheric deposition origins from agricultural sources. For Germany to the Baltic Sea the main sources of total nitrogen are agriculture (38%), inputs from scattered dwellings (20%) and municipal wastewater treatment plants into inland waters (17%).

For basins with still high remaining reduction of both nitrogen and phosphorus compared with the 2020 inputs, removing inputs from wastewater sources (municipal wastewater treatment plants, industry, aquaculture, scattered dwellings and storms waters) are not sufficient to fulfil NIC. A substantial part of the reduction is needed on agricultural sources to fulfil NIC. For phosphorus a higher share might be obtained with reducing wastewater sources as compared with nitrogen.

Table 4.1. Results of NIC assessment for total nitrogen (TN) from table 3.4 (taking into account extra reduction in neighboring basins) combined with result of the PLC-7 source apportionment assessment (load-oriented approach in HELCOM 2022b) for main sources shown for each of the nine HELCOM Contracting Parties. "Input 2020" is the estimated inputs from table 3.4. NBL = natural background load, diff-other = other diffuse waterborne sources, Tot PS = points sources (from wastewater treatment plans, industrial plants with separate discharges and aquaculture plants) discharging both to inland freshwaters and directly into the sea, ATM = atmospheric deposition on the sea. Importance of sources given in percentages of total water + airborne inputs.

Denmark	TN NIC assesment	Remain tonnes	Remain % 2020 input	TN Input 2020	Main TN sources NBL %	Diff-other %	Tot PS %	ATM %
BOB	↓	0	0	155				100
BOS	↓	0	0	628				100
BAP	↓	0	0	8026	4.0	19	0.6	76
GUF	↓	0	0	272				100
GUR	↓	0	0	254				100
DS	↓	0	0	23597	15	57	11	17
KAT	↓	0	0	25280	16	63	3.7	17

Estonia	TN NIC assessment	Remain tonnes	Remain % 2020 input	TN Input 2020	Main TN sources NBL %	Diff-other %	Tot PS %	ATM %
BOB	↓	0	0	82				100
BOS	↓	0	0	288				100
BAP	↓	191	13	1518	32	24	0,0	44
GUF	↓	1392	12	12219	28	61	4.2	.,5
GUR	↑	4473	28	16047	29	69	0.4	1.4
DS	↓	0	0	14				100
KAT	↓	0	0	17				100

Finland	TN NIC assessment	Remain tonnes	Remain % 2020 input	TN Input 2020	Main TN sources NBL %	Diff-other %	Tot PS %	ATM %
BOB	↓	326	1.0	34298	49	35	12	4.4
BOS	↓	0	0	25581	27	52	12	9.0
BAP	↓	0	0	1237				100
GUF	↓	858	4.2	20293	30	50	16	3.5
GUR	↓	0	0	159				100
DS	↓	0	0	35				100
KAT	↓	0	0	46				100

Germany	TN NIC assesment	Remain tonnes	Remain % 2020 input	TN Input 2020	Main TN sources NBL %	Diff-other %	Tot PS %	ATM %
BOB	↓	0	0	628				100
BOS	↓	0	0	2502				100
BAP	↓	847	2.4	34778	1.3	27	2.4	69
GUF	↓	0	0	1263				100
GUR	↓	0	0	1112				100
DS	↓	0	0	18134	1.5	52	8.5	38
KAT	↓	0	0	3487				100

Latvia	TN NIC assesment	Remain tons	Remain % 2020 input	TN Input 2020	Main TN sources NBL %	Diff-other* %	Tot PS %	ATM %
BOB	↓	0	0	71				100
BOS	↓	0	0	308				100
BAP	↑	6780	57	11955	5.2	89	0.5	5.3
GUF	↓	35	13	277				100
GUR		1328	3.2	41735	4.7	94	1.0	0.6
DS	↓	0	0	27				100
KAT	↓	0	0	32				100

*Transboundary inputs have been deducted before making source apportionment

Lithuania	TN NIC assesment	Remain tonnes	Remain % 2020 input	TN Input 2020	Main TN sources NBL %	Diff-other* %	Tot PS %	ATM %
BOB		9	8.3	114				100
BOS		22	4.4	503				100
BAP	↑	31807	61	51857	16	78	2.9	3.0
GUF		68	19	363				100
GUR	↑	5476	43	12868	15	82	1.2	2.2
DS		0	0	62				100
KAT		3	4.1	82				100

*Transboundary inputs have been deducted before making source apportionment

Poland	TN NIC assesment	Remain tonnes	Remain % 2020 input	TN Input 2020	NBL %	Main TN sources Diff-other %	Tot PS %	ATM %
BOB	↓	0	0	556				100
BOS	↓	0	0	2468				100
BAP		30245	18	170361	4.9	65	15	15
GUF	↓	0	0	1317				100
GUR	↓	0	0	1248				100
DS	↓	0	0	1125				100
KAT	↓	0	0	1210				100

Russia	TN NIC assessment	Remain tonnes	Remain % 2020 input	TN Input 2020	NBL %	Main TN sources Diff-other %	Tot PS %	ATM %
BOB	↓	22	2.6	854				100
BOS	↓	0	0	1,918				100
BAP	↓	933	10	9712	15	28	17	39
GUF		16960	23	72640	42	37	18	3.0
GUR	↓	0	0	2775				100
DS	↓	0	0	210				100
KAT	↓	0	0	238				100

Sweden	TN NIC assesment	Remain tonnes	Remain % 2020 input	TN Input 2020	NBL %	Main TN sources Diff-other %	Tot PS %	ATM %
BOB	↓	0	0	13859	75	7.5	14	3.9
BOS	↓	0	0	25800	57	12	23	7.7
BAP		9762	25	38523	36	29	14	21
GUF	↓	0	0	509				100
GUR	↓	0	0	366				100
DS		43	0.7	6053	31	50	17	1.9
KAT	↓	0	0	28257	46	38	13	3.4

Table 4.2. Results of NIC assessment for total phosphorus (TP) from table 3.8 (taking into account extra reduction in neighboring basins) combined with result of the PLC-7 source apportionment assessment (load-oriented approach in HELCOM 2022b) for main sources shown for each of the nine HELCOM Contracting Parties. "Input 2020" is the estimated inputs from table 3.8. NBL = natural background load, diff-other = other diffuse waterborne sources, Tot PS = points sources (from wastewater treatment plans, industrial plants with separate discharges and aquaculture plants) discharging both to inland freshwaters and directly into the sea. Importance of sources given in percentages of total waterborne inputs.

					Main TP sources		
Denmark	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	NBL %	Diff-other %	Tot PS %
BOB							
BOS							
BAP	↓	0	0	44	16	74	10
GUF							
GUR							
DS	↓	0	0	643	22	41	37
KAT	↓	0	0	683	41	46	14

					Main TP sources		
Estonia	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	NBL %	Diff-other %	Tot PS %
BOB							
BOS							
BAP	↓	11	63	17	67	33	0.0
GUF	↓	88	31	281	32	61	6.9
GUR	↓	67	29	233	36	63	1.2
DS							
KAT							

					Main TP sources		
Finland	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	NBL %	Diff-other %	Tot PS %
BOB	↓	0	0	1483	45	51	4
BOS		85	6.6	1283	15	78	7.7
BAP							
GUF	↓	338	55	610	16	73	11
GUR							
DS							
KAT							

Germany	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources NBL %	Diff-other %	Tot PS %
BOB							
BOS							
BAP		219	53	414	13	67	20
GUF							
GUR							
DS	↓	0	0	302	7.8	73	20
KAT							

Latvia	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources NBL %	Diff-other %	Tot PS %
BOB							
BOS							
BAP	↓	111	52	214	9.8	88	2.6
GUF							
GUR		255	21	1198	5.7	90	4.1
DS							
KAT							

*Transboundary inputs have been deducted before making source apportionment

Lithuania	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources NBL %	Diff-other %	Tot PS %
BOB							
BOS							
BAP	↓	322	32	991	15	76	8.5
GUF							
GUR	↓	0	0	7.3	15	77	7.7
DS							
KAT							

*Transboundary inputs have been deducted before making source apportionment

Poland	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	NBL %	Main TP sources Diff-other %	Tot PS %
BOB							
BOS							
BAP	↓	4766	58	8167	5.0	68	27
GUF							
GUR							
DS							
KAT							

Russia	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	NBL %	Main TP sources Diff-other %	Tot PS %
BOB							
BOS							
BAP	↓	365	89	410	19	31	50
GUF	↓	1010	33	3092	39	35	26
GUR	↓	25	24	106	0	100	0
DS							
KAT							

Sweden	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	NBL %	MainTP sources Diff-other %	Tot PS %
BOB		0	0	728	82	12	6.9
BOS	↓	0	0	729	54	21	25
BAP	↓	186	26	706	28	51	21
GUF							
GUR							
DS	↓	0	0	88	18	52	30
KAT		0	0	679	36	50	14

Table 4.3. As table 4.1 (total nitrogen inputs) but compared with a more detailed source apportionment for five HELCOM Contracting Parties with more detailed information. AGL = agricultural loads, ATL = atmospheric inputs on inland surface waters, MFL = managed forestry (not in all countries), NBL = natural background load, SCL= scattered dwelling load, SWL = storm water loads, AQL = aquaculture load, INL = industrial loads, MWL = municipal wastewater, ATM = atmospheric deposition on the sea. Indir = discharging into inland waters, Dir = discharging directly into the sea. Importance of sources given in percentages of total water + airborne inputs.

				TN	Main TN sources												
Denmark	TN NIC assesment	Remain tonnes	Remain % 2020 input	Input 2020	Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL	Dir ATM
BOB	↓	0	0	155													100
BOS	↓	0	0	628													100
BAP	↓	0	0	8026	19	0.1		4.0	0.5	0.2	0.0	0.0	0.2	0.0	0.0	0.4	76
GUF	↓	0	0	272													100
GUR	↓	0	0	254													100
DS	↓	0	0	23597	54	0.82		15	1.00	2.0	0.23	0.016	2.2	1.5	0.37	6.3	17
KAT	↓	0	0	25280	61	0.86		16	0.45	0.71	0.46	0.36	1.1	0.002	0.07	1.7	17

				TN	Main TN sources												
Finland	TN NIC assesment	Remain tonnes	Remain % 2020 input	Input 2020	Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL	Dir ATM
BOB	↓	326	1.0	34298	25	4.4	3.4	49	1.4	0.12	0.10	0.97	3.2	0.051	3.1	4.5	4.4
BOS	↓	0	0	25581	44	2.7	2.0	27	2.3	0.27	0.0048	0.45	6.2	2.0	1.1	2.8	9.0
BAP	↓	0	0	1237													100
GUF	↓	858	4.2	20293	32	12.5	2.6	30	2.5	0.33	0.097	3.0	6.8	0.13	0.69	5.6	3.5
GUR	↓	0	0	159													100
DS	↓	0	0	35													100
KAT	↓	0	0	46													100

Germany	TN NIC assesment	Remain tonnes	Remain % 2020 input	TN Input 2020	Main TN sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL	Dir ATM
BOB	↓	0	0	628													100
BOS	↓	0	0	2502													100
BAP	↓	847	2.4	34778	22	3.9		1.3	0.20	0.91		0.36	1.6	0	0.028	0.43	69
GUF	↓	0	0	1263													100
GUR	↓	0	0	1112													100
DS	↓	0	0	18134	48	2.1		1.5	0.20	2.1		0	5.0	0	0.12	3.4	38
KAT	↓	0	0	3487													100

Poland	TN NIC assesment	Remain tons	Remain % 2020 input	TN Input 2020	Main TN sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL	Dir ATM
BOB	↓	0	0	556													100
BOS	↓	0	0	2468													100
BAP		30245	18	170361	57	1.8	1.4	4.9	3.6	0.88	0.79	3.0	11	0	0.001	0.38	15
GUF	↓	0	0	1317													100
GUR	↓	0	0	1248													100
DS	↓	0	0	1125													100
KAT	↓	0	0	1210													100

Sweden	TN NIC assesment	TN Remain tonnes	Remain % 2020 input	Input 2020	Main TN sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL	Dir ATM
BOB	↓	0	0	13859	2.8	2.2	1.9	75	0.57	0.002	0.009	3.8	4.1	0.028	1.8	3.9	3.9
BOS	↓	0	0	25800	4.7	3.7	2.3	57	1.6	0.12	0.89	1.1	7.6	0.37	4.3	8.3	7.8
BAP		9762	25	38523	24	1.6	0.48	36	2.0	0.27	0.001	0.31	3.2	0.004	0.89	9.9	21
GUF	↓	0	0	509													100
GUR	↓	0	0	366													100
DS		43	0.7	6053	49	0.20	0.048	31	0.99	0.52	0	0.85	3.2	0.084	0.16	13	1.9
KAT	↓	0	0	28257	27	7.8	0.71	46	2.0	0.88	0.18	1.2	5.4	0	0.43	5.4	3.4

Table 4.4. As table 4.2 (total phosphorus inputs) but compared with a more detailed source apportionment for five HELCOM Contracting Parties with more detailed information. AGL = agricultural loads, ATL = atmospheric inputs on inland surface waters, MFL = managed forestry (not in all countries), NBL = natural background load, SCL= scattered dwelling load, SWL = storm water loads, AQL = aquaculture load, INL = industrial loads, MWL = municipal wastewater, ATM = atmospheric deposition on the sea. Indir = discharging into inland waters, Dir = discharging directly into the sea. Importance of sources given in percentages of total waterborne inputs.

Denmark	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL
BOB																
BOS																
BAP	↓	0	0	44	49	0.1		16	18	6.7	0	0.071	5.0	0	0.094	5.0
GUF																
GUR																
DS	↓	0	0	643	14	0.13		22	8.6	18	0.91	0.083	8.1	4.6	0.82	23
KAT	↓	0	0	683	33	0.16		41	4.5	8.0	1.7	1.06	4.9	0.01	0.21	5.8

Finland	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL
BOB	↓	0	0	1483	36	2.82	5.93	45	6.35	0.07	0.23	0.64	0.66	0.12	2.19	0.61
BOS		85	6.6	1283	66	0.84	2.1	15	8.4	0.094	0.005	0.82	1.2	3.9	1.1	0.65
BAP																
GUF	↓	338	107	610	55	4.1	2.4	16	11	0.16	0.12	2.4	1.6	0.43	1.8	4.8
GUR																
DS																
KAT																

Germany	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL
BOB																
BOS																
BAP		219	53	414	38	6.4		13	2.6	20	0	0	17	0	0.25	2.3
GUF																
GUR																
DS	↓	0	0	302	50	2.1		7.8	1.3	19	0	0	16	0	0.078	3.7
KAT																

Poland	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL
BOB																
BOS																
BAP	↓	4766	58	8167	60	1.0	1.5	5.0	2.8	1.8	2.0	1.5	23	0	0.28	0.45
GUF																
GUR																
DS																
KAT																

Sweden	TP NIC assesment	Remain tonnes	Remain % 2020 input	TP Input 2020	Main TP sources Indir AGL	Indir ATL	Indir MFL	Indir NBL	Indir SCL	Indir SWL	Indir AQL	Indir INL	Indir MWL	Dir AQL	Dir INL	Dir MWL
BOB		0	0	728	3.7	4.1	0.62	82	1.8	1.3	0.07	0.20	1.1	0.19	4.6	0.73
BOS	↓	0	0	729	9.8	3.6	0.65	54	4.4	2.3	2.7	0.33	2.1	1.2	16	2.7
BAP	↓	186	26	706	33	1.4	0.24	28	9.5	6.5	0.011	0.56	2.5	0.029	5.5	12
GUF																
GUR																
DS	↓	0	0	88	33	0.10	0.031	18	6.8	12	0	0.21	4.2	1.28	0.64	23
KAT		0	0	679	33	2.3	0.33	36	7.8	6.9	0.46	1.6	2.9	0	2.1	7.1

5 Discussion and Conclusion

The use of break point analysis to estimate current inputs is nowadays an established method to estimate current nutrient inputs and uncertainties in the nutrient input indicator and the NIC assessment. The advantages compared to simpler methods, e.g., averaging over a number of years or similar, become more and more evident as the length of the time-series increases. 81 of the 88 net nitrogen input time-series got at least one significant break point and the corresponding numbers for net phosphorus inputs are that 18 of 29 time-series including significant breakpoints (see Tables 3.13 and 3.16, respectively). The reasons for break points in the time-series could be due to a range of different reasons, most obvious being changes in upstream nutrient sources or changes in monitoring methodology.

One of the advantages of the trend methodology is that the estimate of the latest year nutrient input is more accurate, and the uncertainty is lower, and the results are less sensitive to low data quality in the early part of the time-series. In some few but important catchments, time-series data are even lacking in the first half of the assessment period and nutrient inputs are reconstructed without accurate temporal information. However, in these cases annual data have been reported for at least the last 7-8 or so years, which may be reflected by a breakpoint and thus providing useful information on the trends for the last part of the time-series and an improved assessment.

This assessment uses data for 26 years based on data from more than 350 monitored (about 210 of these have data for all years) and 24 unmonitored catchments. Thus, the time-series are now so long that single years with exceptional nutrient inputs or flow will not significantly change the results. One such example is that TP concentrations were quite high in 2014 for Vistula River, causing quite high normalized TP inputs for Poland that year. Now it is evident that that anomaly is not disrupting the general trend of decreasing TP inputs from Poland (see Figure 3.3), but it had a significant impact on earlier assessments based on data 1995-2014. Making flow normalization on the individual river catchments before aggregation and trend analysis should also make the country-basin inputs less sensitive to individual exceptional nutrient input estimates.

Changes in nutrient inputs are calculated from the beginning to the end of the time-series, i.e., from 1995, and from the reference period (1997-2003 average) to the end of the time-series (see Figure 2.2 and Tables 3.18 - 3.21). The justification for calculating the change since 1995 was that measures introduced in the 1990s caused rather large reductions in nutrient inputs before the reference period (see for example net total phosphorus inputs from Denmark and Germany to Baltic Proper in Figure 3.3) and that the Contracting Parties regarded it important to document these early reductions. The computation of change relative to the reference period was especially relevant in relation to the 2013 nutrient reduction scheme, where the actual agreement was to perform specific reductions (CART) in relation to the inputs in the reference period. Still reference period inputs were used to allocate NICs in the 2021 BSAP, but with the ceilings fixed it is less obvious why reductions should be calculated relative to the reference period.

As the time-series now are quite long, the difference between the two time-periods becomes rather small, i.e., change over 26 or about 20 years, respectively. Results are qualitatively quite similar, and the interpretation of quantitative differences are not so relevant for present challenges in reaching NIC. In many cases, trend reversals make the long-term change to provide a misleading message of the challenges at present (good examples of such cases are recent years with rising waterborne nitrogen inputs to the Baltic Proper from Denmark and Sweden shown in Figure 3.5). To initiate a discussion of a more appropriate description of the relevant changes also for the policy message, results of changes in the first and last of the periods identified by the break point analysis were presented together with the overall change from 1995 to 2020 in Tables 3.22-3.24. These tables provide a more appropriate indication of the present challenges for country-basin net inputs that do not anymore decrease or even may increase. However, the results are in detail rather complex and not so easy to interpret since changes will reflect different periods, so further development and discussions are necessary.

Percentage changes per year can reveal where rapid changes in nutrient inputs occur, as rapid reduction in phosphorus input in first section to some basins, and some very high annual increases in nitrogen in last section (tables 3.22a-3.24a). Further using percentage changes per year makes it easier to compare across country basin how fast changes in inputs take place. For a number of country-basin combinations there are worrying increasing trends in their net total nitrogen inputs in recent years (see tables 3.22-3.22a and 3.24-3.24a). In most cases, these are related to an increase in flow-normalized nitrogen inputs from land (see Figures in Annexes F and I). Higher flow-normalized inputs reflect that annual flow-weighted concentrations are higher than usual. It is beyond the scope of this report to analyze in detail why this is the case, and the explanation may very well be different for different catchments, but clearly the causes for the changes need to be explored.

Reaching NICs for phosphorus remain as the major challenge with large remaining reductions to especially the Baltic Proper. For several countries phosphorus inputs are not significantly decreasing anymore (see table 3.23), demonstrating the increasing difficulty of curbing phosphorus inputs further. Having said that, the comparison with the source apportionment of the nutrient inputs (tables 4.1 and 4.2) clearly shows that the proportion of anthropogenic inputs are still rather high in most sub-basins' catchment areas.

For the NIC-2022 assessment the evaluation of changes as compared to the reference period could be replaced with an assessment of changes of relevant sections of the timeseries, and changes from 1995 to 2022, and further also focusing on changes (in percentages) per year. This will point out where rapid changes in nitrogen and phosphorus inputs take place. Further it is important not only to assess the sum of air and waterborne nitrogen inputs, but also the air and waterborne inputs separately.

6 References

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Annex A Tables of current NIC's

Nutrient input ceilings for country-basin combinations were included in the updated BSAP (HELCOM, 2021) and the derivations of these clearly presented in a background report (HELCOM, 2021). Since then, Germany and Poland agreed upon a new division of their contributions of the nutrient inputs to the Baltic via the river Oder based on improved modeling. Subsequently, nutrient inputs ceilings for Germany and Poland to Baltic Proper are adjusted accordingly. Below follows tables of the current NICs used in the present assessment.

Table A.1. Country-basin net TN nutrient input ceilings in tonnes/yr.

	BOB	BOS	BAP	GUF	GUR	DS	KAT
DE	947	3920	34105	1645	1747	23647	4661
DK	280	1148	9025	421	462	28067	28538
EE	113	404	1478	11334	13099	22	24
FI	35087	28700	1827	20457	295	76	89
LT	108	495	25878	305	8820	66	80
LV	73	330	6457	246	43074	31	34
PL	668	3125	151969	1407	1596	1480	1443
RU	839	1993	10317	61503	3296	238	245
SE	17718	32633	30690	626	525	6056	32799
OC	1375	5008	26947	2986	2188	4933	4502
BSS	284	1141	5180	675	345	651	701
NOS	131	475	2427	196	150	729	884
BY			13456		12820		
CZ			3551				
UA			1693				
MAI	**57622**	**79372**	**325000**	**101800**	**88417**	**65998**	**74000**

Table A.2. Country-basin net TP nutrient input ceilings in tonnes/yr.

	BOB	BOS	BAP	GUF	GUR	DS	KAT
DE			203			401	
DK			21			979	815
EE			9	225	185		
FI	1683	1246		315			
LT			703		175		
LV			167		1061		
PL			4198				
RU			242	2909	99		
SE	811	1133	318			116	753
ATM.DEP.	181	394	1046	150	93	105	118
BY			349		407		
CZ			57				
UA			47				
MAI	**2675**	**2773**	**7360**	**3600**	**2020**	**1601**	**1687**

Table A.3. Nutrient input ceilings in tonnes/yr (TN) for the total as well as the country contributions to each of the transboundary rivers.

RIVER	BASIN	NIC	DE	FI	LT	LV	PL	RU	BY	CZ	UA
NEMUNAS	BAP	29338			18934				10404		
BARTA	BAP	957			427	530					
VENTA	BAP	6033			2896	3137					
LIELUPE	GUR	15863			7255	8608					
DAUGAVA	GUR	38800			1103	22243		2634	12820		
ODER	BAP	49298	1824				43923			3551	
VISTULA	BAP	74807					70062		3052		1693
PREGOLYA	BAP	5493					2498	2995			
NEVA	GUF	43476		4856				38620			

Table A.4. Nutrient input ceilings in tonnes/yr (TP) for total river as well as the country contributions to each of the transboundary rivers.

RIVER	BASIN	NIC	DE	FI	LT	LV	PL	RU	BY	CZ	UA
NEMUNAS	BAP	914			628				285		
BARTA	BAP	25			5	20					
VENTA	BAP	106			20	86					
LIELUPE	GUR	302			135	167					
DAUGAVA	GUR	941			40	395		99	407		
ODER	BAP	1554	132				1365			57	
VISTULA	BAP	2350					2240		63		47
PREGOLYA	BAP	147					51	96			
NEVA	GUF	1398		20				1379			

Annex B Tables of reference inputs 1997-2003

Reference inputs are the average of normalized annual 1997-2003 air- and waterborne inputs country per basin.

Table B.1. Country-basin net TN reference inputs in tonnes/yr.

	BOB	BOS	BAP	GUF	GUR	DS	KAT
DE	1002	3971	44385	2030	1737	23526	4661
DK	297	1163	11746	519	460	27923	28538
EE	120	409	1924	13985	13023	22	24
FI	37149	29068	2378	25241	293	76	89
LT	114	501	33678	377	8769	65	80
LV	78	334	8403	304	42823	31	34
PL	707	3165	197776	1737	1586	1473	1443
RU	888	2018	13426	75887	3277	237	245
SE	18760	33052	39941	772	522	6025	32799
OC	2877	10423	56263	5735	4169	10911	10318
BSS	604	2360	10412	1308	776	1282	1225
NOS	389	1292	6561	548	414	1717	1885
BY			17512		12745		
CZ			2203				
UA			4622				
SUM	**62984**	**87757**	**451227**	**128442**	**90593**	**73288**	**86648**

Table B.2. Country-basin net TP reference inputs in tonnes/yr.

	BOB	BOS	BAP	GUF	GUR	DS	KAT
DE			535			366	
DK			55			893	807
EE			23	521	271		
FI	1790	1278		730			
LT			1852		257		
LV			441		1557		
PL			11057				
RU			638	6734	145		
SE	863	1163	837			106	746
ATM.DEP.	181	394	1046	150	93	105	118
BY			919		598		
CZ			124				
UA			150				
SUM	**2835**	**2836**	**17678**	**8135**	**2921**	**1470**	**1672**

Table B.3. Reference inputs in tonnes/yr (TN) for the total as well as the country contributions to each of the transboundary rivers.

RIVER	BASIN	NIC	DE	FI	LT	LV	PL	RU	BY	CZ	UA
NEMUNAS	BAP	38181			24641				13540		
BARTA	BAP	1246			556	690					
VENTA	BAP	7852			3769	4083					
LIELUPE	GUR	15771			7213	8558					
DAUGAVA	GUR	38574			1097	22114		2619	12745		
ODER	BAP	64157	2374				57162				4622
VISTULA	BAP	97355					91181		3972	2203	
PREGOLYA	BAP	7149					3251	3898			
NEVA	GUF	53644		5992				47652			

Table B.4. Reference inputs in tonnes/yr (TP) for total river as well as the country contributions to each of the transboundary rivers.

RIVER	BASIN	NIC	DE	FI	LT	LV	PL	RU	BY	CZ	UA
NEMUNAS	BAP	2407			1655				752		
BARTA	BAP	67			14	53					
VENTA	BAP	279			53	226					
LIELUPE	GUR	443			198	245					
DAUGAVA	GUR	1382			59	580		145	598		
ODER	BAP	4093	348				3595				150
VISTULA	BAP	6191					5899		167	124	
PREGOLYA	BAP	386					133	253			
NEVA	GUF	3236		45				3191			

Annex C Implementation of nutrient input ceilings for Archipelago Sea

C.1 Background

The desire to have separated calculations of maximum allowable inputs and country-allocated reduction targets for the Archipelago Sea was expressed, primarily by Finland, already in the Baltic Sea Action Plan 2007. Because of limitations in modeling capabilities, MAI can still not be properly calculated for the Archipelago Sea. However, separate nutrient input ceilings can be calculating by assuming that the MAI for the combined Archipelago and Bothnian Sea can be split according to the proportion of nutrient inputs to the two basins in the reference period. Splitting the Bothnian Sea into Bothnian Sea proper and Archipelago Sea does not have any effects on MAI or input ceilings to other basins. Therefore, only results for these basins are presented in this report and the reader is referred to HELCOM (2021) for the other basins.

C.2 Data and Methods

The calculations are performed using the same data set as in HELCOM (2021). The reader is further referred to that report for details of NIC calculation methodology.

C.3 Reference inputs

The basis for allocation of nutrient input ceilings is the reference inputs which is defined by the 1997-2003 average normalized water and airborne nutrient inputs, see Tables 1 and 2. The Archipelago Sea receives about 19% of the TN inputs and 22% of the TP inputs to the total Bothnian Sea inputs.

Table C.1. Total nitrogen reference inputs to the sub-basins (tonnes/yr).

Country	ARC	BOS (without ARC)	BOS (Total)
DE	1137	2834	3971
DK	301	863	1163
EE	127	282	409
FI	8940	20128	29068
LT	150	351	501
LV	104	230	334
PL	932	2233	3165
RU	504	1514	2018
SE	658	32394	33052
OC	2754	7669	10423
BSS	732	1628	2360
NOS	321	971	1292
All	16660 (19%)	71097 (81%)	87757

Table C.2. Total phosphorus reference inputs to the sub-basins (tonnes/yr).

	ARC	BOS (without ARC)	BOS (Total)
FI	569	710	1278
SE	-	1163	1163
OC	67	327	394
All	633 (22%)	2200 (78%)	2836

C.4 Calculation of NIC

The MAI for total Bothnian Sea can be split into one for Archipelago Sea and one for Bothnian Sea without Archipelago Sea using the percentages in Tables 1 and 2.

EMEP have within the ENIRED project calculated expected reductions on atmospheric deposition for the Archipelago Sea separately. Therefore, NICs for other countries and shipping can be computed based on the change between 2005 and 2030.

Using the MAIs and NICs for the airborne contributions from other countries and shipping, NICs for the HELCOM CPs are readily computed according to the methodology presented in HELCOM (2021).

The results are presented in Tables 3 and 4. Although the MAI is distributed according to the total reference inputs to the basins, there are differences in the sum of TN ceilings compared to when allocation is done on the total Bothnian Sea directly. The reason for this is that the expected reduction on other countries and shipping is relatively larger in the Archipelago Sea, this causes the HELCOM CPs to be required to do somewhat more reductions in the Bothnian Sea without Archipelago Sea and somewhat less in the Archipelago Sea. The net of this is somewhat higher ceilings for the sum of the basins for all countries except Sweden and this is because Sweden has such significant contribution to Bothnian Sea. All differences are below 1%.

Table C.3. TN input ceilings to the sub-basins (tonnes/yr). The sum of the two first columns is indicated since it is not exactly the same as allocation done on the total Bothnian Sea due to differences in the expected reductions of the atmospheric deposition between the sub-basins.

	ARC	BOS (without ARC)	Sum	BOS (Total)
DE	1173	2772	3945	3920
DK	310	844	1154	1148
EE	131	276	407	404
FI	9223	19685	28908	28700
LT	155	343	498	495
LV	108	225	333	330
PL	961	2184	3145	3125
RU	520	1481	2001	1993
SE	679	31681	32360	32633
OC	1325	3683	5008	5008
BSS	365	775	1140	1141
NOS	119	356	475	475
MAI	15068	64304	79372	79372

Table C.4. TP input ceilings to the sub-basins (tonnes/yr).

	ARC	BOS (without ARC)	BOS (Total)
FI	554	691	1246
SE	-	1133	1133
OC	67	327	394
MAI	622	2151	2773

Discussion

It is straightforward to define nutrient input ceilings for the Archipelago Sea following the methodology above. In addition, all data from PLC and EMEP is collected resolving the Archipelago Sea. Further, addition of Archipelago Sea does not affect the NICs of other basins except for BOS, and the effect on other countries than Finland that has waterborne inputs to both basins will be minor.

It should be kept in mind that the division of MAI between these two basins is not based on an analysis of the environmental conditions, but only a simple scaling according to the nutrient inputs in the reference period.

Annex D How are “taking into account extra reduction in neighboring basins” calculated

D.1 Background

As a part of the nutrient reduction scheme in the 2013 HELCOM Ministerial Declaration, the following principle was approved:

RECOGNIZING that reductions in nutrient inputs in sub-basins may have wide-spread effects, WE AGREE that extra reductions can be accounted for, in proportion to the effect on a neighboring basin with reduction targets, by the countries in reaching their Country Allocated Reduction Targets.

The rationale behind this statement is that maximum allowable inputs (MAI) was calculated focusing on offshore major basins and with the optimization of aiming for a maximal total nutrient input, which in principle would be the most cost-efficient solution. The necessary reductions to meet MAI were allocated country-wise within each basin. Due to lack of detailed information of reduction potential (or/and costs of measures) in the different countries one had resided on simple principles for this allocation, i.e., countries have to reduce in proportion to their emissions. However, one have to acknowledge that the reduction targets calculated in this way do not necessarily match national plans or be the most cost-efficient solution for individual countries. Several countries implement and/or have implemented measures because of other policies than BSAP (e.g. WFD, Nitrates Directive, Gothenburg Protocol) that results in reductions in basins without reduction requirements or with a magnitude that significantly exceeds the reduction requirements. Thus, inputs to some basins may become significantly lower than MAI leading to winter nutrient concentrations decreasing below the environmental targets. That effect will to some extent spread to adjacent basins, and as a consequence the environmental targets can be reached with somewhat higher inputs than MAI to these “downstream” basins. Thus, under these conditions, making overall larger reductions than required by MAI may be the most cost effective and should be accounted for if it can be shown that the environmental targets are met everywhere.

The paragraph above is somewhat vaguely formulated in the Ministerial Declaration and the following clarifications based on the groundwork for the Declaration can be made:

- The paragraph was clearly developed in the spirit that this accounting would be done for countries individually, (for example, Sweden could take into account some of extra reductions done in the Bothnian Sea in their bookkeeping of reductions to Baltic proper), and not shared between all countries.
- Any relocation of measures should lead to the same environmental improvement as if CART were implemented.

To illustrate the potential of this principle in preparation of the Ministerial Declaration, BNI quantified how much reduction needs to be done in one basin to get the same environmental effect in a “downstream” basin. However, the mechanisms on how to estimate expected effects or how to evaluate compliance were not discussed in the groundwork for the Ministerial Declaration. This ambiguity has led to some confusion as to how to plan and implement the programs of measures to obtain the goals of the BSAP nutrient reduction scheme in this respect. A first comprehensive suggestion was presented at HELCOM PRESSURE 5-2016 (doc 8-3). Thereafter the principles for accounting of extra reductions have been extensively discussed and agreed upon at HELCOM HOD 56-2019 (see below). The allocation of extra reductions was carried over into the 2021 HELCOM BSAP update where it is stated:

Reductions of nutrient inputs in a particular sub-basin may have effects on other sub-basins too. Therefore, a reduction of nitrogen and phosphorus below the NIC for one specific sub-basin can be proportionally taken into account by a country in reaching its input ceiling for another sub-basin. The application of the mechanism for the reallocation of extra reduction is based on the agreed principles.

This document provides a) principles that should be used when evaluating extra reductions, b) a brief description of the methodology and c) examples as to how the methodology could be used for involved countries.

Extra reduction is the margin to NIC (nutrient input ceiling) including the statistical uncertainty for a given country and basin combination.

Missing reduction is defined additional input reduction needed to reach NIC including the statistical uncertainty for a given country and basin combination.

D.2 Principles for accounting extra reductions

HELCOM HOD 56-2019 agreed (ref. outcome of the meeting §3.26) on eight principles to be used for the reallocation of extra reduction to basins with missing reductions (HELCOM 56-2019 doc 3-4). The eight principles are (with some minor editing to update to current MAI-NIC terminology):

1. **Accounting should be based on countries individually**

This implies that countries can plan and implement measures across basins at their own discretion as long as it results in conforming to nutrient input ceilings (NIC after accounting of extra reduction is performed.

2. **Countries could claim accounting for missing reductions even if MAI is exceeded due to inputs from other countries**

No country should need to wait for any other country before claiming themselves fulfilment of NIC.

3. **Any relocation of measures should lead to at least the same environmental improvement as if national nutrient ceilings were reached**

This is imperative for the good environmental status (GES) to be achieved eventually. Inevitably, using extra reductions will lead to less inputs than MAI as seen as a total for the Baltic Sea, but its distribution needs to be such that GES will be achieved everywhere.

4. The effect of extra reductions on neighboring basins with missing reductions should be estimated given that these are minor deviations from MAI

The Baltic Sea is a strongly perturbed system and hence, functioning quite different today compared to how it will function when measures been implemented and status approach GES. The whole calculation of MAI is taking this into account and when deviations to MAI are to be analysed, it should be done assuming that we are close to GES.

5. Accounting for extra reductions in connection with HELCOM nutrient reduction scheme follow-up assessments are to be performed in a uniform way supervised by EG RedCore

Accounting for extra reductions should be included in the regular NIC assessment using a common and harmonized methodology. EG RedCore is the forum that supervises development of methodology and, after appropriate approval, implementation of this in the assessment.

6. The Archipelago Sea phosphorus input reductions should be accounted in the reaching Finnish NIC for Gulf of Finland

Already in BSAP 2007, Finland pointed out that models failed to separate the Archipelago Sea from Bothnian Sea and that this should be taken into account at a later stage. Also, in the 2013 revision of the nutrient reduction scheme, model limitations failed to address separate MAI calculations for the Archipelago Sea. However, in the context of accounting for extra reduction the nutrient inputs to Archipelago Sea can be taken into account separately from the remaining Bothnian Sea inputs.

7. In the context of extra reduction accounting, reductions of phosphorus to Baltic Proper could be accounted as input reduction in Gulf of Finland

In the calculations of MAI, the most limiting targets affecting the distribution of MAI for phosphorus were the winter nutrient concentrations in the Baltic Proper. Strictly following the principle of “maximum” inputs, led to a situation where this gave an optimal solution resulting in removal of virtually all phosphorus inputs to the Baltic Proper and barely any reductions to Gulf of Finland. This solution clearly violated the principle of cost-efficiency so additional calculations based on cost functions for phosphorus input reductions were performed to distribute reductions between Baltic Proper and Gulf of Finland in a cost-efficient way. The obtained MAI results in conforming to phosphorus target in Baltic Proper, but in Gulf of Finland the resulting phosphorus concentrations will be significantly less than target. In line with this, it could be argued for states having phosphorus inputs both to Baltic Proper and Gulf of Finland, that *extra reductions* to Baltic Proper could be deducted from missing reductions in Gulf of Finland with 100% efficiency. However, one should bear in mind that the MAI for nitrogen to Gulf of Finland was determined from applying the HEAT approach, balancing nitrogen and phosphorus concentrations, so if MAI for phosphorus to Gulf of Finland is not achieved fully additional reductions on nitrogen inputs might be necessary.

8. **Following the precautionary principle, re-allocation of extra reduction cannot be used to purposely increase inputs to a neighboring basin**

Following the precautionary principle, extra reductions achieved in a specific basin cannot be used to purposely increase inputs to a neighboring basin beyond the national input ceilings for basins with reduction targets and beyond the inputs in the reference period 1997-2003 for basins without reduction targets, taking statistical uncertainties into account.

Possible use of extra reductions to increase inputs up to the national input ceilings within a basin are not within the scope of the re-allocation principles. This issue is to be further discussed.

Although the re-allocation methodology is based on current scientific knowledge and modelling, it comes with significant uncertainty and will sooner or later be subject of improvement. Therefore, it would be a risk for the environment to increase inputs to neighbouring basins based on this methodology. In addition, a prerequisite for the calculations here is an environment close to GES.

Understanding effects of extra and missing reductions

The Baltic Sea comprises of a series of connected basins, and changes in the environment will lead to changes in adjacent basins as well due to transport of nutrients between the basins. In simple terms, if the nutrient concentrations change in one basin it will cause changes in the nutrient transports to adjacent basins. The magnitude of the nutrient transport change will depend on the water exchange between the basins and concentration difference between the basins. Note however that the nutrient transport also includes nutrients within organic matter and not only the inorganic nutrients. In Figure 1, the simulated phosphorus transports between the basins are shown for the present day situation and for the situation when MAI is achieved. It is clear that at present day, the quite high phosphorus concentrations in the Gulf of Finland and Baltic Proper cause significant fluxes to the other basins, thus causing elevated primary production also in these basins. When MAI is achieved, concentrations in Gulf of Finland and Baltic Proper decrease significantly and therefore fluxes to the other basins decrease significantly.

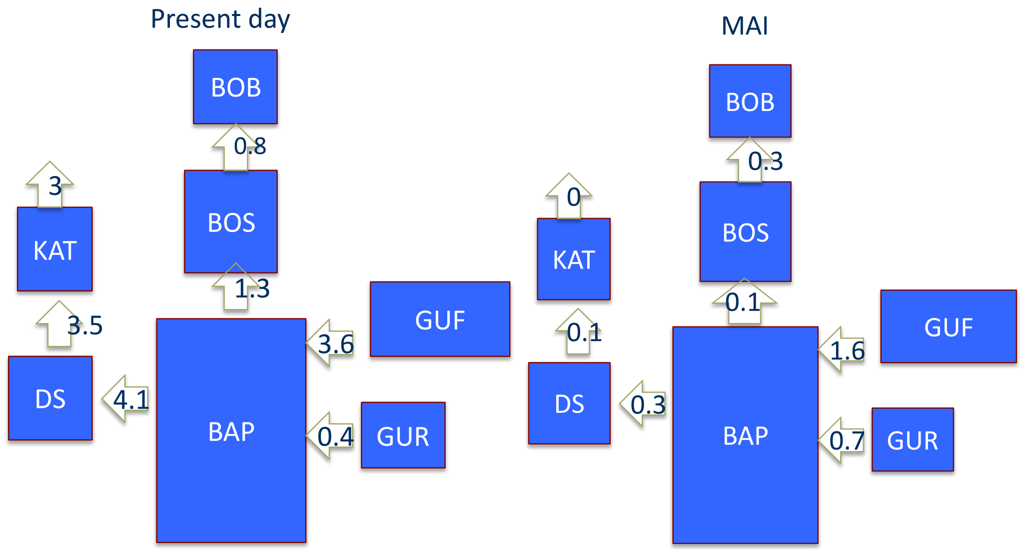

Figure D.1.The average fluxes of phosphorus between the Baltic Sea sub-basins at present day (to the left) and when Baltic Sea adjusted to MAI (to the right). Unit is ktonnes/yr.

When inputs to a basin deviate from MAI, the fluxes in Figure 1 will be perturbed. When inputs are lower than MAI (*extra reduction*), fluxes will increase to that basin and status will improve somewhat in the other basins as well and while higher inputs than MAI (*missing reduction*) will lead to export of nutrients and deterioration in adjacent basins. In Figure 2, examples are shown on what happens with fluxes when there is extra reduction to Bothnian Sea and missing reduction to Baltic Proper, respectively. In this example, if one would trade the missing reduction to Baltic Proper with the extra reduction in Bothnian Sea one must ensure that a) the eutrophication status of the Baltic Proper retained by the additional export to the Bothnian Sea and b) there is no deterioration of status in the other basins. For large missing and extra reductions, this becomes a relatively complicated calculation because of non-linearities in the system, but if the reductions are small compared to the MAI and focus is on single basin pairs of basins a significantly simpler approach is valid.

In principle, one could picture it as ensure that the missing reduction is compensated by a flux of nutrient to the basin with extra reduction. In example in Figure 2, we could assume that the extra reduction in Bothnian Sea will cancel out all the red and green arrows to the basins south and east of Baltic Proper and these basins can then not benefit from extra reduction in Bothnian Sea. However, there will still be some benefit in the Bothnian Bay from the extra reduction, although it should be smaller than if Baltic Proper fulfilled MAI because of the elevated nutrient flux to the Bothnian Sea. Assuming small changes one could probably assume that the net effect of the extra reduction in Bothnian Sea and missing reduction in Baltic Proper on Bothnian Bay would be the difference between the benefit on the Bothnian Bay represented by the green arrow towards Bothnian Sea and the deterioration from not reaching the reductions to Baltic proper represented by the red arrow from Bothnian Sea towards Bothnian Bay in Figure 2.

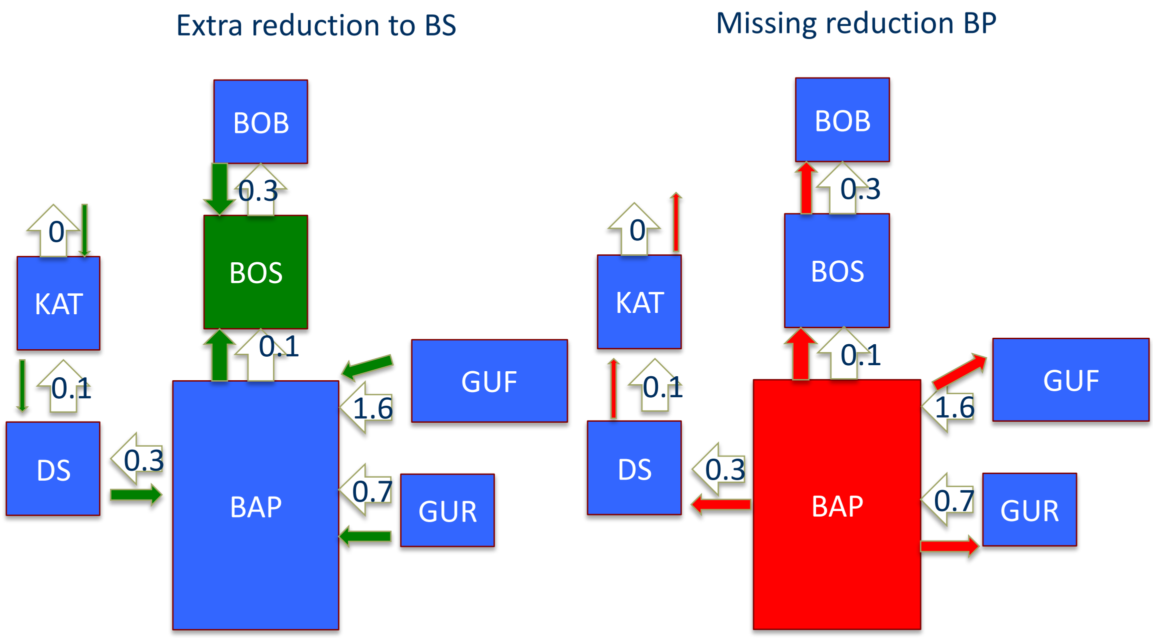

Figure D.2. Illustration on how extra reduction and missing reduction changes the phosphorus fluxes between the basins. To the left it is illustrated with green arrows how an extra reduction to the Bothnian Sea cause additional flux from the Baltic Proper and decreased flux to Bothnian Bay, and how these effects propagate to the exchange with the other basins. To the right it is illustrated with red arrows how missing reduction to the Baltic Proper causing additional flux to Bothnian Sea and the other basins. If the green arrow from the Baltic Proper to the Bothnian Sea is so large that it equals the missing reduction, the environment will be the same in the Baltic Proper as if MAI was applied and the red arrows would all be zero. NB! If there is missing reduction to the Baltic Proper, the basins GF, GR, DS and KT will no longer get any benefit from the extra reduction in BS. Unit is ktonnes/yr.

D.3 A method to match missing reductions with extra reductions

The BALTSEM model was used to find the combination of maximum allowable inputs (MAI) that would eventually lead to the good environmental status as quantified by the eutrophication status targets taking into account the circulation and biogeochemical cycles of the Baltic Sea. The same model can be used to as basis for a method to match missing reductions with extra reductions.

The methodology takes the starting point from the state obtained when MAI is achieved and GES is reached, i.e., the model is run with inputs as given by MAI for a very long time. From this state, a series of model experiments are performed for which N and P inputs are systematically perturbed from MAI, that is different N and P input combinations for one basin at a time. In total about 160 simulations were performed providing a large data set on how the state change in the Baltic basins depending on a nutrient input change to one basin.

To simplify the further analysis, a few assumptions were made:

1. assume that deviation from MAI is relatively small so that linear response can be expected
2. assume the analysis can be done separately for each single nutrient and basin combination

It would be straightforward to evaluate single cases that violate the two assumptions, but presenting the results in an easily understandable way would be difficult.

Equivalent reduction is input reduction to basin A that leads to the equivalent environmental benefit in basin B as 1ton reduction to basin B. **NB!** prerequisite is that all other basins fulfill MAI.

Effective reduction is the apparent input reduction in a basin resulting from extra reductions in another basin, in practice: the **extra reduction** divided by **equivalent reduction. NB!** Missing reductions will lead to “negative” effective reductions because lateral nutrient transports were taken into account when MAI-CART was calculated.

The equivalent reductions for phosphorus and nitrogen obtained from BALTSEM simulations are shown in Tables 1 and 2. Since in general nitrogen retention is higher, the equivalent reductions are in most cases higher for nitrogen than phosphorus. The uncertainty increases for distant basins when the effective reduction becomes really small and equivalent reduction high. Rather arbitrarily, values higher than 10 is not shown in the tables.

Table D.1. Equivalent reductions on phosphorus. The table should be read so that each row provides the necessary input reduction to the basins to the left to provide the equivalent environmental effect in the basins in the top row, e.g., 1.5 tonnes reduction to BS gives the same effect in the BP as 1 tonne reduction directly to BP. NB! That the factors are valid on single basin pairs under condition that all other basins fulfil MAI.

	KAT	DS	BAP	BOS	BOB	GUR	GUF
KAT	1	4.0	–	–	–	–	–
DS	0.8	1	3.2	–	–	–	–
BAP	2.4	2.8	1	3.3	7.7	–	3.8
BOS	3.8	4.6	1.5	1	2.6	–	5.8
BOB	–	–	9.0	8.3	1	–	–
GUR	3.6	4.3	1.6	4.8	–	1	6.5
GUF	3.6	4.2	1.3	4.1	–	–	1

Table D.2. Equivalent reductions on nitrogen. The table should be read so that each row provides the necessary input reduction to the basins to the left to provide the equivalent environmental effect in the basins in the top row, e.g. 1.3 tonnes reduction to GR gives the same effect in the BP as 1 tonne reduction directly to BP. NB! That the factors are valid on single basin pairs under condition that all other basins fulfil MAI.

	KAT	DS	BAP	BOS	BOB	GUR	GUF
KAT	1	7.3	–	–	–	–	–
DS	1.7	1	4.6	–	–	–	–
BAP	–	–	1	–	–	–	–
BOS	–	–	–	1	7.8	–	–
BOB	–	–	–	1.1	1	–	–
GUR	–	–	1.3	–	–	1	–
GUF	–	–	4.0	–	–	–	1

Annex E Results of the NIC-2020 assessment taking into account extra reduction in neighboring basins and compared with NIC-2017 assessment results

This annex supplies tables 3.4 (for total nitrogen table E.1) and table 3.8 (for table phosphorous table E.2) where detailed results on the assessment of progress towards NIC by 2020 for total nitrogen and total phosphorus are compared with the corresponding results from the NIC-2017 assessment (based on 1995-2017 data) where the former NIC's were assessed (results from the original NIC-2017 assessment (Svendsen et al., 2022).

The tables includes the NIC from BSAP 2021 update, the estimated inputs in 2020 (according to PLC guidelines 2022 and Larsen and Svendsen 2022, see chapter 2.2 and 2.3), the test values 2020 (estimated input + estimated uncertainty on these inputs), extra reduction by 2020 (colored green) or remaining reduction by 2020 (colored yellow or red), if there is a remaining reduction by 2020 the percentages of remaining reduction in % of the ceiling (NIC), the results by 2020 if we take into account extra reduction in a neighboring basin and how the extra reduction is applied. Further changes in percentage in inputs since reference period to 2020 if changes are statistically significant as last row in each country per basin table.

From the NIC2017 assessment is included the former NIC (used in the NIC-2017, assessment) the estimated inputs in 2017, the test values 2017 (estimated input + estimated uncertainty), extra reduction by 2017 (colored green) or remaining reduction by 2017 (yellow or red), if there is a remaining reduction by 2017 the percentages of remaining reduction in % of the ceiling (NIC).

Under tables E.1 and E.2 there is one table per country with results per basin. Basins without any input from the country (or source) are left empty.

Table E.1. Assessment of progress towards total nitrogen (TN) NIC by 2020 presented country by basin – see text above. All numbers in the table are in tonnes beside row with "remaining in % of ceilings", "remaining in % of ceilings taking into account extra reduction", and "significant changes since the reference period to 2020", that are in percentages. Only significant percentages changes since the reference period are shown. In chapter 3.2 is explained about lines related to accounting for extra reduction which occurs for some countries. Colors are used as defined in relation to table 3.1.

Denmark TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	280	1148	9025	421	462	28067	28538
B: Estimated input 2020	155	628	8026	272	254	23597	25280
C: Inputs 2020 including uncertainty (test value)	165	662	8339	287	266	25527	26112
Extra reduction by 2020 (A-C)	115	486	686	134	196	2540	2426
Remaining reduction to fulfill NIC by 2020							
Remaining in % of ceiling							
Accounting for extra reduction							
Remaining taking into account extra reduction							
F: Input ceilings from NIC2017 assessment	231	904	7910	334	381	30313	29319
D: Estimate input 2017	151	612	7835	272	246	21079	23615
E: Input 2017 including uncertainty (test value)	157	632	8119	282	253	22747	24707
Extra reduction by 2017 (F-E)	74	272		52	128	7566	4613
Remaining reduction to fulfill NIC by 2017			209				
Remaining in % of ceiling			*3*				
Significant changes since reference period (%) to 2020	-49	-47	-34	-48	-46	-19	-22

Estonia TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	113	404	1478	11334	13099	22	24
B: Estimated input 2020	82	288	1518	12219	16047	14	17
C: Inputs 2020 including uncertainty (test value)	87	304	1671	12726	17572	15	18
Extra reduction by 2020 (A-C)	26	100				7	6
Remaining reduction to fulfill NIC by 2020			193	1392	4473		
Remaining in % of ceiling			*13*	*12*	*34*		
Accounting for extra reduction			*-2*				
Remaining taking into account extra reduction			191				
Remaining in % of ceiling taking into account extra reduction			13				
Extra reduction in DS is used to reduced the remaining reduction requirements in BAP with 2 tons TN							
F: Input ceilings from NIC2017 assessment	95	317	1413	11265	13029	18	20
D: Estimate input 2017	96	338	1766	13604	12726	18	21
E: Input 2017 including uncertainty (test value)	98	346	1840	14183	13501	18	21
Extra reduction by 2017 (F-E)						0	
Remaining reduction to fulfill NIC by 2017	3	29	427	2918	472		1
Remaining in % of ceiling	*3*	*9*	*30*	*26*	*4*		*7*
Significant changes since reference period (%) to 2020	-33	-29	-19	-10	23	-35	-33

Finland TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	35087	28700	1827	20457	295	76	89
B: Estimated input 2020	34298	25581	1237	20293	159	35	46
C: Inputs 2020 including uncertainty (test value)	35642	26917	1284	21315	165	37	48
Extra reduction by 2020 (A-C)		1783	543		130	39	41
Remaining reduction to fulfill NIC by 2020	555			858			
Remaining in % of ceiling	*2*			*4*			
Accounting for extra reduction	*-229*						
Remaining taking into account extra reduction	326						
Remaining in % of ceiling taking into account extra reductic	0,9						
Extra reduction in BOS is used to reduced the remaining reduction requirements in BOB with 229 tons TN							
F: Input ceilings from NIC2017 assessment	35081	29619	1569	20653	255	64	77
D: Estimate input 2017	34393	24446	1406	21396	180	43	56
E: Input 2017 including uncertainty (test value)	35500	26485	1442	22198	185	45	57
Extra reduction by 2017 (F-E)		3135	127		70	19	20
Remaining reduction to fulfill NIC by 2017	419			1544			
Remaining in % of ceiling	*1*			*7*			
Significant changes since reference period (%) to 2020	-8	-12	-48	-20	-48	-52	-51

Germany TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	947	3920	34105	1645	1747	23647	4661
B: Estimated input 2020	628	2502	34778	1263	1112	18134	3487
C: Inputs 2020 including uncertainty (test value)	641	2553	35612	1288	1133	19314	3543
Extra reduction by 2020 (A-C)	306	1367		357	614	4333	1118
Remaining reduction to fulfill NIC by 2020			1507				
Remaining in % of ceiling			*4*				
Accounting for extra reduction			*-660*				
Remaining taking into account extra reduction			847				
Remaining in % of ceiling taking into account extra reduction			2				
Extra reduction in DS, GUF and GUR is used to reduced the remaining reduction requirements in BAP with 660 tons TN							
F: Input ceilings from NIC2017 assessment	817	3170	27473	1312	1465	21957	3285
D: Estimate input 2017	746	2995	37316	1537	1331	18414	4117
E: Input 2017 including uncertainty (test value)	755	3028	38204	1554	1345	19419	4159
Extra reduction by 2017 (F-E)	62	142			120	2539	
Remaining reduction to fulfill NIC by 2017			10731	242			874
Remaining in % of ceiling			*39*	*18*			*27*
Significant changes since reference period (%) to 2020	-37	-36	-20	-36	-35	-21	-31

Latvia TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	73	330	6457	246	43074	31	34
B: Estimated input 2020	71	308	11955	277	41735	27	32
C: Inputs 2020 including uncertainty (test value)	73	313	13237	281	44402	27	33
Extra reduction by 2020 (A-C)	0	17				4	1
Remaining reduction to fulfill NIC by 2020			6780	35	1328		
Remaining in % of ceiling			*105*	*14*	*3*		
Accounting for extra reduction			*-1*				
Remaining taking into account extra reduction			6779				
Remaining in % of ceiling taking into account extra reduction			105				
Extra reduction in DS is used to compensated for the remaining reduction requirement with 1 tons TN in BAP							
F: Input ceilings from NIC2017 assessment	63	273	6091	183	53898	24	25
D: Estimate input 2017	74	328	10965	300	43255	30	35
E: Input 2017 including uncertainty (test value)	76	333	11631	304	46387	30	36
Extra reduction by 2017 (F-E)					7511		
Remaining reduction to fulfill NIC by 2017	12	60	5540	121		6	11
Remaining in % of ceiling	*19*	*22*	*91*	*66*		*24*	*43*
Significant changes since reference period (%) to 2020	-14	-12	48	-10		-14	-13

Lithuania TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	108	495	25878	305	8820	66	80
B: Estimated input 2020	114	503	51857	363	12868	62	82
C: Inputs 2020 including uncertainty (test value)	117	517	57685	373	14296	64	84
Extra reduction by 2020 (A-C)						2	
Remaining reduction to fulfill NIC by 2020	9	22	31807	68	5476		4
Remaining in % of ceiling	*9*	*4*	*123*	*22*	*62*		*5*
Accounting for extra reduction							*-1*
Remaining taking into account extra reduction							3
Remaining in % of ceiling taking into account extra reduction							4
Extra reduction in DS is used to reduced the remaining reduction requirements in KAT with 1 tons TN							
F: Input ceilings from NIC2017 assessment	110	491	33093	261	5795	54	60
D: Estimate input 2017	115	508	49060	382	9558	66	87
E: Input 2017 including uncertainty (test value)	117	517	53565	389	10303	67	89
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017	7	25	20471	128	4509	13	29
Remaining in % of ceiling	*6*	*5*	*62*	*49*	*78*	*24*	*48*
Significant changes since reference period (%) to 2020			62		55		

Poland TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	668	3125	151969	1407	1596	1480	1443
B: Estimated input 2020	556	2468	170361	1317	1248	1125	1210
C: Inputs 2020 including uncertainty (test value)	570	2529	182547	1349	1278	1153	1240
Extra reduction by 2020 (A-C)	98	596		58	318	327	203
Remaining reduction to fulfill NIC by 2020			30578				
Remaining in % of ceiling			*20*				
Accounting for extra reduction			*-333*				
Remaining taking into account extra reduction			30245				
Remaining in % of ceiling taking into account extra reduction			20				
Extra reduction in DS, GUF and GUR is used to reduced the remaining reduction requirements in BAP with 33 tons TN							
F: Input ceilings from NIC2017 assessment	644	2802	160857	1166	1361	1125	1106
D: Estimate input 2017	619	2767	191775	1519	1385	1290	1361
E: Input 2017 including uncertainty (test value)	624	2832	195171	1554	1417	1321	1394
Extra reduction by 2017 (F-E)	20						
Remaining reduction to fulfill NIC by 2017		30	34314	388	56	196	288
Remaining in % of ceiling		*1*	*21*	*33*	*4,1*	*17*	*26*
Significant changes since reference period (%) to 2020	-25	-25	-11	-25	-25	-26	-25

Russia TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	839	1993	10317	61503	3296	238	245
B: Estimated input 2020	854	1918	9712	72640	2775	210	238
C: Inputs 2020 including uncertainty (test value)	861	1935	11437	78463	3063	212	240
Extra reduction by 2020 (A-C)		58			233	26	5
Remaining reduction to fulfill NIC by 2020	22		1120	16960			
Remaining in % of ceiling	*3*		*11*	*28*			
Accounting for extra reduction			*-187*				
Remaining taking into account extra reduction			933				
Remaining in % of ceiling taking into account extra reduction			9				
Extra reduction in DS and GUR is used to reduced the remaining reduction requirements in BAP with 187 tons TN							
F: Input ceilings from NIC2017 assessment	710	1551	9253	62522	2516	174	174
D: Estimate input 2017	876	1992	13841	63185	3761	233	261
E: Input 2017 including uncertainty (test value)	889	2022	14398	65320	4059	237	265
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017	179	471	5145	2798	1543	63	91
Remaining in % of ceiling	*25*	*30*	*56*	*4,5*	*61*	*36*	*52*
Significant changes since reference period (%) to 2020	-11	-11	-29		-14	-12	-11

Sweden TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	17718	32633	30690	626	525	6056	32799
B: Estimated input 2020	13859	25800	38523	509	366	6053	28257
C: Inputs 2020 including uncertainty (test value)	14499	26843	40600	515	370	6615	29043
Extra reduction by 2020 (A-C)	3219	5790		111	155		3756
Remaining reduction to fulfill NIC by 2020			9910			559	
Remaining in % of ceiling			*32*			*9*	
Accounting for extra reduction			*-148*			*-516*	
Remaining taking into account extra reduction			9762			43	
Remaining in % of ceiling taking into account extra reduction			32			1	
Extra reduction in DS and GUR is used to reduced the remaining reduction requirements in BAP with 148 tons TN, and extra reduction in							
is used to reduce remaining reduction requiremetns in DS with 516 tons TN							
F: Input ceilings from NIC2017 assessment	17924	33350	30942	502	449	6224	34206
D: Estimate input 2017	15646	25619	37096	507	354	5142	28210
E: Input 2017 including uncertainty (test value)	16273	26605	38513	513	358	5474	29321
Extra reduction by 2017 (F-E)	1652	6745			91	750	4886
Remaining reduction to fulfill NIC by 2017			7571	11			
Remaining in % of ceiling			*24*	*2*			
Significant changes since reference period (%) to 2020	-26	-22		-33	-30		-20

Belarus TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			13456		12820		
B: Estimated input 2020			16935		10917		
C: Inputs 2020 including uncertainty (test value)			17629		12546		
Extra reduction by 2020 (A-C)					274		
Remaining reduction to fulfill NIC by 2020			4173				
Remaining in % of ceiling			*31*				
F: Input ceilings from NIC2017 assessment			7322		6352		
D: Estimate input 2017			16559		12327		
E: Input 2017 including uncertainty (test value)			18182		13526		
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			10861		7175		
Remaining in % of ceiling			*148*		*113*		
Significant changes since reference period (%) to 2020							

Czeck Republic TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			3551				
B: Estimated input 2020			3524				
C: Inputs 2020 including uncertainty (test value)			4259				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2017			708				
Remaining in % of ceiling			*20*				
F: Input ceilings from NIC2017 assessment			2693				
D: Estimate input 2017			2740				
E: Input 2017 including uncertainty (test value)			3200				
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			507				
Remaining in % of ceiling			*19*				
Significant changes since reference period (%) to 2020			-26				

Ukraine TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			1693				
B: Estimated input 2020			3261				
C: Inputs 2020 including uncertainty (test value)			3670				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			1977				
Remaining in % of ceiling			*117*				
F: Input ceilings from NIC2017 assessment			1948				
D: Estimate input 2017			2784				
E: Input 2017 including uncertainty (test value)			3075				
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			1127				
Remaining in % of ceiling			*58*				
Significant changes since reference period (%) to 2020			49				

Baltic Sea shipping TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	284	1141	5180	675	345	651	701
B: Estimated input 2020	487	1924	8335	1069	622	1002	976
C: Inputs 2020 including uncertainty (test value)	502	1982	8588	1102	641	1032	1006
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020	218	841	3408	427	296	381	305
Remaining in % of ceiling	*77*	*74*	*66*	*63*	*86*	*59*	*43*
F: Input ceilings from NIC2017 assessment	72	292	1434	147	112	165	149
D: Estimate input 2017	440	1719	7583	953	565	934	892
E: Input 2017 including uncertainty (test value)	447	1748	7710	968	574	950	907
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017	375	1455	6276	821	462	785	758
Remaining in % of ceiling	*520*	*498*	*438*	*559*	*412*	*475*	*509*
Significant changes since reference period (%) to 2020	-23	-23	-23	-23	-23	-23	-23

North Sea shipping TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	131	475	2427	196	150	729	884
B: Estimated input 2020	285	951	4838	399	305	1253	1395
C: Inputs 2020 including uncertainty (test value)	291	973	4949	408	312	1282	1427
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020	160	498	2522	212	162	553	543
Remaining in % of ceiling	*122*	*105*	*104*	*108*	*108*	*76*	*61*
F: Input ceilings from NIC2017 assessment	In 2017 included under "Other countries", not assessed seperately						
D: Estimate input 2017							
E: Input 2017 including uncertainty (test value)							
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017							
Remaining in % of ceiling							
Significant changes since reference period (%) to 2020	-27	-27	-27	-27	-27	-27	-27

Other Countries TN	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	1375	5008	26947	2986	2188	4933	4502
B: Estimated input 2020	1837	6657	34429	3715	2731	6137	7054
C: Inputs 2020 including uncertainty (test value)	1866	6763	35012	3772	2775	6249	7161
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020	491	1755	8065	786	587	1316	2659
Remaining in % of ceiling	*36*	*35*	*30*	*26*	*27*	*27*	*59*
F: Input ceilings from NIC2017 assessment	1876	6603	33002	3455	2804	5880	5579
D: Estimate input 2017	2174	7859	41181	4340	3129	7790	7615
E: Input 2017 including uncertainty (test value)	2197	7945	41643	4396	3166	7891	7711
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017	321	1342	8641	941	362	2011	2132
Remaining in % of ceiling	*17*	*20*	*26*	*27*	*13*	*34*	*38*
Significant changes since reference period (%) to 2020	-38	-37	-39	-35	-35	-43	-32

Table E.2. Assessment of progress towards total phosphorus NIC by 2020 presented country by basin – see text above. All numbers in the table are in tonnes beside row with "remaining in % of ceilings", "remaining in % of ceilings taking into account extra reduction", and "significant changes since the reference period to 2020", that are in percentages. Only significant percentages changes since the reference period are shown. In chapter 3.2 is explained about lines related to accounting for extra reduction which occurs for some countries Colors are used as defined in relation to table 3.5.

Denmark TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			21			979	815
B: Estimated input 2020			44			643	683
C: Inputs 2020 including uncertainty (test value)			48			694	704
Extra reduction by 2020 (A-C)						285	111
Remaining reduction to fulfill NIC by 2020			26				
Remaining in % of ceiling			*125*				
Accounting for extra reduction			*-90*				
Remaining taking into account extra reduction			0				
Remaining in % of ceiling taking into account extra reduction			0				
Extra reduction in DS is used to compensated for the remaining reduction requirement of 26 tons TP in BAP							
F: Input ceilings from NIC2017 assessment			21			1040	829
D: Estimate input 2017			41			769	706
E: Input 2017 including uncertainty (test value)			45			818	726
Extra reduction by 2017 (F-E)						222	103
Remaining reduction to fulfill NIC by 2017			23				
Remaining in % of ceiling			*109*				
Significant changes since reference period (%) to 2020			-20			-29	-18

Estonia TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			9	225	185		
B: Estimated input 2020			17	281	233		
C: Inputs 2020 including uncertainty (test value)			20	313	252		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			11	88	67		
Remaining in % of ceiling			*117*	*39*	*36*		
F: Input ceilings from NIC2017 assessment			8	236	239		
D: Estimate input 2017			22	274	210		
E: Input 2017 including uncertainty (test value)			24	317	239		
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			16	81	0		
Remaining in % of ceiling			*194*	*34*	*0*		
Significant changes since reference period (%) to 2020			-26	-45	-18		

Finland TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	1683	1246		315			
B: Estimated input 2020	1483	1283		610			
C: Inputs 2020 including uncertainty (test value)	1561	1346		653			
Extra reduction by 2020 (A-C)	122						
Remaining reduction to fulfill NIC by 2020		100		338			
Remaining in % of ceiling		*8*		*107*			
Accounting for extra reduction		*-15*					
Remaining taking into account extra reduction		85					
Remaining in % of ceiling taking into account extra reduction		7					
Extra reduction in BOB is used to reduced the remaining reduction requirements in BOS with 15 tons TP							
F: Input ceilings from NIC2017 assessment	1668	1255		322			
D: Estimate input 2017	1545	1292		634			
E: Input 2017 including uncertainty (test value)	1608	1357		668			
Extra reduction by 2017 (F-E)	60						
Remaining reduction to fulfill NIC by 2017		103		346			
Remaining in % of ceiling		*8*		*107*			
Significant changes since reference period (%) to 2020	-18			-17			

Germany TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			203			401	
B: Estimated input 2020			414			302	
C: Inputs 2020 including uncertainty (test value)			444			332	
Extra reduction by 2020 (A-C)						69	
Remaining reduction to fulfill NIC by 2020			241				
Remaining in % of ceiling			*119*				
Accounting for extra reduction			*-22*				
Remaining taking into account extra reduction			219				
Remaining in % of ceiling taking into account extra reduction			108				
Extra reduction in DS is used to reduced the remaining reduction requirements in BAP with 22 tons TP							
F: Input ceilings from NIC2017 assessment			101			351	
D: Estimate input 2017			274			324	
E: Input 2017 including uncertainty (test value)			287			350	
Extra reduction by 2017 (F-E)						0	
Remaining reduction to fulfill NIC by 2017			186				
Remaining in % of ceiling			*184*				
Significant changes since reference period (%) to 2020			0			-14	

Latvia TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			167		1061		
B: Estimated input 2020			214		1198		
C: Inputs 2020 including uncertainty (test value)			278		1316		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			111		255		
Remaining in % of ceiling			*66*		*24*		
F: Input ceilings from NIC2017 assessment			74		541		
D: Estimate input 2017			238		1199		
E: Input 2017 including uncertainty (test value)			290		1337		
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			217		796		
Remaining in % of ceiling			*295*		*147*		
Significant changes since reference period (%) to 2020			-50				

Lithuania TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			703		175		
B: Estimated input 2020			991		7		
C: Inputs 2020 including uncertainty (test value)			1091		74		
Extra reduction by 2020 (A-C)					101		
Remaining reduction to fulfill NIC by 2020			388				
Remaining in % of ceiling			*55*				
Accounting for extra reduction			*-66*				
Remaining taking into account extra reduction			322				
Remaining in % of ceiling taking into account extra reduction			46				
Extra reduction in GUR is used to reduced the remaining reduction requirements in BAP with 45 tons TP							
F: Input ceilings from NIC2017 assessment			831		166		
D: Estimate input 2017			984		27		
E: Input 2017 including uncertainty (test value)			1101		97		
Extra reduction by 2017 (F-E)					69		
Remaining reduction to fulfill NIC by 2017			271				
Remaining in % of ceiling			*33*				
Significant changes since reference period (%) to 2020			-45		-97		

Poland TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			4198				
B: Estimated input 2020			8167				
C: Inputs 2020 including uncertainty (test value)			8964				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			4766				
Remaining in % of ceiling			*114*				
F: Input ceilings from NIC2017 assessment			4309				
D: Estimate input 2017			8742				
E: Input 2017 including uncertainty (test value)			9359				
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			5050				
Remaining in % of ceiling			*117*				
Significant changes since reference period (%) to 2020			-22				

Russia TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			242	2909	99		
B: Estimated input 2020			410	3092	106		
C: Inputs 2020 including uncertainty (test value)			607	3919	124		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			365	1010	25		
Remaining in % of ceiling			*151*	*35*	*26*		
F: Input ceilings from NIC2017 assessment			277	2892	185		
D: Estimate input 2017			692	1841	209		
E: Input 2017 including uncertainty (test value)			754	3174	225		
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			477	282	41		
Remaining in % of ceiling			*172*	*10*	*22*		
Significant changes since reference period (%) to 2020			-36	-54	-24		

Sweden TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)	811	1133	318			116	753
B: Estimated input 2020	728	729	706			84	679
C: Inputs 2020 including uncertainty (test value)	842	809	728			89	718
Extra reduction by 2020 (A-C)		324				27	35
Remaining reduction to fulfill NIC by 2020	31		410				
Remaining in % of ceiling	*4*		*129*				
Accounting for extra reduction	*-101*		*-224*				
Remaining taking into account extra reduction	0		186				
Remaining in % of ceiling taking into account extra redu	0		58				
A proportion of extra reduction in BOS is used to compensated for the remaining reduction requirement of 31 tons TP in BOB							
Extra reduction in BOB and DS is used to reduced the remaining reduction requirements in BAP with 224 tons TP							
F: Input ceilings from NIC2017 assessment	826	1125	308			105	740
D: Estimate input 2017	789	760	691			80	735
E: Input 2017 including uncertainty (test value)	870	822	715			85	772
Extra reduction by 2017 (F-E)		303				20	
Remaining reduction to fulfill NIC by 2017	44		407				32
Remaining in % of ceiling			*132*				*4*
Significant changes since reference period (%) to 2020		-37	-14			-20	

Belarus TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			349		407		
B: Estimated input 2020			801		614		
C: Inputs 2020 including uncertainty (test value)			867		655		
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			518		248		
Remaining in % of ceiling			*148*		*61*		
F: Input ceilings from NIC2017 assessment			244		797		
D: Estimate input 2017			880		711		
E: Input 2017 including uncertainty (test value)			964		765		
Extra reduction by 2017 (F-E)					31		
Remaining reduction to fulfill NIC by 2017			720				
Remaining in % of ceiling			*295*				
Significant changes since reference period (%) to 2020			-13				

Czeck Republic TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			57				
B: Estimated input 2020			89				
C: Inputs 2020 including uncertainty (test value)			122				
Extra reduction by 2020 (A-C)							
			65				
Remaining in % of ceiling			*114*				
0							
F: Input ceilings from NIC2017 assessment			108				
D: Estimate input 2017			258				
E: Input 2017 including uncertainty (test value)			312				
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			204				
Remaining in % of ceiling			*189*				
Significant changes since reference period (%) to 2020			-41				

Ukraine TP	BOB	BOS	BAP	GUF	GUR	DS	KAT
A : Input ceiling (NIC BSAP2021 update)			47				
B: Estimated input 2020			159				
C: Inputs 2020 including uncertainty (test value)			178				
Extra reduction by 2020 (A-C)							
Remaining reduction to fulfill NIC by 2020			131				
Remaining in % of ceiling			*279*				
F: Input ceilings from NIC2017 assessment			33				
D: Estimate input 2017			223				
E: Input 2017 including uncertainty (test value)			241				
Extra reduction by 2017 (F-E)							
Remaining reduction to fulfill NIC by 2017			208				
Remaining in % of ceiling			*622*				
Significant changes since reference period (%) to 2020			29				

Annex F Timeseries with total water and airborne nitrogen inputs country per basin

The plots can be found in the file Annex F.

Timeseries plots are made for country per basin on water and/or airborne inputs from each HELCOM country, countries with transboundary waterborne inputs (Belarus, Czech Republic and Ukraine). For airborne nitrogen inputs also “other countries”, Baltic Sea and North Sea shipping are included. There are set of plots for:

- *Total N (waterborne, airborne, total normalized, trend line with break points, NIC’s) – annex F (this annex)*
- Total P (waterborne, airborne (include as a table, not as plots), total normalized, trend line with break points, NIC’s) – annex G
- Airborne N (actual, normalized and trend with break points) – annex H
- Waterborne N (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex I
- Total waterborne P (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex J

The plots in annex F include timeseries of country per basin annual actual water and airborne nitrogen inputs, total normalized nitrogen inputs, NIC for the country basin, and trend lines. Trend line in a section (if there is detected break points), where full line indicated a significant trend and dash type when it is not significant. The estimated inputs in 2020 are indicated with a green dot.

Annex G Timeseries with total waterborne phosphorus inputs country per basin

The plots can be found in the file Annex G.

Timeseries plots are made for country per basin on water and/or airborne inputs from each HELCOM country, countries with transboundary waterborne inputs (Belarus, Czech Republic and Ukraine). For airborne nitrogen inputs also "other countries", Baltic Sea and North Sea shipping are included. There are set of plots for:

- Total N (waterborne, airborne, total normalized, trend line with break points, NIC's) – annex F
- *Total P (waterborne, airborne (include as a table, not as plots), total normalized, trend line with break points, NIC's) – annex G* (this annex)
- Airborne N (actual, normalized and trend with break points) – annex H
- Waterborne N (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex I
- Total waterborne P (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex J

The plots in annex G includes timeseries of country per basin annual actual waterborne phosphorus inputs, total normalized waterborne phosphorus inputs, NIC, and trend lines. Trend line in a section (if there is detected break points), where full line indicated a significant trend and dash type when it is not significant. The estimated inputs in 2020 are indicated with a green dot.

Atmospheric deposition of phosphorus is not included in the plots as it is not possible to quantify the sources of phosphorus, and phosphorus deposition is seen as a background source (HELCOM, 2014). The estimated annual phosphorus deposition per basin per year, based on a fixed rate of 5 kg TP per km^2 sea surface (HELCOM, 2014) is provided in table D.1.

Table G.1. *Estimated annual total phosphorus deposition on HELCOM basins 1995-2020.*

Basin	Phosphorus deposition (tonnes TP/yr)
Bothnian Bay	181
Bothnian Sea	394
Baltic Proper	1046
Gulf of Finland	150
Gulf of Riga	93
Danish Straits	105
Kattegat	118
Baltic Sea	2088

Annex H Timeseries with airborne nitrogen inputs country per basin

The plots can be found in the file Annex H.

Timeseries plots are made for country per basin on water and/or airborne inputs from each HELCOM country, countries with transboundary waterborne inputs (Belarus, Czech Republic and Ukraine). For airborne nitrogen inputs also "other countries", Baltic Sea and North Sea shipping are included. There are set of plots for:

- Total N (waterborne, airborne, total normalized, trend line with break points, NIC's) – annex F
- Total P (waterborne, airborne (include as a table, not as plots), total normalized, trend line with break points, NIC's) – annex G
- *Airborne N (actual, normalized and trend with break points) – annex H* (this annex)
- Waterborne N (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex I
- Total waterborne P (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex J

The plots in annex H includes timeseries of country per basin annual actual airborne nitrogen inputs, normalized nitrogen inputs, and trend lines. Trend line in a section (if there is detected break points), where full line indicated a significant trend and dash type when it is not significant. The estimated inputs in 2020 are indicated with a green dot.

Annex I Timeseries with waterborne nitrogen inputs country per basin

The plots can be found in the file Annex I.

Timeseries plots are made for country per basin on water and/or airborne inputs from each HELCOM country, countries with transboundary waterborne inputs (Belarus, Czech Republic and Ukraine). For airborne nitrogen inputs also “other countries”, Baltic Sea and North Sea shipping are included. There are set of plots for:

- Total N (waterborne, airborne, total normalized, trend line with break points, NIC’s) – annex F
- Total P (waterborne, airborne (include as a table, not as plots), total normalized, trend line with break points, NIC’s) – annex G
- Airborne N (actual, normalized and trend with break points) – annex H
- *Waterborne N (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex I* (this annex)
- Total waterborne P (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex J

The plots in annex I includes timeseries of country per basin annual actual riverine nitrogen inputs, direct nitrogen point source inputs, flow, normalized waterborne inputs, and trend lines Trend line in a section (if there is detected break points), where full line indicated a significant trend and dash type when it is not significant. The estimated inputs in 2020 are indicated with a green dot.

Annex J Timeseries with waterborne phosphorus inputs country per basin

The plots can be found in the file Annex J.

Timeseries plots are made for country per basin on water and/or airborne inputs from each HELCOM country, countries with transboundary waterborne inputs (Belarus, Czech Republic and Ukraine). For airborne nitrogen inputs also "other countries", Baltic Sea and North Sea shipping are included. There are set of plots for:

- Total N (waterborne, airborne, total normalized, trend line with break points, NIC's) – annex F
- Total P (waterborne, airborne (include as a table, not as plots), total normalized, trend line with break points, NIC's) – annex G
- Airborne N (actual, normalized and trend with break points) – annex H
- Waterborne N (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex I
- *Total waterborne P (riverine and direct inputs (actual), normalized waterborne inputs, flow, trend with break points) – annex J* (this annex)

The plots in annex J includes timeseries of country per basin annual actual riverine phosphorus inputs, direct phosphorus point source inputs, flow, normalized waterborne inputs, and trend lines. Trend line in a section (if there is detected break points), where full line indicated a significant trend and dash type when it is not significant. The estimated inputs in 2020 are indicated with a green dot.

Annex K Introducing the dataset with NIC assessment results

With this publication two spreadsheets will be made available. On with the detailed data behind the MAI assessment including annual monitored nitrogen, phosphorus and flow inputs per river, corresponding inputs for unmonitored areas (per country), direct inputs (per country but without flow) and atmospheric inputs per country – called the MAI dataset.

The other spreadsheet available includes *annual net input data (nitrogen, phosphorus, and flow)* from 1995-2020 given country by basin. It includes both actual airborne and waterborne inputs (separated in riverine and direct inputs), the normalized air and waterborne inputs, NIC but also trend lines with breakpoints and indication of significant segment of the timeseries. Further it includes corresponding annual data (expect direct inputs and atmospheric deposition) for the nine big transboundary rivers with NIC. The assessment dataset is available by clicking this link.

The file includes 4 sheets:

- Introduction NIC-dataset
- NIC-data
- Introduction-9rivers
- 9rivers_data

The NIC-data includes the column described below (and this description is included in sheet "Introduction NIC-dataset", and it is possible to filter data by criteria in the columns.

Column A: Country (and source) (se abbreviation below)

Column B: Basin (se abbreviation below)

Column C. Year

Column D. Flow direct (flow from direct discharging point sources) - in m^3 s^{-1}

Column E: Flow river (riverine flow) - in m^3 s^{-1}

Column F: Flow total (sum of column D and E) - in m^3 s^{-1}

Column G: TN air (airborne nitrogen input on the sea) - in tonnes

Column H: TN direct (total nitrogen inputs from point sources discharging directly into the sea) - in tonnes

Column I: TN river (riverine total nitrogen inputs) - in tonnes

Column J: TN waterborne (waterborne total nitrogen inputs, sum of H+I) - in tonnes

Column K: TN transboundary (transboundary total nitrogen inputs) - in tonnes

Column L: TN net water (net (from that specific country to that specific basin) waterborne total nitrogen inputs as sum of column J and K) - in tonnes

Column M: TN net total (net airborne + waterborne total nitrogen input as sum of columns G and L) - in tonnes

Column N: TP air (airborne phosphorus input on the sea – only available per basin, not divided by country) - in tonnes

Column O: TP direct (total phosphorus inputs from point sources discharging directly into the sea) - in tonnes

Column P: TP river (riverine total phosphorus inputs) - in tonnes

Column Q: TP waterborne (waterborne total phosphorus inputs, sum of O+P) - in tonnes

Column R: TP transboundary (transboundary total phosphorus inputs) - in tonnes

Column S: TP net water (net (from that specific country to that specific basin) waterborne total phosphorus inputs as sum of column Q and R) - in tonnes

Column T: TP net total (net airborne + waterborne total phosphorus input as sum of columns S and N) - in tonnes

Column U: TN-norm air (normalized airborne nitrogen input on the sea) - in tonnes

Column V: TN-norm river (normalized riverine total nitrogen inputs) - in tonnes

Column W: TN-norm waterborne (normalized waterborne total nitrogen inputs, sum of H+V) - in tonnes

Column X: TN-norm transboundary (normalized transboundary total nitrogen inputs) - in tonnes

Column Y: TN-norm net water (normalized net (from that specific country to that specific basin) waterborne total nitrogen inputs as sum of column W and X) - in tonnes

Column Z: TN-norm net total (normalized net airborne + waterborne total nitrogen input as sum of columns U and Y) - in tonnes

Column AA: TN NIC (Nutrient input ceiling for total nitrogen for country basin) – in tonnes

Column AB: TN_net trend 1 (net total nitrogen inputs from trend line (on normalized inputs) section 1 country by basin. Trend 1 will always start in 1995 and include at least 5 years. If no break points detected trend 1 will cover 1995-2020, if one breakpoint detected there is a trend 1 and trend 2, with two breakpoints at trend 1, trend 2 and trend 3 etc.) – in tonnes

Column AC: TN-net trend 2 (see explanation for column AB) – in tonnes

Column AD: TN-net trend 3 (see explanation for column AB) – in tonnes

Column AE: TN-net trend 4 (see explanation for column AB) – in tonnes

Column AF: TN_net signif. (for net total nitrogen inputs inform about significancy of the trend for each segment of the time series 1995-2020 country by basin.

0 = no trend

1 = significant

10 = no trend, jump after break point

11 = significant, jump after breakpoint

Column AG: TN_air trend 1 (as column AB but for airborne total nitrogen inputs) – in tonnes

Column AH: TN_air trend 2 (as column AC but for airborne total nitrogen inputs) – in tonnes

Column AI: TN_air trend 3 (as column AD but for airborne total nitrogen inputs) – in tonnes

Column AJ: TN_air trend 4 (as column AE but for airborne total nitrogen inputs) – in tonnes

Column AK: TN_air signif. (as column AF but for airborne total nitrogen inputs) – in tonnes

Column AL: TN_water trend 1 (as column AB but for waterborne total nitrogen inputs) – in tonnes

Column AM: TN_water trend 2 (as column AC but for waterborne total nitrogen inputs) – in tonnes

Column AN: TN_water trend 3 (as column AD but for waterborne total nitrogen inputs) – in tonnes

Column AO: TN_water trend 4 (as column AE but for waterborne total nitrogen inputs) – in tonnes

Column AP: TN_water signif. (as column AF but for waterborne total nitrogen inputs) – in tonnes

Column AQ: TP-norm air (normalized airborne phosphorus inputs on the sea, only per basin, not divided by country) - in tonnes

Column AR: TP-norm river (normalized riverine total phosphorus inputs) - in tonnes

Column AS: TP-norm waterborne (normalized waterborne total phosphorus inputs, sum of O+AR) - in tonnes

Column AT TP-norm transboundary (normalized transboundary total phosphorus inputs) - in tonnes

Column AU: TP-norm net water (normalized net (from that specific country to that specific basin) waterborne total phosphorus inputs as sum of column AS and AT) - in tonnes

Column AV: TP-norm net total (normalized net airborne + waterborne total phosphorus input as sum of columns AU and AQ) - in tonnes

Column AW: TP NIC (Nutrient input ceiling for total phosphorus for country basin) – in tonnes

Column AX: TP_net trend 1 (net total phosphorus inputs from trend line (on normalized inputs) section 1 country by basin. see explanation for column AB) – in tonnes

Column AY: TP-net trend 2 (see explanation for column AB) – in tonnes

Column AZ: TP-net trend 3 (see explanation for column AB) – in tonnes

Column BA: TP-net trend 4 (see explanation for column AB) – in tonnes

Column BB: TP_net signif. (see explanation for column AF) – in tonnes

Abbreviations used in the file:

ALL: Sum of all countries/sources
BSS: Baltic Sea shipping
BY: Belarus
CZ: Czech Republic
DE: Germany
DK: Denmark
EE: Estonia
FI: Finland

LT: Lithuania
LV: Latvia
NOS: North Sea shipping
OC: Other countries – countries (and sources) outside HELCOM
PL: Poland
RU: Russia
SE: Sweden
UA: Ukraine

BAS: Baltic Sea
BAP: Baltic Proper
BOB: Bothnian Bay
BOS: Bothnian Sea
BAP: Baltic Proper
GUF: Gulf of Finland
GUR: Gulf of Riga
DS: Danish Straits
KAT: Kattegat

Norm: Normalized

Signif.: Significant trend

NIC: Nutrient input ceiling
TN: Total Nitrogen
TP: Total phosphorus

The "9 rivers_data" sheet includes the column described below (and this description is included in sheet "Introduction-9rivers", and it is possible to filter data by criteria in the columns.

The assessment of NIC is for the entire river corresponding to RCL in column A and R in column B

Column A: Source code (TRL is a transboundary input, RCL the input from the entire river – the values that have been assessment against the river NIC)

Column B: Source code (T is transboundary input, R is the input from the entire river)

Column C: River name

Column D: Country se abbreviations above)

Column E: Basin (se abbreviations above)

Column F: Year

Column G: Flow riverine (flow transboundary (T in column B) or for the whole river (R I column B) - in $m^3 s^{-1}$

Columns H: TN riverine (total nitrogen inputs) – tonnes

Column I: Norm TN riverine (normalized total nitrogen inputs) - tonnes

Column J: TN NIC (Nutrient inputs ceiling for the whole river) - tonnes

Column K: TN riverine trend1 (riverine total nitrogen inputs from trend line (on normalized inputs) section 1 for the whole river. Trend 1 will always start in 1995 and include at least 5 years. If no break points detected trend 1 will cover 1995-2020, if one breakpoint detected there is a trend 1 and trend 2, with two breakpoints at trend 1, trend 2 and trend 3 etc.) – in tonnes

Column L: TN-riverine trend 2 (see explanation for column K) – in tonnes

Column M: TN-riverine trend 3 (see explanation for column K) – in tonnes

Column N: TN_riverive signif. (for riverine total nitrogen inputs for the whole river inform about significancy of the trend for each segment of the time series 1995-2020.

0 = no trend

1 = significant

10 = no trend, jump after break point

11 = significant, jump after breakpoint

Column O: TP riverine (total nitrogen inputs) – tonnes

Column P: Norm TP riverine (normalized total nitrogen inputs) - tonnes

Column Q: TP NIC (Nutrient inputs ceiling for the whole river) - tonnes

Column R: TP-riverine trend 1 (see explanation for column K) – in tonnes

Column S: TN-riverine trend 2 (see explanation for column K) – in tonnes

Column T: TP-riverine trend 3 (see explanation for column K) – in tonnes

Column U: TP_riverive signif. (see explanation for column N) – in tonnes