APPROACH FOR SETTING COUNTRY-WISE ALLOCATIONS OF NUTRIENT REDUCTION TARGETS IN THE 2007 HELCOM BALTIC SEA ACTION PLAN

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The Expert Meeting for the Eutrophication Segment under the HELCOM Baltic Sea Action Plan (HELCOM BSAP EUTRO EXP/2007) considered the approach to set sub-basin and country-wise nutrient reduction allocations to reach good ecological status of the Baltic Sea presented by Professor Fredrik Wulff, BNI and agreed that document 3.1/3 presented at the meeting provides a good ecosystem based approach for the calculation of needed reductions of nutrient inputs by sub region and by country to reach the targets for eutrophication.

This document contains an updated background report for the eutrophication segment of the HELCOM Baltic Sea Action Plan, including the allocation of transboundary pollution from upstream countries such as Belarus to a common pool to be addressed by joint initiatives. These recalculations have reduced the reduction requirement figures for the downstream countries.

The document seeks to describe the approach to reduce nutrient loads that both results in a good ecological status of the marine environment in the Baltic Sea as a whole and in its sub-basins and is fair and acceptable to all HELCOM contracting parties. The approach takes into account water protection measures that have already been taken by the countries and allows flexibility in terms of future measures to be taken to reach the reduction targets.

The approach is based on HELCOM's ecological objectives and takes into account the complex interactions that control the Baltic Sea ecosystem. It implements the Ecosystem Approach and the Baltic NEST model was used to calculate the nutrient load reductions needed to the reach targets for Secchi depths.

Needed nutrient reductions in total and by sub-region

Chapter 2 describes the calculation how to define the needed nutrient reductions to the Baltic Sea in total and by sub-region in order to reach good environmental status.

Successive model runs were carried out reducing P and N loads to the different Baltic Sea sub basins until an agreement with the environmental targets were reached. First, the loads to the Baltic proper were reduced, then to the Gulf of Finland and the Gulf Riga and finally to the Danish straits. No reductions were needed to the Bothnian Bay and Bothnian Sea since the targets were already reached by reduced advective northward flows of nutrients when the targets were met in the Baltic proper.

	Load 97-03		Needed reduction		Maximum allowable inputs	
	N	P	N	P	N	P
BB	51,436	2,585	0	0	51,436	2,585
BS	56,786	2,457	0	0	56,786	2,457
BP	327,259	19,246	94,000	12,500	233,259	6,746
GF	112,680	6,860	6,000	2,000	106,680	4,860
GR	78,404	2,180	0	750	78,403	1,430
DS	45,893	1,409	15,000	0	30,893	1,409
KT	64,257	1,573	20,000	0	44,257	1,573
SUM	736,714	36,310	135,000	15,250	601,713	21,060

Loads of total nitrogen and phosphorus (tons year^{-1}) to the Baltic Sea sub-basins (riverine and coastal point sources), averaged for 1997-2003 (from official data reported to HELCOM) and the reductions needed to reach the environmental targets as well as maximum allowable inputs.

Allocation of load reductions to countries

The document proposes to use a two-step approach, where the starting point is the needed reduction to reach good marine environment in each sub-basin described in chapter 2.

1) The quantity of load reductions achievable by improved sewage treatment from 2004 levels up to the existing HELCOM Recommendation/EU UWWT Directive levels by each contracting party is calculated. (nitrogen reduction to 70% and phosphorus to 80% for cities above 10,000 inhabitants. For cities below 10,000 and 2,000 inhabitants it is assumed that secondary treatment levels are applied, i.e. 35% for nitrogen and 35% for phosphorus).
2) In the second step, the remaining load reduction, after improved sewage treatment has been implemented, is allocated among the sub-basin HELCOM Contracting States according to their proportion of the present load to that sub-basin (subtracted with the improvement of sewage treatment).

The proposed approach considers both the actual wastewater treatment levels in 2004 of the coastal countries as well as possible and potential measures to further reduce loads. This approach leaves the countries with a flexibility to choose their preferred water protection measures.

The approach also takes into account measures already implemented and going beyond the HELCOM Recommendations' levels and it gives countries credit for them. At the same time this allocation approach is based on a simplistic approach that can be easily verified.

Other approaches considered for allocating the necessary nutrient reductions to the HELCOM countries are presented in Annex 1.

	Loads in sub basins with a reduction need (97-03)		Country reduction allocations	
	Phosphorus	Nitrogen	Phosphorus	Nitrogen
Germany	534	20,848	242	5,621
Denmark	51	57,501	16	17,207
Estonia	1,261	19,054	222	896
Finland	578	15,852	146	1,199
Lithuania	1,336	45,109	881	11,746
Latvia	1,613	10,447	300	2,561
Russia	6,683	89,386	2,500	6,967
Poland	13,717	215,350	8,755	62,395
Sweden	860	72,762	291	20,780
Common pool (Belarus)	1,662	3,779	1,662	3,779
Total	**28,293**	**550,088**	**15,014**	**133,152**

Total land based loads, averaged for 1997-2003 reported to by the countries to HELCOM and the allocated reductions for each country. Loads to sub basins where no reduction is needed are excluded here (see Table1). The common pool corresponds to the WWT load reductions from Belarus.

Transboundary and atmospheric loads

The Expert Meeting agreed that the contributions from transboundary loads from the upstream countries (non-Contracting Parties) should be calculated in a similar manner as for HELCOM Contracting States and a common pool should be established where the transboundary loads would be allocated. The Meeting agreed that reduction needs allocated to the common pool should be reached by initiating joint activities in the upstream countries e.g. by utilising EU neighbourhood policy and funding.

The updated document takes into account UWWT transboundary loads. For instance, the total needed P load reduction to the Baltic proper is 12,500 tons (Table 1) of a total load of 19,246 during 97-03. Improved municipal wastewater treatment will reduce this load with 4,418 tons (Table 5) and the remaining load reduction is then 8,082 tons (Table 7). The load via the Neman River enters the sea via Lithuania but almost 50% of the drainage basin lies in Belarus. Therefore the 1,206 tons reduced load of P, achieved with improved WWT in Belarus, is subtracted from the load of Lithuania and assigned to Belarus. Likewise, calculations have been made for the Gulf of Riga.

The document focuses on waterborne nutrient inputs. Atmospheric loads and natural background loads have been estimated to be constant.

Measures for reducing airborne nitrogen from shipping are included in the Maritime segment of the BSAP.

AN APPROACH TO SET COUNTRY-WISE NUTRIENT REDUCTION ALLOCATIONS TO REACH GOOD ECOLOGICAL STATUS OF THE BALTIC SEA[1]

1. Introduction

Eutrophication is the most acute environmental problem in the Baltic Sea to be solved by the HELCOM Baltic Sea Action Plan.

The total nutrient loads and concentrations in the sea have remained virtually on the same level during the last three decades. Effects of eutrophication, such as cyanobacterial summer blooms and extensive bottom water hypoxia are now more pronounced than ever before. Nutrient pollution does not recognize state borders and nutrient inputs from one country eventually affect the marine environment of all other countries. Reductions in nutrient loads in some regions have been countermanded by increased loads elsewhere.

The HELCOM countries decided already in 1988 to cut nutrient loads from all countries by 50% by 1995. The approach disregards ecosystem properties and does not take into account the highly different potential of different actors to reduce nutrients. The approach is neither cost-effective. This background report to the eutrophication segment of the HELCOM BSAP proposes an ecosystem approach based on up to date science.

The challenge is thus to find an approach to reduce nutrient loads that both results in a good ecological status of the marine environment and is fair and acceptable to all HELCOM contracting parties. The approach is based on HELCOM's ecological objectives and takes into account the complex interactions that control the Baltic Sea ecosystem.

The Baltic Sea consists of a series of highly interlinked sub basins, each with quite different physical, biogeochemical and ecological properties. All regions will be affected by changes in nutrient inputs and properties of one basin and this needs to be taken into account. The approach must also consider the large differences in drainage basins, both in terms of natural properties, population densities, and differences in livelihood structures and in anthropogenic nutrient runoffs. In addition, the approach should also take into account water protection measures that have already been taken by the countries and it should also be flexible enough in terms of future measures to be taken.

This report presents nutrient reductions for each sub-basin and then discusses alternative models for allocating the necessary nutrient reductions to the HELCOM countries. Finally an approach is chosen which allocates the nutrient reductions to the HELCOM countries according to their levels of wastewater treatment (WWT) and their share of years' 1997-2003 nutrient loading to the sea is recommended.

Without clear goals and responsibilities allocated to and accepted by the stakeholders, it likely that the Baltic Sea will remain severely eutrophicated.

2. Load reductions needed to reach a good ecological status of the Baltic Sea

2.1. Good ecological status of the marine environment – HELCOM's ecological objectives for eutrophication

HELCOM has decided on a set of ecological objectives for eutrophication, which reflect good marine environment:

- Concentrations of nutrients close to natural levels;
- Clear water;
- Natural level of algal blooms;
- Natural distribution and occurrence of plants and animals; and
- Natural oxygen levels

[1] Developed by Professor Fredrik Wulff, BNI together with Finland, Sweden and the HELCOM Secretariat

These objectives serve as a starting point for indicators and measurable target values. The HELCOM EUTRO project has considered various criteria that can be used for assessing eutrophication status (HELCOM 2006). Those criteria included i.e. summertime Secchi depths, summer chlorophyll *a* concentrations and winter inorganic N and P concentrations. Target levels were set as a 25 % (Secchi depth) or 50 % (nutrient and chlorophyll) deviation from reference conditions, which reflect good ecological status.

The model used in this report for calculating the needed nutrient reductions to reach these targets takes fully into account all the different eutrophication related parameters. Secchi depth, however, was chosen as the primary parameter. Secchi depth is a measure of water transparency. It reflects the ecological objective of clear water that is also conceivable by laymen. Secchi depth is also an integrative parameter since it depicts the amount of plankton algae, whose quantities depend on availability of nutrients. Furthermore, there exist actual measurements of Secchi depth from around year 1900 (Fig 1).

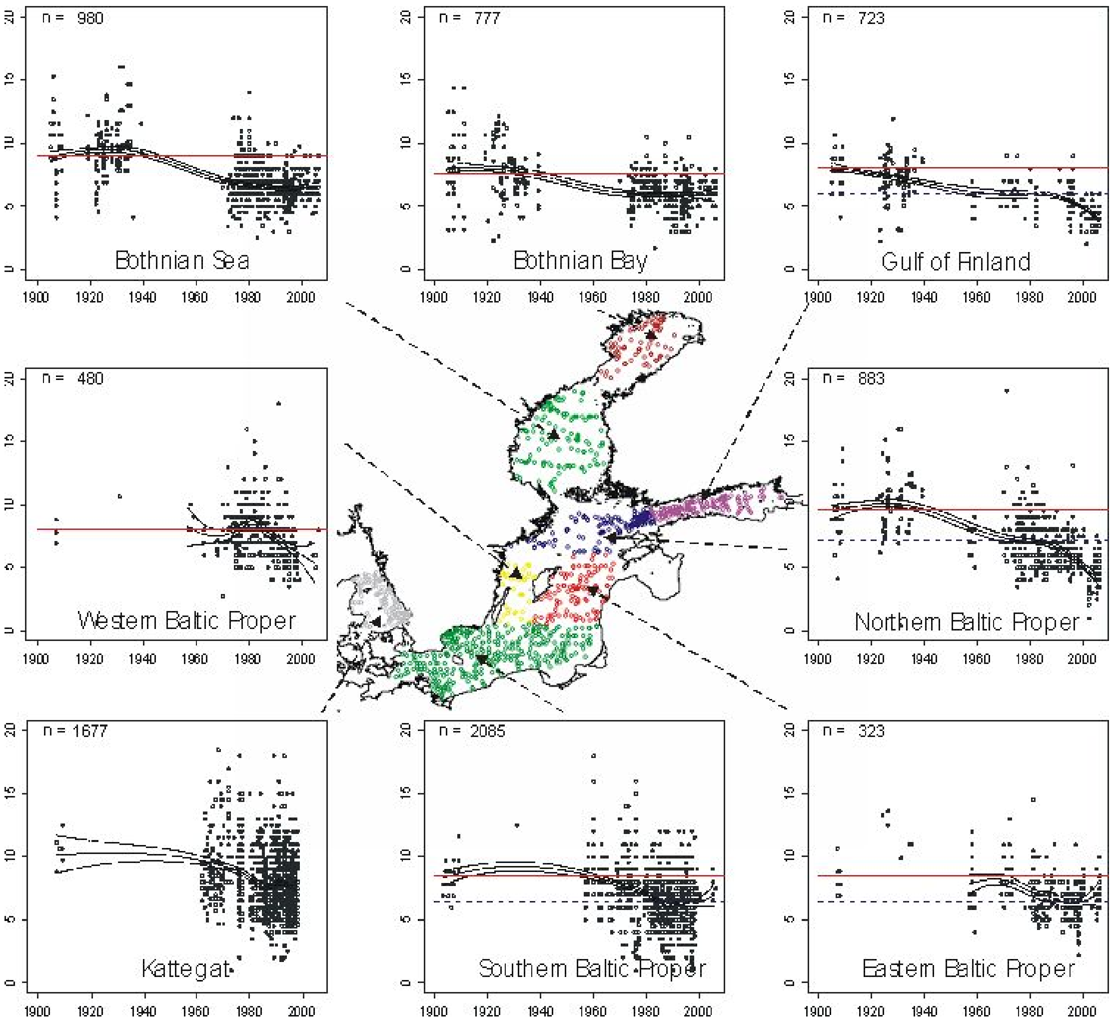

Figure 1. Water transparency in June-September measured as Secchi depth (m) between years 1903 and 2006 in the different sub-regions of the Baltic Sea. Observation sites are indicated on the map with different colors for each of the regions. Secchi depth observations (m) are plotted against the year of observation and the curves fitted with non-linear smoothing and shown with 95 % confidence intervals. The preliminary estimation of reference conditions is shown as a red line and the target value with a blue line. The number of observations (n) is shown on each figure. Vivi Fleming-Lehtinen, Maria Laamanen and Riitta Olsonen, 2006

2.2 The ecosystem approach

The Baltic Sea is a complex ecosystem with multitudes of physical, chemical and biological interactions functioning on various temporal scales. To consider the needed reductions to reach good marine environment in the open sea of the Baltic the ecosystem approach of the entire sea is necessary.

The flows of nutrients between the basins are large for both nitrogen and phosphorus demonstrating the high interdependence between all basins (Gren and Wulff 2004; Savchuk, 2005) (Fig. 2). Thus, the relationships between nutrient load and ecosystem responses cannot be understood by considering only one basin in isolation.

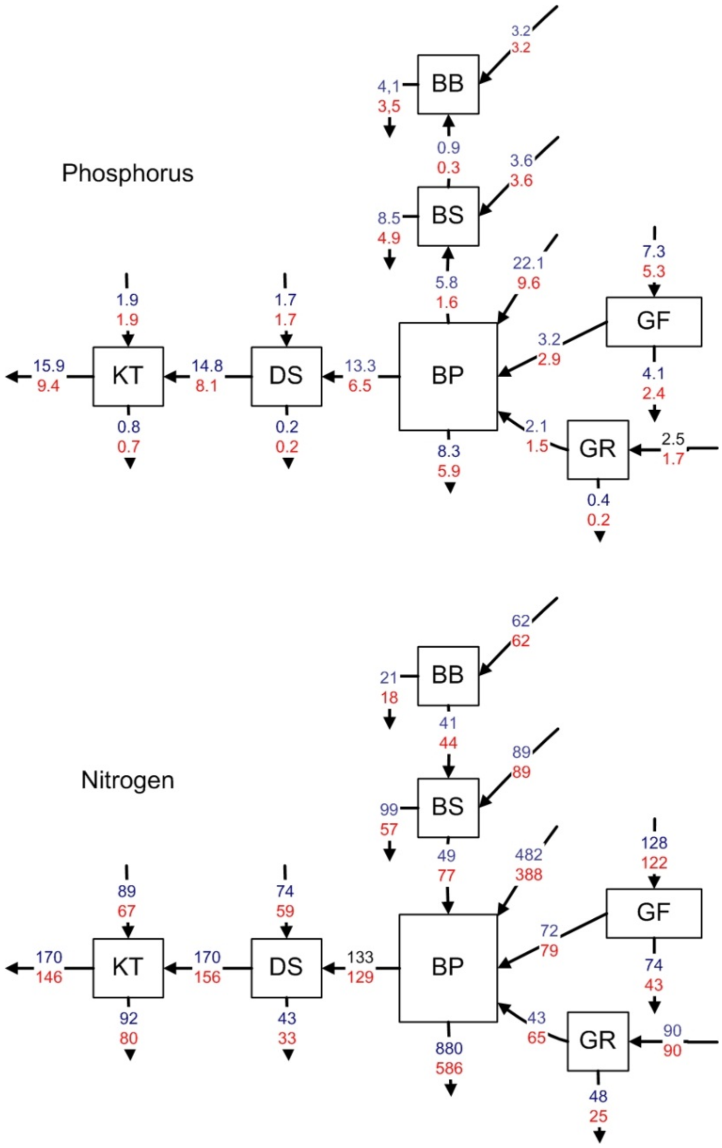

Figure 2. Budgets of total nitrogen and phosphorus of the Baltic Sea for 1997-03 (blue) and when the loads reductions needed to the reach environmental targets have been implemented (red). All numbers are in thousands of tons per year; for nitrogen rounded off to the nearest 1000 and for phosphorus to 100 tons. The arrows between boxes show net advective fluxes. The downward arrows below boxes show the internal loss terms. Inputs to the boxes show total loads, including riverine, coastal point sources and atmospheric depositions.

2.3 Load reductions needed to reach good ecological status of the marine environment

A coupled physical-biogeochemical model of the entire Baltic is used to calculate the nutrient load reductions that are needed to reach target Secchi depths in the open sea. This model is part of the Baltic Sea decision support system Nest (see Wulff et al., 2007; Savchuk & Wulff, 2007a,b). Essentially this approach has its focus on the open sea. The model cannot describe conditions in coastal lagoons and in archipelagos with a limited water exchange.

We have, in successive model runs reduced P and N loads to the different Baltic Sea sub basins until we have reached an agreement with the environmental targets, as close as possible (Tables 1 and 2). First, we reduced the loads to the Baltic proper, then to the Gulf of Finland and the Gulf Riga and finally to the Danish straits. No reductions were needed to the Bothnian Bay and Bothnian Sea since the targets were already reached by reduced advective northward flows of nutrients when the targets were met in the Baltic proper.

	Load 97-03		Needed reduction		Maximum allowable inputs	
	N	P	N	P	N	P
BB	51,436	2,585	0	0	51,436	2,585
BS	56,786	2,457	0	0	56,786	2,457
BP	327,259	19,246	94,000	12,500	233,259	6,746
GF	112,680	6,860	6,000	2,000	106,680	4,860
GR	78,404	2,180	0	750	78,403	1,430
DS	45,893	1,409	15,000	0	30,893	1,409
KT	64,257	1,573	20,000	0	44,257	1,573
SUM	736,714	36,310	135,000	15,250	601,713	21,060

Table 1. Loads of total nitrogen and phosphorus (tons $year^{-1}$) to the Baltic Sea sub-basins (riverine and coastal point sources), averaged for 1997-2003 (from official data reported to HELCOM) and the reductions needed to reach the environmental targets as well as maximum allowable inputs.

Although the Nest model is crude in terms of spatial and temporal resolutions, it encompasses all the seven major sub basins with the Baltic proper divided in the basin below and above the halocline (see Savchuk & Wulff, 2007a,b) and all the major physical and biogeochemical processes that control fluxes and concentrations of nutrients (Conley et al., 2002; Vahtera et al., 2007).

The overall reduction of 135,000 of N and 15,250 tons of P will result in a reduction in net exports to Skagerak with 24,000 tons of N and 6,600 tons of P annually, which again illustrates the importance of internal processes (Fig. 2).

These reductions have been essentially considered from the point of view of the open sea ecosystem. In the near shore or archipelago areas the reductions will have positive effects but those areas will require more detailed consideration to take into account both local or regional conditions. For example, while the off shore regions of the Bothnian Sea do not need any further nutrient reduction, the Archipelago Sea is a eutrophied sub area and in need of further nutrient reductions.

The budget calculations (Fig 2) also illustrate the high interdependencies of the sub-basins. While there is a southward flow of N from the Bothnian Bay and Sea to the Baltic Proper, there is an opposite northwards flux for P. This northwards flux is decreased considerably by the reduced load to the Baltic proper making the two northernmost basins even more P deficient with a lowered primary productivity. This will decrease the internal nitrogen losses, through denitrification and more N are exported southwards. Similar effects arise for the Gulf of Riga.

Average conditions 1997 - 2003

Basin	Tot N µmol	Tot P µmol	DIN µmol	DIP µmol	SECCHI Depth, m	Primary production g C m^{-2} yr^{-1}
BB	21.3	0.2	7.0	0.05	6.2	25
BS	18.7	0.5	3.2	0.25	6.2	124
BP	19.4	0.8	2.5	0.50	7.4	188
GF	24.5	0.8	5.6	0.52	4.6	141
GR	33.2	1.0	7.0	0.49	3.3	260
DS	20.1	0.8	3.1	0.40	7.0	216
KT	17.7	0.7	4.6	0.37	8.5	223

After nutrient reductions						
Basin	Tot N µmol	Tot P µmol	DIN µmol	DIP µmol	SECCHI Depth, m	Primary production g C m^{-2} yr^{-1}
BB	22.5	0.2	8.5	0.06	6.6	21
BS	19.5	0.4	5.4	0.21	8.0	72
BP	18.5	0.5	2.8	0.28	8.1	130
GF	24.6	0.6	7.2	0.37	5.9	81
GR	41.5	0.7	18.9	0.38	4.2	133
DS	18.9	0.6	3.2	0.25	7.7	165
KT	17.0	0.6	4.5	0.32	9.0	193

Table 2. Environmental conditions in the seven major sub basins during 1997-03 and with reduced nutrient inputs (Table 1) calculated with the Nest model. The extension of hypoxic bottoms in the Baltic proper will be reduced from 42,300 to 26,900 km^2. Nitrogen fixation, a measure of the intensity of cyanobacterial blooms, will decrease from about 360 10^3 to 113 10^3 tons yr^{-1} in the Baltic proper

Environmental benefits of the nutrient reductions of Table 1 are considerable. The differences to today's conditions are significant, no matter whether they are considered from the point of view of water transparency, primary production or nutrient concentrations (Table 2).

In this exercise, the modeled Secchi depth target values were used. However, a link to actual measurements exists even though the values derived by the NEST model (Table 2) cannot directly be compared to the targets mostly based on actual measurements as suggested by HELCOM EUTRO. This is due to the fact that the Nest model outputs are annually averaged mean basin values whereas the HELCOM EUTRO targets are summer Secchi depths and surface wintertime DIN and DIP concentrations. However, for Secchi depths there is a close correspondence between the EUTRO values that are based on *in situ* measurements and the modelled NEST values (Table 3) if the relative changes from contemporary to target conditions are used. The modelled Secchi depth target levels are also shown in Fig 1.

BASIN	EUTRO		Nest	
	Today	Target	Today	Target
BB	5.8	5.6	6.2	6.6
BS	7	6.8	6.4	8.1
BP	6.3	7	7.4	8.2

GF	4.1	6	4.6	6.0
GR	3.4	4.5	3.3	4.2
DS			7.0	7.7
KT	8.5	7.9	8.5	9.0

Table 3. A comparison between contemporary and target levels for Secchi depths (meters) produced within the HELCOM EUTRO project, based on actual measurements of summer time Secchi depths, and annual averages derived from observations and by the Nest modeling

2.4 Time delays in the effects of nutrient reductions

The actual decreases of nutrient levels after load reductions progress very slow, in the order of decades (Figure 3). With assumption that the reduced nutrient inputs take place at once, there is an initial rapid decline in the illustrated variables, total nitrogen and primary production, and after that a slower decrease. The declines in Kattegat approach a new steady state more rapidly than in the Baltic proper where the decline continues even after the first 50 years illustrated here.

The model is run until a new steady state is reached with the decreased nutrient inputs. It is these new steady state results that are shown here (Figure 3). In reality, the Baltic Sea will never reach such a steady state since the future development will experience large oscillations caused by large natural variations in both inputs and conditions in the sea caused by variations in climate.

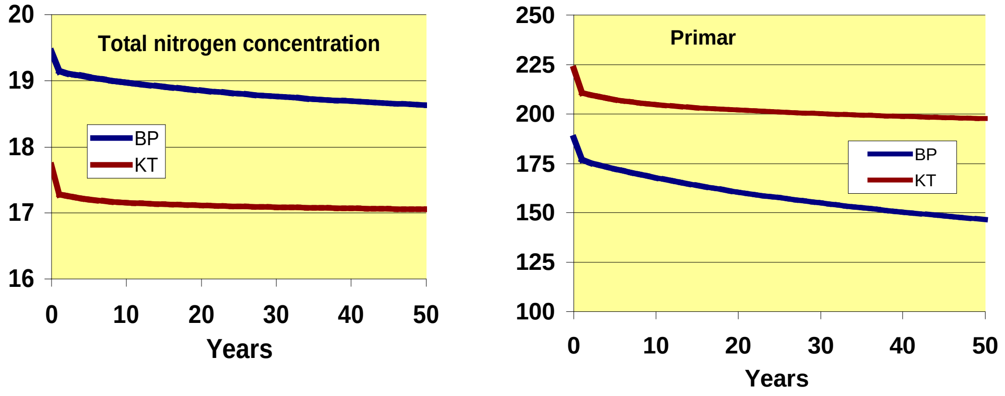

Figure 3. The declines with time of total nitrogen concentrations and primary production in the Baltic proper and Kattegat when the nutrient load reductions to the Baltic region (Table 1) have been implemented.

The differences in biogeochemical or ecological properties of the different sub-basins also influence the response time of changes in nitrogen and phosphorus loads. The combined effects of these properties are illustrated in Figure 3 for Kattegat and the Baltic proper. A more formal way to illustrate is to calculate a half-life ($t_{1/2}$) defined as the time needed to reach half way to steady state. This is 1 and 12 years for total nitrogen in Kattegat and Baltic proper respectively while $t_{1/2}$ for primary production is 5 and 24 years, respectively.

3. Allocation of load reductions to countries

The total load reductions and environmental quality obtained by these calculations all start from a situation based on actual measurements describing the situation around year 2000, or averaged of 1997-2003. Loads, based on flow normalized observations from a longer time period has been chosen rather than data from a specific year due to the large interannual variations. Likewise, when the target loads are reach must be based on a longer time series. It would have been preferable to use more resent data compiled for all countries and basins but they are not yet available, neither for nutrient loads or environmental conditions.

Several potential approaches have been tested and are presented in Annex 1, in addition to the one chosen presented below.

3.1. A two-step approach to calculate country-wise reduction allocations

We propose to use a two-step approach to set the needed reduction to reach good marine environment in each sub-basin and country.

3) The load reductions that can be achieved by improved sewage treatment from the 2004 levels compared to the EU Waste Water Directive (UWWT)/HELCOM Recommendations levels is calculated for each contracting party. It is also calculated for Belarus which encompass substantial sections of the basin and thus of transboundary loads.

4) In the second step, the remaining load reduction, after improved sewage treatment has been implemented, is allocated among the sub-basin catchment's countries based on a percentage proportional to countries’ present inputs to each sub-region (subtracted with improvement of sewage treatment and transboundary loads).

This approach considers both the actual wastewater treatment levels in 2004 of the coastal countries as well as possible and potential measures to further reduce loads. This approach leaves the countries with a flexibility to choose their preferred water protection measures. The approach also takes into account measures already implemented and going beyond the existing HELCOM Recommendations/EU UWWT directive and gives the countries credit for these. At the same time this allocation approach is based on a simplistic approach that can be easily verified.

It has been suggested to use the EU Nitrate directive as an effective regulator of agricultural nitrogen and phosphorus loads to the Baltic. This will reduce nitrogen and phosphorus emissions in some regions with intensive farming today. But the total load could increase if agriculture is shifted to and/or intensified in those large regions of agricultural land in the Baltic region that are not utilized today. These regions are today far below the limits set by the Nitrate Directive. Furthermore, intensive pig meat production is nowadays depending more on imported animal feed and not on locally produced feed and can be placed anywhere, not necessarily in an agricultural region.

The two steps of the country-wise nutrient allocations that we use here could be further improved when more data are available. The sewage treatment allocations presented here show improvements that can be obtained with additional efforts beyond the situation in 2004. For the time being there are not enough data for later years. If we had used sewage treatment levels in 1997-03, as for the previous calculations, all the improvements until 2004 would be disregarded in the allocations. Some of the sewage reduction allocations assigned to the countries below may have already been fulfilled by further measures but this has to be confirmed by actual measurements of riverine and coastal point source loads.

A diffuse load allocation, as described below in detail, sets the remaining load reductions. Alternative simplistic approaches were also evaluated and discarded for reasons explained in Annex 1 to this report.

3.1.1. Improved sewage treatment

The wastewater treatment levels, as required by EU (91/27/EEG) set nitrogen reduction to 70%-80% and phosphorus reduction to 80% for cities above 10,000 inhabitants and are comparable to the HELCOM requirements. For cities between 10,000 and 2,000 inhabitants we are assuming secondary treatment levels, i.e. 35% for nitrogen and 35% for phosphorus.

To estimate the reductions that would be achieved by applying these Recommendations in comparison to the situation in 2004, we have used the compilations by Hannerz and Destouni (2006) on total populations of each country within the Baltic Sea drainage basin and calculations on the inhabitants in cities from Brinkhoff (2007), see Table 4. We also assume that 25% of the remaining populations live in rural areas with no treatment and the remaining populations outside the large cities live in smaller villages or cities with secondary treatment. We had to use these assumptions since no detailed data are yet available.

Germany	56%
Denmark	40%
Estonia	65%
Finland	54%
Lithuania	72%
Latvia	79%
Russia	73%
Poland	51%
Sweden	61%

Table 4. The percentages of the total population in countries with a coastline to the Baltic and within the drainage basin that live in cities with more than 10,000 inhabitants.

The sewage treatment levels of the HELCOM Recommendations/EU UWWT directive result in reductions of N and P loads to the different basins compared to 2004, using the Nest drainage basin model (Mörth et al., 2007) and are shown in Table 5. We have included Belarus in these calculations. Although this country does not belong to HELCOM, almost 4 million of its inhabitants live within the Baltic Sea drainage basin. The most uncertain values in these calculations are for Russia and Belarus, where no official values on sewage treatment levels are available. We have assumed that in 2004, in both Russia and Belarus 50% of the population is connected to secondary treatment (35% P and N reduction) and in addition 25% of the population in Russia is connected to tertiary treatment (90% P and 75% N reduction).

Decreased nitrogen load											
N	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	199	0	0	0	0	0	199
BS	0	0	0	0	141	0	0	0	0	0	141
BP	3,763	0	0	0	0	642	0	235	11,486	238	16,364
GF	16	0	0	588	1,156	0	0	3,924	0	0	5,684
GR	1,304	0	0	0	0	0	16	231	0	0	1,551
DS	0	107	0	0	0	0	0	0	0	13	120
KT	0	0	0	0	0	0	0	0	0	43	43
Σ	5,083	107	0	588	1,496	642	16	4,395	11,486	295	24,102
Decreased phosphorus load											
P	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	3	0	0	0	0	0	3
BS	0	0	0	0	0	0	0	0	0	0	0
BP	1,206	0	0	0	0	327	0	75	2,810	0	4,418
GF	6	0	0	77	84	0	3	1,142	0	0	1,313
GR	450	0	0	3	0	8	64	114	0	0	640
DS	0	0	0	0	0	0	0	0	0	0	0
KT	0	0	0	0	0	0	0	0	0	0	0
Σ	1,662	0	0	80	87	336	67	1,333	2,810	0	6,373

Table 5. Reduced nutrient inputs by the different countries to Baltic Sea sub basins if the HELCOM Recommendations/EU UWWT Directive will be implemented in all countries including Belarus.

These nutrient reductions on urban wastewaters are lower than those that are actually implemented already in some countries and would result in higher inputs than actually take place, as shown in Table 6 A-B. The most pronounced effects are on phosphorus inputs.

Increased nitrogen load											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	0	0	0	0	0	8	8
BS	0	0	0	0	0	0	0	0	0	18	18
BP	0	57	21	1	0	0	46	0	0	0	126
GF	0	0	0	0	0	0	0	0	0	0	0
GR	0	0	0	11	0	38	0	0	0	0	50
DS	0	0	193	0	0	0	0	0	0	0	193
KT	0	0	51	0	0	0	0	0	0	0	51
Σ	0	57	265	13	0	38	47	0	0	26	445

Increased phosphorus load											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	0	0	0	0	0	20	20
BS	0	0	0	0	45	0	0	0	0	70	115
BP	0	49	12	0	0	0	3	0	0	177	241
GF	0	0	0	0	0	0	0	0	0	0	0
GR	0	0	0	0	0	0	0	0	0	0	0
DS	0	45	362	0	0	0	0	0	0	9	416
KT	0	0	80	0	0	0	0	0	0	123	203
Σ	0	94	454	0	45	0	3	0	0	400	996

Table 6 A-B. Increased nutrient inputs by the different countries to Baltic Sea sub basins; if all HELCOM countries and Belarus would fulfil only the existing HELCOM Recommendations / EU WWT Directive levels.

For the purpose of the calculations and to leave room for later gains by these countries from their higher treatment levels we assume that only upgrading to the Recommendations' nutrient reduction levels (Table 5) will take place and that no country will actually downgrade their current standards of sewage treatment (Table 6). The results; for HELCOM countries, 19,013 ton N and 4,713 ton P (Table 5) will only partly fulfil the nutrient reduction needs of 135,000 ton N and 15,250 ton P (Table 1) needed to reach a good ecological status. Further reductions are needed and must be found from other sources such as transboundary loads, diffuse sources, and especially agriculture. Here, the sewage contribution from Belarus is an important source, and as seen in Table 5, the total load reduction would be increased to 24,102 and 6,375 tons if this country would follow the EU UWWT Directive/HELCOM Recommendations.

The draft HELCOM Recommendations on improved urban and scattered dwellings waste water treatment suggested to be included in HELCOM BSAP are more far reaching for phosphorus and set different treatment levels for inhabitants in rural areas (70-80% P, 30% N reductions) and in cities with more than 10,000 inhabitants (90% P, 75% N reductions). These draft Recommendations would decrease phosphorus load from HELCOM countries by 6700 tons which means an additional 2 000 tons compared with the existing HELCOM Recommendations/EU UWWT directive.

3.1.2. Contributions from other sources

Nutrient loading from diffuse sources is nowadays the major source of anthropogenic nutrients in many areas since much of the water protection measures have addressed point sources. Agriculture is the main source of diffuse loads.

The desired improvement of the Baltic Sea will not be obtained with the nutrient reductions obtained by implementing the existing HELCOM Recommendations/EU UWWT directive alone. The additional reductions needed, a total of about 113,000 and 8,900 tons of N and P respectively, are shown in Table 7 and have to be found among other, mainly diffuse sources.

	N	P
BB	0	0
BS	0	0
BP	77,637	8,082
GF	316	687
GR	0	110
DS	14,880	0
KT	19,957	0
Total	112,790	8,877

Table 7. Additional nutrient load reductions (tons yr^{-1}) needed to reach the environmental target of each basin when improved WWT has been implemented in al HELCOM countries and Belarus.

In Annex 1 we present an attempt to use the distribution of agricultural land close to the coast as a proxy to allocate the remaining load reductions between countries. Unfortunately, this approach did not yield realistic numbers, nor did any of the other approaches presented in the annex. Some allocations schemes set country allocations that exceed the total load of a particular country in 97-03.

We therefore suggest a very simplistic approach with the following steps for each sub basin (Table 8). The load reduction from loads of 97-03 (Table 8, row A) obtained by implementing the existing HELCOM Recommendations/EU UWWT Directive is first calculated for each sub-basin and country (Table 5). This reduction is subtracted from the total country load for 97-03 (Table 8, row B). Then the remaining needed total load reductions to each basin are calculated (Table 7). The % share for each country of the remaining total loads to the particular basin is calculated after reductions due to improved wastewater treatment have been subtracted (row C). That % share is then used as the basis for country allocations of the remaining reductions of each country (row D). The country will benefit from UWWT levels that exceed the HELCOM Recommendations/EU UWWT Directive. The reductions achieved by these higher levels are subtracted from the remaining needed reductions of that country (row E). In essence, the country allocation (row F) consists of the reduction to be achieved by the required level of UWWT (row B) and country's share of the remaining needed reduction to that basin (row D) accompanied by reduction of the benefit of requirement exceeding level of UWWT (row E). The last row of Table 8 indicates the % reduction induced by the country allocation from loads of 97-03.

An example for the Baltic Proper with regard to phosphorus:

- 12 500 ton needed to be reduced
- Load 97-03 in row A 19246 tons
- Full implementation of EU WWT directive/HELCOM Recommendations, row B 4418 tons
- Remaining load A-B, 14 828 ton
- Total remaining load reduction, D 12 500-4418=8082
- Percentage share of reduction Xx14828/100=C (eg. DE 4 %)
- Remaining reduction per country cxD(8082),(eg. DE 291 ton)
- Higher reduction E (eg. DE 49 ton)
- Country allocation F (eg. DE 242 ton)

These calculations also take into account UWWT transboundary loads. For instance, the total needed P load reduction to the Baltic proper is 12,500 tons (Table 1) of a total load of 19,246 during 97-03. Improved municipal wastewater treatment will reduce this load with 4,418 tons (Table 5) and the remaining load reduction is then 8,082 tons (Table 7). The load via the Neman River enters the sea via Lithuania but almost 50% of the drainage basin lies in Belarus. Therefore the 1,206 tons reduced load of P, achieved with improved WWT in Belarus, is subtracted from the load of Lithuania and assigned to Belarus.

Russia contribute with 8% and Poland with 74% after the reductions achievable by improved UWWT have been taken into account, which means that these countries have to reduce the P load with an additional 649 and 5,945 tons, respectively. For Germany the contribution is 4% or 291 tons, but since this country would release an additional 49 tons to the Baltic Proper if the existing HELCOM Recommendations / EU UWWT Directive is followed (Table 6) the country allocation is reduced with this amount, to 242 tons.

The initial calculations of nutrient loads reported by HELCOM allocate riverine loads to the country situated at the river mouth. This means that Latvia is assigned the entire load via Daugava to the Gulf of Riga while 32 and 39 % this drainage basin belongs to Russia and Belarus. With the calculation scheme used here, we can calculate the effects of improved sewage treatment in Russia on loads to the Gulf of Riga, i.e. 114 tons and 450 tons from Belarus and 8 tons from Lithuania. Thus we have reassigned this load from Latvia to Russia and Lithuania, see Table 8c. The load from Belarus is finally assigned to a common pool.

Likewise, the load from Belarus to Baltic Proper will be allocated to a common pool and reduced from the load from Lithuania (48% of the Neman drainage basin lies in Belarus, but only 1.8 % in Russia)

Similar calculations should be made for the loads from Ukraine and Czech Republic when relevant data are available. The transboundary pollution loads will form a common pool. For the loads coming from Ukraine and Belarus international joint actions should be initiated, whereas the load from the Czech Republic will be addressed by EU requirements. The total country allocation of nutrient load reductions is summarized in Table 9. Here, the initial 97-03 wastewater load has been reassigned from the HELCOM countries to Belarus (the ‘Common pool’) in accordance to the calculation scheme.

Baltic proper - Phosphorus - Country allocations of the total 12 500 ton reduction need											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03	1,206	534	51	18	0	1,328	266	1,266	13,717	860	19,246
B = decreased load by WWT	1,206	0	0	0	0	327	0	75	2,810	0	4,418
Remaining load (A-B)	0	534	51	19	0	1,001	266	1,192	10,907	860	14,828
C = % of total remaining load	0%	4%	0%	0%	0%	7%	2%	8%	74%	6%	100%
D = Remaining load reduction	0	291	28	10	0	545	145	649	5,945	468	8,082
E = Benefit of high level WWT	0	49	12	0	0	0	3	0	0	177	241
F = Country allocation (D+B-E)	1206	**242**	**16**	**10**	**0**	**873**	**142**	**724**	**8,755**	**291**	**12,259**
F/A		45%	31%	54%	0%	66%	53%	57%	64%	34%	57%

Baltic proper - Nitrogen - Country allocations of the total 94 000 ton reduction need											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03	3,763	7,038	2,257	1,034	0	45,109	10,447	10,594	215,350	31,667	327,259
B = decreased load by WWT	3,763	0	0	0	0	642	0	235	11,486	238	16,364
Remaining load (A-B)	0	7,038	2,257	1,034	0	44,466	10,447	10,359	203,865	31,429	310,895
C = % of total remaining load	0%	2%	1%	0%	0%	14%	3%	3%	66%	10%	100%
D = Remaining load reduction	0	1,757	564	258	0	11,104	2,609	2,587	50,909	7,848	77,636
E = Benefit of high level WWT	0	57	21	1	0	0	46	0	0	0	126
F = Country allocation (D+B-E)	3763	**1,701**	**542**	**257**	**0**	**11,746**	**2,562**	**2,821**	**62,395**	**8,087**	**93,874**
F/A		24%	24%	25%	0%	26%	25%	27%	29%	26%	28%

Table 8a. Total loads and reductions of nitrogen and phosphorus to Baltic Proper, allocated to each country. For explanations, see text.

Gulf of Finland - Phosphorus - Country allocations of the total 2 000 ton reduction need											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03	6	0	0	980	578	0	0	5,302	0	0	6,866
B = decreased load by WWT	6	0	0	77	-84	0	3	1,142	0	0	1,306
Remaining load (A-B)	0	0	0	903	494	0	3	4,160	0	0	5,560
C = % of total remaining load	0%	0%	0%	16%	9%	0%	0%	75%	0%	0%	100%
D = Remaining load reduction	0	0	0	113	62	0	0	519	0	0	693
E = Benefit from high level WWT	0	0	0	0	0	0	0	0	0	0	0
F = Country allocation (D+B-E)	0	**0**	**0**	**190**	**146**	**0**	**2**	**1,661**	**0**	**0**	**1,999**
F/A		0%	0%	19%	25%	0%	0%	31%	0%	0%	29%

Gulf of Finland - Nitrogen - Country allocations of the total 6 000 ton reduction need											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03	16	0	0	18,036	15,852	0	0	78,792	0	0	112,696
B = decreased load by WWT	16	0	0	588	1,156	0	0	3,924	0	0	5,684
Remaining load (A-B)	0	0	0	17,448	14,696	0	0	74,868	0	0	107,012
C = % of total remaining load	0%	0%	0%	16%	14%	0%	0%	70%	0%	0%	100%
D = Remaining load reduction	0	0	0	52	43	0	0	221	0	0	316
E = Benefit from high level WWT	0	0	0	0	0	0	0	0	0	0	0
F = Country allocation (D+B-E)	16	**0**	**0**	**639**	**1,199**	**0**	**0**	**4,145**	**0**	**0**	**6,000**
F/A		0%	0%	4%	8%	0%	0%	5%	0%	0%	5%

Table 8b. Total loads and reductions of nitrogen and phosphorus to Gulf of Finland, allocated to each country. For explanations, see text.

Gulf of Riga - Phosphorus - Country allocations of the total 750 ton reduction need											
	BEL	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03	450	0	0	262	0	8	1,347	114	0	0	2,181
B = decreased load by WWT	450	0	0	3	0	8	64	114	0	0	640
Remaining load (A-B)	0	0	0	258	0	0	1,283	0	0	0	1,541
C = % of total remaining load	0%	0%	0%	17%	0%	0%	83%	0%	0%	0%	100%
D = Remaining load reduction	0	0	0	18	0	0	92	0	0	0	110
E = Benefit from high level WWT	0	0	0	0	0	0	0	0	0	0	0
F = Country allocation (D+B-E)	450	**0**	**0**	**22**	**0**	**8**	**156**	**114**	**0**	**0**	**750**
F/A		0%	0%	1%	0%	0%	7%	5%	0%	0%	34%

Danish Straits - Nitrogen - Country allocations of the total 15 000 ton reduction need										
	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03	13,811	26,697	0	0	0	0	0	0	5,386	45,893
B = decreased load by WWT	107	0	0	0	0	0	0	0	13	120
Remaining load (A-B)	13,704	26,697	0	0	0	0	0	0	5,372	45,773
C = % of total remaining load	30%	58%	0%	0%	0%	0%	0%	0%	12%	100%
D = Remaining load reduction	4,455	8,679	0	0	0	0	0	0	1,747	14,880
E = Benefit from high level WWT	0	193	0	0	0	0	0	0	0	193
F = Country allocation (D+B-E)	4,348	8,486	0	0	0	0	0	0	1,733	14,761
F/A	9%	19%	0%	0%	0%	0%	0%	0%	4%	32%

Table 8c. Total loads and reductions of phosphorus to Gulf of Riga and nitrogen to the Danish Straits, allocated to each country. For explanations, see text.

Kattegat - Nitrogen - Country allocations of the total 20 000 ton reduction need										
	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
A = Load 97-03		28,547	0	0	0	0	0	0	35,710	64,257
B = decreased load by WWT	0	0	0	0	0	0	0	0	43	43
Remaining load (A-B)	0	28,547	0	0	0	0	0	0	35,666	64,213
C = % of total remaining load	0%	44%	0%	0%	0%	0%	0%	0%	56%	100%
D = Remaining load reduction	0	8,872	0	0	0	0	0	0	11,084	19,957
E = Benefit from high level WWT	0	51	0	0	0	0	0	0	0	51
F = Country allocation (D+B-E)	**0**	**8,821**	**0**	**0**	**0**	**0**	**0**	**0**	**11,128**	**19,949**
F/A	0%	14%	0%	0%	0%	0%	0%	0%	17%	31%

Table 8d. Total loads and reductions of nitrogen to Kattegat, allocated to each country. For explanations, see text.

	Loads in sub basins with a reduction need (97-03)		Country reduction allocations	
	Phosphorus	Nitrogen	Phosphorus	Nitrogen
Germany	534	20,848	242	5,621
Denmark	51	57,501	16	17,207
Estonia	1,261	19,054	222	896
Finland	578	15,852	146	1,199
Lithuania	1,336	45,109	881	11,746
Latvia	1,613	10,447	300	2,561
Russia	6,683	89,386	2,500	6,967
Poland	13,717	215,350	8,755	62,395
Sweden	860	72,762	291	20,780
Common pool (Belarus)	1,662	3,779	1,662	3,779
Total	**28,293**	**550,088**	**15,014**	**133,152**

Table 9. Total land based loads, averaged for 1997-2003 reported to by the countries to HELCOM and the allocated reductions for each country. Loads to sub basins where no reduction is needed are excluded here (see Table1). The common pool corresponds to the WWT load reductions from Belarus. Maximum allowable load by country is then the difference between the load and the country reduction allocation.

4. Transboundary and atmospheric pollution loads – sources outside the reach of HELCOM

The calculation schemes presented above assume that all nutrient reductions have to be implemented by the HELCOM contracting parties, i.e. the countries with a coastline to the Baltic. This means that other countries that contribute to the eutrophication will 'get away'. International ship traffic through the Baltic is rapidly becoming a major source of nitrogen atmospheric depositions and actions concerning these issues are discussed in the Maritime segment of the BSAP. Another source is riverine inputs, which originate from non-HELCOM countries within the drainage Basin. It has been calculated that 7-8 % of the total land based load originate from Belarus, Czech Republic and Ukraine (HELCOM 2005). But this calculation compares loads in rivers at country borders with those at the coast and do not account for the substantial riverine retentions on the way to the coasts. Thus transboundary loads might be small compared to total contributions.

The Daugava drainage basin encompass five countries before the nutrient loads enters the bay at the city of Riga; Lithuania, Estonia Belarus, Russia and Latvia. All the countries belong to the HELCOM contracting parties except Belarus, which covers almost 40% of the entire Daugava drainage basin. This, it can be argued that the contracting countries (Estonian and Latvia) would have to reduce more than their 'fair share' since they also have to implement measures that should be done in Belarus. About 48% of the Nemunas catchment, draining into the Baltic Sea (via the Curonian lagoon) is situated in Belarus, as well.

Therefore the contributions from transboundary loads coming from Belarus are now calculated in a similar manner using the drainage basin model in Nest (Mörth et al., 2007) and are allocated to a common pool. Similar calculations should be made for the loads from Ukraine and Czech Republic when relevant data are available. The transboundary pollution loads will form a common pool. For the loads coming from Ukraine and Belarus international joint actions should be initiated, whereas the load from the Czech Republic will be addressed by EU requirements (see chapter 3.1.2).

Atmospheric N deposition on the Baltic Sea represents about 25 % of the total N load and reductions of these sources are dependent on measures in many countries outside the Baltic Sea region and cannot be tackled directly by HELCOM, see Fig 4. The HELCOM countries contribute with 126,000 tons or 45 %, almost the same as the needed total reduction. Around 10 % equivalent to 30 000 tons of the airborne nitrogen deposition to the Baltic Sea originate from shipping. However, according to scenarios calculated in another HELCOM project on the deposition of airborne nitrogen suggest that there will be no significant reduction in the near future even when existing requirements of the EU NEC Directive and Gothenburg protocol are implemented, mainly due to increased shipping and agricultural productivity. In this report, we consider the atmospheric load to be constant, and focus on the waterborne nutrients alone. In a similar manner, natural background loads are not considered and considered constant. Another important source for both N and P are inflows of Skagerak water into Kattegat. Some of these nutrients originate from countries draining into the North Sea and cannot be tackled within HELCOM.

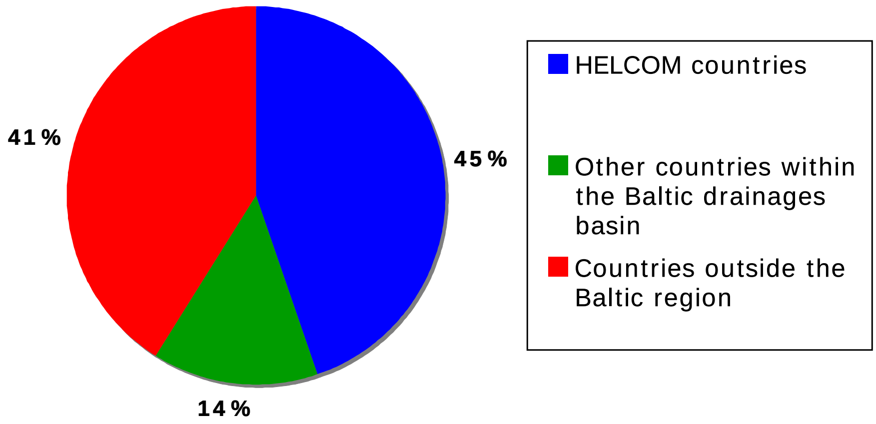

Figure 4. Total deposition of inorganic nitrogen over the Baltic Sea related to the countries of the emissions (Tarrasón et al., 2005).

5. Natural variations and uncertainties in calculations

Naturally, the calculations presented here have many degrees of uncertainties embedded. The numerical models are highly aggregated but encompass all major processed and is based on comparisons with actual observations from the most intensively studied marine system in the world. The models have been evaluated, reviewed and published in the international scientific literature. Better models will undoubtedly emerge in the future with higher spatial and temporal resolution. The results must be re-evaluated and corrected when future improved models are available.

Results are presented as single numbers without any range, which may give a false impression of a high degree of precision. The interannual natural variations are large; for instance the actual marine measurements used in the calculations for the basin vide concentrations show a variation (SD/mean for the period 1991 – 2002) of about 10% for total nitrogen and phosphorus and about 20% for DIN and DIP. The interannual variations in nutrient loads are large, sometimes approaching 50% due to natural climatic induced variations. Embedded in the data are analytical errors in the measurements as well. But in spite of these uncertainties, intercalibrations of sampling and analytical methods, the long time series available in databases available to the entire scientific community, have formed the basis of a common understanding of Baltic ecosystem properties. There are no other marine regions in the world where such massive databases are available.

In conclusion, the calculations presented here are based on the best available scientific knowledge available today on large-scale ecosystem properties for the entire Baltic region.

6. Concluding remarks

1. The nutrient load reductions and country allocations presented here means that substantial and very costly measures have to be implemented in all the Baltic Sea countries, in order to reach a good marine environment.
2. Some of these measure will reduce the loads to the Baltic Sea as soon as they are implemented, like improved sewage treatment. Some measures within agriculture will have considerable delays (decades) before substantial decreases are seen in river runoff. Similarly, the large amount of nutrients that have accumulated in the water column and sediments of the Baltic will cause a considerable delay before improvements of the environmental quality are seen. Thus, it is imperative that these measures are implemented as soon as possible.
3. The reductions calculated here have only been allocated to measures in very broad terms: It is up to each country to decide which measures are the most convenient and cost efficient. Improvements in wastewater treatment plant can be supplemented by other measures, i.e. the use of P-free detergents and especially measures in agriculture.
4. These country-wise nutrient reduction allocations could also be used as the foundation for a system of nutrient trading within and between countries since the foundations for the system are easily verifiable.
5. Parts of the quotas allocated to the different countries, as shown in Table 12, may already be fulfilled by measures implemented during recent years. However, the effects of these measures have to be verified with actual measurements of river runoff and from coastal point sources. For instance, increased loads from diffusive sources might counteract a decrease in point source loads.
6. Natural variations in the eutrophication related parameters are high and difficult to capture, which has an effect on the accuracy of estimated load reductions. In addition, the models used here can be improved when more data become available. However, this is the first time that eutrophication problem of the entire Baltic Sea is considered using exact targets and an ecosystem approach in combination with the state of the art model that covers the whole drainage basin and sea.

ANNEX 1:

Other approaches studied for allocation of load reductions to countries

1 Population-based approach

The most obvious approach would be to allocate country-wise reductions based on each country's share of the total population within a sub drainage basin. This approach has been used in Table 10.

Population, 10^3 individuals										
	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	976	0	0	0	0	336	1,311
BS	0	0	0	1,254	0	0	0	0	1,116	2,371
BP	1,432	102	31	0	2,837	353	874	39,678	4,590	49,896
GF	0	0	966	3,536	0	0	7,785	0	0	12,287
GR	0	0	214	0	0	1,380	0	0	0	1,594
DS	1,440	3,399	0	0	0	0	0	0	382	5,221
KT	0	3,399	0	0	0	0	0	0	1,994	5,393
Σ	2,871	6,901	1,210	5,766	2,837	1,734	8,658	39,678	8,417	78,073

Total nitrogen reductions, tons										
	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	0	0	0	0	0	0
BS	0	0	0	0	0	0	0	0	0	0
BP	2,697	192	58	0	5,345	666	1,646	74,750	8,647	94,000
GF	0	0	472	1,727	0	0	3,801	0	0	6,000
GR	0	0	0	0	0	0	0	0	0	0
DS	4,136	9,767	0	0	0	0	0	0	1,096	15,000
KT	0	12,606	0	0	0	0	0	0	7,394	20,000
Σ	6,834	22,566	529	1,727	5,345	666	5,447	74,750	17,137	135,000

Total phosphorus reductions, tons										
	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	0	0	0	0	0	0
BS	0	0	0	0	0	0	0	0	0	0
BP	359	26	8	0	711	89	219	9,940	1,150	12,500
GF	0	0	157	576	0	0	1,267	0	0	2,000
GR	0	0	101	0	0	649	0	0	0	750
DS	0	0	0	0	0	0	0	0	0	0
KT	0	0	0	0	0	0	0	0	0	0
Σ	359	26	265	576	711	738	1,486	9,940	1,150	15,250

Table 10 A-C. Total populations in the drainage basins to the seven major Baltic Sea sub basins, expressed in thousands of inhabitants (A) calculated from {Hannerz, 2006 #5187}. The following tables B and C show allocations of country-wise reductions if the total load reductions to each sub basin are in relation to each countries share of the total population in the sub-drainage basin, expressed as tons yr^{-1}.

Total nitrogen									
	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE
BB									
BS									
BP	38%	9%	6%		11%	6%	16%	35%	27%
GF			3%	11%			5%		
GR									
DS	30%	37%							20%
KT		44%							21%

Total phosphorus									
P	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE
BB									
BS									
BP	214%	50%	42%		28%	33%	17%	72%	134%
GF			16%	100%			24%		
GR			38%			34%			
DS									
KT									

Table 11. Reductions of N and P loads, expressed as % of total loads by country (average 97-03) if population based allocations are used.

This reduction approach is not realistic, particularly for P, since Germany has to reduce its P load by more than twice and Finland the entire current load, including natural background (Table 11).

2. Area-based approach
Similarly, reduction allocations based on total areas belonging to the different countries would also give unrealistic country quotas. For instance Sweden and Poland have about the same total areas but Poland has about 30 million more inhabitants.

3. Sub-basin -specific reduction needs shared equally among the basin's countries
Another simplistic approach would be to calculate the total % reduction from 1997-2002 loads needed for each sub-basin and then apply this percentage equally to the loads of all countries bordering that particular basin.

	N red %	P red %
BB	0%	0%
BS	0%	0%
BP	29%	66%
GF	5%	29%
GR	0%	34%
DS	33%	0%
KT	31%	0%
AVE	18%	42%

Table 12. The reductions of nitrogen and phosphorus loads (according to Table 1) needed to reach good environmental status, expressed as percentage change from the

Total nitrogen reductions, tons									
N	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE
BB	0	0	0	0	0	0	0	0	0
BS	0	0	0	0	0	0	0	0	0
BP	2,021	648	297	0	14,038	3,001	3,043	61,856	9,096
GF	0	0	960	844	0	0	4,196	0	0
GR	0	0	0	0	0	0	0	0	0
DS	4,514	8,726	0	0	0	0	0	0	1,760
KT	0	8,885	0	0	0	0	0	0	11,115
SUM	6,535	18,260	1,257	844	14,038	3,001	7,238	61,856	21,971

Total phosphorus reductions, tons									
P	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE
BB	0	0	0	0	0	0	0	0	0
BS	0	0	0	0	0	0	0	0	0
BP	111	34	12	0	1,678	176	838	9,082	569
GF	0	0	286	168	0	0	1,546	0	0
GR	0	0	90	0	0	660	0	0	0
DS	0	0	0	0	0	0	0	0	0
KT	0	0	0	0	0	0	0	0	0
SUM	111	34	388	168	1,678	836	2,384	9,082	569

Table 13. The load reductions by each country to the different sub-basins, if all countries will apply the same reduction as the overall percentage (Table 12).

This approach is far better but it does not take into account measures already implemented in reducing sewage effluents, nor does it have any relationship to actual diffuse loads from those countries. Of the total reductions, Poland will be responsible for 45% of N and 60% of P which clearly is not realistic.

4. A two-step approach based on municipal waste water treatment levels and agricultural land proxy

In this two-step approach, the starting point is the needed reduction to reach good marine environment in each sub-basin.

5) The quantity of load reductions achievable by improved sewage treatment from 2004 levels up to the existing HELCOM Recommendations'/ EU Directive’s levels by each contracting party is calculated (similarly to the proposed approach in chapter 3).
6) In the second step, the remaining load reduction, after improved sewage treatment has been implemented, is allocated among the sub-basin catchment's countries according to their share of the total agricultural land in the coastal strip of that sub-basin.

This approach considers both the actual wastewater treatment levels in 2004 of the coastal countries as in the proposed approach in chapter 3. A diffuse load allocation, as described below in detail, sets the remaining load reductions.

Improved sewage treatment

The Recommendations on improved urban and scattered dwellings waste water treatment suggested to be included in HELCOM BSAP set different treatment levels for inhabitants in rural areas (70% P, 30% N reductions), agglomerations <2000 p.e. 80% P and in cities with more than 10,000 inhabitants (90% P, 75% N reductions).

To estimate the reductions that would be achieved by applying these Recommendations in comparison to situation in 2004, we have used the compilations by Hannerz (2006) on total populations of each country within the Baltic Sea drainage basin and calculations on the inhabitants in cities from (http://www.citypopulation.de/cities), see Table 1 in Annex 2.

The sewage treatment levels of the proposed Recommendations result in reductions of N and P loads to the different basins, compared to 2004, using the Nest drainage basin model (Mörth et al., 2007) as shown in Table 14 A-B. The most uncertain values in these calculations are for Russia, where no official values on sewage treatment levels are available. We have assumed that in 2004, 50% of the population is connected to secondary treatment (35% P and N reduction) and 25% of the population was connected to tertiary treatment (90% P and 75% N reduction).

N	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	-87	0	0	0	0	0	-87
BS	0	0	0	0	0	0	0	0	0	0
BP	0	0	5	0	-626	0	-236	-1,722	-39	-2,619
GF	0	0	-530	-1,313	0	-3	-4,127	0	0	-5,973
GR	0	0	0	0	0	-79	-233	0	0	-312
DS	0	0	0	0	0	0	0	0	-10	-10
KT	0	0	0	0	0	0	0	0	0	0
Σ	0	0	-525	-1,400	-626	-81	-4,597	-1,722	24	-9,001

P	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	-88	0	0	0	0	0	-88
BS	0	0	0	-60	0	0	0	0	0	-60
BP	0	0	-1	0	-514	-15	-116	-4,897	-63	-5,607
GF	0	0	-114	-395	0	-7	-1,537	0	0	-2,053
GR	0	0	-15	0	-34	-155	-174	0	0	-379
DS	-6	-219	0	0	0	0	0	0	-6	-231
KT	0	0	0	0	0	0	0	0	-43	-43
Σ	-6	-219	-130	-543	-548	-177	-1,827	-4,897	-112	-8,461

Table 14 A-B. Reduced nutrient inputs by the different countries to Baltic Sea sub basins if the Recommendations suggested to be included in the HELCOM BSAP on improved urban and scattered dwellings waste water treatment improvements will be implemented.

These nutrient reductions on urban wastewaters are lower than those that are actually implemented already in some countries and would result in higher inputs, as shown in Table 6 A-B. The most pronounced effects are on nitrogen inputs since the required % reduction level is only 30 % for rural areas.

N	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	0	0	0	0	47	47
BS	0	0	0	26	0	0	0	0	149	175
BP	320	64	5	0	0	38	0	0	0	426
GF	0	0	0	0	0	0	0	0	0	0
GR	0	0	29	0	42	0	0	0	0	71
DS	140	498	0	0	0	0	0	0	0	638
KT	0	371	0	0	0	0	0	0	73	444
Σ	459	933	33	26	42	38	0	0	269	1,801

P	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	Σ
BB	0	0	0	0	0	0	0	0	1	1
BS	0	0	0	0	0	0	0	0	3	3
BP	5	4	0	0	0	0	0	0	0	9
GF	0	0	0	0	0	0	0	0	0	0
GR	0	0	0	0	0	0	0	0	0	0
DS	0	0	0	0	0	0	0	0	0	0
KT	0	20	0	0	0	0	0	0	0	20
Σ	5	24	0	0	0	0	0	0	4	33

Table 15 A-B. Increased nutrient inputs by the different countries to Baltic Sea sub basins if the suggested HELCOM nitrogen (A) and phosphorus (B) sewage treatment levels are implemented.

For the purpose of the calculations and to leave room for later gains by countries from higher treatment levels we assume that only upgrading to the Recommendations' nutrient reduction levels (Table 15 A-B) will take place and that no country will actually downgrade their current standards of sewage treatment (Table 15 A-B). The results; of 9,001 ton N and 8,461 ton P (Table 14 A-B) will only partly fulfill the nutrient reduction of 135,000 ton N and 15,250 ton P (Table 1) needed to reach good marine environment. Further reductions are needed and must be found from diffuse sources, particularly agriculture.

Contributions from diffuse sources, in particular agriculture

Nutrient loading from diffuse sources is nowadays the major source of nutrients in many areas since much of the water protection measures have addressed point sources. Agriculture is the main source of diffuse loads. Other minor sources are i.e. forestry, peat mining and storm waters.

The desired improvement of the Baltic Sea will not be obtained if only the nutrient reductions obtained by implementing the suggested HELCOM Recommendations' levels of sewage treatments are achieved. The additional reductions needed, a total of about 126,400 and 7,300 tons of N and P respectively, are shown in Table 16 and have to be found among diffuse sources.

	N	P
BB	0	0
BS	0	0
BP	91,381	6,893
GF	27	0
GR	0	371
DS	14,990	0
KT	20,000	0
Total	126,398	7,264

Table 16. Additional nutrient load reductions (tons yr^{-1}) needed to reach the environmental target of each basin when improved WWT has been implemented.

Here the distribution of agricultural land close to the coast is used as a *proxy* for the agricultural contributions from the different countries. This can readily be done by using the GIS analysis of land type distributions within Europe, compiled by EU (JRC/ISPRA).

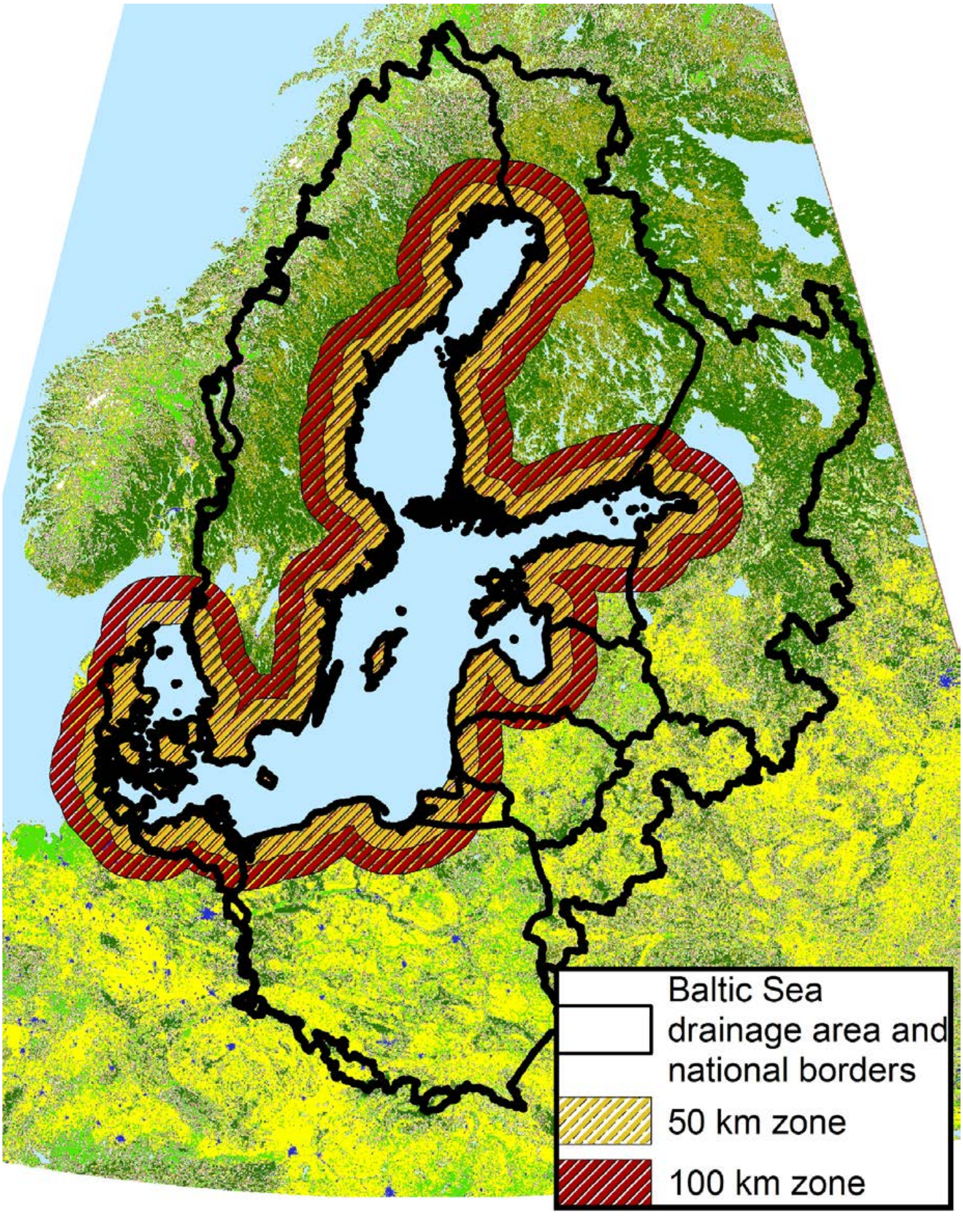

Fig 5. The Baltic Sea drainage basin and the regions encompassed by 50 and 100 km from the shoreline.

We have compiled the areas of agricultural land within a 50 and 100 km from the shoreline (Fig 3) for each sub basin and country. As seen in Table 3 and 4 in Annex 2 there are no fundamental differences using either distance from the coastline and we have therefore chosen the 50 km boundary since the 100 km limit would go far beyond the extension of some drainage basins. A narrower coastal strip will also reduce the effect of regional variations in nutrient retentions.

Country-wise reduction allocations based on this approach

With the information presented above, country-wise reduction allocations are finally calculated and presented in Table 17. The first row in each table, WWT, is the reductions in N or P loads if the HELCOM recommendations are adopted (from Tables 8 and 9). The second row shows the % of agricultural land in each country within the drainage basin of each Baltic Sea sub basin (from Table 18). These numbers are then used as an agriculture proxy to allocate the remaining loads (see Table 18), when the WWT reductions have been subtracted from the total loads needed to reach the environmental targets (Table 1). The total load reductions obtained this way are in some cases slightly lower than the overall reduction targets, since some countries have already implemented stricter WWT reduction than the suggested HELCOM recommendations; the load reductions beyond these levels (Table 18) are then subtracted from the ‘agricultural quota’. The differences are small (usually less than one %), compared to Table 1 and would not affect target Secchi depths.

The results show that improved wastewater treatment (WWT) would fulfill almost half of the needed P reductions to the Baltic proper and Gulf of Riga and all the reductions needed for the Gulf of Finland. Sewage treatment has very limited effect on N reductions, particularly to the southernmost basins. Here substantial reductions in land runoff, particularly from agriculture are needed.

The allocations of total load reductions to each country are shown in Table 18.

N - BP	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT, tons	320	64	5	0	-626	38	-236	-1,722	-39	-2,198
Agr. proxy	12%	3%	1%	0%	8%	9%	11%	33%	23%	100%
Diff. Red.	-11,082	-2,677	-1,367	0	-7,292	-8,109	-10,020	-30,045	-21,209	-91,801
SUM	-10,762	-2,613	-1,363	0	-7,918	-8,071	-10,256	-31,767	-21,249	-93,999

P - BP	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT	5	4	-1	0	-514	-15	-116	-4,897	-63	-5,598
Agr. proxy	12%	3%	1%	0%	8%	9%	11%	33%	23%	100%
Diff. Red.	-832	-201	-103	0	-547	-609	-752	-2,256	-1,593	-6,893
SUM	-827	-197	-104	0	-1,062	-624	-868	-7,153	-1,656	-12,491

N - GF	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT	0	0	-530	-1,313	0	-3	-4,127	0	0	-5,973
Agr. proxy	0%	0%	35%	22%	0%	0%	42%	0%	0%	100%
Diff. Red.	0	0	-9	-6	0	0	-11	0	0	-27
SUM	0	0	-539	-1,320	0	-3	-4,139	0	0	-6,000

P - GF	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT	0	0	-114	-395	0	-7	-1,537	0	0	-2,053
Agr. proxy	0%	0%	35%	22%	0%	0%	42%	0%	0%	100%
Diff. Red.	0	0	19	12	0	0	22	0	0	53
SUM	0	0	-95	-383	0	-7	-1,515	0	0	-2,000

P - GR	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT	0	0	-15	0	-34	-155	-174	0	0	-379
Agr. proxy	0%	0%	44%	0%	0%	56%	0%	0%	0%	100%
Diff. Red.	0	0	-164	0	0	-207	0	0	0	-371
SUM	0	0	-180	0	-34	-362	-174	0	0	-750

N - DS	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT	140	498	0	0	0	0	0	0	-10	628
Agr. proxy	32%	57%	0%	0%	0%	0%	0%	0%	11%	100%
Diff. Red.	-4,815	-8,514	0	0	0	0	0	0	-1,661	-14,990
SUM	-4,675	-8,015	0	0	0	0	0	0	-1,672	-14,362

N - KT	DE	DK	EST	FIN	LIT	LAT	RU	PO	SE	SUM
WWT	140	498	0	0	0	0	0	0	-10	628
Agr. proxy	0%	67%	0%	0%	0%	0%	0%	0%	33%	100%
Diff. Red.	0	-13,356	0	0	0	0	0	0	-6,645	-20,001
SUM	140	-12,858	0	0	0	0	0	0	-6,655	-19,373

Table 17. Allocation of country quotas for the reduction of nitrogen and phosphorus loads to the Baltic Sea sub basins. For explanations, se text.

	Phosphorus	Nitrogen
Denmark	197	23,486
Estonia	379	1,902
Finland	383	1,320
Germany	827	15,437
Latvia	993	8,074
Lithuania	1,096	7,918
Poland	7,153	31,767
Russia	2,557	14,395
Sweden	1,656	29,575
Total	*15,240*	*133,874*

Table 18. Allocation of nitrogen and phosphorus loads reduction to the different HELCOM contracting countries

This approach would mean that e.g. Germany would have to reduce more than the total nutrient load coming from Germany today.

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Abbreviations used

BB = Bothnian Bay
BS = Bothnian Sea
BP = Baltic proper
GF = Gulf of Finland
GR = Gulf of Riga
DS = Danish Straits
KT = Kattegat

N = Nitrogen
P = Phosphorus
DIN = Dissolved inorganic nitrogen
DIP = Dissolved inorganic phosphorus

BEL = Belarus
DE = Germany
DK = Denmark
EST = Estonia
FIN = Finland
LIT = Lithuania
LAT = Latvia
RU = Russia
PO = Poland
SE = Sweden