Revised Nutrient Input Ceilings

to the BSAP update

Baltic Marine Environment Protection Commission

Nutrients

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List of abbreviations

MAI	Maximum Allowable Inputs
NIC	Nutrient Input Ceilings
CART	Country-Allocated Reduction Targets
NECA	NOx Emission Control Area
NEC Directive	National Emission reduction Commitments Directive
TN	Total nitrogen
TP	Total phosphorus
DE	Germany
DK	Denmark
EE	Estonia
FI	Finland
LT	Lithuania
LV	Latvia
PL	Poland
RU	Russia
SE	Sweden
BY	Belarus
CZ	Czeck Republic
UA	Ukraine
OC	Other countries: represents the sum of all other sources than HELCOM Countries and Baltic and North Sea shipping
BSS	Baltic Sea Shipping
NOS	North Sea Shipping
BOB	Bothnian Bay
BOS	Bothnian Sea
BAP	Baltic Proper
GUF	Gulf of Finland
GUR	Gulf of Riga
DS	Danish Straits
KAT	Kattegat
BAS	Baltic Sea

1. Introduction

This report provides technical documentation on the calculations of proposed Nutrient Input Ceilings (NIC) for the HELCOM Baltic Sea Action Plan (BSAP) update in 2021. It includes a comparison with the NIC derived from the Country-Allocated Reduction Targets (CART) established in the 2013 Copenhagen Ministerial Declaration (HELCOM, 2013c). In addition to national NIC, the novel approach of attributing NIC for selected major transboundary rivers is introduced. The report includes a complete overview of NIC and background data relevant for future assessments of progress towards fulfilling MAI and nutrient reduction requirements in BSAP. Further, it includes all information on how NIC are calculated and summaries of all used data behind the calculations.

1.1. Background

In the HELCOM Baltic Sea Action Plan (HELCOM, 2007) scientifically derived Maximum Allowable Inputs (MAI) where defined that if achieved should ensure that the goal of a Baltic Sea unaffected by eutrophication would be reached. Further, the BSAP specified reduction requirements, so called Country-Allocated Reduction Targets (CART) indicating how the burden of achieving MAI should be shared between HELCOM Contracting Parties. A substantial revision of MAI and CART was initiated by the 2010 Moscow Ministerial Meeting (HELCOM, 2010) and in the 2013 Copenhagen Ministerial Declaration (HELCOM, 2013c) the revised MAI and CART were established (thereafter named HELCOM Nutrient Reduction Scheme).

It was soon realized that it was not optimal to formulate the country commitments in terms of reduction requirements relative to nutrient inputs in a specific reference period, since they cannot guarantee fulfillment of MAI when reference inputs are updated. Therefore, the 2018 Brussels Ministerial Declaration (HELCOM, 2018) stated that although recalling the CART of the 2013 Ministerial Meeting that in the update of the BSAP national commitments should be formulated in a way that ensures fulfillment of MAI. The 2018 Brussels Ministerial Declaration decided to further engage with river basin authorities.

The workshop "Land-based nutrient loads to the Baltic Sea" (NutriRed WS) followed up and discussed possible improvements of the HELCOM Nutrient Reduction Scheme in the light of content of the HELCOM Brussels Ministerial Declaration. Based on the workshop outcomes, Reduction Scheme Core Drafting Group (RedCore DG) prepared a list of possible improvements of the Scheme, including also associated issues like data flows and assessment products, that where subsequently submitted and discussed at HELCOM PRESSURE 10-2019 (Document 6.1) and in edited form approved by HELCOM HOD 56-2019 (Document 3-16). The mission provided by HOD with this was to calculate nutrient input ceilings utilizing up-to-date data on transboundary loads and atmospheric deposition without changing the basic principles and calculate indicative reduction needs for individual rivers.

Following these formal decisions, Baltic Nest Institute (BNI) of Stockholm University and the Danish Centre For Environment And Energy (DCE) of Aarhus University have supported the Seventh Baltic Sea Pollution Load Compilation (PLC-7) project and RedCore DG with the practical data analysis and calculations to compute Nutrient Input Ceilings. The data basis was extensively validated through the PLC-7 and preliminary results was presented to HELCOM PRESSURE 11-2019 and 12-2020, as well as a dedicated workshop (NIC WS) in connection with HELCOM PRESSURE 12-2020.

1.2. The HELCOM nutrient reduction scheme (2013 Ministerial Declaration)

The HELCOM Nutrient Reduction Scheme includes Maximum Allowable Inputs (MAI) of nutrients to seven major Baltic Sea sub-basins in order to fulfil good environmental status. The basis for MAI is that the quantitative targets on specific eutrophication indicators (HELCOM, 2013a) should be reached. The physical-biogeochemical model BALTSEM (Gustafsson et al., 2012; Savchuk et al., 2012) to obtain pressure-response relationships that in turn could be used to find the optimal combination of (maximal) nutrient inputs to the sub-basins that ensures that the targets are fulfilled (HELCOM, 2013b).

Based on MAI the country-wise nutrient reduction targets (CART) were set based on the inputs in a reference period (1997-2003) (HELCOM, 2013b, 2013c). The allocation of reduction targets in the HELCOM BSAP Nutrient Reduction Scheme followed the following principles:

- All nutrient inputs to a sub-basin originating from HELCOM Countries were reduced with the same percentage relative to the reference input period (1997-2003).
- Sharing of reductions were based on nutrient inputs in the period 1997-2003, using flow-normalized riverine inputs, direct point source inputs, normalized atmospheric nitrogen deposition from EMEP (European Monitoring and Evaluation Programme) and estimated atmospheric phosphorus inputs.
- Expected reductions due to emission reductions in non-HELCOM countries from implementation of the Gothenburg Protocol were considered before allocating reductions.
- Expected reductions due to emission reductions by Baltic Sea shipping from implementation of NECA were considered before allocating reductions.
- Major waterborne transboundary inputs from non-HELCOM Countries (i.e., Belarus, Czech Republic and Ukraine) were assumed to reduce their inputs with the same percentage as HELCOM Countries.
- After reductions were achieved, the total input to the basin should equal to Maximum Allowable Inputs (MAI) for that basin.

The country-wise nutrient reduction targets (CART) of the 2013 Ministerial Declaration have been followed up using after-the-fact calculated Nutrient Input Ceilings (NIC) that caps the nutrient inputs from each country-basin combination. The sum of NIC for each source to a basin should result in MAI for that particular basin. NIC has de facto replaced CART in the assessment of progress towards the goals of the HELCOM BSAP Nutrient Reduction Scheme, mainly due to practical/technical advantages.

NIC is defined as the difference between the inputs in the reference period and CART. In the years since 2013, there has been a number of various updates to the nutrient input data in the reference period, that forced a choice of either use to the formally agreed CART and not necessary achieve MAI or use NIC as calculated with the original reference inputs and loose some of basis in the fundamental agreements. The choice has been to go the latter way in the assessments of progress for the countries, which was also acknowledged in the HELCOM Brussel Ministerial Declaration (HELCOM, 2018).

1.3. Constrains on calculating updated NIC

A revision of NIC should not include any changes to MAI, nor changing any of the principles of allocation of CARTs listed above in Section 1.2. However, it has been identified that the update of the BSAP serves as a good opportunity to take into account the NIC to correct a few deficiencies of the CART of the 2007 BSAP and the 2013 Ministerial Declaration and in some cases update to current policies in order to make the NIC future-proof and policy relevant. In addition, NIC can be calculated directly from new updated nutrient input data sets making it up-to-date.

The following specific updates and requirements have been identified and considered following the discussions and decisions as described above in Section 1.1:

Take into account expected reductions in atmospheric deposition from decreased ship emissions in both North Sea and the Baltic Sea as a result of implementation of NECA

NECA negotiations were not complete in 2013 and it was decided that only expected reductions due to decreased emissions of the Baltic Sea international shipping should be taken into account. However, now NECA is agreed and under implementation for both Baltic Sea as well as North Sea ship traffic, and since North Sea shipping is a significant source for atmospheric nitrogen deposition on the Baltic Sea it is important to include these expected reductions as well.

Take into updated calculations of expected reductions in atmospheric deposition from emissions as a result of implementation of Gothenburg Protocol/EU NEC Directive and NECA

EMEP recently made calculations of expected reductions of nitrogen inputs to the Baltic Sea following implementation up-to-date air quality policies (Gauss et al., 2020). These data should be used in the update of NIC.

Increase robustness of riverine transboundary parts of NIC

NIC should take into account national shares of transboundary waterborne inputs. So far, the waterborne transboundary contributions (share of transboundary inputs from a country taking into account downstream river retention) are included in the country contribution without an explicit notion. For some countries, e.g., Latvia and Lithuania, the transboundary share of NIC is of large significance. However, still there are major uncertainties in the computation of transboundary inputs, not the least in river retention, and large improvements of these estimates are anticipated in years to come. It is imperative that NIC are constructed and presented in a manner that addresses the potential and probable need of updating the computation of the transboundary part of NIC in a way that is transparent and consistent with formal agreements.

Highlight the contributions of the major (transboundary) rivers

The five rivers Vistula, Oder, Neva, Nemunas and Daugava are by far the largest rivers in terms of nutrient inputs. Together they contribute with nearly a third of the total nitrogen and almost half of the phosphorus inputs to the Baltic Sea. Further, they drain to sub-basins with reduction requirements and, in practice, it is not possible to reach MAI without significant reductions in these rivers. In addition, they are all transboundary rivers where joint action is needed by several HELCOM and/or non-HELCOM countries.

Take into account updated data

The calculation of CART in 2013 was based on time-series obtained within the PLC 5.5 project. At that time data was available for the period 1994-2010. Since then the length of the time-series was increased substantially (data until 2017 is used here) and various updates have increased the data quality. The following major updates have been identified:

— EMEP have updated atmospheric deposition data using new emissions data sets and improved modelling and updated meteorological data1
— River retention and border load data are updated fr the river transboundary calculations
— Latvia has reported corrected total phosphorus inputs for the earlier part of the time-series that significantly improve the data quality of the reference period.
— Denmark has reported new data for the whole time-series based on improved modelling.

Take into account methodologies developed within PLUS, MAI-CART OPER, PLC-6 and PLC-7 in preparing data and calculating nutrient inputs

— Improved quality control and assurance
— Flow normalization are now performed on each catchment individually, previously on country-basin aggregated inputs

1 See “Reasons for changes in N-deposition in reference period” presentation by Gauss, Nyiri and Fagerli at PLC-7 IG 9-2019 available at helcom.fi

2. Methods

2.1. Principles of the NIC calculation

The mathematical description of the calculations is provided in Annex 1 and detailed examples of the calculations are provided in Annex 5-6.

2.2. Data

Data on waterborne nutrient inputs and water flow were retrieved for 1995-2017 from the PLC-water database (retrieved on April 17, 2020[1]) and merged with the previously performed and approved gap-filling for older missing data within PLC-6 and PLC-7. The river nutrient input data was flow normalized individually for all sub-catchments. The methodology for flow normalization is described in Annex 1. Transboundary rivers, which also include the five largest (in terms of nutrient inputs) rivers, are analyzed separately. The same transboundary rivers as were used in the 2013 MD calculations are selected. Excepting the transboundary rivers, normalized waterborne loads were aggregated according to country and basin. From these time-series, the nutrient inputs in the reference period were derived as the average of 1997-2003 annual inputs.

Normalized atmospheric nitrogen deposition per country and basin 1995-2017 was delivered by EMEP on 24th of September, 2019. Atmospheric phosphorus deposition is not attributed to sources in the countries and are treated as a constant source using the same (5 kg km-2y-1) rate as in the CART calculations in 2013.

The reference inputs per country and basin are given in Tables A2.1 and A2.2 in Annex 2, together with some other tables showing reference transboundary and airborne inputs.

An updated assessment of the transboundary contributions has been performed as described in Annex 3.

Within the ENIRED II project EMEP made projections of expected nitrogen deposition from emissions in countries and from the shipping sector to the Baltic sub-basins at present (2005) and in the future (2030) given implementation of NECA and Gothenburg protocol/EU-NEC (Gauss et al., 2020). These data were used to estimate expected reductions of atmospheric deposition as described in chapter 3.1.

1 Due to an error in reporting, the retrieval was complemented manually with missing flow for a few years for the Danish river Maglemose Å.

3. Results

3.1. Atmospheric Total Nitrogen deposition from non-HELCOM countries, shipping and other sources

The scenarios from the ENIRED II project (Gauss et al., 2020) show that between 2005 and 2030 contributions from the Baltic Sea and North Sea shipping to the TN deposition will reduce with about 50 and 60%, respectively. Further, it is expected that TN deposition from emissions in other countries/sources outside HELCOM countries will decrease with almost 50%.

Unfortunately, ENIRED II projections of deposition in 2030 cannot not be used directly, because that data set is incompatible with the regular normalized atmospheric time-series data set provided by EMEP due to methodological differences. In this analysis, we instead apply the percentage change between 2005 and 2030 from the ENIRED II scenarios to the regular normalized TN deposition in 2005 to compute the nutrient input ceilings for "other countries" and shipping. The quantitative difference depositions in 2030 in the ENIRED II results and the application of the percentage change to year 2005 of the normalized time-series is relatively large for a few country-basin combinations. However, the difference varies randomly, so overall basin-wise or country-wise sums conform well.

The results of calculating NIC for these sources are presented in Table 1, together with reference inputs (average of the normalized time-series 1997-2003) and the expected reduction computed as the difference between reference inputs and NIC. There are notable changes in the expected reductions compared to what was used in 2013. Then only Baltic Sea shipping was considered separately, but a much larger reduction of 80% was assumed compared to about 50% in the new shipping data. Also, the expected reductions from the implementation of the Gothenburg Protocol/EU-NEC Directive changed significantly, formerly it was assumed that nitrogen deposition would decrease by about 30% while the new expected reduction is more than 50%. In addition, EMEP have recalculated depositions in general using improved models and revised emission and meteorological data, which have resulted in significant overall higher deposition (approx. 30%) than was used in preparation of CART for the 2013 Ministerial Declaration, see Table A2.8. These changes results in a lower ceiling on the Other Countries source and a much higher ceiling on the Baltic Sea shipping, see Table A4.1 below.

Table 1. Expected reductions and calculated TN ceilings on atmospheric deposition from non-HELCOM countries (OC) and North (NOS) and Baltic Sea shipping (BSS). Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
REFERENCE INPUTS								
OC	2877	10423	56263	5735	4169	10911	10318	100696
BSS	604	2360	10412	1308	776	1282	1225	17967
NOS	389	1292	6561	548	414	1717	1885	12806
EXPECTED REDUCTION								
OC	1502	5415	29316	2750	1981	5978	5816	52758
BSS	320	1219	5232	633	431	631	524	8989
NOS	258	817	4134	352	264	988	1001	7814
NUTRIENT INPUT CEILINGS								
OC	1375	5008	26947	2985	2188	4933	4502	47938
BSS	284	1141	5180	675	345	651	701	8978
NOS	131	475	2427	196	150	729	884	4992

3.2. Updated nutrient input ceilings

Updated nutrient input ceilings for total nitrogen (TN) and total phosphorus (TP) are presented in Table 2 and 3. Separate NIC are calculated for each of the transboundary rivers and not included in the country ceilings in these tables. The ceiling on atmospheric deposition of phosphorus is the same as the estimated reference inputs and this is unchanged from CART in the 2013 Ministerial Declaration.

The NIC for the transboundary rivers are subsequently split into country-wise NIC describing the cap on the nutrient inputs to the sea from that country, i.e., after retention using the data presented in Annex 2 and Annex 3.

Table 2. Nutrient input ceilings for TN (BAS is computed with decimals and does therefore not always match the sum of the rounded values for the basins). OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	947	3920	32281	1645	1747	23647	4661	68848
DK	280	1148	9025	421	462	28067	28538	67942
EE	113	404	1478	11334	13099	22	24	26474
FI	35087	28700	1827	15600	295	76	89	81674
LT	108	495	3620	305	462	66	80	5136
LV	73	330	2789	246	12222	31	34	15727
PL	668	3125	35486	1407	1596	1480	1443	45205
RU	839	1993	7321	22883	662	238	245	34181
SE	17718	32633	30690	626	525	6056	32799	121049
OC	1375	5008	26947	2986	2188	4933	4502	47938
BSS	284	1141	5180	675	345	651	701	8978
NOS	131	475	2427	196	150	729	884	4992
NEMUNAS			29338					29338
BARTA			957					957
VENTA			6033					6033
LIELUPE					15863			15863
DAUGAVA					38800			38800
ODER			49298					49298
VISTULA			74807					74807
PREGOLYA			5493					5493
NEVA				43476				43476
MAI	**57622**	**79372**	**325000**	**101800**	**88417**	**65998**	**74000**	**792209**

Table 3. Nutrient input ceilings for TP (BAS is computed with decimals and does therefore not always match the sum of the rounded values for the basins). Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			71			401		472
DK			21			979	815	1815
EE			9	225	185			419
FI	1683	1246		296				3225
LT			50					50
LV			61		499			560
PL			543					543
RU			146	1531				1677
SE	811	1133	318			116	753	3132
Atm. DEP.	181	394	1046	150	93	105	118	2088
NEMUNAS			914					914
BARTA			25					25
VENTA			106					106
LIELUPE					302			302
DAUGAVA					941			941
ODER			1554					1554
VISTULA			2350					2350
PREGOLYA			147					147
NEVA				1398				1398
MAI	**2675**	**2773**	**7360**	**3600**	**2020**	**1601**	**1687**	**21716**

Table 4. Nutrient input ceilings (TN) for the country contributions to each of the transboundary rivers. Abbreviations for the sea basins are explained in the beginning of the report.

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	1796				43951			3551	
VISTULA	BAP	74807					70062		3052		1693
PREGOLYA	BAP	5493					2498	2995			
NEVA	GUF	43476		4856				38620			

Table 5. Nutrient input ceilings (TP) for the country contributions to each of the transboundary rivers. Abbreviations for the sea basins are explained in the beginning of the report.

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	38				1459			57	
VISTULA	BAP	2350					2240		63		47
PREGOLYA	BAP	147					51	96			
NEVA	GUF	1398		20				1379			

3.3. Net nutrient input ceilings

Net nutrient input ceilings are defined to follow up the national obligations to keep nutrient inputs below ceilings to fulfil MAI. The net nutrient input ceiling is the sum of the country NIC to the basin in question from Table 2 (or 3 for TP) and the country NIC to the rivers discharging to that basin from Table 4 (or 5 for TP). Thus, the net input ceilings are fully consistent with the NIC above. See Annex 5 for an example of how to calculate net nutrient input ceilings.

Table 6. Updated country-basin net TN nutrient input ceilings (BAS is computed with decimals and does therefore not always match the sum of the rounded values for the basins). OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	947	3920	34077	1645	1747	23647	4661	70644
DK	280	1148	9025	421	462	28067	28538	67942
EE	113	404	1478	11334	13099	22	24	26474
FI	35087	28700	1827	20457	295	76	89	86531
LT	108	495	25878	305	8820	66	80	35751
LV	73	330	6457	246	43074	31	34	50245
PL	668	3125	151997	1407	1596	1480	1443	161717
RU	839	1993	10317	61503	3296	238	245	78430
SE	17718	32633	30690	626	525	6056	32799	121049
OC	1375	5008	26947	2986	2188	4933	4502	47938
BSS	284	1141	5180	675	345	651	701	8978
nos	131	475	2427	196	150	729	884	4992
BY			13456		12820			26275
CZ			3551					3551
UA			1693					1693
MAI	**57622**	**79372**	**325000**	**101800**	**88417**	**65998**	**74000**	**792209**

Table 7. Updated country-basin net TP nutrient input ceilings (BAS is computed with decimals and does therefore not always match the sum of the rounded values for the basins). Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			109			401		510
DK			21			979	815	1815
EE			9	225	185			419
FI	1683	1246		315				3243
LT			703		175			878
LV			167		1061			1228
PL			4291					4291
RU			242	2909	99			3250
SE	811	1133	318			116	753	3132
ATM.DEP.	181	394	1046	150	93	105	118	2088
BY			349		407			756
CZ			57					57
UA			47					47
MAI	**2675**	**2773**	**7360**	**3600**	**2020**	**1601**	**1687**	**21716**

3.4. Reduction requirements

The updated ceilings imply somewhat changed reduction requirements. It is illustrated below with tables showing the required percentage reductions compared to the reference period. The principles of allocation results in that all countries and transboundary rivers will have the same percentage reduction requirement. The exceptions are the sources with precalculated NIC, i.e. atmospheric deposition from non-HELCOM sources, Baltic and North Sea shipping and atmospheric phosphorus deposition.

The generally higher updated atmospheric deposition caused reference TN inputs to be higher than MAI in all basins, leading to reductions requirements in all basins (Table 8). This does not, however, necessarily imply that NIC are lower, see 6.5 below. Notable is that the higher reduction requirement in GUR and DS are covered fully by the expected reductions in shipping and other countries making NIC for HELCOM countries slightly higher than reference inputs.

MAI for TP in DS is actually higher than the revised reference input, making reduction requirements for DS negative (Table 9). The percentage reductions are otherwise small for the basins that previously did not have reduction requirements (BOB, BOS, DS and KAT). The new Latvian TP data has significantly increased inputs to GUR (see Table A2.7 and Table A2.10), therefore 32% reduction is necessary on the TP inputs to GUR.

Table 8. Percentage needed reductions to obtain NIC for TN relative to the reference period. OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT
HELCOM CP and rivers	6	1	23	19	-1	-1	7
OC	52	52	52	48	48	55	56
BSS	53	52	50	48	55	49	43
NOS	66	63	63	64	64	58	53
TOTAL	**9**	**10**	**28**	**21**	**2**	**10**	**15**

Table 9. Percentage needed reductions to obtain NIC for TP relative to the reference period. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT
HELCOM CP and rivers	6	2	62	57	32	-10	-1
ATM.DEP.	0	0	0	0	0	0	0
NEVA				57			
TOTAL	**6**	**2**	**58**	**56**	**31**	**-9**	**-1**

3.5. Comparison with net nutrient input ceilings computed from the CART of the 2013 Ministerial Declaration

Inclusion of expected reductions on North Sea shipping is the only one principal difference between the updated and old net nutrient input ceilings. Remaining differences arise from updated reference inputs, including updated distribution of loads in the transboundary rivers. To compare with the ceilings based on the 2013 Ministerial Declaration, the ceiling on North Sea shipping has to be added into non-HELCOM countries (OC). The changes between the new and old net input ceilings for TN and TP are shown in Tables 10 and 11, respectively. For convenience, the net nutrient input ceilings based on the 2013 Ministerial Declaration are provided in Tables A4.1 and A4.2.

Table 10. Change (%) between the updated and net nutrient input ceilings based on the 2013 Ministerial Declaration (TN). OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	16	24	24	25	19	8	42	19
DK	21	27	14	26	21	-7	-3	-2
EE	19	27	5	1	1	23	21	1
FI	0	-3	16	-1	16	19	16	-1
LT	-2	1	-22	17	52	21	33	-10
LV	17	21	7	35	-20	30	37	-17
PL	4	12	-6	21	17	32	31	-4
RU	18	29	11	-2	31	37	41	2
SE	-1	-2	-1	25	17	-3	-4	-2
OC (incl NOS)	-20	-17	-11	-8	-17	-4	-3	-11
BSS	294	291	261	359	208	295	371	278
BY			84		102			92
CZ			32					32
UA			-13					-13
MAI	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 11. Change (%) between the updated and net nutrient input ceilings based on the 2013 Ministerial Declaration (TP). OC = non-HELCOM countries. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			8			14		13
DK			-1			-6	-2	-4
EE			9	-5	-23			-13
FI	1	-1		-2				0
LT			-15		6			-12
LV			126		96			100
PL			0					0
RU			-13	1	-47			-3
SE	-2	1	3			11	2	1
OC	0	0	0	0	0	0	0	0
BY			43		-49			-27
CZ			-47					-47
UA			43					43
MAI	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

4. Discussion

There is a contradiction between the need of having nutrient input ceilings that clearly show what reduction effort each country is committing to, and providing ceilings that remain valid even when new data, models and knowledge becomes available. From the country perspective, it is natural to utilize the net nutrient input ceilings that also allows for the necessary flexibility to plan and implement cost-effective measures to reduce nutrient inputs. The countries also need to consider, for example, eutrophication of inland and coastal waters when implementing measures. However, the division of nutrient inputs of the transboundary rivers between countries is quite uncertain as most of the retention estimates used are rather crudely estimated in a project carried out about 10 years ago. For example, in Latvia on-going modeling initiatives will most probably provide improved estimates of retention in the coming years. New estimates of river retention for the reference period will make the division of the input ceilings within the river basins presented here obsolete. Thus, it is from a scientific standpoint an important step to transparently document the division of nutrient input ceilings for each of the transboundary rivers.

There are significant differences between the updated and net nutrient input ceilings based on the 2013 Ministerial Declaration (Tables 10 and 11). Primary causes are the rather large changes in the nitrogen atmospheric deposition and waterborne transboundary inputs in the reference period (see Annex 2) due to updated data sets. There are also a few cases where new waterborne input data have been reported by the countries, primarily Denmark and Latvia, causing significant differences. In the Gulf of Riga, the re-reporting of TP inputs by Latvia also significantly changed the ceilings for Estonia, see Annex 6. Higher nitrogen deposition causes larger overall reduction requirement for the basin. However, as in the example of TP in Gulf of Riga in Annex 6, the countries with a large relative increase in reference inputs, i.e. the countries with only atmospheric inputs, in this case will get higher nutrient input ceilings, while the countries with only small changes in reference inputs, i.e. the countries with waterborne inputs will get decreased ceilings even though the percentage reduction is the same for all countries. A good example is Bothnian Sea where the ceilings increase with about 20 - 29% for most of the countries with only atmospheric deposition inputs, while the Finnish and Swedish ceilings are lowered with 2 - 3%. For Finland and Sweden, the atmospheric deposition only contributes with about 10% of the TN input to Bothnian Sea and therefore their TN inputs only changed marginally.

The large differences in net inputs (Tables A2.6-A2.7) and net input ceilings (Tables 10 - 11) for countries with large proportions of waterborne transboundary inputs, such as for example Lithuania and Latvia, highlights that singling out nutrient input ceilings for the transboundary rivers (as done in Tables 2 and 3) make the overall ceilings more robust to future improvements in the estimation of contributions from different countries to the transboundary river loads. Singling out nutrient input ceiling for the transboundary rivers, when for example new modeling provide updated estimates on retention, only Tables 4 and 5 are affected.

The new outline with ceilings for individual rivers is fully compatible with the net nutrient input ceilings on country by basin division. Therefore, future assessments of countries progress towards NIC can be performed on net nutrient input ceilings as they are today.

5. Acknowledgment

Participants in PLC-7 and PLC-8 projects are greatly acknowledged for providing additional data and promptly clarify outstanding issues with reported data, as well as, discussing various methodologies related to the calculation of NIC. We thank Michael Gauss and his colleagues at EMEP for providing, explaining and discussing the atmospheric deposition data, both the regular time-series as well as the ENIRED II results. We also thank Alexander Sokolov for developing appropriate on-line extraction and aggregation tools that enables efficient processing of the PLC-water data. Dmitry Frank-Kamenetsky is acknowledged for excellent support and encouragement of this project.

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6. References

Gauss, M., Nyiri, A., Klein, H., Jalkanen, J.-P., 2020. Estimation of Country-wise Reductions of Atmospheric Nitrogen Deposition, achievable by 2030 through Implementation of the Gothenburg Protocol/EU-NEC Directive. HELCOM report, 35pp

HELCOM, 2007. HELCOM Baltic Sea Action Plan. HELCOM Ministerial Meeting 1–101.

HELCOM, 2010. HELCOM Moscow Ministerial Declaration on the implementation of the HELCOM Baltic Sea Action Plan.

HELCOM, 2013a. Approaches and methods for eutrophication target setting in the Baltic Sea region (No. 133). Baltic Sea Environment Proceedings.

HELCOM, 2013b. Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan. Background document for the 2013 HELCOM Ministerial Meeting 1–23.

HELCOM, 2013c. HELCOM Copenhagen Ministerial Declaration. HELCOM Ministerial Meeting 1–20.

HELCOM, 2018. HELCOM Brussels Ministerial Declaration.

Gustafsson, B.G., Schenk, F., Blenckner, T., Eilola, K., Meier, H.M., Müller-Karulis, B., Neumann, T., Ruoho-Airola, T., Savchuk, O.P., Zorita, E., 2012. Reconstructing the Development of Baltic Sea Eutrophication 1850–2006. AMBIO: A Journal of the Human Environment 41, 534–548. https://doi.org/10.1007/s13280-012-0318-x

Savchuk, O.P., Gustafsson, B.G., Müller-Karulis, B., 2012. BALTSEM - a marine model for decision support within the Baltic Sea Region (No. 7). Baltic Nest Institute.

Stålnacke, P., Pengerud, A., Vassiljev, A., Smedberg, E., Mörth, C.-M., Hägg, H.E., Humborg, C., Andersen, H.E., 2015. Nitrogen surface water retention in the Baltic Sea drainage basin. Hydrology and Earth System Sciences 19, 981–996. https://doi.org/10.5194/hess-19-981-2015

Annex 1.
Technical aspects of the calculations

Calculation of nutrient input ceilings

It turns out that the whole allocation scheme of 2013 Ministerial Declaration can be formulated in terms of NIC with just one equation.

The nutrient input ceiling $NIC_{i,j}$ for source/country j to i sub-basin can be computed from

(A1.1)

$$NIC_{i,j} = \frac{L_{i,j}}{\sum_{j \neq other} L_{i,j}} (MAI_i - NIC_{i,other})$$

Where $L_{i,j}$ is the reference inputs from source/country j to sub-basin i and $NIC_{i,j}$ is the nutrient input ceiling for other sources which are not sharing reduction requirements (i.e. atmospheric deposition from non-sharing countries, international shipping etc). $NIC_{i,other}$ is the maximum allowable input for the sub-basin.

$NIC_{i,other}$ for nitrogen includes expected reductions from non-HELCOM countries/sources according to the Gothenburg protocol/EU NEC directive and from international shipping according to implementation of the IMO-NECA. Nitrogen deposition from countries that have not signed the Gothenburg protocol and other sources are assumed to stay at the level computed for the reference period 1997-2003. For phosphorus, $NIC_{i,other}$ comprise of the estimated atmospheric deposition which is assumed to not change in the future, i.e., 5 kg km- $^{2}y^{1}$, as in the 2013 Ministerial Declaration CART calculation. An in-depth example of how to calculate nutrient input ceilings is presented in Annex 5.

Flow normalization

The aim of flow normalization is to remove natural variability in nutrient inputs caused by variations of water flow. This can be done in several ways, but here normalization is performed on log-transformed flow and load which after trials seems to provide the best normalization for PLC data[1]. First, we find the best linear fit between log-transformed flow and load, that is the function of flow that best describes the loads

(A1.2)

$$\ln l_i = \alpha \ln q_i + \beta + \epsilon_i$$

were l_i is the load and q_i is the flow at year i. α and β are fitting parameters and ε_i is the residuals of the linear fit. The parameters are found individually for each river by least square method.

The normalized load, n_i , (or in this case the log-transformed normalized load) is the part that cannot be described by the linear regression parameters, i.e., the residuals εi plus the average, that is

(A1.3)

$$\ln n_i = \alpha \overline{\ln q_i} + \beta + \epsilon_i$$

Where the overbar represent average over the time-series.

Equations (A1.2) and (A1.3) can be combined into a formula that does not require explicit computation of the residuals.

(A1.4)

$$\ln n_i = \ln l_i + \alpha\left(\overline{\ln q_i} - \ln q_i\right)$$

Due to the log-transformation, the average normalized load of the time-series will not be exactly the same as the average non-normalized load. This is compensated by simply making sure that the averages of the normalized and non-normalized loads are the same, i.e.,

(A1.5)

$$n_{i,final} = \frac{\bar{l_\iota}}{\bar{n_\iota}} n_i$$

1 See "Flow normalization methods" presentation by Bo Gustafsson at PLC7 IG7–2019

Annex 2.
Reference inputs, including comparison with old reference inputs

The updated reference inputs used in the calculation of NIC are presented in Tables A2.1 and A2.2. The atmospheric input part of the nitrogen inputs is shown in Table A2.3. Atmospheric phosphorus inputs are not attributed to countries and therefore directly included under Atm.Dep. in Table A2.2. The transboundary shares of the transboundary rivers are shown in Tables A2.4 and A2.5.

Table A2.1. Updated TN reference inputs (t/y) for 1997–2003. BAS and TOTAL are computed with decimals and do therefore not always match the sum of the presented rounded values. OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	1002	3971	42011	2030	1737	23526	5025	79301
DK	297	1163	11746	519	460	27923	30767	72875
EE	120	409	1924	13985	13023	22	26	29508
FI	37149	29068	2378	19249	293	76	96	88309
LT	114	501	4712	377	459	65	86	6314
LV	78	334	3630	304	12151	31	37	16565
PL	707	3165	46182	1737	1586	1473	1556	56406
RU	888	2018	9528	28235	658	237	265	41829
SE	18760	33052	39941	772	522	6025	35362	134434
OC	2877	10423	56263	5735	4169	10911	10318	100697
BSS	604	2360	10412	1308	776	1282	1225	17967
NOS	389	1292	6561	548	414	1717	1885	12806
NEMUNAS			38181					38181
BARTA			1246					1246
VENTA			7852					7852
LIELUPE					15771			15771
DAUGAVA					38574			38574
ODER			64157					64157
VISTULA			97355					97355
PREGOLYA			7149					7149
NEVA				53644				53644
TOTAL	**62984**	**87757**	**451227**	**128442**	**90593**	**73288**	**86648**	**980940**

Table A2.2. Updated TP reference inputs (t/y) for 1997–2003. BAS and TOTAL are computed with decimals and do therefore not always match the sum of the presented rounded values. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			187			366		553
DK			55			893	807	1756
EE			23	521	271			815
FI	1790	1278		684				3753
LT			131					131
LV			162		732			894
PL			1429					1429
RU			385	3543				3928
SE	863	1163	837			106	746	3716
ATM.DEP.	181	394	1046	150	93	105	118	2088
NEMUNAS			2407					2407
BARTA			67					67
VENTA			279					279
LIELUPE					443			443
DAUGAVA					1382			1382
ODER			4093					4093
VISTULA			6191					6191
PREGOLYA			386					386
NEVA				3236				3236
TOTAL	**2835**	**2836**	**17678**	**8135**	**2921**	**1470**	**1672**	**37546**

Table A2.3. Updated TN atmospheric deposition reference inputs (t/y) 1997–2003. BAS and TOTAL are computed with decimals and do therefore not always match the sum of the presented rounded values. OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	1002	3971	34473	2030	1737	9799	5025	58037
DK	297	1163	9651	519	460	5211	6090	23391
EE	120	409	810	980	269	22	26	2635
FI	2125	2991	2378	1463	293	76	96	9421
LT	114	501	2561	377	459	65	86	4164
LV	78	334	1239	304	517	31	37	2539
PL	707	3165	24229	1736	1586	1473	1556	34452
RU	888	2018	5356	2591	658	237	265	12012
SE	968	3207	8853	772	522	468	1108	15899
OC	2877	10423	56263	5735	4169	10911	10318	100697
BSS	604	2360	10412	1308	776	1282	1225	17967
NOS	389	1292	6561	548	414	1717	1885	12806
TOTAL	**10168**	**31835**	**162785**	**18363**	**11860**	**31293**	**27717**	**294022**

Table A2.4. Updated TN transboundary river reference inputs (t/y) 1997–2003.
Abbreviations for the sea basins are explained in the beginning of the report.

RIVER	BASIN	TOTAL	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	2337				57198			4622	
VISTULA	BAP	97355					91181		3972		2203
PREGOLYA	BAP	7149					3251	3898			
NEVA	GUF	53644		5992				47652			

Table A2.5: Updated TP transboundary river reference inputs (t/y) 1997–2003.

RIVER	BASIN	TOTAL	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	101				3842			150	
VISTULA	BAP	6191					5899		167		124
PREGOLYA	BAP	386					133	253			
NEVA	GUF	3236		45				3191			

Comparison with old reference inputs

In order to compare with reference inputs used to compute the present ceilings from the reference inputs used to compute the CART for the 2013 Ministerial Declaration, the net country by basin inputs are computed including the transboundary shares (following Annex 3). The old reference inputs are provided in Annex 4. Further, North Sea shipping (NOS) is included into the OC category. The percentage change from the old reference inputs are shown in Tables A2.6 and A2.7. In Table A2.8, the change of the atmospheric nitrogen deposition between the new and the old reference inputs presented and in Tables A2.9 and A2.10 the changes in waterborne inputs are presented.

Table A2.6. Change (%) of the net country-basin reference inputs (1997-2003) for TN. + = reference inputs have increased. OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	25	33	27	37	21	14	49	24
DK	31	36	17	38	23	-2	2	3
EE	29	37	7	10	2	29	30	7
FI	8	4	19	9	17	27	22	7
LT	6	8	-20	28	54	27	41	-10
LV	26	29	9	48	-19	35	42	-15
PL	12	20	-3	32	19	39	37	-2
RU	28	38	14	8	33	45	49	10
SE	7	5	2	37	19	3	1	3
OC incl NOS	22	24	32	27	14	46	51	33
BSS	67	62	45	77	38	55	63	51
BY			88		105			95
CZ			35					35
UA			-11					-11
TOTAL	**9**	**11**	**6**	**11**	**2**	**11**	**10**	**8**

Table A2.7. Change (%) of the net country-basin reference inputs (1997–2003) for TP. + = reference inputs have increased. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			4			4		4
DK			-7			-14	-3	-9
EE			0	3	-2			1
FI	7	2		7				5
LT			-18		34			-14
LV			117		148			141
PL			-4					-4
RU			-16	9	-33			5
SE	4	3	-1			1	1	2
ATM.DEP.	0	0	0	0	0	0	0	0
BY			38		-35			-5
CZ			-49					-49
UA			37					37
TOTAL	**6**	**2**	**-4**	**8**	**25**	**-8**	**-1**	**2**

Table A2.8. Change (%) of the nitrogen deposition reference inputs (1997–2003). + = reference inputs have increased. OC = non-HELCOM countries, NOS = North Sea shipping and BSS = Baltic Sea shipping. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	25	33	34	37	21	25	49	33
DK	31	36	18	38	23	-2	8	12
EE	29	37	23	44	9	26	27	31
FI	20	28	19	47	17	28	22	26
LT	5	8	7	28	5	27	41	10
LV	27	29	28	48	17	34	42	28
PL	12	20	23	32	19	39	37	24
RU	28	38	38	48	29	45	49	39
SE	28	26	12	37	19	22	18	17
OC (incl NOS)	36	40	46	48	23	60	69	48
BSS	67	62	45	77	38	55	63	51
TOTAL	**24**	**29**	**29**	**38**	**18**	**28**	**37**	**29**

Table A2.9. Change (%) of the waterborne TN reference inputs (1997–2003). + = reference inputs have increased. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			10			7		8
DK			12			-2	1	0
EE			-2	8	2			5
FI	7	2		5				5
LT			-5					-5
LV			13		0			2
PL			-5					-5
RU			3	7				7
SE	6	3	-1			1	0	2
TOTAL	**7**	**2**	**-3**	**7**	**0**	**1**	**1**	**1**

Table A2.10: Change (%) of the waterborne TP reference inputs (1977–2003). + = reference inputs have increased. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			7			4		5
DK			-7			-14	-3	-9
EE			0	3	-2			1
FI	7	2		8				5
LT			-4					-4
LV			89		31			38
PL			-5					-5
RU			-20	9				5
SE	4	3	-1			1	1	2
TOTAL	**6**	**3**	**-4**	**9**	**27**	**-9**	**-1**	**2**

Annex 3. Transboundary input estimates

Table A3.1 contains a description of the data sets and processing performed to estimate transboundary load estimates for the reference period. In Table A3.2, the border loads and transboundary loads are compared on an aggregated level with the data set used to compute the CART in the 2013 Ministerial Declaration.

Table A3.1. Data set and retention values used in estimation of transboundary inputs. If nothing else stated retention was calculated by Per Stålnacke within the project BONUS RECOCA. Nitrogen retention estimated from this study was published in (Stålnacke et al., 2015) while phosphorus retention estimates are not properly published although more information is available in BONUS RECOCA Deliverable reports.

River	Upstream country	Data set	TN Retention	TP Retention
Nemunas	BY	Lithuanian border loads from Nemunas and Neris	0.11[1]	0.22[1]
Barta	LT	Both Lithuania and Latvia monitor close to the border and averaged data should be used. Latvian data is available from 2001	0.047	0.4
Venta	LT	Both Lithuanian and Latvian monitoring (from 2001), but both stations are at some distance from the border. Average stations give approximate loads at the border. Prior 2001 that border loads = 1.228 * LT loads	0.16	0.48
Lielupe	LT	Lithuanian monitoring in Musa and Nemunelis used. Add unmonitored area (3037 km^2) to monitored (5693 km^2), i.e., multiply with (5693+3037)/5693 = 1.53.	0.15	0.6
Daugava	LT	Contribution not monitored, estimate by using annual area specific loads from Musa and Nemunelis. Area in LT is 1821 km^2, i.e. multiply Musa and Nemunilis loads with 1821/5693 = 0.32 to get border loads	0.38	0.43
Daugava	BY	Latvian monitoring data at the border	0.38	0.43
Daugava	RU	BY monitoring data is available 2004-16. TN not monitored but estimated by multiplying DIN with a factor of 1.76 deduced from comparing Latvian and Belarussian monitoring data at the Latvian-Belarussian border. For 1995-2003, border loads are assumed to be TN 34% and TP 56% of the loads at the BY-LV border based on average ratio 2004-2010. 2017 is estimated as TN 23% and TP 18% of the BY-LV border load based on average ratio for 2014-2016.	0.38 (in BY) 0.62 (total)	0.43 (in BY) 0.68 (total)
Neva	FI	Finnish border load data	0.3[2]	0.7[2]
Oder	DE	It has been estimated by German modeling that the German contribution to Oder during the reference period was 2337 ton/y and 101 ton/y of TN and TP, respectively. These result to 3.6 % (TN) and 2.5% (TP) of total Oder loads.	0	0
Oder	CZ	Polish border load data, 1995-2010 previously supplied, 2012-2017 reported to PLC, 2011 estimated 9.5% of total Oder loads	0.3	0.64
Vistula	BY	Estimated as 6% of total Vistula loads based on 2012-2017 data reported to PLC	0.32	0.55
Vistula	UA	Polish load data from Bug, 1995-2010, 2012-2017 reported to PLC, 2011 estimated as 7.5% of the total Vistula loads	0.32	0.55
Pregolya	PL	Polish data time-series provided 1995-2010, 2012-2017 reported to PLC, 2011 estimated as 49% of total Pregolya loads	0.25	0.58

1 Retention figures supplied by LT
2 Retention figures supplied by FI

Table A3.2: Comparison of border loads, retention coefficients and transboundary inputs of the updated data set and the data set used for CART calculations in 2013.

			Data used for 2013 CART						New data set					
From	Via	To	Border		Retention		To Baltic		Border		Retention		To Baltic	
			TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
			t/y	t/y			t/y	t/y	t/y	t/y			t/y	t/y
From non-Contracting Parties:														
Czech	Poland	BAP	5700	410	0.4	0.28	3420	295	6602	416	0.3	0.64	4622	150
Belarus	Lithuania	BAP	13600	914	0.54	0.53	6256	430	15213	964	0.11	0.22	13540	752
Ukraine	Poland	BAP	4124	127	0.4	0.28	2474	91	3239	277	0.32	0.55	2203	124
Belarus	Poland	BAP	5071	331	0.4	0.28	3043	238	5841	371	0.32	0.55	3972	167
Total		BAP					15193	1055					24336	1193
Belarus	Latvia	GUR	8532	1360	0.27	0.32	6228[1]	925[1]	24780	1303	0.38	0.43	15364[1]	743[1]
Between Contracting Parties														
Lithuania	Latvia	BAP	5516	158	0.39	0.58	3365	66	5071	124	0.15[2]	0.46[2]	4325	67
Poland	Russia	BAP	4400	320	0.3	0.37	3080	202	4335	318	0.25	0.58	3251	133
Germany	Poland	BAP					2337	101					2337	101
Total		BAP					8782	369					10933	316
Lithuania	Latvia	GUR	7185	282	0.27	0.32	5245	192	10255	598	0.19[3]	0.57[3]	8310	257
Russia	Latvia	GUR	4256	734	0.54	0.71	1957	215	6813	377	0.62	0.68	2619	145
Total		GUR					7202	407					9275	433
Finland	Russia	GUF			0.48	0.82	5353	49	8560	151	0.3	0.7	5992	45

1 Includes also the Russian contribution to Baltic Sea loads via Daugava.
2 Weighted average retention in Barta and Venta.
3 Weighted average retention in Daugava and Lielupe.

Annex 4. Nutrient input ceilings based on CART in the 2013 Ministerial Declaration

The country-basin net nutrient input ceilings based on the CARTs from the 2013 Ministerial Declaration are provided in Tables A4.1 and A4.2. The net reference inputs, including the transboundary riverine shares, from that was used to calculated the net nutrient input ceilings are shown in Tables A4.3 and A4.4.

Table A4.1. Country–basin net TN nutrient input ceilings based on the CART from the 2013 Ministerial Declaration. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	817	3170	27473	1312	1465	21957	3285	59480
DK	231	904	7910	334	381	30313	29319	69392
EE	95	317	1413	11265	13029	18	20	26156
FI	35081	29619	1569	20653	255	64	77	87318
LT	110	491	33093	261	5795	54	60	39864
LV	63	273	6091	183	53898	24	25	60558
PL	644	2802	160857	1166	1361	1125	1106	169062
RU	710	1551	9253	62522	2516	174	174	76900
SE	17924	33350	30942	502	449	6224	34206	123597
OC	1876	6603	33002	3455	2804	5880	5579	59199
BSS	72	292	1434	147	112	165	149	2372
BY			7322		6352			13673
CZ			2693					2693
UA			1948					1948
MAI	**57622**	**79372**	**325000**	**101800**	**88417**	**65998**	**74000**	**792212**

Table A4.2. Country-basin net TP nutrient input ceilings based on the CART from the 2013 Ministerial Declaration. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			101			351		451
DK			21			1040	829	1890
EE			8	236	239			483
FI	1668	1255		322				3245
LT			831		166			996
LV			74		541			615
PL			4309					4309
RU			277	2892	185			3354
SE	826	1125	308			105	740	3104
OC	181	394	1046	150	93	105	118	2087
BY			244		797			1041
CZ			108					108
UA			33					33
MAI	**2675**	**2773**	**7360**	**3600**	**2020**	**1601**	**1687**	**21717**

Table A4.3. The country-basin TN reference inputs (including the transboundary river shares) used as basins for CART in the 2013 Ministerial Declaration. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE	801	2994	34892	1477	1437	20708	3364	65673
DK	226	854	10046	376	374	28588	30027	70491
EE	93	299	1795	12684	12777	17	20	27684
FI	34389	27978	1993	23256	250	60	79	88005
LT	108	464	42028	294	5682	51	61	48689
LV	62	258	7736	206	52853	23	26	61164
PL	631	2647	204293	1313	1335	1061	1133	212413
RU	696	1465	11751	70401	2467	164	178	87123
SE	17571	31501	39298	565	440	5869	35032	130277
OC	2685	9451	47727	4941	4013	8631	8090	85538
BSS	361	1461	7169	739	561	826	751	11868
BY			9299		6228			15527
CZ			3420					3420
UA			2474					2474
TOTAL	57622	79372	423922	116252	88418	65998	78762	910346

Table A4.4. The country–basin TP reference inputs (including the transboundary river shares) used as basins for CART in the 2013 Ministerial Declaration. Abbreviations for the sea basins are explained in the beginning of the report.

	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
DE			276			351		626
DK			59			1040	829	1928
EE			23	504	277			804
FI	1668	1255		686				3609
LT			2272		192			2463
LV			203		627			830
PL			11786					11786
RU			758	6169	215			7142
SE	826	1125	843			105	740	3639
OC	181	394	1046	150	93	105	118	2087
BY			668		925			1593
CZ			295					295
UA			91					91
TOTAL	2675	2773	18320	7509	2328	1601	1687	36894

Annex 5.
Example – computation of nutrient input ceilings

The case of TP to Gulf of Riga is used as an example of how to practically use Equation A1.1 in Annex 1 to aid understanding of how the nutrient input ceilings are computed. Note that in this example calculations are done using reference nutrient inputs rounded to whole numbers while the actual calculation behind the proposed ceilings are done without prior rounding.

Input ceilings

The reference inputs from Estonia, Latvia, the two transboundary rivers Daugava and Lielupe, and atmosphere are given in Table A2.2. The MAI for Gulf of Riga is 2020 t/y. Since atmospheric TP deposition (= 93 t/y) is assumed not to change, it will take up a part of the MAI and leave for the two countries and two rivers to share. Thus, the remainder that can be shared is:

(A5.1)

$$MAI_{GUR} - NIC_{GUR,OC} = 2020 - 93 = 1927 \text{ t/y}$$

Further, the sum of reference nutrient inputs for the countries and rivers are:

(A5.2)

$$\sum_{j \neq OC} L_{GUR,j} = L_{GUR,EE} + L_{GUR,LV} + L_{GUR,DAUGAVA} + L_{GUR,LIELUPE} =$$
$$= 271 + 732 + 1382 + 443 = 2828 \text{ t/y}$$

With these intermediate calculations done Equation A1.1 can be applied for each of the countries/rivers to reproduce the ceilings in Table 3.

(A5.3)

$$NIC_{GUR,EE} = \frac{L_{GUR,EE}}{\sum_{j \neq OC} L_{GUR,j}} \left(MAI_{GUR} - NIC_{GUR,OC} \right) = \frac{271}{2828} 1927 \approx 185 \text{ t/y}$$

(A5.4)

$$NIC_{GUR,LV} = \frac{L_{GUR,LV}}{\sum_{j \neq OC} L_{GUR,j}} \left(MAI_{GUR} - NIC_{GUR,OC} \right) = \frac{732}{2828} 1927 \approx 499 \text{ t/y}$$

(A5.5)

$$NIC_{GUR,DAUGAVA} = \frac{L_{GUR,DAUGAVA}}{\sum_{j \neq OC} L_{GUR,j}} \left(MAI_{GUR} - NIC_{GUR,OC} \right) = \frac{1382}{2828} 1927 \approx 941 \text{ t/y}$$

(A5.6)

$$NIC_{GUR,LIELUPE} = \frac{L_{GUR,LIELUPE}}{\sum_{j \neq OC} L_{GUR,j}} \left(MAI_{GUR} - NIC_{GUR,OC} \right) = \frac{443}{2828} 1927 \approx 302 \text{ t/y}$$

River input ceilings

The nutrient input ceilings for the transboundary rivers are divided between the countries in an analogous way. For the rivers there are no *other* contributions in Equation A1.1. For example, the equation for country j's nutrient input ceiling to Daugava becomes:

(A5.7)

$$NIC_{DAUGAVA,j} = \frac{L_{DAUGAVA,j}}{L_{GUR,DAUGAVA}} NIC_{GUR,DAUGAVA}$$

The reference inputs to the river from the different countries ($L_{DAUGAVA,J}$) are found in Table A2.5. As the sum of the country contributions is known as the total reference input via the river a summation is not needed in the denominator of Eq. A5.7. The computations of the individual country-river ceilings in Table 5 are:

(A5.8)

$$NIC_{DAUGAVA,LT} = \frac{L_{DAUGAVA,LT}}{L_{GUR,DAUGAVA}} NIC_{GUR,DAUGAVA} = \frac{59}{1382} 941 \approx 40 \text{ t/y}$$

(A5.9)

$$NIC_{DAUGAVA,LV} = \frac{L_{DAUGAVA,LV}}{L_{GUR,DAUGAVA}} NIC_{GUR,DAUGAVA} = \frac{580}{1382} 941 \approx 395 \text{ t/y}$$

(A5.10)

$$NIC_{DAUGAVA,RU} = \frac{L_{DAUGAVA,RU}}{L_{GUR,DAUGAVA}} NIC_{GUR,DAUGAVA} = \frac{145}{1382} 941 \approx 99 \text{ t/y}$$

(A5.11)

$$NIC_{DAUGAVA,BY} = \frac{L_{DAUGAVA,BY}}{L_{GUR,DAUGAVA}} NIC_{GUR,DAUGAVA} = \frac{598}{1382} 941 \approx 407 \text{ t/y}$$

The Latvian and Lithuanian shares of Lielupe is calculated in the same way, i.e.,

(A5.12)

$$NIC_{LIELUPE,LT} = \frac{L_{LIELUPE,LT}}{L_{GUR,LIELUPE}} NIC_{GUR,LIELUPE} = \frac{198}{443} 302 \approx 135 \text{ t/y}$$

(A5.13)

$$NIC_{LIELUPE,LV} = \frac{L_{LIELUPE,LV}}{L_{GUR,LIELUPE}} NIC_{GUR,LIELUPE} = \frac{245}{443} 302 \approx 167 \text{ t/y}$$

Net input ceilings

The net input ceilings are the sum of the ceilings for a country. In the specific example of TP to Gulf of Riga the net input ceilings shown in Table 7 are given by:

(A5.14)

$$NetNIC_{GUR,EE} = \mathrm{NIC}_{GUR,EE} = 185 \text{ t/y}$$

(A5.15)

$$NetNIC_{GUR,LT} = \mathrm{NIC}_{LIELUPE,LT} + \mathrm{NIC}_{DAUGAVA,LT} = 135 + 40 = 175 \text{ t/y}$$

(A5.15)

$$NetNIC_{GUR,LV} = \mathrm{NIC}_{GUR,LV} + \mathrm{NIC}_{LIELUPE,LV} + \mathrm{NIC}_{DAUGAVA,LV} = \\ = 499 + 167 + 395 = 1061 \text{ t/y}$$

(A5.15)

$$NetNIC_{GUR,RU} = \mathrm{NIC}_{DAUGAVA,RU} = 99 \text{ t/y}$$

(A5.15)

$$NetNIC_{GUR,BY} = \mathrm{NIC}_{DAUGAVA,BY} = 407 \text{ t/y}$$

Annex 6. Example of changed reduction requirements

For some countries, there are significant changes between the proposed NIC and the ones based on CART in the 2013 Ministerial Declaration even though the nutrient input data from that country has not changed significantly. One example is TP for Estonia where the updated ceiling to Gulf of Riga is 23% lower than the old one, see Table 11. The reason is that Latvia re-analyzed and re-reported TP inputs and that these are significantly higher than in the old data set.

From Annex 5, Eq. A5.3 we can follow that the new NIC is given by:

(A6.1)

$$NIC_{GUR,EE} = \frac{L_{GUR,EE}}{\sum_{j \neq OC} L_{GUR,j}} \left(MAI_{GUR} - NIC_{GUR,OC}\right) = \frac{271}{2828} 1927 \approx 185 \text{ t/y}$$

Where the sum of the loads $\sum_{j \neq OC} L_{GUR,j} = 2828$ t/y and $L_{GUR,EE} = 271$ t/y.

Looking back to the data set used to set the old input ceilings (see Table A4.4) we find that the sum of the loads (without OC) were:

(A6.2)

$$\sum_{j \neq OC} L^{Old}_{GUR,j} = 2235 \text{ t/y}$$

and the old reference inputs for Estonia:

(A6.3)

$$L^{Old}_{GUR,EE} = 277 \text{ t/y}$$

The term $MAI_{GUR} - NIC_{GUR,OC}$ is the same as in the new calculation so the old NIC is reproduced by:

(A6.4)

$$NIC^{Old}_{GUR,EE} = \frac{L^{Old}_{GUR,EE}}{\sum_{j \neq OC} L^{Old}_{GUR,j}} \left(MAI_{GUR} - NIC_{GUR,OC}\right) = \frac{277}{2235} 1927 \approx 239 \text{ t/y}$$

Thus, we have verified that Estonia gets a significantly lower input ceiling than the one based on CART from the 2013 Ministerial Declaration. What is happening is that when the TP inputs via Latvia has increased, the overall reduction requirement for the basin increased from the previous reference input minus MAI equal 2328 – 2020 = 308 t/y or 13% to the present 2921 – 2020 = 901 t/y or 31%. That Estonias share of the TP inputs to the Gulf of Riga reduced from 277/2328 = 12% to the present 271/2921 = 9% does not help, since reduction percentage is still increasing from 13 to 31% and the ceiling consequently is decreased.