Compatibility of targets under different marine policies – Sufficiency of the EU WFD targets for individual rivers basins to achieve the BSAP goals

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Compatibility of targets under different marine policies

Contents

1. Introduction

1.1. Aim

The main aim of this analysis is to evaluate whether the EU Water Framework Directive (WFD, 2000/60/EC) targets are sufficient to achieve the HELCOM Baltic Sea Action Plan (HELCOM BSAP, https://helcom.fi/baltic-sea-action-plan/) nutrient load reduction targets (https://helcom.fi/baltic-sea-action-plan/nutrient-reduction-scheme/targets/).

Nutrient concentrations defined by countries at the limnic/marine border when implementing WFD are used to estimate the nutrient load that could be expected from the achievement of WFD Good Ecological Status. The same water discharge is assumed as used when estimating the loads in the HELCOM nutrient reduction scheme. The aim is to inform countries whether their WFD targets are sufficient to achieve the HELCOM BSAP load reduction targets, and if not, what targets are appropriate or what changes to direct point source loads are necessary. The analysis contributes to the harmonisation of WFD, BSAP and EU Marine Strategy Framework Directive (MSFD, 2008/56/EC) targets. It may highlight a need for additional actions in the catchment to achieve MSFD Good Environmental Status (GES) at sea, beyond those required to achieve Good Ecological Status according to WFD.

We aim to find nutrient loads per country and the Baltic Sea sub-basin (HELCOM division for pollution load compilation (PLC) is used; http://maps.helcom.fi/website/mapservice/), which would reflect the loads if rivers would be in Good Ecological Status (GES loads) according to WFD. Annex V of WFD defines good status as nutrient concentrations not exceeding the levels to ensure the functioning of the ecosystem and the achievement of good status based on the biological quality elements. Nutrient concentrations used here are the values that mark the boundary between the good and moderate ecological status of rivers (referred to as boundary conditions or good/moderate boundary). Since we are interested in total loads of nutrients, total nitrogen (TN) and total phosphorus (TP) concentrations at good/moderate boundary are applied. Not in all countries are the TN and/or TP concentrations part of the WFD ecological classification scheme in rivers. If available, the maximum nutrient loads defined to ensure that the coastal water bodies are in Good Ecological Status are used instead.

The outcome of the analysis will contribute to the compilation of recommendations on ways to improve the compatibility of targets under various legislative instruments. In order to illustrate the compatibility of the existing WFD ecological classification schemes with the planned update of the Baltic Sea Action plan, the draft nutrient input ceilings (NIC) are also considered in the analysis. We estimated the average concentrations of TN and TP in rivers (freshwater discharge) per country and sub-basin, corresponding to the suggested NIC values. We compared these estimates with the WFD good/moderate boundaries (related TN and TP concentrations) applied in the contracting parties (if available).

2. Data and methods

2.1. Nutrient boundary conditions in rivers

The aim was to calculate nutrient loads per country and Baltic Sea sub-basin corresponding to the loads if rivers would be in Good Ecological Status. Ecological classification schemes for the surface waters are implemented in all EU Member States, as requested by the Water Framework Directive (WFD, 2000/60/EC). Although the status of river waters is assessed based on biological quality elements, the supporting physical-chemical quality elements also include nutrient concentrations in most of the countries. Where such criteria are defined, the total nitrogen (TN) and total phosphorus (TP) concentrations, which mark the boundary between good and moderate quality classes in the river mouths, are used in the present analysis. It is assumed that these TN and TP concentrations mean the annual average concentrations. Since the nutrient boundary conditions in rivers differ between the countries and river types, a set of TP and TN boundary concentrations corresponding to the defined river types were acquired from each HELCOM country.

The WFD classification system for rivers includes TN and TP concentrations in Finland, Estonia, Latvia, Lithuania, Poland, and Germany. Thus, from those countries, the TN and TP concentrations at the boundary between the good and moderate classes were applied in the present analysis. In Finland, TP concentrations were not defined for one river type where it was not relevant. In Germany, instead of the TN concentration, corresponding to the boundary of good and moderate classes, an average TN concentration corresponding to the maximum allowable load from rivers to achieve good ecological status of the Baltic Sea coastal waters was applied in the analysis.

Denmark has set total nitrogen loads (but not total phosphorus loads) per year for sub-watersheds, which correspond to the good ecological status in the coastal waters. We used these values as the TN loads for Denmark (corresponding to WFD requirements) in the analysis. When it was not possible to assign a sub-watershed to a single HELCOM sub-basin, the load from that sub-watershed was divided between the sub-basins. The analysis was not done for the phosphorus load and concentrations.

Compared to other countries with available data, Sweden has proposed a different approach for setting boundary conditions at the good/moderate boundary. In the present analysis, we used TN and TP concentrations corresponding to the boundary between good and moderate ecological status at the border of riverine waters and coastal sea where salinity is 0 g kg^{-1}. Thus, coastal values corresponding to freshwater instead of river values are applied (for more specific explanation, please see the Swedish results in chapter 3.9).

Russia has provided allowable concentrations in river mouths for dissolved inorganic nitrogen and phosphorus, which in principle could be recalculated into TN and TP concentrations. However, these allowable concentrations are set based on human health criteria and are not comparable with the GES values used in the rest of the Baltic Sea countries. Therefore, this part of the analysis does not include the estimates for Russia.

2.2. River runoff data

For the load estimates corresponding to good ecological status of rivers, runoff data are needed. In the project application, it was determined to use river discharge values from the Reference Period of the HELCOM nutrient reduction scheme (1997-2003). However, for this exercise, we chose to use the annual mean runoff values found as arithmetic averages over the entire measurement period 1995-2017 that is covered by the Pollution Load Compilation (PLC). The average freshwater discharge from monitored rivers and unmonitored coastal areas were estimated using the PLC database provided by Bo Gustafsson (Stockholm University) and available via meeting materials for HELCOM PRESSURE 12-2020[1]. All initial data, including runoff estimates from the unmonitored coastal areas, were reported to the PLC database by the HELCOM countries.

2.3. Loads corresponding to Good Ecological Status (according to WFD)

An estimate of the annual load from a river into the Baltic Sea corresponding to Good Ecological Status of rivers (GES load) is calculated by multiplying the runoff with the TN or TP concentration marking the boundary between the good and moderate ecological status (for that specific river type). The GES load estimate for monitored rivers was obtained as a sum of loads from all monitored rivers in a specific sub-basin for a specific country. The total GES load was obtained when the load from unmonitored coastal areas is added to the load from the monitored rivers.

The load from the unmonitored coastal areas was estimated by multiplying the runoff from this unmonitored coastal area by the nutrient boundary concentration. However, since different river types could be assigned to the unmonitored rivers (streams, etc.), this approach has its weaknesses. We had to define the boundary concentrations for TN and TP. Where it was possible to define a single river type, the type-specific concentrations (for this type) were used. Where it was not possible, an average of boundary concentrations for relevant types was used. Since, in most cases, the nutrient concentrations corresponding to boundaries between good and moderate classes for different river types do not vary a lot within a country, this approach should not create large uncertainties in the estimates.

[1] HELCOM PRESSURE 12-2020. Document 3-6 Att2 Provisional values for the updated nutrient input ceilings.

2.4. Maximum allowable inputs and nutrient input ceilings

To determine if GES loads would be appropriate to achieve/maintain good environmental status in the sub-basins, we compared the found GES loads to maximum allowable inputs (MAI) of nutrients. MAI of nutrients indicates the maximal level of inputs of water- and airborne nitrogen and phosphorus to the Baltic Sea sub-basins that can be allowed to fulfil the targets for a non-eutrophied sea. Based on information in the Summary Report on Maximum Allowable Inputs (MAI) and Country Allocated Reduction Targets (CART)[2], we were able to define waterborne MAI for total nitrogen and total phosphorus per country and sub-basin. Note that the waterborne loads include both the riverine load and the direct load. The waterborne MAI values for phosphorus are equal to the country- and basin-specific phosphorus load in the reference period 1997-2003 (Table 9.6 in HELCOM, 2013) except for the Baltic Proper, the Gulf of Finland and the Gulf of Riga where the applied MAI was found by subtracting basin-specific CART (Table 6, column "Country by basin reduction before deducting transboundary shares") from the phosphorus load in the reference period. The waterborne MAI values for nitrogen are equal to the country- and basin-specific waterborne nitrogen load in the reference period 1997-2003 (calculated using data in Table 9.5 and Table 9.7 in HELCOM, 2013) except for the Baltic Proper, the Gulf of Finland and the Kattegat where the applied MAI was found by subtracting basin-specific waterborne CART from the waterborne nitrogen load in the reference period. It was assumed that the share of waterborne CART in the total CART is equal to the share of the waterborne nitrogen input in the total load in the reference period (values in Table 5, column "Country by basin reduction before deducting transboundary shares" were multiplied by the proportion of waterborne load in the total load in the reference period).

In the process of the BSAP update, HELCOM is considering replacing MAI and CART with nutrient input ceilings (NIC). Nutrient input ceilings are similar to MAI defined as maximum inputs via water and air to achieve good status with respect to eutrophication for the Baltic Sea sub-basins. To give an insight into how well the WFD targets correspond to the suggested NIC values, we also compared the estimated GES loads with the draft NIC values available from the HELCOM PRESSURE 12-2020[3] and HELCOM HOD 58-2020[4]. NIC and MAI are the same for the HELCOM sub-basins, but since the load estimates for the reference period 1997-2003 were recently updated, the NIC values for a country and sub-basin differ if compared with MAI adopted in 2013.

We used two approaches to estimate NIC values relevant to the freshwater discharge (including monitored rivers and unmonitored coastal areas). First, we assumed the proportional reduction of all loads. For each country and sub-basin pair, the sub-basin-specific percentages of required reductions to achieve NIC were applied to the riverine loads in 1997-2003 as suggested in the HELCOM PRESSURE

[2] HELCOM, 2013. Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan.
[3] HELCOM PRESSURE 12-2020. Document 3-6-Rev1 Provisional values for the updated nutrient input ceilings.
[4] HELCOM HOD 58-2020. Document 4-7 Draft updated HELCOM nutrient input reduction scheme.

12-2020 Document 3-6-Rev1 Provisional values for the updated nutrient input ceilings; see Tables 6 and 7 and for reference loads, Tables A2.1-A2.3). Secondly, we estimated average atmospheric deposition and direct loads for each country and sub-basin pair in the last five years with available data (2013-2017). Then, the riverine NIC values were found by subtracting five-year average atmospheric and direct nutrient inputs from the draft NIC values.

A third approach in estimating riverine NIC values could be used for nitrogen by assuming that all countries reduce the atmospheric inputs due to the NEC Directive[5] implementation up to 2030. We did not implement this approach but mention that it would mostly result in higher NIC values and lower reduction requirements for the waterborne loads. We discuss the impact of the NEC Directive implementation on the riverine NIC values and the maximal allowable nutrient concentrations in rivers in the Discussion and concluding remarks section of the report.

2.5. Nutrient concentrations in rivers to achieve nutrient input ceilings

Further background information to assess the compatibility of targets under different policies is obtained by estimating the maximal allowable nutrient concentrations in rivers to achieve the HELCOM nutrient input ceilings. We used the suggested NIC values for nitrogen and phosphorus per country and sub-basin and estimated the riverine NIC values from a country to a sub-basin as described in the previous sub-section. The riverine NICs estimated using two approaches – the proportional reduction approach and the approach accounting for achieved reduction in direct and atmospheric inputs – could differ. Which of those is higher depends on the achieved reduction in atmospheric and direct inputs between 1997-2003 and 2013-2017.

The NIC values for transboundary rivers were added to the allowable load for that country and sub-basin, where the river enters the Baltic Sea. The average flow per country and sub-basin and for transboundary rivers in 1995-2017 was calculated using the PLC database[6]. The flow from transboundary rivers was similarly added to the relevant country and sub-basin as for NIC. Finally, the TN and TP concentrations in rivers were estimated by dividing the riverine NIC values by the average runoff. Since two approaches for estimating riverine NICs were applied, two estimates of maximum allowable concentrations of nutrients in the freshwater discharge were obtained. These country and sub-basin specific TN and TP concentrations were compared with the good and moderate boundaries according to the WFD classification system (if available).

[5] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC.

[6] HELCOM PRESSURE 12-2020. Document 3-6 Att2 Provisional values for the updated nutrient input ceilings.

3. Results – river typology, nutrient boundary conditions and GES loads

The following sub-chapters describe river typology and nutrient boundary conditions per country together with the sources of these data, freshwater runoff from rivers and unmonitored areas and estimated nutrient loads to the sub-basins. The obtained load estimates are compared with maximum allowable load and draft nutrient input ceilings. The riverine NICs estimated using the sub-basin-specific percentages of required reductions to achieve NIC are shown in the tables in rows "Riverine NIC proportional (t year^{-1})". The riverine NIC values found by subtracting the five-year average atmospheric and direct nutrient inputs (2013-2017) from the draft NIC values are shown in the tables in rows "Riverine NIC left (t year^{-1})".

3.1. Denmark

Denmark has four river basin districts (RBD) and 23 main river basins/water catchment areas[7]. Rivers are divided into three types based on their size (and bottom sediment type). Denmark assesses the environmental status of the rivers based on indices for biological data. There are no set boundaries for total nutrients in the rivers that would mark the achievement of good ecological status. According to the WFD, Denmark has set total nitrogen loads per year for sub-watersheds that correspond to the good ecological status[8].

As seen from Table 3.1.2, the Danish TN loads corresponding to the good ecological status of the receiving coastal waters (later as GES loads) are lower than waterborne MAI and NIC for the Kattegat and the Danish Straits. It holds if the average direct load of nitrogen in 2013-2017 (459 t year^{-1} and 1836 t year^{-1}, respectively) is subtracted from the MAI. For the Baltic Proper, the GES load of TN is larger than the waterborne MAI and riverine NIC if the proportional reduction approach is applied (Table 3.1.2, row "Riverine NIC proportional"). However, when considering the achieved reduction in direct loads and atmospheric deposition by 2013-2017, the GES load is lower than the riverine NIC (1878 t year^{-1} *versus* 2775 t year^{-1}; Table 3.1.2 row "Riverine NIC left").

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[7] The Commission's assessment of the Danish River Basin management plans (http://ec.europa.eu/environment/water/participation/map_mc/countries/denmark_en.htm)

[8] Miljø- og Fødevareministeriet. 2016. Vandområdeplan 2015-2021 for Vandområdedistrikt Sjælland. [https://mst.dk/media/122171/revideret-vandomraadeplan-sjaelland-d-28062016.pdf]

Table 3.1.2. Total nitrogen load from Danish rivers to the coastal sea as a target load to achieve or maintain good ecological status of coastal water bodies. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	Receiving coastal area	Sub-watershed ID	TN GES load (t year^{-1})
Kattegat	Nordlige Kattegat	154, 222, 225	2292
	Mariager Fjord	159, 160	586
	Randers Fjord	135, 136, 137	2105
	Djursland	138, 139, 140	1079
	Roskilde Fjord	1, 2, 24, 165	1659
	Øresund - Kattegat	200, 205	247
	Limfjorden	156, 157, 158	7758
	GES load (t year^{-1})		**15726**
	Waterborne MAI (t year^{-1})		**23817**
	Riverine NIC proportional (t year^{-1})		**22389**
	Riverine NIC left (t year^{-1})		**23686**
Danish Straits	Djursland	141	20
	Aarhus Bugt	142, 144, 145, 147, 219	1059
	Horsens Fjord	127, 128, 146, 219	964
	Lillebaelt/Jylland	101-106, 108-110, 113, 114, 122-125, 216, 217, 224	2550
	Lillebaelt/Fyn	74-76, 78, 80-82, 87, 213, 216, 217, 224	1208
	Odense Fjord	59, 61, 62, 92, 93, 219	1019
	Storebaelt	83-86, 95, 96	545
	Det Sydfynske Øhav	63-65, 68-72, 89, 90, 212, 214	856
	Kalundborg	28, 29, 200, 204	781
	Øresund	6, 9	842
	Køge Bugt	201	1230
	Smålandsfarvandet	16-18, 25, 26, 34-38, 41, 45, 206, 207	3711
	Østersøen	209, 1/2 of 44+208*	3301
	GES load (t year^{-1})		**15116**
	Waterborne MAI (t year^{-1})		**23276**
	Riverine NIC proportional (t year^{-1})		**20787**
	Riverine NIC left (t year^{-1})		**22439**
Baltic Proper	Østersøen	46-49, 1/2 of 44+208*	916
	Bornholm	56, 57	962
	GES load (t year^{-1})		**1878**
	Waterborne MAI (t year^{-1})		**1468**
	Riverine NIC proportional (t year^{-1})		**1547**
	Riverine NIC left (t year^{-1})		**2775**

*) Target load into the coastal areas ID 44 and 208 were equally divided between the Danish Straits and the Baltic Proper.
**) NIC for Danish Straits is sum of draft NIC values for Sound and Western Baltic.

3.2. Estonia

Estonia has three RBDs. Rivers are divided into seven types based on catchment size and organic matter content. Type A waters are rich in humic substances, and type B waters contain little organic matter. Catchment size typology is divided into four classes: type I (10–100 km^2), type II (>100–1000 km^2), type III (>1000–10 000 km^2) and type IV (>10 000 km^2). Type IV is used only for river Narva[9]. Boundary conditions for total nitrogen and total phosphorus are the yearly mean concentrations (Table 3.2.1.)[10].

Table 3.2.1. Nutrient boundary conditions (good/moderate boundary) for Estonian river types.

River type	G/M boundary for TN	G/M boundary for TP
Type I A, II A, III A	3.0 mg N l^{-1}	0.08 mg P l^{-1}
Type I B, II B, III B	3.0 mg N l^{-1}	0.08 mg P l^{-1}
Type IV (Narva)	0.7 mg N l^{-1}	0.06 mg P l^{-1}

Flow data and nutrient load estimates were available for 14 rivers for the period 1995-2017. Rivers with incomplete runoff time series (e.g., the Pirita River) were aggregated into the unmonitored areas. Types of specific rivers are available in the appendixes of Estonian regulation[11]. Total estimated TN and TP GES load into the Gulf of Finland are 11747 t year^{-1} and 501 t year^{-1}, and into the Gulf of Riga 16048 t year^{-1} and 428 t year^{-1}, respectively (Table 3.2.2). For both nutrients and all sub-basins, the GES loads are higher than the waterborne MAI (remember that these MAI figures also include direct loads) and riverine NIC values. The GES loads of TP are twice as high as the draft NIC (updated BSAP) in the Gulf of Finland and the Gulf of Riga and four times higher than the draft NIC in the Baltic Proper (although the absolute values are small).

[9] Estonian regulation (RT I, 25.11.2010, 15) in the frames of Water Act (https://www.riigiteataja.ee/akt/125112010015), see § 6 p.2 (in Estonian)
[10] Estonian regulation (RT I, 25.11.2010, 15) in the frames of Water Act (https://www.riigiteataja.ee/akt/125112010015) , see § 38 Appendix 4 (in Estonian)
[11] Estonian regulation (RT I, 25.11.2010, 15) in the frames of Water Act (https://www.riigiteataja.ee/akt/125112010015), see Appendixes 1 & 2 (in Estonian)

Table 3.2.2. Average flow, applied G/M boundaries, and estimated GES load of TN and TP from Estonian rivers and unmonitored areas. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River/area	Average flow 1995-2017 ($m^3 s^{-1}$)	River type	Applied G/M boundary		TN GES load (t $year^{-1}$)	TP GES load (t $year^{-1}$)
				TN (mg N l^{-1})	TP (mg P l^{-1})		
Baltic Proper	BAPEELAND*	14.5	-	3.0	0.08	1370	37
	Waterborne MAI (t $year^{-1}$)					**893**	**9**
	Riverine NIC proportional (t $year^{-1}$)					**849**	**8**
	Riverine NIC left (t $year^{-1}$)					**785**	**8**
Gulf of Finland	JÄGALA	13.1	III B	3.0	0.08	1237	33
	KEILA	6.9	II B	3.0	0.08	652	17
	KUNDA	5.8	II B	3.0	0.08	548	15
	LOOBU	3.0	II B	3.0	0.08	287	8
	NARVA**	143.8	IV	0.7	0.06	3175	272
	PUDISOO	1.2	I A	3.0	0.08	115	3
	PURTSE	7.0	II A	3.0	0.08	658	18
	PÜHAJÕGI	1.8	II B	3.0	0.08	173	5
	VALGEJÕGI	4.0	II B	3.0	0.08	379	10
	VIHTERPALU	4.5	II A	3.0	0.08	424	11
	VÄÄNA	2.9	II B	3.0	0.08	271	7
	SELJAJÕGI	4.1	II B	3.0	0.08	387	10
	GUFEELAND*	36.4	-	3.0	0.08	3441	92
	GES load (t $year^{-1}$)					**11747**	**501**
	Waterborne MAI (t $year^{-1}$)					**10660**	**242**
	Riverine NIC proportional (t $year^{-1}$)					**9451**	**199**
	Riverine NIC left (t $year^{-1}$)					**9987**	**200**
Gulf of Riga	KASARI	30.9	III B	3.0	0.08	2927	78
	PÄRNU	64.8	III B	3.0	0.08	6129	163
	GUREELAND*	73.9	-	3.0	0.08	6993	186
	GES load (t $year^{-1}$)					**16048**	**428**
	Waterborne MAI (t $year^{-1}$)					**12530**	**240**
	Riverine NIC proportional (t $year^{-1}$)					**12816**	**177**
	Riverine NIC left (t $year^{-1}$)					**12790**	**182**

*) Runoff from unmonitored coastal areas that is not covered by river monitoring. Values are GES loads calculated using river type A and B boundary values (same for both types).
**) River Narva is a border river, with 33% of the loads designated to Estonia and 67% to Russia. Runoff and GES loads in this table represent 33%.

3.3. Finland

Finland has eight RBDs[12]. Rivers are divided into 11 types based on size and geology[13]. Boundary conditions for nutrients are the yearly mean concentrations (Table 3.3.1). Total nitrogen boundary values are not used for clay-type rivers (Ssa, Ksa, Psa)[14]. For this exercise we assigned a 0.80 mg N l^{-1} value as total nitrogen boundary concentration for clay-type rivers.

Table 3.3.1. Nutrient boundary conditions (good/moderate boundary) for Finnish river types

River type	G/M boundary for TN	G/M boundary for TP
St, Est, Kt, Pt	0.90 mg N l^{-1}	0.040 mg P l^{-1}
Sk, Esk, Kk, Pk	0.80 mg N l^{-1}	0.035 mg P l^{-1}
Ssa, Ksa, Psa	0.80 mg N l^{-1}*	0.060 mg P l^{-1}

*) Boundary value assigned to clay-type rivers for estimating the full load to sub-basins.

Flow data and nutrient load estimates were available for 28 rivers for the period 1995-2017. Types of specific rivers were assigned using the information found on the web-page of the state environmental administration[15]. There was no available list containing the information on all rivers and their types; therefore, maps were used. Total TN and TP GES load into the Bothnian Sea (includes the Archipelago Sea) is 11318 t $year^{-1}$ and 561 t $year^{-1}$, into the Bothnian Bay 47506 t $year^{-1}$ and 2107 t $year^{-1}$, and into the Gulf of Finland 11053 t $year^{-1}$ and 558 t $year^{-1}$, respectively (Table 3.3.2).

[12] The Commission's assessment of the Finnish River Basin management plans (http://ec.europa.eu/environment/water/participation/map_mc/countries/finland_en.htm).
[13] Aroviita et al. 2012. Ohje pintavesien ekologisen ja kemiallisen tilan luokitteluun vuosille 2012-2013 – päivitetyt arviointiperusteet ja niiden soveltaminen. Ympäristöhallinnon ohjeita. See Annex 2.4 (in Finnish).
[14] Personal communication with Antton Keto (Ministerial Adviser from the Ministry of the Environment).
[15] Vesienhoitoalueet (https://www.ymparisto.fi/fi-FI/Vesi/Vesiensuojelu/Vesienhoidon_suunnittelu_ja_yhteistyo/Vesienhoitoalueet)

Table 3.3.2. Average flow, applied G/M boundaries, and nutrient GES load for Finnish rivers. Please note that TN GES loads for river types Ssa, Ksa and Psa are estimated using a boundary value proposed in this exercise. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River	Average flow 1995-2017 ($m^3 s^{-1}$)	River type	Applied G/M boundary		TN GES load (t year-1)	TP GES load (t year^{-1})
				TN (mg N l^{-1})	TP (mg P l^{-1})		
Bothnian Sea (including Archipelago Sea)	AURAJOKI	7.8	Ksa	0.8	0.06	198	15
	KISKONJOKI	9.8	Sk	0.8	0.035	247	11
	PAIMIONJOKI	9.1	Ssa	0.8	0.06	231	17
	USKELANJOKI	5.7	Ksa	0.8	0.06	145	11
	ARCFILAND*	52.1	-	0.83	0.045	1369	74
	EURAJOKI	8.9	Ssa	0.8	0.06	224	17
	LAPVÄÄRTINJOKI	14.3	St	0.9	0.04	405	18
	KOKEMÄENJOKI	223.3	Esk	0.8	0.035	5633	246
	NÄRPIÖNJOKI	9.7	Kt	0.9	0.04	275	12
	BOSFILAND*	98.6	-	0.83	0.045	2590	140
	GES load (t year^{-1})					**11318**	**561**
	Waterborne MAI (t year^{-1})					**25641**	**1255**
	Riverine NIC proportional (t year^{-1})					**23561**	**1178**
	Riverine NIC left (t year^{-1})					**25274**	**1178**
Bothnian Bay	IIJOKI	178.5	Est	0.9	0.04	5067	225
	KALAJOKI	45.8	St	0.9	0.04	1300	58
	KEMIJOKI	576.6	St	0.9	0.04	16366	727
	KIIMINGINJOKI	49.0	St	0.9	0.04	1390	62
	KYRÖNJOKI	43.5	St	0.9	0.04	1234	55
	LAPUANJOKI	32.9	St	0.9	0.04	934	42
	LESTIJOKI	12.9	St	0.9	0.04	367	16
	OULUJOKI	272.3	Esk	0.8	0.035	6870	301
	PERHONJOKI	23.7	St	0.9	0.04	674	30
	PYHÄJOKI	33.9	St	0.9	0.04	963	43
	SIIKAJOKI	43.9	St	0.9	0.04	1246	55
	SIMOJOKI	49.6	St	0.9	0.04	1407	63
	TORNE ÄLV – TORNIONJOKI**	200.7	Est	0.9	0.04	5696	253
	BOBFILAND*	140.6	-	0.9	0.04	3991	177
	GES load (t year^{-1})					**47506**	**2107**
	Waterborne MAI (t year^{-1})					**32625**	**1668**
	Riverine NIC proportional (t year^{-1})					**30857**	**1617**
	Riverine NIC left (t year^{-1})					**31100**	**1629**
Gulf of Finl	KARJAANJOKI	17.7	Ksa	0.8	0.06	446	33

	KOSKENKYLÄNJOKI	8.4	Ksa	0.8	0.06	213	16
	KYMIJOKI	305.8	Esk	0.8	0.035	7714	337
	MUSTIJOKI	6.8	Ksa	0.8	0.06	172	13
	PORVOONJOKI	11.7	Ssa	0.8	0.06	296	22
	VANTAANJOKI	16.1	Ssa	0.8	0.06	405	30
	VIROJOKI	4.5	Kk	0.8	0.035	112	5
	GUFFILAND*	67.1	-	0.8	0.0475	1694	101
	GES load (t $year^{-1}$)					**11053**	**558**
	Waterborne MAI (t $year^{-1}$)					**14451**	**305**
	Riverine NIC proportional (t $year^{-1}$)					**12088**	**255**
	Riverine NIC left (t $year^{-1}$)					**13130**	**239**

*) Runoff from unmonitored coastal areas that is not covered by river monitoring. Values for TN and TP GES loads are calculated using an average of river boundary conditions or most relevant for the specific sub-basin.
**) River Torne älv/Tornionjoki is a border river, with 45% of loads designated to Finland and 55% to Sweden. Runoff and GES loads in this table represent 45%.

The estimated GES loads of TN and TP are much lower than the waterborne MAI and riverine NIC for the Bothnian Sea but higher than the waterborne MAI and riverine NIC for the Bothnian Bay. For the Gulf of Finland, the GES load of TN is lower than both MAI and NIC. At the same time, the GES load of TP (558 t $year^{-1}$) is higher than waterborne MAI (305 t $year^{-1}$) and approximately twice as high as the riverine NIC (either 255 t $year^{-1}$ or 239 t $year^{-1}$).

3.4. Germany

Germany has 10 RBDs. The information on the boundary conditions was taken from the German Surface Water Protection Ordinance[16]. For phosphorus, the river type specific good/moderate boundaries of the rivers were used, while for nitrogen, the applied concentration of 2.6 mg N l^{-1} is a management value that was specifically set for the rivers so that the coastal and marine waters in the Baltic Sea reach good status with respect to eutrophication.

[16] Verordnung zum Schutz von Oberflächengewässern, Bundesgesetzblatt Jahrgang 2016 Teil I Nr. 28, ausgegeben zu Bonn am 23. Juni 2016.

Table 3.4.2. Average flow, applied nutrient concentrations (good/moderate boundary for TP and the management value for TN), and estimated nutrient GES loads for German rivers. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River	Average flow 1995-2017 ($m^3 s^{-1}$)	Applied nutrient concentrations		TN GES load (t $year^{-1}$)	TP GES load (t $year^{-1}$)
			TN (mg N l^{-1})	TP (mg P l^{-1})		
Baltic Proper	BARTHE	1.4	2.6	0.10	115	4
	DUVENBAEK	0.3	2.6	0.10	23	1
	PEENE	19.6	2.6	0.10	1606	62
	RECKNITZ	3.5	2.6	0.10	290	11
	RYCK	0.8	2.6	0.10	65	3
	UECKER	7.3	2.6	0.10	598	23
	ZAROW	2.2	2.6	0.10	178	7
	BAPDELAND*	14.9	2.6	0.10	1223	47
	GES load (t $year^{-1}$)				**4097**	**158**
	Waterborne MAI (t $year^{-1}$)				**5391**	**70**
	Riverine NIC proportional (t $year^{-1}$)				**5685**	**68**
	Riverine NIC left (t $year^{-1}$)				**5747**	**64**
Western Baltic (part of Danish Straits)	AALBEK	0.4	2.6	0.10	32	1
	FÜSINGER AU	2.6	2.6	0.10	217	8
	GODDERSTORFER AU	0.3	2.6	0.10	24	1
	HAGENER AU	0.8	2.6	0.10	64	2
	HELLBACH	1.2	2.6	0.10	98	4
	KOSELER AU	0.5	2.6	0.15	43	2
	KOSSAU	1.0	2.6	0.10	79	3
	LANGBALLIGAU	0.4	2.6	0.10	37	1
	LIPPINGAU	0.5	2.6	0.10	40	2
	MAURINE	0.8	2.6	0.10	67	3
	OLDENBURGER GRABEN	0.6	2.6	0.15	46	3
	SCHWARTAU	1.9	2.6	0.15	153	9
	SCHWENTINE	6.4	2.6	0.10	521	20
	STEPENITZ	3.0	2.6	0.10	246	9
	WALLENSTEINGRABEN	1.4	2.6	0.10	113	4
	WARNOW	14.7	2.6	0.10	1205	46
	TRAVE	7.8	2.6	0.10	642	25
	WEBDELAND*	29.8	2.6	0.125	2443	94
	GES load (t $year^{-1}$)				**6069**	**238**
	Waterborne MAI (t $year^{-1}$)				**12843**	**351**
	Riverine NIC proportional (t $year^{-1}$)				**12048**	**380**
	Riverine NIC left (t $year^{-1}$)				**14200**	**386**

*) Runoff from unmonitored coastal areas that is not covered by river monitoring; applied TP concentrations are the average values of G/M boundaries for the relevant sub-basin.

Flow data and nutrient load estimates were available for 22 rivers for the period 1995-2017. The estimated total TN and TP GES load into the Baltic Proper are 4097 t $year^{-1}$ and 158 t $year^{-1}$ and the Western Baltic (part of the Danish Straits) 6069 t $year^{-1}$ and 238 t $year^{-1}$, respectively (Table 3.4.1). While the GES loads are lower than the targets (both MAI and NIC) for the Danish Straits and TN GES load to the Baltic Proper, the GES load of TP to the Baltic Proper is higher than MAI and both NIC estimates.

3.5. Latvia

Latvia has four RBDs[17]. Rivers are divided into 6 types based on size, slope and bottom sediments[18]. Boundary conditions for nutrients are the yearly mean concentrations (Table 3.5.1).

Table 3.5.1. Nutrient boundary conditions (good/moderate boundary) for Latvian river types

River type	G/M boundary for TN	G/M boundary for TP
5	2.8 mg N l^{-1}	0.065 mg P l^{-1}
6	2.8 mg N l^{-1}	0.09 mg P l^{-1}

Flow data and nutrient load estimates were available for eight rivers for the period 1995-2017. Types for specific rivers were found using information based on personal communication and HELCOM BSEP 126B. The estimated total TN and TP GES load into Baltic Proper were 13916 t $year^{-1}$ and 420 t $year^{-1}$, and into Gulf of Riga 81777 t $year^{-1}$ and 2629 t $year^{-1}$, respectively (Table 3.5.2). All GES loads are higher than the MAI and NIC values for the relevant sub-basins whereas the proportional gap is larger for the TP loads.

[17] The Commission's assessment of the Latvian River Basin management plans (http://ec.europa.eu/environment/water/participation/map_mc/countries/latvia_en.htm)
[18] Latvian Environment, geology and meteorology agency. Characteristics of the Latvian river basin districts. A review of the impact of human activity on the status of surface waters and on groundwater. Economic analysis of water use (Article 5 report). 2005

Table 3.5.2. Average flow, applied G/M boundaries, and estimated GES load of TN and TP from Latvian rivers and unmonitored areas. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River	Average flow 1995-2017 ($m^3 s^{-1}$)	River type	Applied G/M boundary		TN GES load (t $year^{-1}$)	TP GES load (t $year^{-1}$)
				TN (mg N l^{-1})	TP (mg P l^{-1})		
Baltic Proper	BARTA	20.5	5	2.8	0.065	1812	42
	SAKA	11.6	6	2.8	0.09	1021	33
	VENTA	97.4	6	2.8	0.09	8601	276
	BAPLVLAND*	28.1	-	2.25	0.0775	1995	69
	GES load (t $year^{-1}$)					**13429**	**420**
	Waterborne MAI (t $year^{-1}$)					**7979**	**108**
	Riverine NIC proportional (t $year^{-1}$)					**8675**	**182**
	Riverine NIC left (t $year^{-1}$)					**8494**	**188**
Gulf of Riga	GAUJA	78.3	6	2.8	0.09	6910	222
	IRBE	17.0	6	2.8	0.09	1505	48
	LIELUPE	115.5	6	2.8	0.09	10200	328
	SALACA	38.5	6	2.8	0.09	3395	109
	DAUGAVA	636.0	6	2.8	0.09	56162	1805
	GURLVLAND*	40.8	-	2.25	0.0775	2896	100
	GES load (t $year^{-1}$)					**81069**	**2612**
	Waterborne MAI (t $year^{-1}$)					**65843**	**1699**
	Riverine NIC proportional (t $year^{-1}$)					**65274**	**1594**
	Riverine NIC left (t $year^{-1}$)					**66576**	**1691**

*) Runoff from unmonitored coastal areas that are not covered by river monitoring; applied TN and TP concentrations are the average values of G/M boundaries for the River type 1: G/M boundary for TN is 2.0 mg/l; for TP it is 0.065 mg/l and River type 2: G/M boundary for TN is 2.5 mg/l; for TP it is 0.09 mg/l[19].

[19] Personal communication by Ilga Kokorite, Latvian Environment, Geology and Meteorology Center.

3.6. Lithuania

Lithuania has four RBDs[20]. Rivers are divided into five types based on the characteristics of their aquatic communities. Boundary conditions for nutrients are the yearly mean concentrations[21] (Table 3.6.1).

Table 3.6.1. Nutrient boundary conditions (good/moderate boundary) for Lithuanian river types.

River type	G/M boundary for TN	G/M boundary for TP
Type 1-5	3.0 mg l^{-1}	0.14 mg l^{-1}

Flow data and nutrient load estimates were available for two rivers for the period 1995-2017. Types for specific rivers were found from the same source as the boundary conditions[22]. The estimated total TN and TP GES load into the Baltic Proper are 60616 t year^{-1} and 2829 t year^{-1}, respectively (Table 3.6.2). If compared with the NIC values, the obtained GES loads are two times higher than the riverine NIC for TN and almost three times higher than the riverine NIC for TP.

Table 3.6.2. Average flow, applied G/M boundaries, and estimated GES load of TN and TP from Lithuanian rivers and unmonitored areas. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River	Average flow 1995-2017 ($m^3 s^{-1}$)	Applied G/M boundary		TN GES load (t year^{-1})	TP GES load (t year^{-1})
			TN (mg N l^{-1})	TP (mg P l^{-1})		
Baltic proper	AKMENA-DANE	7.1	3.0	0.14	670	31
	NEMUNAS	617.8	3.0	0.14	58450	2728
	BAPLTLAND*	15.8	3.0	0.14	1496	70
	GES load (t year^{-1})				**60616**	**2829**
	Waterborne MAI (t year^{-1})				**33493**	**1059**
	Riverine NIC proportional (t year^{-1})				**30666**	**941**
	Riverine NIC left (t year^{-1})				**30208**	**955**

*) Runoff from unmonitored coastal areas that are not covered by river monitoring; for GES load estimates, the TN and TP concentrations corresponding to the G/M boundary of monitored rivers are applied.

[20] The Commission's assessment of the Lithuanian River Basin management plans (http://ec.europa.eu/environment/water/participation/map_mc/countries/lithuania_en.htm)

[21] Lithuanian River Basin Management plans from CIRCABC, e.g. “DAUGUVOS UPIŲ BASEINŲ RAJONO VALDYMO PLANO PROJEKTAS” 2015.

[22] Lithuanian River Basin Management plans from CIRCABC, e.g. “DAUGUVOS UPIŲ BASEINŲ RAJONO VALDYMO PLANO PROJEKTAS” 2015.

3.7. Poland

Poland has ten RBDs, but for the next River Basin Management Plan (RBMP) cycle, there will be nine RBDs as defined by the New Water Law Act[23]. Rivers are divided into 26 types based on the WFD Annex II system A[24]. Boundary conditions for nutrients are the yearly mean concentrations (Table 3.7.1). Please note that the riverine typology will be changed for the next RBMPs cycle (2022-2027). The conceptual work has been done, and based on that, there are going to be 20 river types. Polish experts have set the boundaries between the ecological quality classes based on the tool recommended by JRC/WG ECOSTAT CIS WFD, following the in-depth testing of the tool using a broad set of collected monitoring data. The new G/M boundary concentrations that will be used from 2022 vary between 3.0 and 3.5 mg N l^{-1} for TN and 0.30 and 0.35 mg P l^{-1} for TP. Though, in this analysis, we used the existing typology and G/M boundary concentrations (Table 3.7.1).

Table 3.7.1. Nutrient boundary conditions (good/moderate boundary) for Polish river types that are defined for the current RBMP cycle (until 2021).

River type	G/M boundary for TN	G/M boundary for TP
20	4.1 mg N l^{-1}	0.27 mg P l^{-1}
21	4.0 mg N l^{-1}	0.30 mg P l^{-1}
22	2.7 mg N l^{-1}	0.31 mg P l^{-1}
24	2.8 mg N l^{-1}	0.21 mg P l^{-1}

Flow data and nutrient load estimates were available for 12 rivers for the period 1995-2017. Types of rivers, including direct tributaries of Baltic, are determined in River Basin Management Plans for Oder and Vistula[25]. The information was received via personal communication[26]. Total TN and TP GES load into the Baltic Proper are 231119 t $year^{-1}$ and 17761 t $year^{-1}$, respectively (Table 3.7.2). These estimates are higher than the MAI and NIC values, especially for TP, where the GES load is approximately four times as large as the riverine NIC value.

[23] Polish Water Law Act, http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20170001566
[24] The Commission's assessment of the Polish River Basin management plans (http://ec.europa.eu/environment/water/participation/map_mc/countries/poland_en.htm)
[25] http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20160001967 and http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20160001911 (in Polish)
[26] Boundary conditions obtained via personal communication with Piotr Panek (Chief Inspectorate for Environmental Protection, Poland)

Table 3.7.2. Average flow, applied G/M boundaries, and estimated GES load of TN and TP from Polish rivers and unmonitored areas. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River	Average flow 1995-2017 ($m^3 s^{-1}$)	River type	Applied G/M boundary		TN GES load (t year-1)	TP GES load (t $year^{-1}$)
				TN (mg N l^{-1})	TP (mg P l^{-1})		
Baltic Proper	GRABOWA	8.5	24	2.8	0.21	750	56
	INA	14.1	24	2.8	0.21	1242	93
	LEBA	20.4	22	2.7	0.31	1734	199
	LUPAWA	9.9	22	2.7	0.31	845	97
	ODER	558.0	21	4.0	0.30	70388	5279
	PARSETA	28.9	22	2.7	0.31	2461	283
	PASLEKA	16.7	20	4.1	0.27	2159	142
	REDA	5.0	22	2.7	0.31	425	49
	REGA	20.1	22	2.7	0.31	1708	196
	SLUPIA	17.0	22	2.7	0.31	1445	166
	WIEPRZA	17.3	22	2.7	0.31	1474	169
	VISTULA	1084.4	21	4.0	0.30	136792	10259
	BAPPLLAND*	89.9	-	3.42	0.2725	9695	773
	GES load (t $year^{-1}$)					**231119**	**17761**
	Waterborne MAI (t $year^{-1}$)					**151833**	**4946**
	Riverine NIC proportional (t $year^{-1}$)					**140418**	**4421**
	Riverine NIC left (t $year^{-1}$)					**137961**	**4409**

*) Runoff from unmonitored coastal areas that are not covered by river monitoring; applied TN and TP concentrations are the average values of G/M boundaries.

3.8. Russia

Russia has provided allowable concentrations in river mouths for inorganic nutrients, which could be recalculated to TN and TP concentrations. However, these concentrations are not set for ecological quality status assessment. They are the quality standards for the admissible impact of chemical substances on human health. These values cannot be used for the purpose of this analysis.

3.9. Sweden

Sweden has ten RBDs[27]. Sweden does not have any type-specific nutrient boundaries for rivers, but Sweden has proposed boundary values (based on the work done by Philip Axe[28]). The proposed values are derived from WFD based targets for the coastal areas, which are salinity related. It is assumed that water exiting land has a salinity of 0 g kg^{-1}, and therefore that end-member concentration could be used to give total N and total P loads. To get target concentrations from these N and P loads, the discharge data from PLC 5.5 was used (note that PLC basins do not match up exactly with the WFD water types).

For this exercise, we received annual mean TN and TP target values at zero salinity divided by coastal water types (Table 3.9.1). To assign nutrient boundary values to rivers, we used coastal water type information from Swedish regulations.

Table 3.9.1. Nutrient boundary conditions (good/moderate boundary) for Swedish coastal water types at salinity of 0 g kg^{-1}.

Coastal water type	G/M boundary for TN	G/M boundary for TP
5 - S. Halland and N. Öresund coastal water	0.3 mg N l^{-1}	0.02 mg P l^{-1}
6 - Öresund coastal water	0.3 mg N l^{-1}	0.02 mg P l^{-1}
7 - Skånes coastal water	0.8 mg N l^{-1}	0.04 mg P l^{-1}
8 - Blekinge Archipelago and Kalmar Sound, inner coastal waters	0.8 mg N l^{-1}	0.03 mg P l^{-1}
13 - Östersgötlands Archipelago	0.7 mg N l^{-1}	0.04 mg P l^{-1}
16 - S. Bothnian Sea inner coastal waters	0.4 mg N l^{-1}	0.02 mg P l^{-1}
18 - N. Bothnian Sea, High coast inner coastal waters	0.3 mg N l^{-1}	0.01 mg P l^{-1}
20 - N. Quark Inner coastal waters	0.3 mg N l^{-1}	0.01 mg P l^{-1}
22 - N. Bothnian Bay, Inner coastal waters	0.3 mg N l^{-1}	0.02 mg P l^{-1}
24 - Stockholms archipelago and Hallsfjärden	0.5 mg N l^{-1}	0.03 mg P l^{-1}
25 - Göta älvs och Nordre älvs estuaries	0.5 mg N l^{-1}	0.02 mg P l^{-1}

Flow data and nutrient load estimates were available for 38 rivers for the period 1995-2017. Based on available data, the total TN and TP GES load into the Baltic Proper were 12492 t $year^{-1}$ and 596 t $year^{-1}$, the Bothnian Bay 16588 t $year^{-1}$ and 1106 t $year^{-1}$, the Bothnian Sea 25587 t $year^{-1}$ and 997 t $year^{-1}$, the Kattegat 12742 t $year^{-1}$ and 581 t $year^{-1}$ and the Danish Straits 230 t $year^{-1}$ and 15 t $year^{-1}$, respectively (Table 3.9.2). Most of the estimated GES loads from Sweden to the Baltic sub-basins

[27] The Commission's assessment of the Swedish River Basin management plans (http://ec.europa.eu/environment/water/participation/map_mc/countries/sweden_en.htm)
[28] Personal communication, Philip Axe.

are lower than the waterborne MAI and riverine NIC values. Higher GES load compared to MAI and NIC is found for the phosphorus load to the Baltic Proper and the Bothnian Bay. The obtained TP GES load to the Bothnian Sea is approximately equal to the riverine NIC value.

Table 3.9.2. Average flow, applied G/M boundaries, and estimated GES load of TN and TP from Swedish rivers and unmonitored areas. For comparison, waterborne MAI and two estimates of riverine NIC values are shown (see sub-sections 2.4-2.5 for the explanation).

Sub-basin	River	Average flow 1995-2017 ($m^3 s^{-1}$)	Coastal water type	Applied G/M boundary		TN GES load (t $year^{-1}$)	TP GES load (t $year^{-1}$)
				TN (mg N l^{-1})	TP (mg P l^{-1})		
Baltic Proper	ALSTERÅN	11.3	8	0.8	0.03	285	11
	BOTORPSSTRÖMMEN	6.1	8	0.8	0.03	154	6
	EMÅN	30.4	8	0.8	0.03	767	29
	HELGE Å	44.4	7	0.8	0.04	1120	56
	LJUNGBYÅN	4.3	8	0.8	0.03	109	4
	LYCKEBYÅN	6.0	8	0.8	0.03	152	6
	MOTALA STRÖM	98.0	8	0.8	0.03	2472	93
	MÖRRUMSÅN	28.2	8	0.8	0.03	712	27
	NORRSTRÖM, MÄLARENS UTLOPP	164.8	24	0.5	0.03	2599	156
	NYKÖPINGSÅN	22.0	13	0.7	0.04	486	28
	BAPSELAND*	164.6	-	0.7	0.035	3634	182
	GES load (t $year^{-1}$)					**12492**	**596**
	Waterborne MAI (t $year^{-1}$)					**24710**	**339**
	Riverine NIC proportional (t $year^{-1}$)					**20696**	**270**
	Riverine NIC left (t $year^{-1}$)					**20336**	**217**
Bothnian Bay	ALTERÄLVEN	4.9	22	0.3	0.02	46	3
	KALIX ÄLV	329.8	22	0.3	0.02	3120	208
	LULE ÄLV	539.5	22	0.3	0.02	5104	340
	PITE ÄLV	183.3	22	0.3	0.02	1655	110
	RICKLEÅN	16.7	22	0.3	0.02	158	11
	RÅNE ÄLV	50.0	22	0.3	0.02	473	32
	SKELLEFTE ÄLV	175.0	22	0.3	0.02	1655	110
	TORNE ÄLV – TORNIONJOKI**	245.3	22	0.3	0.02	2320	155
	TÖRE Å	5.51	22	0.3	0.02	56	3
	BOBSELAND*	203.5	-	0.3	0.02	1925	128
	GES load (t $year^{-1}$)					**16588**	**1106**
	Waterborne MAI (t $year^{-1}$)					**16813**	**826**
	Riverine NIC proportional (t $year^{-1}$)					**15724**	**775**
	Riverine NIC left (t $year^{-1}$)					**15875**	**761**
Bothnian Sea	DALÄLVEN	359.4	16	0.4	0.02	4534	227
	DELÅNGERSÅN	17.1	16	0.4	0.02	216	11

	FORSMARKSÅN	2.6	16	0.4	0.02	33	2
	GAVLEÅN	18.9	16	0.4	0.02	238	12
	GIDE ÄLV	37.9	18	0.3	0.01	359	12
	INDALSÄLVEN	464.7	18	0.3	0.01	4396	147
	LJUNGAN	134.3	18	0.3	0.01	1270	42
	LJUSNAN	228.7	16	0.4	0.02	2885	144
	LÖGDE ÄLV	20.0	18	0.3	0.01	189	6
	UME ÄLV	457.3	20	0.3	0.01	4326	144
	ÅNGERMANÄLVEN	521.7	18	0.3	0.01	4936	165
	ÖRE ÄLV	36.6	20	0.3	0.01	347	12
	BOSSELAND*	176.9	-	0.333	0.0133	1858	74
	GES load (t year^{-1})					**25587**	**997**
	Waterborne MAI (t year^{-1})					**28965**	**1125**
	Riverine NIC proportional (t year^{-1})					**26407**	**936**
	Riverine NIC left (t year^{-1})					**27166**	**977**
Kattegat	GÖTA ÄLV	593.5	25	0.5	0.02	9359	374
	LAGAN	78.4	5	0.3	0.02	742	49
	NISSAN	44.4	5	0.3	0.02	420	28
	RÖNNE Å	18.7	5	0.3	0.02	177	12
	VISKAN	42.0	5	0.3	0.02	398	27
	ÄTRAN	55.4	5	0.3	0.02	524	35
	KATSELAND*	89.0	-	0.4	0.02	1122	56
	GES load (t year^{-1})					**12742**	**581**
	Waterborne MAI (t year^{-1})					**33287**	**740**
	Riverine NIC proportional (t year^{-1})					**29912**	**657**
	Riverine NIC left (t year^{-1})					**30367**	**705**
Danish Straits (including the Sound)	RÅÅN	1.7	6	0.3	0.02	16	1
	SOUSELAND*	22.6	-	0.3	0.02	214	14
	GES load (t year^{-1})					**230**	**15**
	Waterborne MAI (t year^{-1})					**5486**	**105**
	Riverine NIC proportional (t year^{-1})					**4552**	**82**
	Riverine NIC left (t year^{-1})					**4895**	**93**

*) Runoff from unmonitored coastal areas that are not covered by river monitoring; applied TN and TP concentrations are the average values of G/M boundaries.

**) River Torne älv/Tornionjoki is a border river, with 45% of loads designated to Finland and 55% to Sweden. Runoff and GES loads in this table represent 55%.

3.10. Summary of the results by the Baltic Sea sub-basins

Table 3.10.1 summarizes the results by comparing the estimated GES loads with the waterborne MAI and the riverine NIC values. The comparison is made by the Baltic Sea sub-basins. The sum of GES loads and respective basin-wise waterborne MAI and riverine NIC are presented. For those countries, where the GES load was not possible to obtain, the nutrient input equal to “Riverine NIC left” was added to get the total GES load to the sub-basin. Please note that not all figures of GES load are found by the same method; thus, care has to be taken to interpret the results. The details of the methods used for each country can be found in the results chapter in the sub-sections of countries.

In general, the sum of riverine GES loads of nitrogen to the Baltic Sea sub-basins from the surrounding countries are close or lower than required by the Baltic Sea Action Plan expressed as MAI and NIC. The Baltic Sea sub-basins, where the total TN GES load is higher than the MAI and NIC values, are the Baltic Proper, the Gulf of Riga, and the Bothnian Bay. The comparison was not possible for the Gulf of Finland. The largest discrepancy between the TN GES load and targets is in the Baltic Proper, where the TN GES load from Poland is as high as the riverine NIC value for the entire sub-basin and the TN GES load from Lithuania is twice as high as the riverine NIC for Lithuania.

The riverine GES loads of phosphorus to the Baltic Sea sub-basins from the surrounding countries are higher than the BSAP targets except for the Bothnian Sea, the Danish Straits and the Kattegat. Like the nitrogen load, the largest discrepancy between the TP GES load and the BSAP targets is in the Baltic Proper. Here, the TP GES load from Poland and Estonia are four times as high as the respective country-specific riverine NIC value. For the rest of the surrounding countries, where the comparison of targets was possible, the TP GES load is at least twice as high as the riverine NIC. The estimated GES load to the Gulf of Finland from Estonia and Finland is also two times higher than the proposed NIC values.

Please note that the estimated GES loads are not the actual loads but theoretical loads corresponding to good ecological status in rivers (river mouths) according to the WFD classification system. In reality, most of the rivers entering the Baltic Sea have good ecological status with average nutrient concentrations less than the set good/moderate boundary for total nutrients. The loads according to the latest pollution load compilations and even the reference loads in 1997-2003 are for many countries and sub-basins lower than the calculated GES loads in this report. As seen in Table 3.10.2, the GES loads are clearly higher than the observed (estimated) loads in 1997-2003 for seven pairs of countries and sub-basins. It indicates that the set WFD classification schemes for those cases showed good ecological status in rivers in 1997-2003. However, the 2-4-fold higher GES loads of phosphorus in comparison with the MAI and NIC values indicate a significant gap between the load when the rivers are in good ecological status and the BSAP targets to achieve good environmental status of the Baltic Sea.

Table 3.10.1. Summary table of GES loads by the Baltic Sea sub-basins. Green cells indicate the GES loads that do not exceed the set MAI and NIC values and light green if at least one NIC estimate is not exceeded, while red cells refer to the GES loads exceeding the set MAI and NIC values two times or more. Since it was not possible to estimate the GES loads for Russia and the TP GES loads for Denmark, their "Riverine NIC left" values (instead of GES load) are added to get the sum of GES loads for the respective sub-basin.

Sub-basin	Country	TN GES load (t year^{-1})	Waterborne MAI TN (t year^{-1})	Riverine NIC proportional TN (t year^{-1})	Riverine NIC left TN (t year^{-1})	TP GES load (t year^{-1})	Waterborne MAI TP (t year^{-1})	Riverine NIC proportional TP (t year^{-1})	Riverine NIC left TP (t year^{-1})
GUR	Estonia	16048	12530	12816	12790	428	240	177	182
	Latvia	81777	65843	65274	66576	2629	1699	1594	1691
	SUM	**97825**	**78373**	**78090**	**79366**	**3057**	**1939**	**1771**	**1873**
GUF	Estonia	11747	10660	9451	9987	501	242	199	200
	Finland	11053	14451	12088	13130	558	305	255	239
	Russia	n/a	66309	56983	56205	n/a	2981	1818	2587
	SUM	**79005***	**91419**	**78522**	**79322**	**3646***	**3528**	**2272**	**3026**
BAP	Denmark	1878	1468	1547	2775	n/a	24	17	18
	Estonia	1370	893	849	785	37	9	8	8
	Germany	4097	5391	5685	5747	158	70	68	64
	Latvia	13916	7979	8675	8494	420	108	182	188
	Lithuania	60616	33493	30666	30208	2829	1059	941	955
	Poland	231119	151833	140418	137961	17761	4946	4421	4409
	Russia	n/a	8622	7316	6080	n/a	386	213	97
	Sweden	12492	24710	20696	20336	596	339	270	217
	SUM	**331568***	**234388**	**215852**	**212386**	**21916***	**6941**	**6120**	**5956**
KAT	Denmark	15726	23817	22389	23686	n/a	829	744	766
	Sweden	12742	33287	29912	30367	581	740	657	705
	SUM	**28468**	**57104**	**52301**	**54053**	**1347***	**1569**	**1401**	**1471**
DS	Denmark	15116	23276	20787	22439	n/a	1040	675	733
	Germany	6069	12843	12048	14200	238	351	380	386
	Sweden	230	5486	4552	4895	15	105	82	93

	SUM	**21415**	**41605**	**37387**	**41534**	**986***	**1496**	**1137**	**1212**
BOS	Finland	11318	25641	23561	25274	561	1255	1178	1178
	Sweden	25587	28965	26407	27166	997	1125	936	977
	SUM	**36905**	**54606**	**49968**	**52440**	**1558**	**2380**	**2114**	**2155**
BOB	Finland	47506	32625	30857	31100	2107	1668	1617	1629
	Sweden	16588	16813	15724	15875	1106	826	775	761
	SUM	**64094**	**49438**	**46581**	**46975**	**3213**	**2494**	**2392**	**2390**

Table 3.10.2. Comparison of the GES loads and the riverine loads in 1997-2003 (reference loads). The GES loads that are clearly higher than the observed loads in 1997-2003 are marked in red.

Country	Basin	TN GES load (t year^{-1})	TN load 1997-2003 (t year^{-1})	TP GES load (t year^{-1})	TP load 1997-2003 (t year^{-1})
Denmark	KAT	15726	24076	n/a	
	DS	15116	20582	n/a	
	BAP	1878	2009	n/a	
Germany	BAP	4097	7384	158	180
	DS	6069	11929	238	345
Estonia	GUF	11747	11668	501	462
	GUR	16048	12689	428	260
	BAP	1370	1102	37	20
Finland	BOB	47506	32826	2107	1720
	BOS	11318	23799	561	1148
	GUF	11053	14923	558	594
Lithuania	BAP	60616	39826	2829	2477
Latvia	BAP	13916	11266	420	480
	GUR	81777	64628	2629	2345
Poland	BAP	231119	182361	17761	11633
Sweden	BOB	16588	16727	1106	824
	BOS	25587	26674	997	955
	BAP	12492	26878	596	710
	DS	230	4507	15	74
	KAT	12742	32163	581	650

This analysis shows that the WFD targets and the BSAP targets are often not compatible. One reason for that could be that the WFD targets used for this analysis are mostly set to characterize the good ecological status for rivers while the BSAP targets are defined for the Baltic Sea sub-basins. A way forward would be if the countries evaluate the load from land to achieve or maintain good ecological status in coastal water bodies. This is done in some countries but still needs to be done in many countries surrounding the Baltic Sea. We expect that such estimates, required by the WFD, should be in a better accordance with the BSAP targets. It also could lead to a re-evaluation of the good and moderate class boundaries defined by TN and TP concentrations.

3.11. Example of load estimates using high/good boundary and reference values

Since the estimated GES loads often exceeded the BSAP targets, we carried out an additional analysis for the Gulf of Riga, where the GES loads, especially for TP, were higher than the riverine NIC values. It is an example to assess whether the loads corresponding to the high and good boundary in the WFD classification (HG load) or the defined reference conditions (REF load) meet the BSAP targets regarding nutrient input ceilings or not.

The found HG and REF loads are presented in Table 3.11.1. For Latvia, the same values for both the high and good boundary and the reference conditions were used. For total nitrogen, both the HG load and the REF load are lower than the riverine NIC values. It is the case for both countries (Estonia and Latvia) and the total load estimates.

However, the result is different for the estimated phosphorus loads. For Latvia, the HG load and the REF load of TP (the estimates are equal since the same concentrations were used for high and good boundary and reference conditions) are lower than the riverine NIC load. For Estonia, both the HG load and the REF load for total phosphorus are higher than the riverine NIC value. At the same time, if to compare the REF load with the waterborne MAI, the HG load would be close to MAI and the REF load would be below it. Thus, the suggested changes in the BSAP targets for the phosphorus load from Estonia to the Gulf of Riga and the reference conditions in rivers regarding phosphorus concentrations are not compatible. Since even the reference loads for this pair of country and basin (Estonia and the Gulf of Riga) do not fulfil the BSAP targets for phosphorus input, further actions to find an agreement between different policies have to be initiated.

Table 3.11.1. Example of the Gulf of Riga, when using the boundary values between the high ecological status and the good ecological status and when using the concentrations corresponding to the defined reference conditions in rivers.

	Country	Average flow 1995-2017 ($m^3 s^{-1}$)	Very good – good boundary	HES load (t $year^{-1}$)	Reference concentration	Ref load (t year-1)	Waterborne MAI (t $year^{-1}$)	Riverine NIC proportional (t $year^{-1}$)	Riverine NIC left (t $year^{-1}$)
TN	Estonia	169.6	1.5 (mg N l^{-1})	8024	1.2 (mg N l^{-1})	6419	12530	12816	12790
	Latvia	926.1	1.8 (mg N l^{-1})	52571	1.8 (mg N l^{-1})	52571	65843	65274	66576
	SUM			**60595**		**58990**	**78373**	**78090**	**79366**
TP	Estonia	169.6	0.05 (mg P l^{-1})	267	0.04 (mg P l^{-1})	214	240	177	182
	Latvia	926.1	0.045 (mg P l^{-1})	1314	0.045 (mg P l^{-1})	1314	1699	1594	1691
	SUM			**1581**		**1528**	**1939**	**1771**	**1873**

4. Results – maximum allowable nutrient concentrations in rivers to achieve updated BSAP goals (NIC values)

Maximum allowable nutrient concentrations in the freshwater discharge from the HELCOM countries to the Baltic Sea sub-basins were found by dividing the riverine NIC values by the average run-off in 1995-2017. Comparison of these concentrations with the defined boundaries between the good and moderate ecological status in rivers allows evaluating the compatibility of the targets in the HELCOM BSAP and the WFD river basin management plans.

The agreement-disagreement pattern of targets is the same as described when comparing the country and sub-basin specific riverine NIC values and GES loads (see Section 3). Maximum allowable nutrient concentrations are lower than the G/M boundary concentrations for both nitrogen and phosphorus in the Gulf of Riga, the Baltic Proper and the Bay of Bothnia. The targets disagree for phosphorus also in the Gulf of Finland. Furthermore, the maximum allowable concentrations of TP are more than twice as low as the G/M boundary concentrations for all evaluated countries in the Baltic Proper and the Gulf of Finland and for Estonia in the Gulf of Riga. The largest disagreement is found for Estonia and the Baltic Proper with 4.7 times higher G/M boundary concentrations than the maximum allowable TP concentrations to achieve BSAP goals.

We also compared the maximum allowable nutrient concentrations between the Baltic Sea sub-basins. The lowest values of TN concentrations (to achieve NIC) were found for the Bay of Bothnia (0.43 mg N l^{-1}), the Bothnian Sea (0.54-0.57 mg N l^{-1}) and the Gulf of Finland (0.69 mg N l^{-1}). The largest concentrations in the rivers flowing into the Baltic Sea are allowed in the Danish Straits (5.80-6.44 mg N l^{-1}). The disagreement between the BASP and WFD targets is found in the Bay of Bothnia, where the allowable TN concentrations are the lowest, but also in the Baltic Proper and the Gulf of Riga, where the maximum allowable concentrations were at an average level. The allowable TN concentrations vary between the countries sharing the same sub-basin a lot. The highest allowable TN concentrations in the rivers flowing into the Baltic Proper are found for Denmark and Germany. About 2-4 times lower TN concentrations are allowed to achieve BSAP targets for the same sub-basin (Baltic Proper) for Lithuania. Note also that these found maximum allowable concentrations are two times lower than the Lithuanian G/M boundary concentrations.

Large variability in basin-specific maximum allowable concentrations is also seen regarding total phosphorus. The lowest TP concentrations are allowed in the freshwater discharge to the Gulf of Finland, the Bay of Bothnia and the Bothnian Sea – from 0.20 to 0.26 mg P l^{-1}. These low TP concentrations disagree with the WFD-related G/M boundaries for the Bay of Bothnia and more than two times for the Gulf of Finland (Estonia and Finland; no boundary values available for Russia).

The maximum allowable TP concentrations in the freshwater discharge to the Baltic Proper and the Gulf of Riga (> 0.050 mg P l^{-1}) are twice as high as to the Gulf of Finland, the Bay of Bothnia and the Bothnian Sea, but for those countries that have set G/M boundaries, the latter are even at a higher level. The lowest TP concentrations have to be achieved in the freshwater discharge to the Baltic Proper in Sweden (0.012-0.015 mg P l^{-1} that is more than two times lower than the applied G/M boundaries) and Estonia (0.017 mg P l^{-1} that is more than four times lower than the applied G/M boundaries). The largest maximum allowable concentrations around the Baltic Proper were found for Poland (0.074 mg P l^{-1}) and Denmark (0.067-0.072 mg P l^{-1}), whereas the Polish values are still more than two times lower than the adopted G/M boundary concentrations.

In the Gulf of Riga, the maximum allowable TP concentrations in freshwater discharge also differ between the countries – in the run-off from Estonia 0.033-0.034 mg P l^{-1} and run-off from Latvia 0.055-0.058 mg P l^{-1} are allowed to achieve the BSAP goals. Since the G/M boundaries are almost similar in Estonia and Latvia, it results in much larger disagreement between the BSAP and WFD targets for Estonia.

The largest TP concentrations to achieve the BSAP goals are allowed in the freshwater discharge to the Danish Straits – 0.176-0.178 mg P l^{-1} that is about 8-9 times higher than the corresponding values for the Gulf of Finland, the Bay of Bothnia and the Bothnian Sea.

Table 4.1.1. Comparison of the maximum allowable (average) concentrations of total nitrogen and phosphorus in freshwater discharge from HELCOM countries to the Baltic Sea sub-basins and the concentrations of total nitrogen and phosphorus corresponding to the set good and moderate boundary in the WFD classification system for rivers.

Sub-basin	Country	Average flow ($m^3 s^{-1}$)	Riverine NIC proportional TN (t $year^{-1}$)	Riverine NIC left TN (t $year^{-1}$)	Maximum allowable TN concentration (mg N l^{-1})	G/M boundary TN concentration (mg N l^{-1})	Riverine NIC proportional TP (t $year^{-1}$)	Riverine NIC left TP (t $year^{-1}$)	Maximum allowable TP concentration (mg P l^{-1})	G/M boundary TP concentration (mg P l^{-1})
GUR	Estonia	169.6	12816	12790	2.40-2.39	3.0	177	182	0.033-0.034	0.08
	Latvia	926.1	65274	66576	2.23-2.28	2.8	1594	1691	0.055-0.058	0.09
	SUM	**1095.7**	**78090**	**79366**	**2.26-2.30**		**1771**	**1873**	**0.051-0.055**	
GUF	Estonia	234.4	9451	9987	1.28-1.35	0.7-3.0	199	200	0.027-0.027	0.06-0.08
	Finland	438.1	12088	13130	0.87-0.95	0.8	255	239	0.018-0.017	0.035-0.06
	Russia	2956.4	56983	56205	0.61-0.60	n/a	1818	2587	0.020-0.028	n/a
	SUM	**3628.9**	**78522**	**79322**	**0.69-0.69**		**2272**	**3026**	**0.020-0.026**	
BAP	Denmark	8.0	1547	2775	6.10-10.94	n/a	17	18	0.067-0.072	n/a
	Estonia	14.5	849	785	1.86-1.72	3.0	8	8	0.017-0.017	0.08
	Germany	50.0	5685	5747	3.61-3.65	2.6	68	64	0.043-0.040	0.10
	Latvia	157.6	8675	8494	1.75-1.71	2.8	182	188	0.037-0.038	0.09
	Lithuania	640.7	30666	30208	1.52-1.50	3.0	941	955	0.047-0.047	0.14
	Poland	1890.1	140418	137961	2.36-2.31	2.7-4.1	4421	4409	0.074-0.074	0.21-0.31
	Russia	144.3	7316	6080	1.61-1.34	n/a	213	97	0.047-0.021	n/a
	Sweden	580.3	20696	20336	1.13-1.11	0.5-0.8	270	217	0.015-0.012	0.03-0.04
	SUM	**3485.5**	**215852**	**212386**	**1.96-1.93**		**6120**	**5956**	**0.056-0.054**	
KAT	Denmark	157.7	22389	23686	4.50-4.76	n/a	744	766	0.150-0.154	n/a
	Sweden	921.5	29912	30367	1.03-1.04	0.3-0.5	657	705	0.023-0.024	0.02
	SUM	**1079.2**	**52301**	**54053**	**1.54-1.59**		**1401**	**1471**	**0.041-0.043**	
DS	Denmark	106.1	20787	22439	6.21-6.71	n/a	675	733	0.202-0.219	n/a
	Germany	74.0	12048	14200	3.61-3.65	2.6	380	386	0.163-0.165	0.10-0.15
	Sweden	24.3	4552	4895	5.94-6.39	0.3	82	93	0.107-0.121	0.02

	SUM	**204.4**	**37387**	**41534**	**5.80-6.44**		**1137**	**1212**	**0.176-0.188**	
BOS	Finland	439.3	23561	25274	1.70-1.82	0.8-0.9	1178	1178	0.081-0.085	0.035-0.06
	Sweden	2476.2	26407	27166	0.34-0.35	0.3-0.4	936	977	0.012-0.013	0.01-0.02
	SUM	**2915.5**	**49968**	**52440**	**0.54-0.57**		**2114**	**2155**	**0.023-0.023**	
BOB	Finland	1704.0	30857	31100	0.57-0.58	0.8-0.9	1617	1629	0.030-0.030	0.035-0.04
	Sweden	1753.4	15724	15875	0.28-0.29	0.3	775	761	0.014-0.014	0.02
	SUM	**3457.4**	**46581**	**46975**	**0.43-0.43**		**2392**	**2390**	**0.022-0.022**	

5. Discussion and concluding remarks

This study aimed to evaluate sufficiency of targets set for the ecological status of rivers in the Baltic Sea catchment area under the EU WFD for achieving the HELCOM BSAP targets regarding the maximum allowable inputs of nutrients. Firstly, riverine inputs of total nitrogen and total phosphorus corresponding to the WFD good/moderate boundary were computed and compared with the waterborne MAI and riverine NIC values. The waterborne MAI and riverine NIC values were estimated for the purposes of the current study as given in Sections 2 and 3. Secondly, maximum allowable nutrient concentrations in freshwater entering the Baltic Sea required for achieving recently proposed net national NICs for sub-basins were derived using the flow data from HELCOM PLC database[29]. Then, these concentrations were compared with the G/M boundaries defined in the WFD classification schemes.

Both approaches show the same pattern of agreement-disagreement between the WFD and BSAP targets. Regarding nitrogen, the highest difference, illustrating insufficiency of the WFD targets to achieve the BSAP goal, was found for the Baltic Proper. The WFD targets set for rivers inflowing to the Gulf of Riga and the Bay of Bothnia are also not sufficient to reach MAI for these basins. Much larger gaps were found between respective WFD and BSAP targets set for phosphorus. The largest disagreements, resulting from stricter BSAP than WFD targets, are in the Baltic Proper, the Gulf of Finland and for Estonian inputs to the Gulf of Riga. In some cases, the respective BSAP targets are 2-4 times stricter than ones set for the WFD.

Partly, the found inconsistences between the targets could be related to the used approaches and the uncertainties in the estimates. First of all, we compared the targets initially defined for different purposes. The WFD classification scheme (from where the G/M boundaries were obtained and the GES loads were found) is developed to assess the ecological status of rivers and it is not always considered whether the loads based on these concentrations also assure achieving the good environmental status of receiving marine waters. In some countries, maximum loads are set to achieve the good ecological status of coastal waters. These load estimates could be more relevant to compare with the BSAP targets, and as a fact, are more in line with BSAP targets. Similar exercises for defining the loads are recommended for all countries, although it is quite a difficult task, especially for more open coastal areas, where the open sea conditions could have the dominant impact on the nutrient conditions and ecological status.

Uncertainties are also related to used methods for estimating the waterborne MAI and riverine NIC. The former was obtained by assuming the same proportion of the waterborne input in the total nutrient load as was originally assessed in the reference period for the MD2013. For the riverine NIC estimates, a proportional reduction approach of all types of loads and a method accounting for already

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[29] HELCOM PRESSURE 12-2020. Document 3-6 Att2 Provisional values for the updated nutrient input ceilings.

achieved reduction in direct and airborne inputs were used. In most cases, these estimates were not very different, but since the estimates of the atmospheric deposition of nitrogen during the reference period were considerably increased lately and contain large proportions of human-induced input, the proportional approach to estimate NIC values for nitrogen could be not the best. Furthermore, the emission reduction commitments of the NEC Directive (see Annex II of the Directive[30]) are stricter than the percentages of needed reduction in the suggested BSAP update (Table 6 in HELCOM PRESSURE 12-2020 Doc. 3.6-Rev1[31]). However, in the most problematic situations, where the WFD and BSAP targets differ more than two times, those uncertainties do not explain the disagreement between the targets in the policies.

The estimated maximum allowable concentrations in the freshwater discharge derived from the riverine NIC values were compared with concentrations set for the WFD G/M boundaries. A comparison of the maximum allowable concentrations estimated for different sub-basins and different countries within the same sub-basin was carried out. The latter analysis revealed large variability of concentrations needed to achieve BSAP targets between the sub-basins and countries. The sum of national net NIC values for a sub-basin is equal to the MAI derived to achieve the good environmental status of marine waters. To define whether the suggested load reductions to the sub-basins (from surrounding countries) are feasible or not and how much resources have to be allocated to achieve the targets, also natural conditions as well as the share of anthropogenic and natural loads in the inputs have to be considered.

The proportional reduction approach has been applied to estimate NIC values per country and sub-basin (from MAI and NIC for sub-basins)[32]. The estimates of the reference period (1997-2003) atmospheric deposition of nitrogen and riverine loads of nutrients (for some countries) have been significantly changed recently. Due to the used proportional reduction approach, it resulted in changes of country/sub-basin NIC values and corresponding maximum allowable concentrations in rivers also for those countries, where the reference input estimates were almost not changed. To be more in line with the HELCOM polluter-pays principle, the calculation and re-allocation of nutrient input ceilings should consider the proportion of the anthropogenic part in the reference inputs (and in their corrections).

To illustrate the consequences of using the proportional approach when re-allocating reduction targets, we use the phosphorus input ceilings to the Gulf of Riga. If we take the NIC for phosphorus load from Estonia based on the 2013 CART (239 t year^{-1}; see Annex 4 in HELCOM PRESSURE 12-2020 Document 3.6 Rev1[33]), subtract the direct inputs for the last 5 years to the Gulf of Riga (3 t year^{-1}), and divide it by

[30] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC.
[31] HELCOM PRESSURE 12-2020. Document 3-6-Rev1 Provisional values for the updated nutrient input ceilings.
[32] HELCOM PRESSURE 12-2020. Document 3-6-Rev1 Provisional values for the updated nutrient input ceilings.
[33] HELCOM PRESSURE 12-2020. Document 3-6-Rev1 Provisional values for the updated nutrient input ceilings.

the average run-off (169.6 m^3 s^{-1}), the allowable TP concentration in the freshwater discharge would be 0.044 mg P l^{-1}. According to the new NIC estimates, where an increased phosphorus load from Latvia during the reference period is assumed, the maximum allowable TP concentration in Estonian rivers is 0.034 mg P l^{-1} (if extracting the same direct load for the last 5 years from the NIC). It means that the original (MD2013) requirement regarding allowed phosphorus concentrations in rivers, that was already lower than the WFD G/M boundary (currently valid), has been further lowered. To implement the new NIC values, a detailed feasibility analysis is needed considering natural background loads in different river basins.

The present analysis is not assessing, which targets are right, and which are wrong. We just point out large differences in targets under the two considered policies. To move towards a better agreement of the BSAP and WFD targets, we recommend the following actions:

- Where possible, evaluate the nutrient input ceilings to the coastal water bodies.
- Promote co-operation between the countries to analyse nutrient concentrations for reference conditions in different types of rivers.
- Make steps towards harmonized WFD classification schemes for nutrient concentrations in rivers and/or methodology to define nutrient input ceilings for coastal water bodies.
- Conduct further analyses to estimate the proportion of anthropogenic and natural loads in the riverine input of nutrients.
- Consider nutrient concentrations for reference conditions and the proportion of anthropogenic and natural background loads when calculating nutrient input ceilings per country and Baltic Sea sub-basin.

All these steps would harmonize the targets set based on different policies and follow the HELCOM polluter-pays principle better. At the same time, the present analysis does not question the overall HELCOM nutrient reduction targets. In order to achieve good environmental status of the Baltic Sea joint efforts are needed to reduce the nutrient loads as agreed in BSAP.