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Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan

This document was prepared for the 2013 HELCOM Ministerial Meeting
to give information on the progress in implementing
the HELCOM Baltic Sea Action Plan

Baltic Marine Environment Protection Commission

Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan

0 SUMMARY

The aim of this summary report is to describe in a concise way how the revised HELCOM Baltic Sea Action Plan (BSAP) Maximum Allowable Inputs (MAI) and updated Country Allocated nutrient Reduction Targets (CART) have been developed. The main target audience of this report is the decision-makers of the Baltic Sea coastal countries, as well as any stakeholders interested in understanding the revision process of the nutrient reduction scheme of the HELCOM Baltic Sea Action Plan.

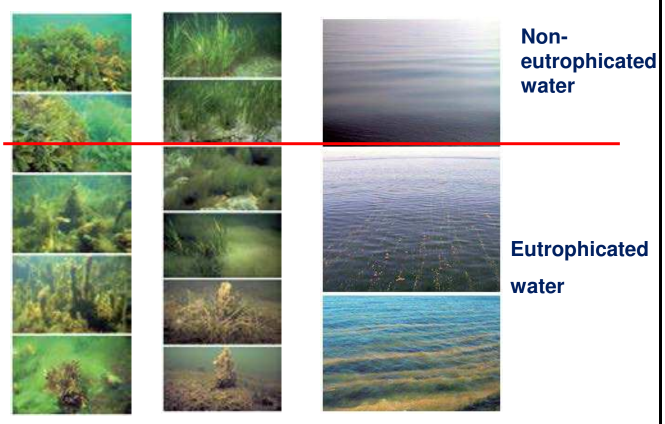
The HELCOM Nutrient Reduction Scheme is a regional approach to sharing the burden of nutrient reductions to achieve the goal of a Baltic Sea unaffected by eutrophication, as agreed on by HELCOM.

The Scheme was first introduced and agreed on in 2007, in the HELCOM Baltic Sea Action Plan. At that time, the countries agreed on provisional nutrient reduction targets and decided that the figures would be revised using a harmonised approach and most updated data as well as through enhanced modelling. The revision process started in 2008 and has been completed in 2013.

There are two main components of the nutrient reduction scheme:

- **Maximum Allowable Inputs (MAI)** of nutrients, indicating the maximal level of inputs of water- and airborne nitrogen and phosphorus to Baltic Sea sub-basins that can be allowed to fulfill the targets for a non-eutrophied sea;
- **Country Allocated Reduction Targets (CART)**, indicating how much the HELCOM countries need to reduce nutrient inputs compared to a reference period (1997-2003).

A great deal of work has been carried out to improve the scientific basis of the scheme.



1. New eutrophication targets describing good eutrophication status of the Baltic Sea
2. Improved marine model (BALTSEM) of the Baltic Nest Institute (BNI) Sweden
3. Calculation of revised Maximum Allowable Inputs (MAI) with BALTSEM, using new eutrophication targets for Baltic Sea sub-basins
4. Agreement of allocation principles for calculating new Country Allocated Reduction Targets (CART)
5. Updated dataset on water- and airborne nutrient inputs for 1994-2010
6. Calculation of new Country Allocated Reduction Targets (CART)
7. Scientific documentation of the process

Detailed information on the development and calculation of MAI and CART will be included in the scientific report by the Baltic Nest Institute (BNI, Stockholm) “Revision of the Maximum Allowable Loads and Country Allocation Scheme of the Baltic Sea Action Plan” (Gustafsson & Mörth, in prep).

Revised Maximum Allowable Inputs

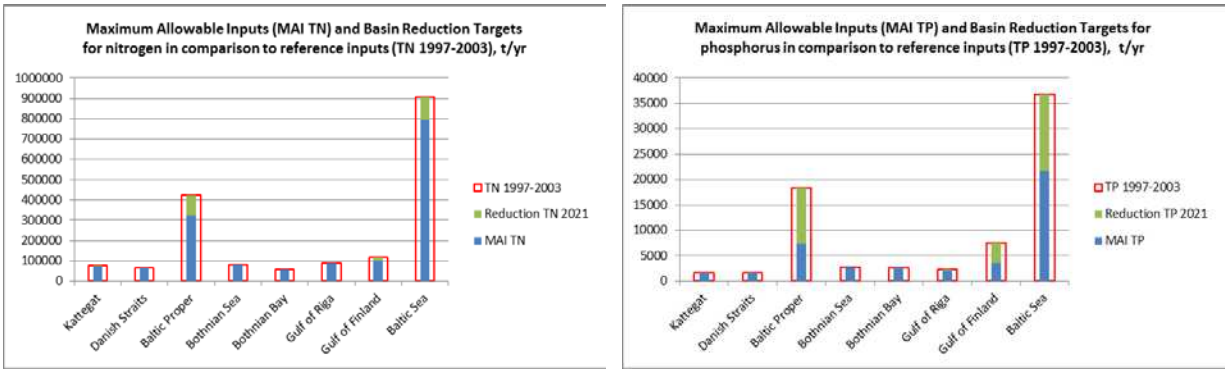


Figure 1. By comparing Maximum Allowable Inputs and actual nitrogen and phosphorous inputs during the reference period (1997-2003), we can see what the needed reductions for total nitrogen (TN) and total phosphorus (TP) are in individual sub-basins of the Baltic Sea (cf. Table 9.1 in Annex).

The proposed Country Allocated Reduction Targets

The following Country Allocated Reduction Targets for nitrogen and phosphorus have been proposed for adoption by the 2013 HELCOM Ministerial Meeting:

Table 1. Country Allocated Reduction Targets for nitrogen and phosphorus per country (rounded figures)

Country	PHOSPHORUS	NITROGEN
Denmark	38	2,890
Estonia	320	1,800
Finland	330+26*	2,430+600*
Germany	110+60*	7,170+500*
Latvia	220	1,670
Lithuania	1,470	8,970
Poland	7,480	4,3610
Russia	3,790*	10,380*
Sweden	530	9,240

***** *Reduction requirements stemming from:*

- *German contribution to the river Odra inputs, based on ongoing modeling approaches with MONERIS*
- *Finnish contribution to inputs from river Neva catchment (via Vuoksi river)*
- *these figures include Russian contribution to inputs through Daugava, Nemunas and Pregolya rivers*

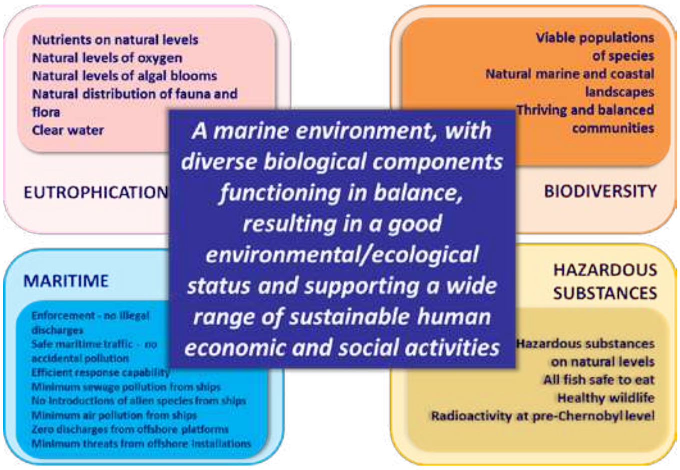
The figures for transboundary inputs originating in the Contracting Parties and discharged to the Baltic Sea through other Contracting Parties are preliminary and require further discussion within relevant transboundary water management bodies

The Country Allocated Reduction Targets take into account transboundary inputs in order to give the clearest indication of the national reduction demand. The anticipated nutrient input reductions resulting from emission reductions from non-Contracting Countries by implementation of the Gothenburg Protocol and from international shipping are taken into account as well as anticipated reductions of transboundary waterborne inputs by non-Contracting Countries.

The basis for calculating the revised MAI and updated CART is the best available scientific knowledge. Ecological targets and revised MAI and CART have been developed with the involvement of all the Baltic Sea countries.

1 BACKGROUND

In November 2007, the environment ministers of the HELCOM countries and the high-level representative of the EU adopted the HELCOM Baltic Sea Action Plan (BSAP), which aims to reduce pollution of the Baltic Sea and reverse its degradation by 2021 (HELCOM 2007a).



Each of the main goals of the BSAP is defined by *ecological objectives,* which describe the characteristics of the sea that we aspire towards. Ecological objectives for eutrophication include:

- clear water
- concentrations of nutrients close to natural levels
- natural levels of algal blooms
- natural distribution and occurrence of plants and animals
- natural oxygen levels.

Adaptive management is one of the principles of HELCOM's work. In Figure 2 the management cycle of the BSAP is shown.

Monitoring and assessment are the tools for measuring the progress towards the ecological objectives, using a set of indicators with quantitative targets. These targets collectively define good environmental status, and the distance to targets indicates to what extent further measures are needed in order to reduce pressures on the Baltic Sea. Monitoring is then continued and the effects of implemented measures are again assessed in the next management cycle.

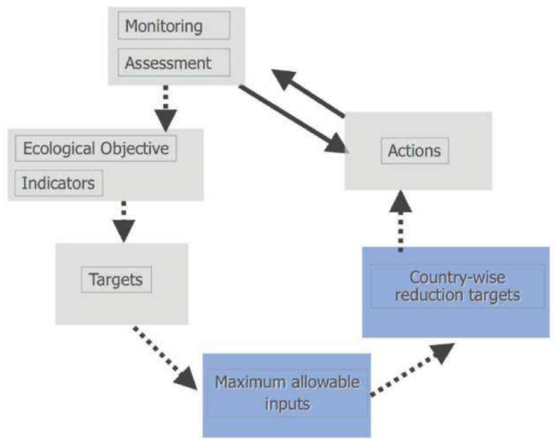


Figure 2. The management cycle of the BSAP.

To reach good eutrophication status of the Baltic Sea, the countries agreed in 2007 on a provisional nutrient reduction scheme which was based on the concept of maximum allowable nutrient inputs via water and air. These are the maximum nutrient inputs allowed in order for the Baltic Sea to reach a good ecological status.

In BSAP 2007 the Baltic Sea coastal countries acknowledged that 'there is a need to reduce the nutrient inputs and that the needed reductions shall be fairly shared by all Baltic Sea countries. Initial estimates of MAI to reach the eutrophication target (clear water) were calculated using the SANBALT model developed by the MARE Research programme in Sweden (Wulff et al 2007). Based on the MAI and agreed allocation principles for dividing the reduction burden between HELCOM countries, nutrient reduction targets were calculated. The reduction targets were derived by comparing MAI for each sub-basin with the average nutrient input during a reference period (1997-2003). Based on those, HELCOM Contracting Parties identified priority actions to reducing nutrient loading.

The calculated figures were provisional though, based on the best available scientific information at the time, and requiring review and revision using a harmonized approach and data.

In 2010, the HELCOM Moscow Ministerial Meeting agreed to carry out a review of the HELCOM BSAP environmental targets for eutrophication, the Maximum Allowable Inputs and the nutrient reduction targets, as well as the Ccountry-wise nutrient reduction targets including updated information on the atmospheric nitrogen deposition by 2012.

2 REVISION OF NUTRIENT REDUCTION SCHEME

Since 2008, work has been on-going to improve the nutrient reduction scheme, including:

- The scientific basis for review of the ecological targets for eutrophication of the HELCOM BSAP within the TARGREV project,
- The Baltic Nest Institute-Sweden (BNI) has further developed its marine models to a new BALTSEM model for calculating the MAI,
- The HELCOM PLC-5.5 project has compiled an updated and more complete data set on waterborne and airborne pollution inputs to the Baltic Sea. The data set covers the period of 1994-2010 and input data has also been normalized to smooth out the influence of annual variations in weather conditions,
- BNI has developed a new software tool for calculating CART,
- Allocation principles have been revised.

Furthermore, the HELCOM Expert Group on follow-up of national progress towards reaching BSAP nutrient reduction targets (HELCOM LOAD) has been developing tools for following up on fulfilment by the countries regarding the nutrient input reduction requirements (Larsen, S.E. and Svendsen, L.M., in press).

2.1 Revised eutrophication (status) targets

The revision of the scientific basis underlying the ecological targets for eutrophication was carried out by the HELCOM TARGREV project (HELCOM, 2013).

In the 2007 BSAP only one indicator for good environmental status with regard to eutrophication - clear water/transparency (expressed as annual average Secchi depth) - was used to calculate MAI. To increase the reliability of the eutrophication status assessment, four more eutrophication indicators have been developed.

Indicators used to describe the Baltic Sea in a good environmental status with regard to eutrophication.	
BSAP 2007	**2013**
• Secchi depth (annual)	• Secchi depth (summer) • winter nutrient concentrations of DIP • winter nutrient concentrations of DIN • Chl α (summer) • oxygen debt/concentration

Eutrophication status targets are available for all 18 HELCOM open sea areas (Table 9.2 in the Annex, HELCOM HOLAS sub-division). However, they have been aggregated into the seven-basins that MAI are calculated on and correspond to the ones used in BSAP 2007 (Table 9.3 in the Annex).

2.2 Allocation principles

One step in developing the revised MAI and CART is the agreement on allocation principles for calculating updated Country Allocated Reduction Targets. The overall principle is the use of the polluter pays principle according to Article 3 in the Helsinki Convention (HELCOM, 1992). It has been supplemented with further principles as listed in Table 2.

Table 2. Comparison of allocation principles used for BSAP 2007 and the new nutrient reduction scheme.

Allocation Principle	BSAP 2007	BSAP Review 2013
Polluter pays	Yes	Yes
Maximum Allowable Inputs	Waterborne inputs	Water- and airborne inputs
Reference inputs	Waterborne inputs	Water- and airborne inputs
Reference period	1997-2003	1997-2003
Flow normalization	No	Yes
Compensation for improved sewage treatment	Yes	No
Retention deducted on transboundary inputs	No	Yes
Common pool	Yes	No, but instead non-Contracting Parties' waterborne inputs are allocated to the emitting country
Gothenburg Protocol expected reductions by 2020 from non-Contracting Parties	No	Yes
Expected reductions from shipping	No	Yes

In BSAP 2007 all atmospheric deposition of phosphorus and nitrogen (amounting to 6,300 tonnes phosphorus and 230,000 tonnes nitrogen respectively) was treated as background inputs to the Baltic Sea (it was taken into account when deriving MAI but the reduction targets were only calculated from, and allocated on, the waterborne inputs).

Atmospheric nitrogen deposition originating from HELCOM countries' emissions are now included in the updated reduction targets. As a consequence HELCOM countries have to meet the reduction target also for sub-basins they are not bordering to. Reductions in both airborne and waterborne nitrogen inputs can be accounted for in fulfilling the reduction targets.

All **atmospheric phosphorus input is also this time treated as background input** as the sources to these inputs are not known. A survey of available monitoring of phosphorus deposition has led to a revised deposition estimate from the 6,300 tonnes used in BSAP 2007 to 2,100 tonnes phosphorus for the whole Baltic Sea, using a fixed deposition rate of 5 kg P km^{-2} in the 2013 revision.

Keeping the 1997-2003 reference period makes it easier and statistically safer to evaluate trends and effects of taken measures since **long time series are available**.

The reference (1997-2003) waterborne inputs used in BSAP 2007 and the new waterborne reference inputs are shown in Table 9.4 (cf. Annex). The new waterborne reference inputs have been updated with updated and corrected pollution input data and flow normalization.

In BSAP 2007, an *ex ante* reduction of discharges from municipal wastewater treatment in countries not fulfilling the HELCOM Recommendation and EU UWWT Directive was applied in the CART calculation, while some countries (Sweden, Denmark and Germany) received an extra bonus as compensation for higher treatment levels than required. **In the revised scheme the *ex ante* principle has not been applied**. BNI studies during 2010-2011 show that it is not possible to accurately estimate the sewage treatment potential. Further, according to the polluter pays principle reduction requirements to a sub-basin are divided according to real input of each HELCOM country. Therefore, if a HELCOM country has reduced their wastewater emissions they also get a lower reduction requirement, and hence *ex ante* accounting would lead to a kind of double compensation.

For two border rivers between the Contracting Parties (Neva and Torne rivers), the riverine inputs are divided according to the agreed proportion of input from the involved countries.

In BSAP 2007, transboundary waterborne inputs reaching the Baltic Sea from non-HELCOM countries was estimated without taking into account the retention on the transboundary inputs from the border down to the coast. **For calculation of the new CART, retention is deducted from the transboundary waterborne inputs entering HELCOM countries**. Retention plays an important role as on average 25-50% of nitrogen and 30-60% of phosphorus entering as transboundary inputs in the coastal countries are retained in the catchment before rivers enter the Baltic Sea. Retention in coastal areas, after waterborne inputs have entered the Baltic Sea, is not taken separately into account and is indirectly included in the BALTSEM model when it is calibrated with water- and airborne inputs.

In BSAP 2007 a common pool of was allocated for transboundary waterborne inputs from upstream countries such as Belarus. The common pool of 3,779 tonnes of nitrogen and 1,662 tonnes of phosphorus was based on a very rough estimate of potential input reductions resulting from improved waste water treatment in Belarus and inputs via rivers to the Baltic Sea.

The revised CART take into account expected reductions of transboundary inputs from non-HELCOM countries. For the waterborne transboundary inputs, the expected reductions are calculated by allocating according to the same principles as for HELCOM countries, which lowers reduction requirements for the countries with waterborne inputs to the Baltic Proper and the Gulf of Riga. Also the expected reduction of atmospheric nitrogen deposition due to the implementation of the Gothenburg Protocol in non-HELCOM countries is taken into account. This lowers nitrogen reduction requirement for all HELCOM countries to the Baltic Sea sub-basins. Further, 80% reduction of nitrogen deposition originating from shipping (implementation of the Baltic NECA) is assumed.

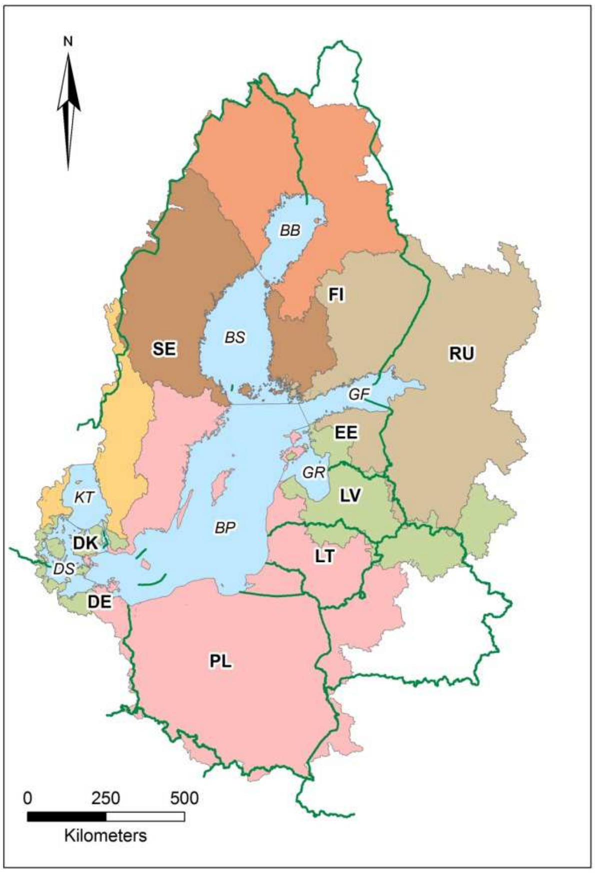


Figure 3. The basin division of the Baltic Sea and the parts of the catchment contributing to the waterborne inputs to each of the basins. Further the borders of Contracting Parties are inserted to illustrate that besides the 9 HELCOM countries five countries: Belarus, Ukraine, Czech Republic, Slovakia and Norway contribute with waterborne inputs to the Baltic Sea (transboundary waterborne inputs).

3 HOW ARE THE REVISED MAI CALCULATED

MAI is calculated using the coupled physical-biogeochemical model BALTSEM. The model simulates circulation and development of stratification driven by meteorology, river flow and boundary conditions to the North Sea, as well as simulating cycles of inorganic and organic nutrients and dominating plankton groups.

The model explicitly takes into account sediment biogeochemistry so that the complete nutrient cycles of phosphorus, nitrogen and silica, including their internal loading, are covered.

Obtaining MAI is formally an optimization problem: finding the highest possible inputs that will still satisfy the given environmental targets. In practice, a pragmatic approach needs to be used to solve the mathematical problem. The model is run from present day conditions long enough into the future so that it is absolutely certain that the Baltic Sea is in balance with imposed nutrient inputs (125 years), thereafter averaged indicator values are calculated from an additional 75 years of simulation. By running the model with different combinations of nutrient inputs a database of indicator values and associated inputs is created. From the database complex, pressure-response relationships are established and these are used to find MAI, as well as to assess the sensitivity of MAI to various sources of uncertainty. For basins without additional reduction requirements, the 1997-2003 normalized averaged inputs obtained from the PLC 5.5 project are used as MAI.

BNI results show that the optimal MAI can be estimated by first considering inputs and target fulfilment in the Baltic Proper, Gulf of Riga and Gulf of Finland and thereafter in the remaining four main sub-basins.

The basin-wise MAI, as presented in Table 3 (cf. Table 9.1 in the Annex), are obtained by satisfying all targets in all basins, with a few exceptions, of which the most important ones are:

1. Nitrogen input reductions were not considered necessary to the Bothnian Bay and Gulf of Riga because of extremely strong phosphorus limitations of the ecosystem in these basins (resulting in a situation where DIN targets are not fulfilled)
2. A less strict application of the targets in the Gulf of Finland by applying the so-called HEAT approach on winter nutrient concentration
3. Model bias on phosphorus in the Bothnian Bay made it impossible to use the winter phosphorus (DIP) target for this basin.

Table 3. Maximum Allowable nutrient Inputs to main Baltic Sea sub-basins. Values that represent reductions compared with reference inputs (1997-2003) are highlighted by italics.

	Maximum Allowable Inputs	
Baltic Sea sub-basin	**Total nitrogen, tonnes**	**Total phosphorus, tonnes**
Kattegat	*74,000*	1,687
Danish Straits	65,998	1,601
Baltic Proper	*325,000*	*7,360*
Bothnian Sea	79,372	2,773
Bothnian Bay	57,622	2,675
Gulf of Riga	88,417	*2,020*
Gulf of Finland	*101,800*	*3,600*
Baltic Sea	792,209	21,716

4 HOW ARE THE UPDATED CART WAS DETERMINED

4.1 Establishing a complete dataset on air- and waterborne inputs to the Baltic Sea

The data set on nutrient inputs to the Baltic Sea has significantly improved in most aspects since BSAP 2007.

- The HELCOM PLC data set, now covering 1994-2010, has been revised and updated, data gaps have been filled in, some data have been corrected and the dataset quality has been assured as far as possible. This has resulted in a more complete and consistent dataset (PLC-5.5 project). Use of flow normalized riverine data and climate normalized airborne deposition data before calculating average water- and airborne inputs during the reference period, as compared with using a simple average of non-normalized water and airborne inputs from 1997-2003 in BSAP 2007. Normalization creates time-series with strongly reduced variability caused by annual weather and river flow variations.

- Air emission data, the meteorological and the chemical model used for deposition modelling have all been improved, resulting in revised annual deposition data.

The reference inputs are defined as the average of normalized airborne and flow normalized waterborne inputs of nitrogen and phosphorus per country and per basin in the reference period 1997-2003. The inputs are compiled in Table 9.5 and Table 9.6 for total nitrogen and total phosphorus, respectively (cf. Annex).

4.2 Transboundary inputs

4.2.1 Waterborne inputs from non-Contracting Parties

Estimates of waterborne nutrient inputs entering the Baltic Sea are based on monitoring at the river mouth. For some rivers, a share of the nutrient inputs originates from catchment areas upstream of the country bordering the sea. Such inputs are called transboundary inputs, and can originate from both non-Contracting Parties and HELCOM countries. A part of these transboundary inputs never enter the Baltic Sea due to retention in the surface waters in the receiving HELCOM countries. In principle, the HELCOM countries receiving transboundary inputs should not be accounted for these shares.

Net transboundary inputs from non-Contracting Parties in most cases constitute only small percentages (1-6%) of the waterborne nutrient inputs entering the Baltic Proper from Poland and Lithuania (Table 9.8), but constitute more than 40% of the total waterborne phosphorus input to the Gulf of Riga from Latvia. In Table 9.8 of the Annex, the net transboundary inputs from non-Contracting Parties have been estimated.

The potential reductions in these transboundary inputs have been estimated assuming the same level of ambition as for HELCOM countries (cf. section 4.4).

4.2.2 Waterborne inputs from HELCOM countries

For two border rivers (Torne Älv and Narva) the countries sharing the waterborne inputs have agreed in advance on a percentage division of these rivers.

However, there are five country-by-basin catchments where upstream HELCOM countries contribute to the waterborne inputs:

- Lithuania contributes to the waterborne inputs from Latvia to the Baltic Proper,
- Poland contributes to Russian waterborne inputs to the Baltic Proper,
- Germany contributes to Polish waterborne inputs to the Baltic Proper,
- Lithuania and Russia contribute to the waterborne inputs from Latvia to the Gulf of Riga, and
- Finland contributes to the waterborne inputs from Russia to the Gulf of Finland.

The net waterborne inputs from these upstream catchment areas are summarised in Table 9.8 in the Annex. Using these net waterborne inputs the reduction burden can be shared between HELCOM countries.

4.2.3 Airborne inputs from outside HELCOM countries

EMEP has estimated the potential reduction in nitrogen deposition due to national NOx and NH_3 emission reduction commitments for 2020 under the Gothenburg Protocol. This includes quantification of the decrease in nitrogen deposition per sub-basins resulting from the decrease of emissions from non-Contracting Parties. These figures make it possible to follow up on the development in relation to expected reductions from non-Contracting Parties due to these regulatory frameworks. The results are presented in Table 4.

In addition, the implementation of the NOx Emission Control Area for shipping would significantly reduce the emissions from shipping (80%) by 2030.

Table 4. Modelled reduction in atmospheric deposition of nitrogen (tonnes) by 2020 as compared with deposition in the reference period due to emission reduction commitments under the Gothenburg Protocol as calculated by EMEP. "EU20" is non-HELCOM EU countries (including Croatia) and "other sources" are all other non-Contracting countries and sources contributing to nitrogen deposition, including Baltic Sea shipping.

Source	BOB	BOS	BAP	GUF	GUR	DS	KAT	BAS
HELCOM countries	1,396	3,999	20,059	1,816	1,393	4,120	3,730	**36,513**
"EU20"	642	2,242	12,917	1,093	955	2,741	2,482	**23,072**
Other sources	167	606	1,808	393	254	10	29	**3,267**
All sources	**2,205**	**6,847**	**34,784**	**3,302**	**2,602**	**6,871**	**6,241**	**62,854**

For the whole Baltic Sea, the reduction in atmospheric nitrogen deposition in 2020 (as compared to the level in the reference period 1997-2003) is estimated to be nearly 63,000 tonnes from all deposition sources; of which nearly 60% (more than 36,000 tonnes) is reduction from HELCOM countries. The highest estimated nitrogen deposition reductions from Contracting Parties are from Germany (12,600 tonnes), Denmark (8,700 tonnes) and Poland (7,300 tonnes).

Approximately 13% of the reduction requirement to the Baltic Proper can be achieved by the expected reductions from EU countries that are not HELCOM Contracting Parties, and for Kattegat it amounts to about 52%.

There has already been a substantial decrease in airborne nutrient inputs from non-Contracting Parties.

4.3 Steps for calculating country allocated reduction targets (CART)

The calculation of CART (allocation scheme) is described in simple **steps** below:

1. Establish reference data on country by sub-basin inputs including all sources (all riverine inputs, coastal point sources discharging directly to the Baltic Sea and atmospheric deposition) - table 9.5-9.7 in Annex.
2. Subtract atmospheric nitrogen deposition from non-HELCOM countries and ship traffic and atmospheric phosphorus deposition on the Baltic Sea from the reference inputs to each sub-basin
3. Calculate the share (%) of input from each country to each basin based on steps 1-2.
4. Calculate needed reduction per sub-basin by subtracting the reference inputs with the Maximum Allowable Inputs (MAI).
5. Reduce the calculated needed reduction per sub-basin by the anticipated reduction of nitrogen deposition from decreased emissions in non-Contracting Parties (implementation of the Gothenburg Protocol) and from reduced shipping emissions (implementation of NECA).
6. Obtain the country by basin allocation by multiplying the results from Step 5 with the share computed in Step 3.
7. Where there are transboundary waterborne contributions from upstream countries, the country by basin allocation is shared among these countries.

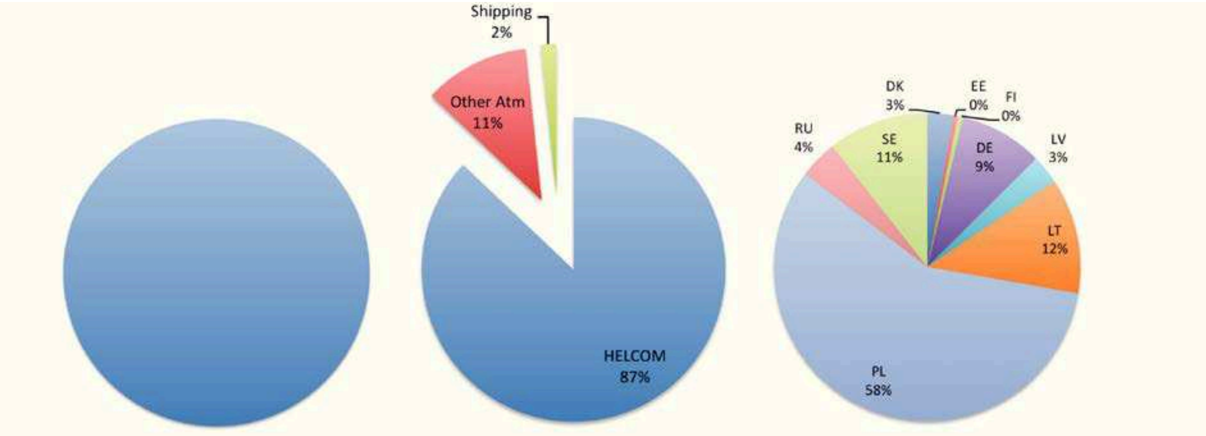
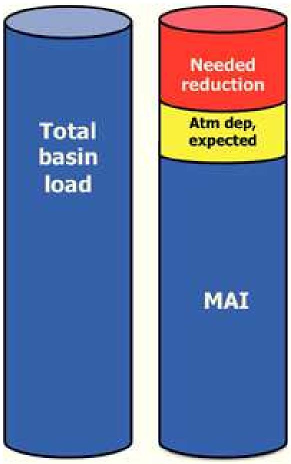


Figure 4. How the shares of total nitrogen inputs from different HELCOM countries to a Baltic Sea sub-basin are determined.

The left figure on Figure 4 illustrates all waterborne and airborne nitrogen inputs to the Baltic Sea. From this, atmospheric inputs from non-Contracting Parties are subtracted, i.e. nitrogen deposition on the Baltic Sea and shipping (middle). The remaining 87% of the inputs originating from Contracting Parties are then divided between the nine HELCOM countries (right), in this example showing that e.g. Poland contributes with 58% of total nitrogen inputs originating from HELCOM countries.



In Figure 5 the left bar illustrates the reference input to a sub-basin in the reference period (as given in Table 9.5 and Table 9.6 in the Annex). The needed reduction is the difference between the reference inputs of nitrogen and phosphorus and the calculated MAI to the basin (cf. Table 9.1 in Annex). A proportion of the needed nitrogen reduction is allocated as the expected reductions on atmospheric deposition by non-Contracting Parties. The needed nitrogen reduction requirement to sub-basins is then shared between the HELCOM countries based on their share of the pollution inputs.

Figure 5. (to the left) Illustrates how needed reduction in nutrient inputs to a Baltic Sea sub-basin is calculated in table 9.1 (in annex).

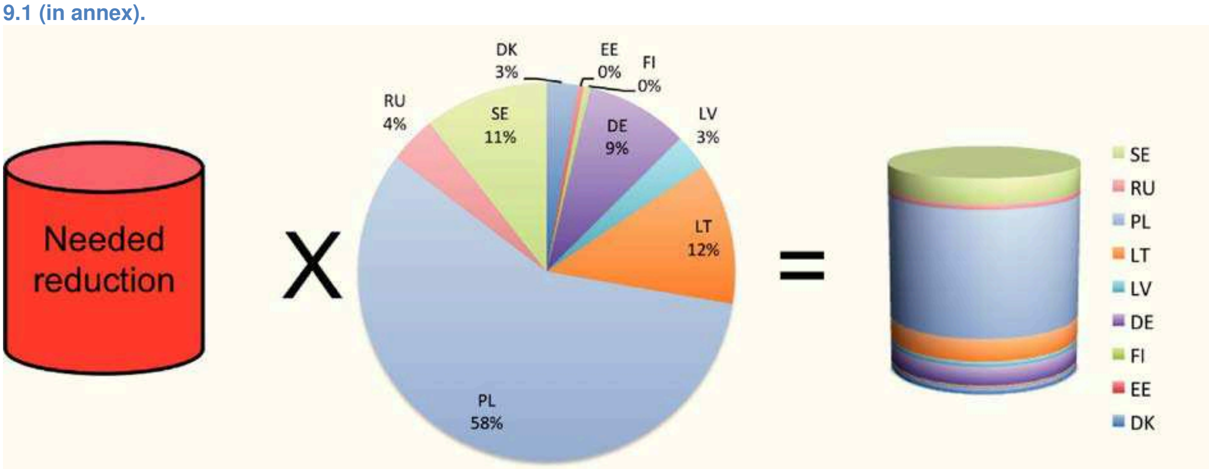


Figure 6. Illustrates how each HELCOM country's share of the reduction requirements to a Baltic Sea sub-basin is calculated.

As shown in figure 6, the needed reduction (see Figure 5) is multiplied by each HELCOM country's share of the reference input to the sub-basin (see Figure 4). In the example Poland had 58% of the total reference water- and airborne input originating from HELCOM countries to this sub-basin and therefore has 58% of the reduction requirement (right figure). For HELCOM countries that receive transboundary inputs, a share of the reduction requirement is calculated for each of the upstream countries, both HELCOM and non-HELCOM. To obtain the final Country Allocated Reduction Targets the shares are added or subtracted to each HELCOM country (see section 4.4).

4.4 Proposed CART

Based on the steps above, the updated CART are calculated for waterborne and airborne inputs of nitrogen (Table 5) and phosphorus (Table 6) for countries and specific sub-basins. In these tables the country by basin reduction requirement without deduction of transboundary sharing is given, which may easily be compared with the annual PLC data set. Further, the waterborne transboundary reduction shares (calculated with retention to the river mouths) are singled out and the total country by basin reduction target is calculated. The country-wise summaries comprise of the sums of the sub-basin-wise reduction (cf. rounded figures in Table 1).

Table 5. Proposed country by basin allocation of nitrogen reductions CART (tonnes).

NITROGEN	**Country by basin reduction before deducting transboundary shares**	**Transboundary shares**		**CART**
		HELCOM countries	**non-HELCOM countries**	
Baltic Proper				
Denmark	2,136			2,136
Estonia	382			382
Finland	424			424
Germany	6,922	497		7,419
Latvia	2,360	-715		1,645
Lithuania	9,550	715	-1,330	8,935
Poland	45,178	158	-1,900	43,436
Russia	3,153	-655		2,498
Sweden	8,356			8,356
Gothenburg Protocol expected reduction in non-Contracting Parties	*14,725*			*14,725*
Expected reduction from shipping	*5,735*			*5,735*
Belarus			*1,977*	*1,977*
Czech Republic			*727*	*727*
Ukraine			*526*	*526*
Sum	**98,921**	**0**	**0**	**98,921**
Gulf of Finland				
Denmark	42			42
Estonia	1,419			1,419
Finland	2,004	599		2,603
Germany	165			165
Latvia	23			23
Lithuania	33			33
Poland	147			147
Russia	8,478	-599		7,879
Sweden	63			63
Gothenburg Protocol expected reduction in non-Contracting Parties	*1486*			*1486*
Expected reduction from shipping	*592*			*592*
Sum	**14,452**	**0**		**14,452**

Kattegat				
Denmark	708			708
Estonia	0			0
Finland	2			2
Germany	79			79
Latvia	1			1
Lithuania	1			1
Poland	27			27
Russia	4			4
Sweden	826			826
Gothenburg Protocol expected reduction in non-Contracting Parties	*2,511*			*2,511*
Expected reduction from shipping	*602*			*602*
Sum	**4,761**			**4,761**

Table 6. Proposed country by basin allocation of phosphorus reductions CART (tonnes).

PHOSPHORUS	**Country by basin reduction before deducting transboundary shares**	**Transboundary shares**		**CART**
		HELCOM countries	**non-HELCOM countries**	
Baltic Proper				
Denmark	38			38
Estonia	15			15
Finland	0			0
Germany	111	64		175
Latvia	171	-42		129
Lithuania	1,671	42	-272	1,441
Poland	7,810	64	-397	7,477
Russia	609	-128		481
Sweden	535			535
Belarus			*424*	*424*
Czech Republic			*187*	*187*
Ukraine			*58*	*58*
Sum	**10,960**	**0**	**0**	**10,960**
Gulf of Finland				
Denmark				
Estonia	268			268
Finland	338	26		364
Germany				
Latvia				
Lithuania				
Poland				
Russia	3,303	-26		3,277
Sweden				
Sum	**3,909**	**0**	**0**	**3,909**
Gulf of Riga				
Denmark				
Estonia	38			38
Finland				
Germany				
Latvia	270	-56	-128	86
Lithuania		26		26
Poland				
Russia		30		30
Sweden				
Belarus			*128*	*128*
Sum	**308**	**0**	**0**	**308**

4.5 Indication of reduction requirements on an air- and a waterborne part

The airborne and a waterborne part of CART can be illustrated using the proportion of airborne to waterborne inputs during the reference period, and adding/subtracting the share of waterborne transboundary inputs on the waterborne part. The results are shown in Table 4.4. As all atmospheric deposition of phosphorus is included as a part of the background inputs there are no reduction requirements on the airborne phosphorus inputs for the HELCOM countries.

Table 7. Illustration of HELCOM Contracting Parties nitrogen reductions requirements split into atmospheric and waterborne parts for sub-basins.

Country/basin, tonnes	BAP		GUF		KAT		Total	
	air	water	air	water	air	water	air	water
Denmark	1,740	396	42	0	133	575	1,915	971
Estonia	141	241	76	1,343	0	0	217	1,584
Finland	424	0	111	2,492	2	0	537	2,492
Germany	5,466	1,953	165	0	79	0	5,710	1,953
Latvia	206	1,439	23	0	1	0	230	1,439
Lithuania	507	8,428	33	0	1	0	541	8,428
Poland	4,179	39,257	147	0	27	0	4,353	39,257
Russia	825	1,673	196	7,683	4	0	1,025	9,356
Sweden	1,683	6,673	63	0	22	804	1,768	7,477
Baltic Sea total	15,171	60,060	856	11,518	269	1,379	16,296	72,957

5. PROGRESS

The trend and development in waterborne input from 1994 to 2010 and from the reference period to 2008-2010 is tested and reported in HELCOM PLC-5.5 extended summary report (in press). From 1995 to 2010 there have been significant reductions of approximately 16% on total airborne and waterborne nitrogen inputs to the Baltic Sea and approximately 18% of the total phosphorus inputs, with some countries having even higher significant reductions (up to 35% for nitrogen and 29% for phosphorus), but with one or two countries having significant increases in nutrient inputs.

For sub-basins with reduction requirements according to table 9.1 (cf. Annex), there have been reductions in total nitrogen and phosphorus inputs (except for the Gulf or Riga) since the reference period to 2008-2010 (Figure 7). For Kattegat, the reduction in nitrogen inputs is about 3 times higher than the reduction requirement. For the Baltic Proper and the Gulf of Finland in 2008-2010 more than one third of the needed reduction requirement has been obtained by 2008-2010, while for phosphorus the input reduction has been about 22-25% of the required reduction. To the Gulf of Riga it seems as phosphorus inputs have increased since the reference period.

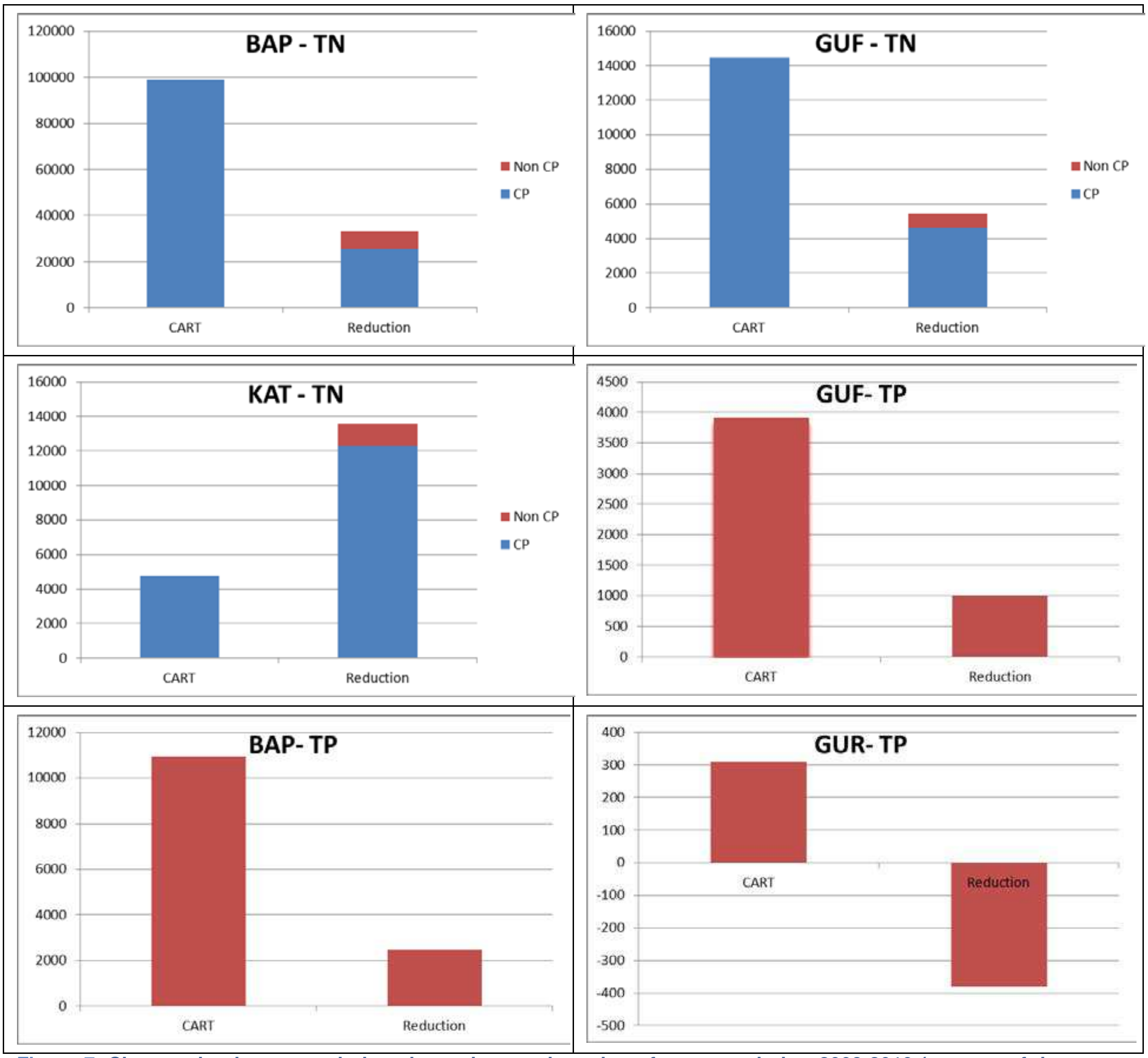


Figure 7. **Changes in nitrogen and phosphorus inputs since the reference period to 2008-2010 (average of three year normalized inputs) for sub-basins with reduction requirements. Phosphorus inputs to Gulf of Riga have increased with nearly 400 tonnes. Reduction from non-Contracting Parties is related to reduced atmospheric deposition.**

6. Perspectives

6.1 Response in the Baltic Sea to the nutrient input reductions

It is a generally accepted scientific fact that it will take substantial time to restore the Baltic Sea from the long period of large anthropogenic pressure it has been under. Exactly predicting the path of recovery is more challenging than estimating the ultimate state because of the many non-linear processes involved in the biogeochemical cycles. However, model predictions of time-scales give reasonable account for the time-scales involved and inter-comparisons show that in this respect BALTSEM provides a rather conservative estimate compared to other models.

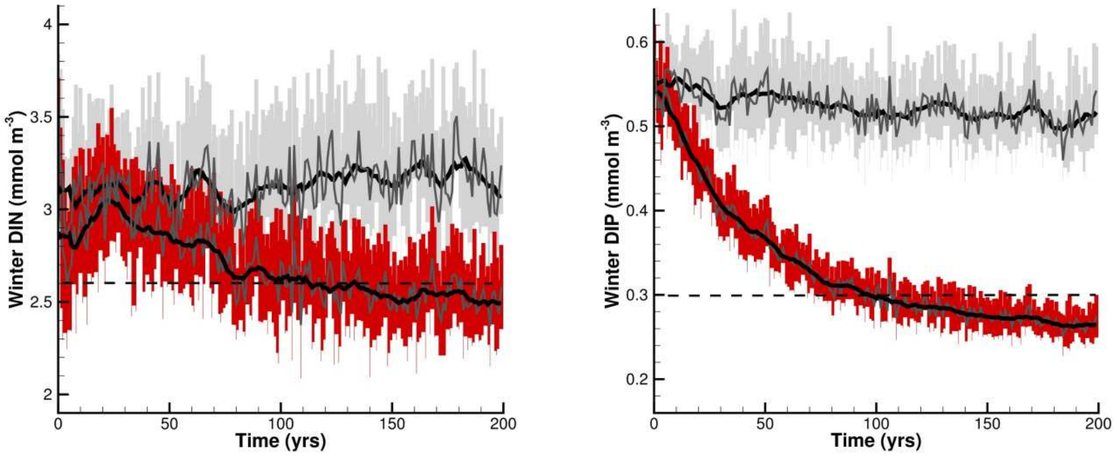


Figure 8. Time development of inorganic winter nutrient concentrations in the Baltic proper surface waters. The grey bars with associated curves represent the case with inputs as in the reference period (1997-2003) during the whole scenario, and the red represents inputs reduced to MAI by year 0. The thick lines are 11-years running average, thin lines average of 10 realizations using different weather forcing and the grey and red bars indicate the range of natural variability. The dotted line is the target.

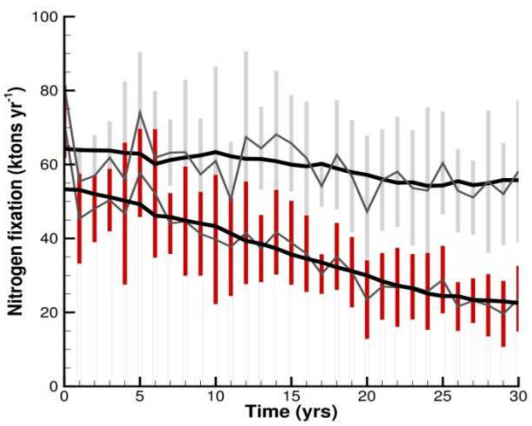


Figure 9. Time development of nitrogen fixation in the Gulf of Finland. The grey bars with associated curves represents the case with inputs during all 30 years as in the reference period and the red represents inputs reduced to MAI by year 0. The thick lines are 11-years running average, thin lines average of 10 realizations using different weather forcing and the grey and red bars indicate the range of natural variability.

After implementation of full input reductions, it may take a long time before the Baltic Sea reaches an equilibrium with the new inputs, which is clearly seen, for example, in surface winter nutrient concentrations in the Baltic Proper (Figure 8). The intricate dynamics of nitrogen makes the path of winter DIN reduction somewhat bumpy, contrary to the steady reduction of winter DIP**. But it is very important to notice that significant improvements will be seen much more rapidly. For example, as shown in** Figure 9**, already the first year after the implementation**, nitrogen fixation in the Gulf of Finland will decrease with almost 20% and a decade after implementation the higher end of natural variability in nitrogen fixation, indicating risk of cyanobacteria blooms, will be below present day average. Thus, we could quite soon anticipate seeing less summer blooms.

6.2 Validity of the results of the revised BSAP nutrient reduction scheme figures

<u>PLC-5.5 data set</u>

The used PLC-5.5 data set of airborne and waterborne nutrient inputs to the Baltic Sea is the most complete and consistent pollution input data set established so far within HELCOM.

The highest uncertainty of nutrient input data seems to apply to the Gulf of Finland and the Gulf of Riga, but overall it is evaluated that the PLC-5.5 dataset gives rather robust results, and further corrections on the data set would not give markedly different MAI and CART. However, especially for phosphorus, it is possible that inputs from some big point sources are not quantified at all, which would underestimate the reduction requirement and the share of the reductions in the countries where these point sources are situated.

Why not consider economy before MAI and CART are settled

The vision of HELCOM is to have a healthy sea. Eutrophication targets and nutrient reduction schemes have been developed with natural science models, in order to calculate optimized necessary nutrient reductions to the individual sub-basins needed to fulfill eutrophication targets from an ecological viewpoint.

Economic cost-benefit models are relevant when evaluating and selecting among the palette of nutrient reduction measures that could be identified, and where the most cost efficient measures can be taken and implemented. Further, economical cost-benefit models are not developed to determine the ecological optimal solutions for the Baltic Sea.

Uncertainty of the MAI and CART figures

The uncertainty of eutrophication status targets was not explicitly assessed by the TARGREV project, however, targets have been ranked into groups according to their confidence.

It is straightforward but laborious to explore how MAI varies with changes in target values from the pressure-response relationships. The laborious aspect arises from the numerous combinations of uncertainty that can arise if many indicator values and basins are simultaneously taken into account. However, the impression is that the most challenging target for most basins is nitrogen, as in most cases there are no, or only few, trustworthy measurements to indicate the eutrophication situation in the early levels. Also, the relationship between nitrogen input and concentrations in sea waters is rather weak in basins featuring hypoxia, i.e., the Baltic Proper and the Gulf of Finland unless phosphorus input reductions are so large that a strong phosphorus limitation occur.

In the calculation of MAI, it has been attempted to take biases in BALTSEM into account, either by discarding indicators in basins were they are not adequately modelled, but also to raise a concern whether MAI is really trustworthy because of model deficiency/bias. An especially intricate example, still under investigation, is the Danish Straits.

NB: both MAI and CART calculations are affected by the input data to the model. If input data are inconsistent, it may lead both to over- or underestimation of MAI and CART, and thus to an unfair distribution of reduction requirement between countries.

The highest uncertainty regarding input data is in the calculation of the proportion of transboundary waterborne input data entering the Baltic Sea, because there is a need to take into account retention in surface waters in the countries receiving the transboundary input. Despite much work done to model and estimate retention, these should still be seen as rather rough averages for big catchments.

Finally it should be stressed that the calculated MAI are the minimum reduction requirement to fulfill the eutrophication targets. They are derived for Baltic Sea open sea areas and they are therefore not directly comparable with reduction targets derived for fulfilling targets in coastal waters.

Implications of climate change on MAI, CART and needed measures

Recent findings indicate that climate change may reinforce effects from eutrophication and thus increase the risk of not reaching the environmental targets. However, it is also clearly shown that without curbing inputs the situation will deteriorate even further. In this perspective, reducing nutrient inputs could be seen also as a precautionary measure against the negative effects from climate change.

At present, scientific knowledge and tools are not in place to make a proper assessment of MAI under the constraints of climate change. There is also another more fundamental problem with addressing climate change and targets because climate change is inherently a time-dependent process whereas the target definition is static. Thus, one needs either to set a time-fixed goal (*sensu* the 2 degree by 2100 target for climate change) or make some sort of adaptation with climate change so that one stays within targets despite changing conditions. However, at present, the best foreseeable way to handle climate change issues is to initiate a cyclical revision of MAI.

7. References

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8. DEFINITIONS/GLOSSARY

Airborne	Nutrients carried or distributed by air.
Anthropogenic	Caused by human activities.
Atmospheric deposition	Airborne nutrients or other chemical substances originating from emissions to the air and deposited from the air on the surface (land and water surfaces).
Border river	A river that has its outlet to the Baltic Sea at the border between two countries. For these rivers, the inputs to the Baltic Sea are divided between the countries in relation to each country's share of total input.
BSAP	Baltic Sea Action Plan.
Catchment area	The area of land bounded by watersheds draining into a body of water (river, basin, reservoir, sea).
Contracting parties	Signatories of the Helsinki Convention (Denmark, Estonia, European Commission, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden).
Country-Allocated Reduction Targets (CART)	Country-wise requirements to reduce waterborne and airborne nutrient inputs (in tonnes per year) to reach the maximum allowable nutrient input levels in accordance to the Baltic Sea Action Plan.
Diffuse sources	Sources without distinct points of emission e.g. agricultural and forest land, natural background sources, scattered dwellings, atmospheric deposition (mainly in rural areas)
DIN and DIP	Dissolved inorganic nitrogen and dissolved inorganic phosphorus compounds.
Direct Sources	Point sources discharging directly to coastal or transitional waters.
Eutrophication	Condition in an aquatic ecosystem where increased nutrient concentrations stimulate excessive primary production, which leads to an imbalanced function of the ecosystem.
Flow normalization	A statistical method that adjusts a data time series by removing the influence of variations imposed by river flow, e.g. to facilitate assessment of development in e.g. nitrogen or phosphorus inputs.
HOLAS open sea sub-basins	Open sea areas not affected by coastal dynamics. Bothnian Bay, Bothnian Sea, Åland and Archipelago Sea, Northern Baltic Proper, Gulf of Finland, Western Gotland Basin, Eastern Gotland Basin, Gulf of Riga, Gulf of Gdansk, Bornholm Basin, Arkona Basin, Kiel and Mecklenburg Bight, Belt Sea, Kattegat
Input ceiling	The allowable amount of nitrogen and phosphorus input per country and sub-basin. It is calculated by subtracting the CART from the input of nitrogen and phosphorus during the reference period of the BSAP (1997-2003).
Maximum Allowable Input (MAI)	The maximum annual amount of a substance that a Baltic Sea sub-basin may receive and still fulfill HELCOM's ecological objectives for a Baltic Sea unaffected by eutrophication.
Monitored areas	The catchment area upstream the river monitored point. The chemical monitoring decides the monitored area in cases where the locations of chemical and hydrological monitoring stations do not coincide.
Monitoring stations	Stations where hydrographic and/or chemical parameters are monitored.
Non-contracting parties	Countries that are not partners to the Helsinki Convention 1992, but that have an indirect effect on the Baltic Sea by contributing with inputs of nutrients or other substances via water and/or air.
PLC	Baltic Sea Pollution Load Compilation
Point sources	Municipalities, industries and fish farms that discharge (defined by location of the outlet) into monitored areas, unmonitored areas or directly to the sea (coastal or transitional waters).
Reference period	1997-2003
Reference input	The average normalized water + airborne input of nitrogen and phosphorus during 1997-2003 used to calculate CART and input ceilings.
Retention	The amount of a substance lost/retained during transport in soil and/or water including groundwater from the source to a recipient water body. Often retention is only related to inland surface waters in these guidelines.
Riverine inputs	The amount of a substance carried to the maritime area by a watercourse (natural or man-made) per unit of time.
Statistically significant	In statistics, a result is called "statistically significant" if it is unlikely to have occurred by chance. The degree of significance is expressed by the probability, P. $P< 0.05$ means that the probability for a result to occur by chance is less than 5%.
Sub-basins	Subdivision units of the Baltic Sea. Kattegat (KAT), Belt Sea (BES), Western Baltic (WEB), Baltic Proper (BAP), Gulf of Riga (GUR), Gulf of Finland (GUF), Archipelago Sea (ARC) Bothnian Sea (BOS) and Bothnian Bay (BOB).
Transboundary input	Transport of an amount of a substance (via air or water) across a country border.
TN and TP	Total nitrogen and total phosphorus which includes all fractions of nitrogen and phosphorus.
Unmonitored area	Any sub-catchment(s) located downstream of the (riverine) chemical monitoring point within the catchment and further all unmonitored catchments. It includes also the coastal areas, which have been used in former version of the guidelines.
Waterborne	Substances carried or distributed by water.

9. Technical Annex

The Technical Annex contains data tables used in calculation of Maximum Allowable Inputs and Country Allocated Reduction Targets.

Table 9.1. Needed reductions for total nitrogen (TN) and total phosphorus (TP) in individual sub-basins of the Baltic Sea in comparison to Maximum Allowable Inputs and nitrogen and phosphorous inputs in the reference period (1997-2003).

Baltic Sea Sub-basin	Maximum Allowable Inputs		Reference inputs		Needed reductions	
	TN tonnes	TP tonnes	TN tonnes	TP tonnes	TN tonnes	TP tonnes
Kattegat	74,000	1,687	78,761	1,687	4,761	0
Danish Straits*	65,998	1,601	65,998	1,601	0	0
Baltic Proper	325,000	7,360	423,921	18,320	98,921	10,960
Bothnian Sea*	79,372	2,773	79,372	2,773	0	0
Bothnian Bay*	57,622	2,675	57,622	2,675	0	0
Gulf of Riga	88,417	2,020	88,417	2,328	0	308
Gulf of Finland	101,800	3,600	116,252	7,509	14,452	3,909
Baltic Sea	792,209	21,716	910,343	36,893	118,134	15,177

*See the text in the Ministerial Declaration concerning need for addition actions to reduce nutrients also in basins without reduction targets.

Table 9.2. HELCOM targets for nutrients (in µmol l^{-1}), summer chlorophyll a (in µg l^{-1}) and summer Secchi depth (m) for the Baltic Sea HOLAS open sea sub-basins. Winter means are December-February and summer means are June-September.

Basin	Winter DIN	Winter DIP	Summer Chl *a*	Summer Secchi depth)
Kattegat	5.0	0.49	1.5	7.6
The Sound	3.3	0.42	1.2	8.2
Great Belt	5.0	0.59	1.7	8.5
Little Belt	7.1	0.71	2.8	7.3
Kiel Bay	5.5	0.57	2.0	7.4
Bay of Mecklenburg	4.3	0.49	1.8	7.1
Gdansk Basin	4.2	0.36	2.2	6.5
Arkona Sea	2.9	0.36	1.8	7.2
Bornholm Sea	2.5	0.30	1.8	7.1
Eastern Gotland Basin	2.6	0.29	1.9	7.6
Western Gotland Basin	2.0	0.33	1.2	8.4
Northern Baltic Proper	2.9	0.25	1.7	7.1
Gulf of Riga	5.2	0.41	2.7	5.0
Gulf of Finland	3.8	0.59	2.0	5.5
Åland Sea	2.7	0.21	1.5	6.9
Bothnian Sea	2.8	0.19	1.5	6.8
The Quark	3.7	0.10	2.0	6.0
Bothnian Bay	5.2	0.07	2.0	5.8

In addition to the eutrophication targets listed in table 2.1 oxygen debt targets have been agreed:

- Gotland Sea and Gulf of Finland: 8.66 mg l^{-1}
- Bornholm Basin: 6.37 mg l^{-1}
- and on oxygen concentration >2 mg l^{-1} in Danish Straits and Kattegat

Table 9.3. HELCOM eutrophication status targets for 18 HELCOM open sea areas (Table 9.2) were aggregated into seven-basins that MAI are calculated on by an area-weighted average for all variables. Winter means are December-February and summer means are June-September.

Basin	Winter DIN (µmol l^{-1})	Winter DIP (µmol l^{-1})	Summer Chl *a* (µg l^{-1})	Summer Secchi (m)
Kattegat	5.0	0.49	1.5	7.6
Danish Straits	5.0	0.56	1.9	7.8
Baltic Proper	2.6	0.30	1.7	7.4
Bothnian Sea	2.8	0.19	1.5	6.8
Bothnian Bay	5.2	0.07	2.0	5.8
Gulf of Riga	5.2	0.41	2.7	5.0
Gulf of Finland	3.8	0.59	2.0	5.5

Table 9.4. Waterborne reference inputs (tonnes) used in BSAP 2007 and the new waterborne and airborne reference inputs used for calculating the new nutrient reduction requirements to the Baltic Sea (in BSAP 2007 reference atmospheric input was approx. 280,000 tonnes nitrogen and 6,300 tonnes phosphorus).

Basins/ inputs in tonnes	BSAP 2007 waterborne reference inputs		New reference waterborne inputs		New reference airborne inputs	
	Total N	Total P	Total N	Total P	Total N	Total P
Kattegat	64,257	1,573	58,484	1,569	20,277	118
Danish Straits	45,893	1,409	41,605	1,496	24,393	105
Baltic Proper	327,259	19,246	297,679	17,274	126,243	1,046
Bothnian Sea	56,786	2,457	54,605	2,379	24,767	394
Bothnian Bay	51,436	2,585	49,437	2,494	8,185	181
Gulf of Riga	78,404	2,180	78,373	2,235	10,045	93
Gulf of Finland	112,680	6,860	102,919	7,359	13,333	150
Baltic Sea total	**736,714**	**36,310**	**683,102**	**34,807**	**227,242**	**2,087**

In Table 9.5, atmospheric input from the Contracting Parties included in the total inputs to the sub-basins, while nitrogen deposition from non-Contracting Parties (in total 85,500 tonnes nitrogen) and shipping on the Baltic Sea (in total nearly 11,900 tonnes nitrogen) to the main sub-basin is shown separately. In Table 9.7 the normalized deposition of atmospheric nitrogen deposition in the reference period is shown. Phosphorus deposition on the Baltic Sea (ca. 2,100 tonnes phosphorus) cannot be allocated to any country and is therefore given in a separate row in Table 9.6.

Table 9.5. Total country by basin normalized nitrogen inputs to the Baltic Sea during the reference period 1997-2003. "Baltic Shipping" is shipping within Baltic Sea, "EU 20 atm" is atmospheric deposition from non Contracting Parties EU countries (including Croatia) and "other countries" are deposition from other non-Contracting Parties and other sources on the Baltic Sea sub-basins.

Country/Basin	BOB	BOS	BAP	GUF	GUR	DS	KAT	Total
Denmark	226	854	10,046	376	374	28,587	30,027	70,490
Estonneia	93	299	1,795	12,683	12,777	17	20	27,684
Finland	34,389	27,978	1,993	17,903	250	60	79	82,652
Germany	801	2,994	32,554	1,477	1,437	20,708	3,364	63,335
Latvia	62	258	11,100	206	66,284	23	26	77,959
Lithuania	108	464	44,920	294	437	51	61	46,335
Poland	631	2,647	212,486	1,313	1,335	1,061	1,133	220,606
Russia	696	1,465	14,831	75,754	510	164	178	93,598
Sweden	17,571	31,502	39,299	565	440	5,870	35,032	130,279
Other atm. sources	1,090	3,793	15,278	2,166	1,572	1,958	2,152	28,009
Baltic Shipping	361	1,461	7,169	739	561	826	751	11,868
EU 20 atm.	1,595	5,658	32,449	2,775	2,441	6,673	5,938	57,528
Baltic Sea	57,622	79,372	423,921	116,252	88,417	65,998	78,761	910,343

Table 9.6. Total country by basin normalized phosphorus inputs to the Baltic Sea during the reference period 1997-2003. “Atm. Dep” is atmospheric deposition of phosphorus on the Baltic Sea.

Country/Basin	BOB	BOS	BAP	GUF	GUR	DS	KAT	Total
Denmark	0	0	59	0	0	1,040	829	1,928
Estonia	0	0	23	504	277	0	0	804
Finland	1,668	1,255	0	637	0	0	0	3,560
Germany	0	0	175	0	0	351	0	526
Latvia	0	0	269	0	1,958	0	0	2,227
Lithuania	0	0	2,635	0	0	0	0	2,635
Poland	0	0	12,310	0	0	0	0	12,310
Russia	0	0	960	6,218	0	0	0	7,178
Sweden	826	1,125	843	0	0	105	740	3,639
Atm. dep.	181	394	1,046	150	93	105	118	2,087
Baltic Sea	2,675	2,773	18,320	7,509	2,328	1,601	1,687	36,893

Table 9.7. Total country by basin normalized atmospheric nitrogen deposition during the reference period 1997-2003. “Baltic Shipping” is shipping within Baltic Sea, “EU 20 atm” is atmospheric deposition from non HELCOM Contracting Parties EU countries (including Croatia) and “other countries” are deposition from other non-Contracting Parties on the Baltic Sea sub-basins.

Country/Basin	BOB	BOS	BAP	GUF	GUR	DS	KAT	Total
Denmark	226	854	8,182	376	374	5,311	5,635	20,958
Estonia	93	299	661	680	247	17	20	2,017
Finland	1,764	2,337	1,993	994	250	60	79	7,476
Germany	801	2,994	25,708	1 477	1 437	7,865	3,364	43,646
Latvia	62	258	967	206	441	23	26	1,983
Lithuania	108	464	2,384	294	437	51	61	3,799
Poland	631	2,647	19,655	1 313	1 335	1,061	1,133	27,774
Russia	696	1,465	3,881	1 748	510	164	178	8,642
Sweden	758	2,537	7,916	565	440	384	941	13,541
Other countries	1,090	3,793	15,278	2,166	1,572	1,958	2,152	28,009
Shipping	361	1,461	7,169	739	561	826	751	11,868
EU 20 atm.	1,595	5,658	32,449	2,775	2,441	6,673	5,938	57,528
Baltic Sea	8,185	24,767	126,243	13,333	10,045	24,393	20,277	227,243

Table 9.8. Transboundary riverine inputs (in tonnes yr^{-1}) from HELCOM countries and non-Contracting Parties used in the CART calculations. Retention coefficient is from table 9.4 in Gustafsson and Mörth (in prep). All data are averaged 1997-2003 except for the Belarusian data which are averaged 2004-2011. Input at the border is multiplied with the retention coefficient to estimated net waterborne input to the Baltic Sea. “Share of inputs” is - expressed in percentage - how big proportion of the total input at the river mouth originates from the non-contracting Party.

From	Via	To	Border		Retention		To Baltic		Share of input	
			TN tonnes	TP tonnes	TN	TP	TN tonnes	TP tonnes	TN (%)	TP (%)
From non-Contracting Parties:										
Czech	Poland	BAP	5,700	410	0.4	0.28	3,420	295	1.1	1.7
Belarus	Lithuania	BAP	13,600	914	0.54	0.53	6,256	430	2.1	2.5
Ukraine	Poland	BAP	4,124	127	0.4	0.28	2,474	91	0.8	0.5
Belarus	Poland	BAP	5,071	331	0.4	0.28	3,043	238	1.0	1.4
Total		**BAP**					**15,193**	**1,055**	**5.1**	**6.1**
Belarus	Latvia	GUR	8,532	1,360	0.27	0.32	**6,228**	**925**	**7.9**	**41.4**
Between Contracting Parties										
Lithuania	Latvia	BAP	5,516	158	0.39	0.58	3,365	66	1.1	0.4
Poland	Russia	BAP	4,400	320	0.30	0.37	3,080	202	1.0	1.2
Germany	Poland	BAP					2.337	101	0.8	0.6
Total		**BAP**					**8,782**	**369**	**3.0**	**2.1**
Lithuania	Latvia	GUR	7,185	282	0,27	0,32	5,245	192	6.7	8.6
Russia	Latvia	GUR	4,256	734	0,54	0,71	1,957	215	2.5	9.6
Total		**GUR**					**7,202**	**407**	**9.2**	**18.2**
Finland	Russia	GUF			0.48	0.82	5,353	49	5.2	0.7