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Agenda Item 3 Draft outline and structure of the HELCOM BSAP

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MANAGEMENT OPTIONS, NUTRIENT LOADS AND ECOSYSTEM RESPONSES FOR THE BALTIC SEA; POLICY SCENARIOS FROM BNI/NEST JANUARY 2007

The Meeting is invited to consider the attached policy scenarios on Management options, nutrient loads and ecosystem responses for the Baltic Sea and to agree to use these results as guidance for the development of actions under the eutrophication segment in the Baltic Sea Action Plan.

Management options, nutrient loads and ecosystem responses for the Baltic Sea; Policy scenarios from BNI/NEST Jan 2007

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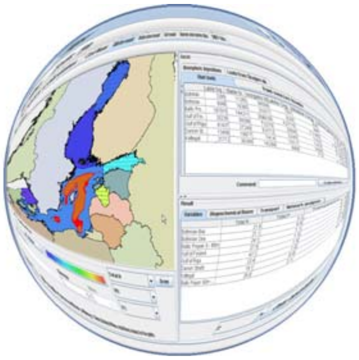


Introduction

We have now, with the NEST decision support system updated the scenario calculations, supplied to HELCOM in Nov 2006 with more detailed scenarios where the effects from measures in individual countries are presented, as requested for an analysis of cost efficient solutions, to be done by COWI (Anette Gudum). The detailed load-effect calculations are presented in Appendix 1-2. Some of the results are slightly different, compared to the previous report, due to updates of the data behind the drainage basin model but the differences are small, within ±1.5 %, and will not change the conclusions.

The absolute numbers on load and conditions in the Baltic may vary from those found in previous reports from HELCOM. The main reason for this is that there are considerable interannual natural variations in loads and environmental conditions in the sea, due to climate variations. The following tables and graphs were compiled from official data supplied to HELCOM, describing average annual loads for the period 1997-2003.

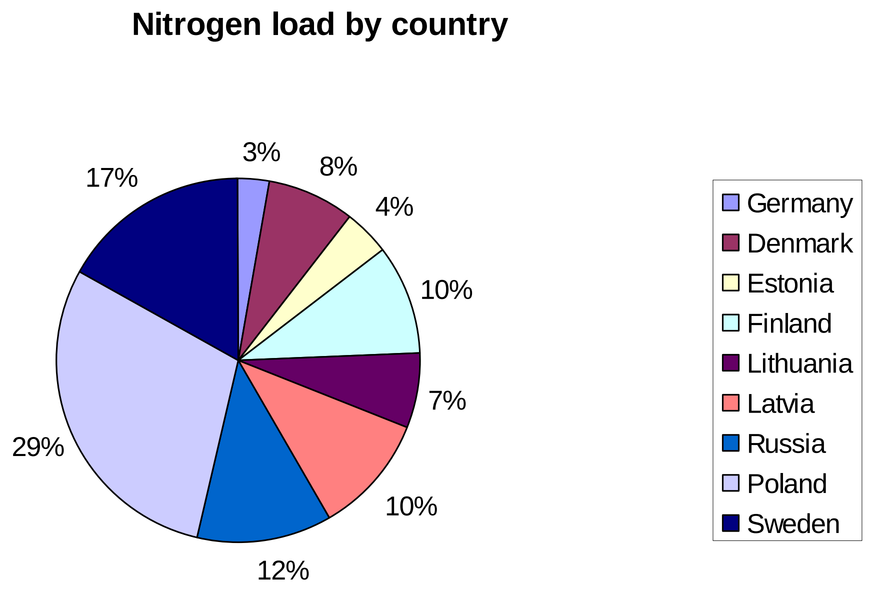
Nitrogen	Germany	Denmark	Estonia	Finland	Lithuania	Latvia	Russia	Poland	Sweden	SUM
BB				30,688					20,749	51,436
BS				24,571					32,215	56,786
BP	7,038	2,257	1,034		48,872	10,447	10,594	215,350	31,667	327,259
GF			18,036	15,852			78,792			112,680
GR			11,800			66,604				78,404
DS	13,811	26,697							5,386	45,893
KT		28,547							35,710	64,257
SUM	20,848	57,501	30,870	71,110	48,872	77,051	89,386	215,350	125,726	736,714
%	3%	8%	4%	10%	7%	10%	12%	29%	17%	100%

Phosphorus	Germany	Denmark	Estonia	Finland	Lithuania	Latvia	Russia	Poland	Sweden	SUM
BB				1,550					1,035	2,585
BS				1,220					1,236	2,457
BP	168	51	18		2,534	266	1,266	13,717	860	18,880
GF			980	578			5,302			6,860
GR			262			1,919				2,180
DS	365	944							100	1,409
KT		800							773	1,573
SUM	533	1,795	1,261	3,348	2,534	2,184	6,569	13,717	4,003	35,944
%	1%	5%	4%	9%	7%	6%	18%	38%	11%	100%

Table 1a-b. Load of nitrogen (top) and phosphorus (bottom) via rivers and coastal points sources, averaged for 1997-2003, according to data reported to HELCOM.

The modeled scenarios also take into account that nutrients originate from countries that are not directly bordering the sea but are within the drainage basin, i.e. Belarus, the Czech Republic and Norway. Ukraine has also a part within the drainage basin but is not considered yet, due to lack of data. Nor now we are simply assuming that none of the nutrients originating in Ukraine actually reach the Baltic Sea.

The nutrient contributions by the different counties will of course vary with the size of the drainage basins and populations and on the intensity of agriculture, etc.



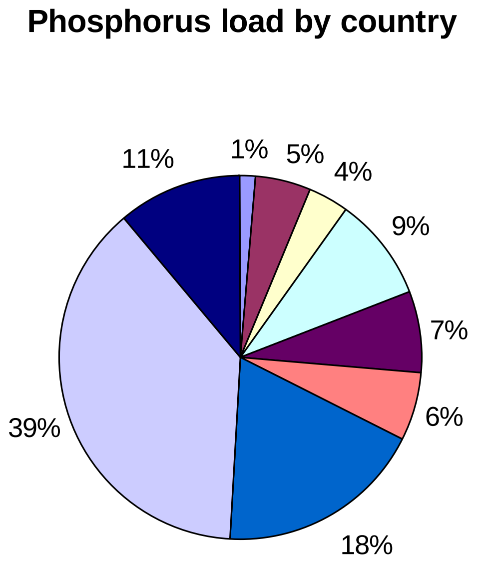


Figure 1 a-b. Load of nitrogen (top) and phosphorus (bottom) to the Baltic Sea, % contributions by country, averaged for 1997-2003. From official HELCOM data.

The loads per capita will also vary, depending on industrial and human activities, including agriculture. However, nutrient retentions will vary greatly in the drainage basins as well, due to soil types, climate and hydrology.

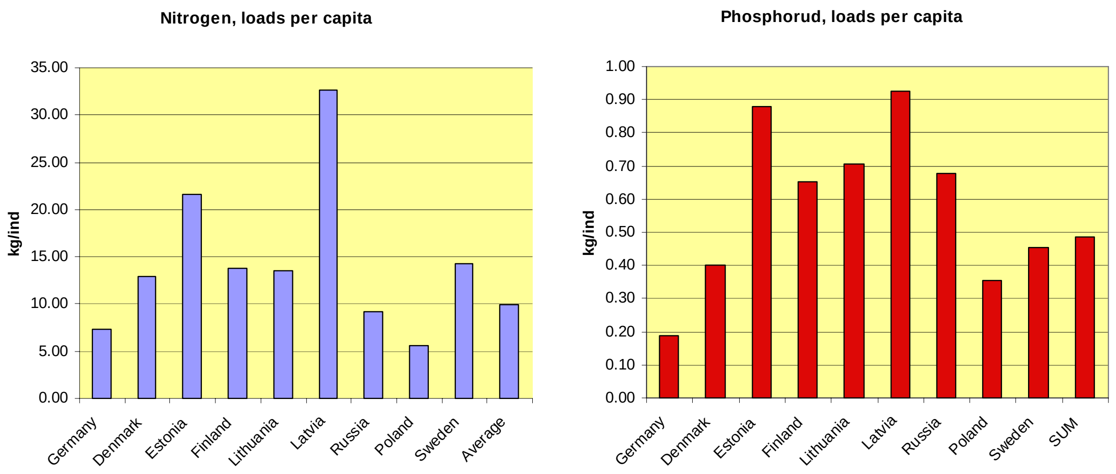


Figure 2 a-b. Load per capita of nitrogen and phosphorus to the Baltic Sea, averaged for 1997-2003.

Improved sewage treatment scenarios

The initial scenario runs were made with official statistics from EUROSTAT (http://europa.eu.int/comm/eurostat/) except for Belarus and Russia which were ‘guesses’. All other figures were mean values for the period 1996-2000. Efforts by the HELCOM member countries made it possible to update this information with more recent data. The status, Oct 06, is the following describing the % of people connected to different sewage treatment in 2004.

% Population connected to	**BE**	**CZ**	**D**	**DK**	**ES**	**FI**	**LIT**	**LAT**	**N**	**PO**	**RU**	**SE**
Primary wwt	0	0	0	2	2.2	0	33	1.79	0	2.2	0	0
Secondary wwt	50	61	9	5.2	34.4	0	6	35.08	5.8	23.3	50	5.8
Tertiary wwt	0	0	85	81.4	33.6	80	18	33.07	85.8	33.5	0	85.8

Table 3. Levels of sewage treatment in 2004

Latvia, Poland, Germany, Finland, Denmark and Sweden supplied data in the format we requested. We have also though informal discussions with Russian and Belarusian scientists updated these data, assuming that 50% of the populations in the Baltic Sea drainage basins of these countries are now connected to secondary sewage treatment.

The nutrient load, based on the information supplied by HELCOM countries for 2004 will give the following initial conditions in the Baltic Sea basins, calculated with NEST:

Initial conditions	Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	Meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	21.5	0.2	6.3	27	0	
Bothnian Sea	20.0	0.5	6.4	133	14	
Baltic Proper	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	25.6	0.8	4.5	141	26	
Gulf of Riga	35.4	1.1	3.0	240	9	
Danish Straits	22.2	0.8	6.0	195	9	
Kattegat	18.7	0.7	7.8	213	6	

Table 4. Initial conditions in the Baltic Sea for 2004

These values, expressed as annual averages for the entire basins are close to contemporary observed values aggregated with the same spatial and temporal resolution, as shown by Savchuk & Wulff, 2007b.

In our scenario calculations, we have assumed that no further improvement will occur in the Nordic countries or Germany, compared to 2000. The other countries will have an improvement, corresponding to the current situation in Sweden. The drainage basin model (Mörth et al., 2007) yields the following 5 year mean load reductions to the different basins from each country into the corresponding drainage basins.

P reductions, tons	Belarus	Czech rep	Estonia	Lithuania	Latvia	Russia	Poland	SUM	%
Bothnian Bay	0	0	0	0	0	0	0	0	0%
Bothnian Sea	0	0	0	0	0	0	0	0	0%
Baltic Proper	-1,447	-391	-2	-570	-17	-290	-5,292	-8,009	64%
Gulf of Finland	-7	0	-114	0	-7	-3,108	0	-3,236	26%
Gulf of Riga	-523	0	-17	-46	-162	-431	0	-1,179	9%
Danish Straits	0	0	0	0	0	0	0	0	0%
Kattegat	0	0	0	0	0	0	0	0	0%
SUM	-1,977	-391	-133	-615	-187	-3,829	-5,292	-12,424	100%
%	16%	3%	1%	5%	2%	31%	43%	100%	

N reductions, tons	Belarus	Czech rep	Estonia	Lithuania	Latvia	Russia	Poland	SUM	%
Bothnian Bay	0	0	0	0	0	0	0	-10	0%
Bothnian Sea	0	0	0	0	0	0	0	0	0%
Baltic Proper	-4,184	-1,293	-4	-1,097	2	-1,050	-13,338	-20,963	62%
Gulf of Finland	-17	0	-585	0	-8	-9,947	0	-10,557	30%
Gulf of Riga	-1,374	0	-15	-54	-197	-1,131	0	-2,770	8%
Danish Straits	0	0	0	0	0	0	0	0	0%
Kattegat	0	0	0	0	0	0	0	0	0%
SUM	-5,574	-1,293	-604	-1,151	-203	-12,138	-13,338	-34,300	100%
%	16%	4%	0%	3%	1%	36%	39%	100%	

Table 5. Load reductions for phosphorus and nitrogen, from levels calculated for 2004, if modern sewage treatment was implemented.

The overall nitrogen load has thus been reduced by 5% and for phosphorus loads by 33% in this scenario. No reductions occur in the Bothnian Bay or Sea, the Danish Straits or Kattegat since direct loads to these basins originate only from the Nordic countries and Germany (Danish Straits). These calculations are of course highly dependent on the data we have used. The largest uncertainty is the role of Russia and Belarus due to the lack or reliable data on the current levels of sewage treatment. The largest reduction of both P and N load with improved sewage treatment is from Poland (43%), followed by Russia (31%) and Belarus (16%).

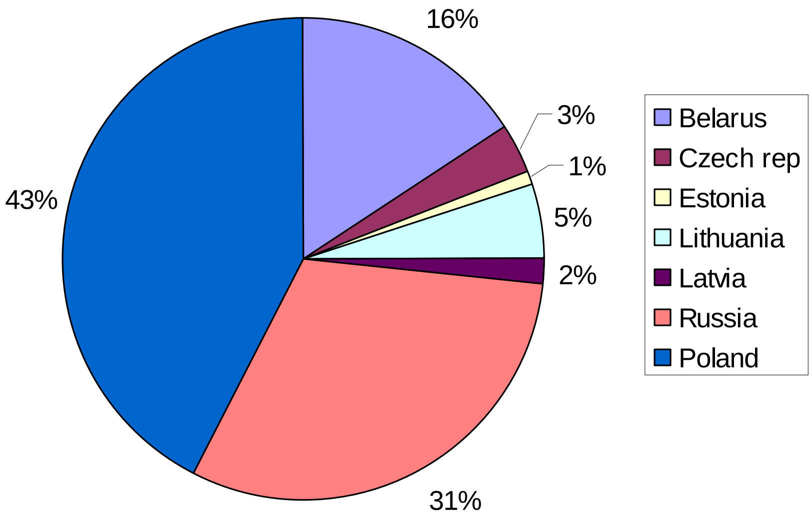


Figure 3. The contribution by country to the total load reduction of N and P, if modern sewage treatment was implemented in these countries.

The *load reductions per capita* vary greatly between the countries. The differences are related to nutrient retentions in the drainage basins and to differences between contemporary and projected degree of sewage treatment for the populations of the different countries. While Russia and Belorussia have the largest potential for load reductions, Poland is below the average. The dominating role of Poland in terms of absolute numbers is determined by the large population, almost half of the total population in the entire drainage basin of the Baltic Sea Region (Hannerz & Destouni, 2006).

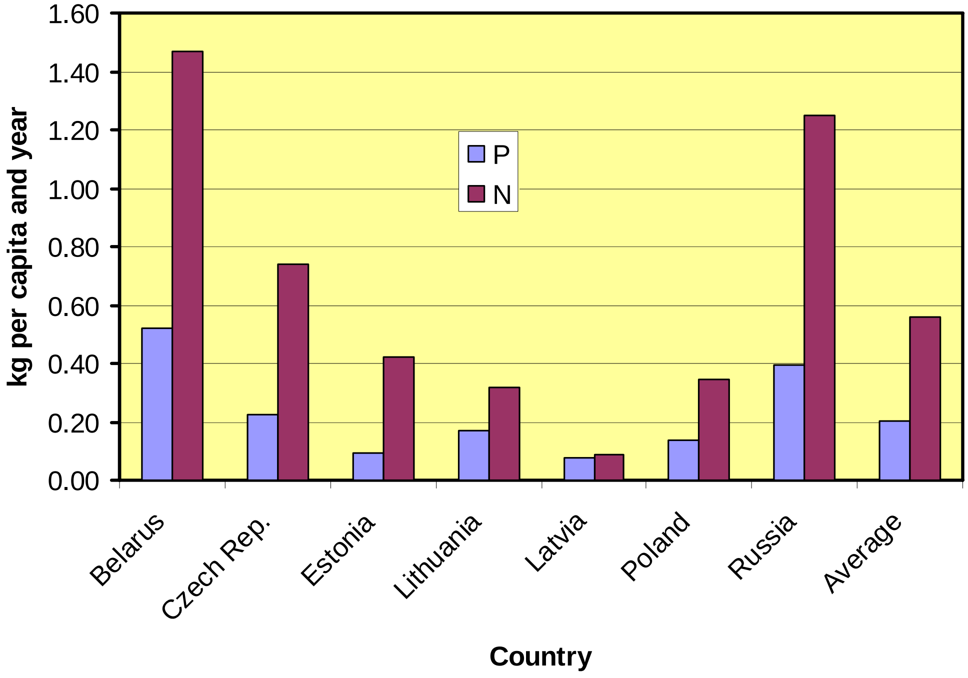


Figure 4. The contributions by capita and country to the load reduction of N and P, if modern sewage treatment was implemented in these countries.

The reductions of N and P loads with more efficient municipal sewage treatment in all countries give the following effects on the marine ecosystem, expressed in % of initial (2004) conditions. The results are presented as steady states, disregarding natural interannual variations. Thus, as a 'rule of thumb', changes within ± 10% would not be detected in field observations and be considered significant.

% change from initial conditions	Load reductions, tons		Nutrient concentrations,		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P				
Bothnian Bay	0%	0%	5%	0%	5%	-11%		
Bothnian Sea	0%	0%	4%	-20%	25%	-33%	-100%	
Baltic Proper	-6%	-40%	-3%	-25%	17%	-22%	-53%	-26%
Gulf of Finland	-11%	-49%	-4%	-38%	36%	-43%	-96%	
Gulf of Riga	-4%	-49%	5%	-36%	37%	-40%	-100%	
Danish Straits	0%	0%	-2%	-25%	17%	-12%		
Kattegat	0%	0%	-1%	-14%	1%	-5%		

Table 6.

All basins are affected, even those where there are no direct reduction of loads from the surrounding drainage basins, because the advective inflows from other basins are reduced. Atmospheric dinitrogen fixation, which can be considered as a proxy for the intensity of cyanobacterial blooms, are virtually eliminated in all the basins, except in the Baltic proper. The blooms in the Baltic proper will be halved and the extension of hypoxic areas will be reduced with 26% from 42,000 km^2 but the effect on water transparency will be limited (+17%). Changes in the Gulf of Finland and Riga will be more pronounced, in addition to the elimination of cyanobacterial blooms, with improved water transparency and reduced primary productivity. The Gulf of Riga will switch from being limited by N to P, which is also reflected in an increase in concentrations of unutilized N. The smallest effects are seen in the northernmost Bothnian Bay. The conditions in the nitrogen limited Danish Straits and Kattegat are not affected significantly since this scenario primary reduce P loads.

The largest effects can be seen in the Baltic proper and in the Gulf of Finland and Riga. The effects of individual country reductions and the responses on the environmental in all the Baltic Sea sub-basins are tabulated in Appendix 1.

A hypoxic bottom area is a permanent contemporary condition in the Baltic proper, with a default extension of 42.400 km^2, as generated by the models. The graph below show the reductions generated by improved sewage treatment, individually for each country and if all countries have jointly implemented these measures.

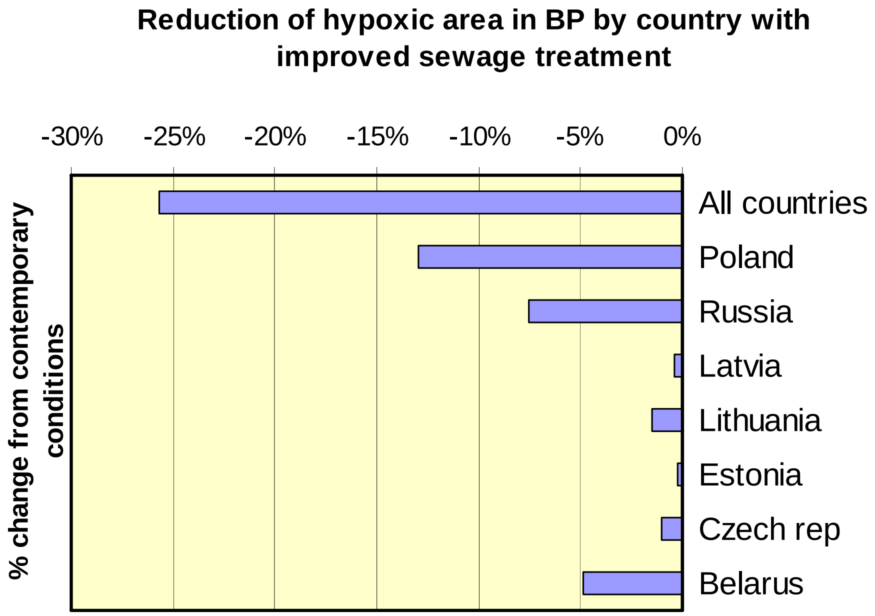


Figure 5

Using P free detergents

We have used the assumptions that each person emits 1.16 and 3.94 kg P and N per inhabitant and year, respectively. These estimated originate from Behrendt & Dannowski (2005) who also calculated that, by using P-free detergents, emissions of phosphorus are reduced to 0.6 kg. However, P contributions from the use of phosphates in detergents are largely dependent on use patterns, marketing conditions and the adoption on specific conditions on the use of phosphates in detergents either through regulatory or voluntary agreements. It is likely that these numbers will vary between countries. We have, in a literature survey, found that the annual contribution from detergents range from 0.13 to 0.22 kg per person (Zessner & Lindtner, 2005; Madariaga et al., 2006; Ryegård et al 2006). Considering the great uncertainty and range in these estimates, we have chosen to run two scenarios where P emissions are reduced by 0.6 and by 0.2 kg per person and year, respectively in order to cover maximum and minimum effects, due to a ban of detergents containing P. The total P load reductions to the different basins are then:

BASIN	MAX	MIN
Bothnian Bay	-3%	-1%
Bothnian Sea	-5%	-2%
Baltic Proper	-28%	-10%
Gulf of Finland	-32%	-12%
Gulf of Riga	-31%	-11%
Danish Straits	-16%	-6%
Kattegat	-8%	-3%
SUM	-24%	-9%

Table 7

The load reductions, expressed in tons, for each country into each basin, assuming that P-free detergents reduce the load with 0.2 kg per year, are, according to the model:

P	**BE**	**CZ**	**DK**	**EST**	**FI**	**LIT**	**LAT**	**N**	**RU**	**PO**	**SE**	**SUM**	**%**
BB	0	0	0	0	-29	0	0	0	0	0	-4	-33	1%
BS	0	0	0	0	-28	0	0	0	0	0	-14	-43	1%
BP	-294	-80	-1	-1	0	-182	-7	0	-59	-1,326	-51	-2,000	62%
GF	-1	0	0	-27	-103	0	-2	0	-623	0	0	-757	23%
GR	-106	0	0	-5	0	-19	-46	0	-87	0	0	-263	8%
DS	0	0	-93	0	0	0	0	0	0	0	-3	-96	3%
KT	0	0	-10	0	0	0	0	-2	0	0	-34	-47	1%
SUM	-401	-80	-104	-33	-160	-202	-55	-3	-769	-1,326	-106	-3,238	100%
%	12%	2%	3%	1%	5%	6%	2%	0%	24%	41%	3%	100%	

Table 8

The load reductions, expressed in tons, for each country into each basin, assuming that P-free detergents reduce the load with 0.6 kg per year are, according to the model:

P	**BE**	**CZ**	**DK**	**EST**	**FI**	**LIT**	**LAT**	**N**	**RU**	**PO**	**SE**	**SUM**	**%**
BB	0	0	0	0	-80	0	0	0	0	0	-11	-92	1%
BS	0	0	0	0	-79	0	0	-1	0	0	-40	-120	1%
BP	-823	-225	-3	-2	0	-510	-19	0	-164	-3,712	-142	-5,600	62%
GF	-4	0	0	-76	-288	0	-6	0	-1,746	0	0	-2,120	23%
GR	-295	0	0	-15	0	-54	-129	0	-243	0	0	-737	8%
DS	0	0	-260	0	0	0	0	0	0	0	-9	-269	3%
KT	0	0	-29	0	0	0	0	-6	0	0	-95	-131	1%
SUM	-1,122	-225	-292	-93	-448	-564	-154	-7	-2,153	-3,712	-297	-9,067	100%
%	12%	2%	3%	1%	5%	6%	2%	0%	24%	41%	3%	100%	

Table 9

The overall reduction of P loads would then increase from about 3,000 to 9,000 tons, if the higher estimate of P content in detergents was correct.

The effects on the marine ecosystem, expressed as % change from the default 2004 conditions if P detergents contain 0.2 kg P person^{-1} yr^{-1}, are

BASIN	TotN conc.	TotP conc.	Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Bothnian Bay	0%	0%	2%	-4%		
Bothnian Sea	0%	0%	5%	-7%	-70%	
Baltic Proper	0%	0%	0%	-6%	-14%	-7%
Gulf of Finland	0%	0%	7%	-10%	-28%	
Gulf of Riga	0%	-9%	7%	-7%	-39%	
Danish Straits	0%	0%	2%	-3%		
Kattegat	0%	0%	0%	-1%		

Table 10.

The effects would be very limited and not detectable in the sea, except that cyanobacterial blooms would be reduced in the Gulf of Riga (-39%) and in the Gulf of Finland (-28%). The reduction in the Bothnian Sea (-70%) would be from an already very low level.

The effects on the marine ecosystem if P detergents contain 0.6 kg P person^{-1} yr^{-1} are

BASIN	TotN	TotP	Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Bothnian Bay	3%	0%	5%	-10%		
Bothnian Sea	2%	-20%	13%	-23%	-100%	
Baltic Proper	-2%	-13%	12%	-15%	-39%	-18%
Gulf of Finland	-2%	-25%	22%	-28%	-79%	
Gulf of Riga	-2%	-27%	20%	-19%	-100%	
Danish Straits	-1%	-13%	10%	-9%		
Kattegat	-1%	-14%	-12%	-4%		

Table 11.

The effects of this maximum scenario for P-free detergents are more pronounced. The will be a substantial reduction in primary production and cyanobacterial blooms in the Bothnian Sea, and in the Gulfs of Finland and Riga. For the Baltic proper there will be on a reduction in the extension of hypoxic bottoms and a substantial reduction in cyanobacterial blooms but the decrease in productivity is less pronounced than in the Gulfs. Any effects on environmental quality in the Danish straits and Kattegat will not be seen in these N limited basins.

The detailed information of load reductions and effect for each country are found in Appendix 1.

Improved sewage treatment and P free detergents combined

In this scenario we have combined the effect of improving sewage treatments, compared to the situation in 2004 with the use of P-free detergents, assuming that this means a reduction of 0.6 kg P person^{-1} yr^{-1}. We have not used the lower estimate of 0.2 kg P person^{-1} yr^{-1} since it would give very small effects in this combined scenario.

The overall effects on nutrient loads to the basins are:

	Reduction in tons yr^{-1}		% of initial load	
BASIN	Tot N	Tot P	Tot N	Tot P
Bothnian Bay	0	-96	0%	-4%
Bothnian Sea	0	-120	0%	-5%
Baltic Proper	-20,963	-9,742	-6%	-48%
Gulf of Finland	-10,557	-3,793	-11%	-58%
Gulf of Riga	-2,770	-1,347	-4%	-56%
Danish Straits	0	-269	0%	-16%
Kattegat	0	-131	0%	-8%
SUM	-34,290	-15,498	-5%	-41%

Table 12

The combined effect gives a total P load reduction which is less than the sum of each measure. This is because most people are now already connected to sewage treatment with highly efficient P removal in this scenario. The effects on the marine ecosystem are:

% difference: WWT/Initial	TotN conc	TotP conc	Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Bothnian Bay	7%	0%	6%	-15%		
Bothnian Sea	7%	-20%	25%	-42%		
Baltic Proper	-3%	-38%	33%	-26%	-66%	-30%
Gulf of Finland	-2%	-38%	44%	-52%	-100%	
Gulf of Riga	10%	-45%	43%	-50%	-100%	
Danish Straits	-2%	-25%	23%	-14%	-70%	
Kattegat	-1%	-14%	1%	-6%		

Table 13

The combined effect of improved sewage treatment and removal of P containing detergents are substantial. Primary production will be halved in the Gulf of Riga and Finland, and with a quarter in the Baltic proper compared to year 2004. Detectable reductions would be seen in the Bothnian Sean and Baltic proper as well. The extension of hypoxic bottom areas will be reduced by 30%. Improved water transparency (Secchi depth) will be detected in all basins except in the Bothnian Bay and Kattegat.

Agricultural scenarios

We have earlier, for HELCOM, calculated the effect on nitrogen loads, if 50% of all agricultural land in each drainage basin was converted to forests or grasslands. These were indeed drastic and highly unrealistic measures but were made in order to see the effects of a substantial reduction of N loads on the Baltic which can only be obtained by changing land use or agricultural practices, or atmospheric depositions. We have now gone further and, with the help of agricultural experts, developed two scenarios, to illustrate a positive and negative view on the future of the Baltic ecosystem, depending in the future development of agricultural practices.

Business as usual

During the last century, agricultural practices have change dramatically. New technologies, crops, animal breeding and, particularly, the introduction of artificial fertilizers, have increased productivity enormously. At the same time, consumer preferences have changed dramatically towards a large proportion of meat in human consumption. These changes have been most pronounced in the western countries but similar changes are now occurring in the new EU member states, as well as in Russia and Belorussia. Higher living standards and EU agricultural subsidies are driving this development.

In this scenario we have assumed that all countries around the Baltic will develop their agriculture to the same state as in Denmark, the country that is leading in terms of agricultural development. More specifically, we assume that each country will have the same number of milk cow and other cattle’s, sows and slaughter pigs per agricultural areas as in Denmark. Moreover, the productivity, in term of meat and milk per animal will increase to Danish levels, which also means that nutrient excretion per unit animal will increase.

In this ‘pessimistic’ scenario we will also assume that sewage treatment will remain at the 2004 levels and no further restriction in the use of P in detergents will be implemented.

The overall effects on nutrient loads to the basins are:

	Increase in tons yr^{-1}		% of initial load	
BASIN	Tot N	Tot P	Tot N	Tot P
Bothnian Bay	1,118	117	2%	4%
Bothnian Sea	2,376	138	5%	6%
Baltic Proper	238,314	10,460	70%	52%
Gulf of Finland	37,882	1,901	40%	29%
Gulf of Riga	55,304	2,933	82%	122%
Danish Straits	2,394	214	6%	13%
Kattegat	3,543	312	5%	18%
SUM	340,932	16,074	48%	43%

Table 14

This is indeed a massive increase in loads; doubled P inputs to the Baltic proper and a 70% increase in N loads, with even higher relative increases for the Gulf of Riga.

The overall effects on the marine system depict a ‘horror scenario’:

% difference WWT/Initial	TotN conc.	TotP conc.	Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Bothnian Bay	0%	0%	-6%	15%		
Bothnian Sea	6%	20%	-16%	36%	248%	
Baltic Proper	8%	38%	-17%	43%	45%	51%
Gulf of Finland	9%	25%	-13%	53%	30%	
Gulf of Riga	22%	64%	-27%	110%	109%	
Danish Straits	5%	25%	-7%	24%	51%	
Kattegat	2%	14%	-4%	10%		

Table 15

The total hypoxic bottom areas will increase from about 42,400 to almost 64,000 km^2! Nitrogen fixation that today is small in the Bothnia Sea will increase 2.5 times and undoubtedly cause environmental damage obvious to humans. The Gulf of Riga will have drastically reduced water transparency, doubled primary production and cyanobacterial blooms. Even the Danish Straits will see clear deteriorations of the environmental conditions. Only the Bothnian Bay and Kattegat will be relatively unaffected, compared to the present situation in this scenario.

The contributions of additional nutrient loads for each country are dependent on the differences between the current states of animal productivity in agriculture and that of

Denmark, and of the total area of agricultural land in each country's drainage basin to the Baltic.

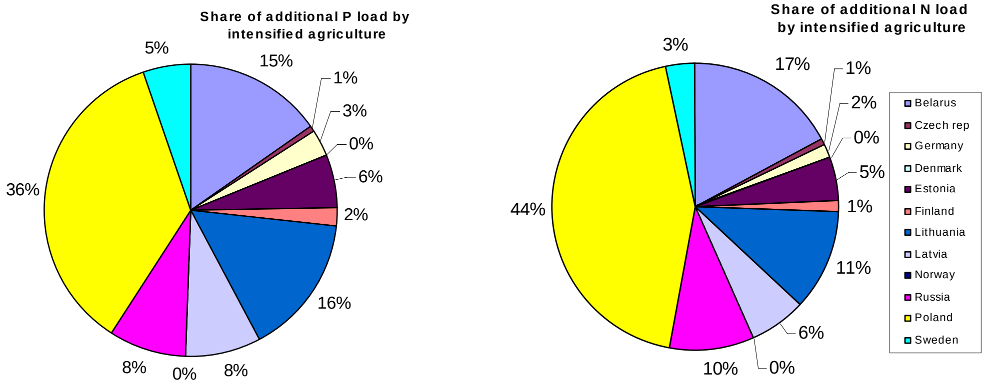


Figure 6. The % contribution by country to increased nutrient loads if all counties intensified agriculture to Danish levels.

Increased input of nutrients by country, expressed as tons yr^{-1} to each basin, caused by intensified agriculture for P and N are:

P	BE	CZ	D	EST	FI	LIT	LAT	N	RU	PO	SE	SUM
BB	0	0	0	0	103	0	0	0	0	0	14	117
BS	0	0	0	0	58	0	0	2	0	0	78	138
BP	1,476	117	275	37	0	2,004	240	0	148	5,736	428	10,461
GF	16	0	0	629	158	0	91	0	1,007	0	0	1,901
GR	957	0	0	259	0	499	1,007	0	211	0	0	2,933
DS	0	0	190	0	0	0	0	0	0	0	23	214
KT	0	0	0	0	0	0	0	18	0	0	294	312
SUM	2,449	117	465	925	318	2,504	1,339	21	1,366	5,736	836	16,076
%	15%	1%	3%	6%	2%	16%	8%	0%	8%	36%	5%	100%

N	BE	CZ	D	EST	FI	LIT	LAT	N	RU	PO	SE	SUM
BB	0	0	0	0	1,004	0	0	0	0	0	106	1,110
BS	0	0	0	0	1,190	0	0	52	0	0	1,135	2,376
BP	36,078	2840	3,203	567	0	31,229	4,053	0	4,340	149,761	6,212	238,283
GF	333	0	0	11,112	1,917	0	1,336	0	23,183	0	0	37,881
GR	22,273	0	0	4,650	0	7,600	15,893	0	4,887	0	0	55,301
DS	0	0	1,996	0	0	0	0	0	0	0	397	2,393
KT	0	0	0	0	0	0	0	208	0	0	3,334	3,542
SUM	58,684	2,839	5,199	16,329	4,105	38,825	21,278	255	32,406	149,756	11,182	340,859
%	17%	1%	2%	5%	1%	11%	6%	0%	10%	44%	3%	100%

Table 16

Best possible agricultural practices

A variety of measures are available for reducing the loads from agriculture, including a balanced animal feeding strategy, housing, manure handling and spreading strategy, as cell as in cultivation strategies. Current practices of concentrating animals in different regions from where animal feed is produced, and supplementing animal fodder with a large proportion in imported food contribute to excess nutrient leakage. However, the effects of agricultural practices on nutrient loads to the Baltic vary to a great extent, due to variations in soil properties, climate and hydrology between different regions. The current version of the drainage basins model included in NEST cannot model these differences in detail, due to lack of data. We have therefore to rely on 'expert judgment' on the combined net effect on nutrient loads if all possible measures were implemented, which indicate that the net P load would be eliminated and that the N load would be halved (47%). The effects on current total loads, varies from a few % to the northern basins with a small proportion of cultivated land to almost a third of the N load and almost half of the P load to the Danish Straits.

BASIN	Total area, km^2	% cultivated	Reduction, %	
			N	P
Bothnian Bay	26,362,519	4%	-2%	-4%
Bothnian Sea	22,637,213	5%	-2%	-4%
Baltic Proper	57,153,463	57%	-21%	-17%
Gulf of Finland	43,110,463	20%	-8%	-6%
Gulf of Riga	13,378,794	51%	-22%	-20%
Danish Straits	2,883,425	79%	-33%	-44%
Kattegat	7,934,431	22%	-10%	-19%

Table 17

The effects on the marine ecosystems are

% difference WWT/Initial	TotN conc.	TotP conc.	Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Bothnian Bay	-7%	0%	5%	-6%		
Bothnian Sea	-14%	0%	9%	-12%	-62%	
Baltic Proper	-16%	-13%	33%	-12%	-15%	-14%
Gulf of Finland	-13%	0%	7%	-12%	-16%	
Gulf of Riga	-19%	-18%	37%	-17%	-24%	
Danish Straits	-14%	-13%	27%	-8%		
Kattegat	-7%	0%	12%	-4%		

Table 18

There will be a substantial reduction in water transparency (Secchi depth) in the Baltic proper, Gulf of Riga and Danish straits in this scenario but the effects on primary production and cyanobacterial blooms (nitrogen fixation) are small. For this scenario it is very difficult to calculate the contributions by each country with the present model.

A combination of all scenarios – best case

The combined effects of improved sewage treatment, P-free detergent and best possible agricultural practices results in an overall reduction of almost 150,000 tons of N and about 21,000 tons of P, corresponding to a reduction to 21% and 56 % of the loads for 2004.

	Reduction in tons yr^{-1}		Reduction, %	
BASIN	N	P	N	P
Bothnian Bay	-950	-198	-2%	-7%
Bothnian Sea	-1,138	-224	-2%	-9%
Baltic Proper	-93,878	-13,238	-27%	-65%
Gulf of Finland	-17,871	-4,159	-19%	-64%
Gulf of Riga	-17,683	-1,823	-26%	-76%
Danish Straits	-12,237	-993	-33%	-61%
Kattegat	-6,599	-458	-10%	-26%
SUM	-150,356	-21,093	-21%	-56%

Table 19

The effects on the marine ecosystems, expressed as % of the 2004 scenario are:

BASIN	TotN conc	TotP conc	Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Bothnian Bay	2%	0%	11%	-20%		
Bothnian Sea	-4%	-40%	41%	-55%	-100%	
Baltic Proper	-19%	-50%	50%	-37%	-83%	-57%
Gulf of Finland	-13%	-50%	62%	-63%	-100%	
Gulf of Riga	-7%	-55%	73%	-65%	-100%	
Danish Straits	-17%	-38%	37%	-21%		
Kattegat	-8%	-14%	14%	-10%		

Table 20

Primary production and nitrogen fixation levels in the Baltic proper are substantially reduced, approaching pristine conditions' at the turn of the last century, see Savchuk et al (2007). In the following section, these measures are compared to the pristine (reference) and target levels set up by the HELCOM EUTRO project.

Scenario calculations in relation to HELCOM environmental targets

For Secchi depths, the HELCOM EUTRO team has calculated reference Secchi depths and set target levels, based on a 25% increase from reference (pristine) conditions for all basins. For the Baltic proper, mean values of levels found for northern, western and south eastern sub regions are used. The values are compared to the Secchi depth found for the combined scenario where improved waste water treatment is combined with a ban of P containing detergents plus the best possible agricultural scenario.

Secchi, m	HELCOM EUTRO			BNI		
BASIN	Reference	Target	Present	Pristine	Scenario	Present
Bothnia Bay	7.5	5.6	5.8	8.5	7.0	6.2
Bothnian Sea	9.0	6.8	7.0	9.7	9.0	6.4
Gulf of Finland	8.0	6.0	4.1	7.0	7.3	4.6
Baltic Proper	9.3	7.0	6.3	10.0	9.0	7.4
Gulf of Riga	6.0	4.5	3.4	5.5	5.2	3.3
Kattegat	10.5	7.9	8.5	10.2	8.9	8.5

Table 21

In this comparison, it is important to note that the HELCOM EUTRO values are based on summer (June-Aug) measurements while the NEST models calculate annual means. However, the differences in EUTRO and those obtained with the NEST model are small for present levels < 17%. The EUTRO target levels are equal or lower than obtained from the combined target. Considering the uncertainties in these calculations, it still seems reasonable to consider that the combined NEST scenario will reach target levels of all basins with an overall reduction of 150,000 and 21,000 tons of N and P.

The reference, targets (+ 50% of reference values) and contemporary wintertime surface DIN concentrations were also set by HELCOM EUTRO. They are here compared with the NEST combined scenario. In this case, no measurements are available, except for contemporary conditions where the discrepancies are considerable larger than for Secchi depths, as large as 40% for Kattegat but very small for the Bothnian Bay. These differences are due to spatial and temporal variations; NEST calculates mean annually averaged values for the entire water body while EUTRO select specific stations for a few months. The difference between EUTRO target and NEST concentrations are also considerable; the NEST target (scenario) DIN concentration is considerable higher than EUTRO's for the Bothnian Bay and Gulfs of Riga and Finland. The NEST model takes into account that these systems becomes severely P limited and that unutilized DIN will accumulate while the EUTRO calculation assume a similar % change in all basins. The differences between the two approaches are smaller for the basins that will remain N limited but the NEST model calculate lower DIN concentrations than the EUTRO assumption of +50% of pristine levels.

DIN [µmol]	HELCOM EUTRO			NEST		
	Reference	Target	Present	Pristine	Scenario	Present
Bothnia Bay	3.50	5.25	7.10	5.15	12.5	7.04
Bothnian Sea	2.00	3.00	2.71	4.29	6.87	3.23
Gulf of Finland	2.50	3.75	8.80	4.97	7.11	5.59
Baltic Proper	2.17	3.25	3.10	2.87	2.83	2.47
Gulf of Riga	4.00	6.00	11.20	6.43	13.4	6.96
Kattegat	4.50	6.75	8.26	4.09	4.20	4.59

Table 22

Finally, reference, targets (+ 50% of reference values) and contemporary wintertime surface DIP concentrations were also set by HELCOM EUTRO. They are here compared with the NEST combined scenario.

DIP [µmol]	HELCOM EUTRO			NEST		
	Reference	Target	Present	Pristine	Scenario	Present
Bothnia Bay	0.10	0.15	0.04	0.06	0.06	0.05
Bothnian Sea	0.20	0.30	0.17	0.20	0.20	0.25
Gulf of Finland	0.30	0.45	0.90	0.34	0.31	0.52
Baltic Proper	0.25	0.38	0.52	0.24	0.25	0.50
Gulf of Riga	0.13	0.20	0.85	0.35	0.31	0.49
Kattegat	0.40	0.60	0.59	0.33	0.30	0.37

Table 23

Again, the differences between the two approaches are large for DIP, for the same reasons as for DIN, but less pronounced. The EUTRO approach, i.e. set target levels as a fixed % deviation from ‘pristine’ reference conditions, intuitively assumes a linear relationship between loads and target concentrations. This approach also ignore fundamental differences in biogeochemical characteristics of the different basins, from the oligotrophic P limited Bothnian Bay to the naturally much more productive and N limited Kattegat. The NEST model considerer these fundamental differences in biogeochemistry but also that the advective flows between are considerable; a load reduction to one basin affects total input to other basins. Reference values on nutrient concentrations appreciating pristine conditions can never be set from measurements and has to be approximated from ‘expert judgment’ or by modeling. So far, only the NEST modeling calculations are available but work is in progress to calculate pristine (reference) nutrient concentrations by another model (Jesper Andersen, pers. comm.)

Conclusions

Naturally, these calculations have many uncertainties still embedded. Improvement in data describing nutrient inputs and retentions in the various drainage basins and countries are needed as well as improvements in the models of the marine basins. A better understanding on how changes in land use and agricultural practices will affect loads to the sea is urgently needed. Conflicting data exist on the quantitative importance of using P-free detergents makes it difficult to judge the importance of this measure. Target and references values of nutrients, based on expert judgments, are difficult to use, particularly since they assume equal % changes in all basins.

However, in spite of these uncertainties, it is clear that considerable reductions of nutrient inputs to the Baltic, particularly of phosphorus, can be reached if efficient modern municipal sewage treatments are implemented in the entire drainage basin. Improving agricultural practices will further reduce the P load but also cause a substantial reduction of N loads. The combined effects on the marine ecosystems are considerable and will most likely reach and surpass target levels for Secchi depths in all basins. However, the good future of the Baltic Sea is by no way guaranteed if the current rapid development of agriculture continues, as show in the ‘business as usual’ scenario.

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Appendix 1. Load reductions (N, P, expressed as tons per year) compared to 2004, for improved sewage treatments in the new EU countries, Russia and Belarus and the corresponding effects on the major sub-basins of the Baltic Sea.

Initial conditions	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table1

Belarus	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.4	26	0	
Bothnian Sea	0	0	19.8	0.5	6.6	127	8	
Baltic Proper	-4184	-1447	22.2	0.8	6.0	181	377	*40,339*
Gulf of Finland	-17	-7	25.5	0.8	4.6	136	24	
Gulf of Riga	-1374	-523	34.9	1.0	3.2	215	5	
Danish Straits	0	0	22.1	0.8	6.1	190	8	
Kattegat	0	0	18.7	0.7	7.8	211	6	

Table 2

Czech republic	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	132	12	
Baltic Proper	-1,293	-391	22.3	0.8	6.0	187	406	*41,972*
Gulf of Finland	0	0	25.6	0.8	4.6	140	26	
Gulf of Riga	0	0	35.4	1.1	3.0	239	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 3

Denmark	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 4

Estonia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^{2} yr^{-1}	tons N yr^{-1}	km^{2}
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	13	
Baltic Proper	-4	-2	22.3	0.8	6.0	189	411	*42,286*
Gulf of Finland	-585	-114	25.6	0.8	4.6	139	26	
Gulf of Riga	-15	-17	35.4	1.1	3.0	239	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 5

Finland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^{2} yr^{-1}	tons N yr^{-1}	km^{2}
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 6

Germany	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 7

Lithuania	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	19.9	0.5	6.0	131	12	
Baltic Proper	-1,097	-570	22.3	0.8	6.0	187	402	*41,761*
Gulf of Finland	0	0	25.6	0.8	4.6	139	26	
Gulf of Riga	-54	-46	35.4	1.1	3.0	237	8	
Danish Straits	0	0	22.2	0.8	6.0	193	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 8

Latvia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	19.9	0.5	6.0	131	12	
Baltic Proper	-1,097	-570	22.3	0.8	6.0	187	402	*41,761*
Gulf of Finland	0	0	25.6	0.8	4.6	139	26	
Gulf of Riga	-54	-46	35.4	1.1	3.0	237	8	
Danish Straits	0	0	22.2	0.8	6.0	193	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 9

Norway	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 10

Poland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.6	0.2	6.5	25	0	
Bothnian Sea	0	0	19.8	0.5	6.9	116	0	
Baltic Proper	-13,338	-5,292	21.9	0.7	6.3	168	314	*36,907*
Gulf of Finland	0	0	25.4	0.8	4.8	127	20	
Gulf of Riga	0	0	35.1	1.0	3.2	224	6	
Danish Straits	0	0	21.9	0.7	6.3	183	7	
Kattegat	0	0	18.6	0.7	7.8	207	5	

Table 11

Russia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.4	26	0	
Bothnian Sea	0	0	19.8	0.5	7.0	123	4	
Baltic Proper	-1,050	-290	22.1	0.8	6.1	177	357	*39,208*
Gulf of Finland	-9,947	-3,108	24.7	0.7	5.3	104	12	
Gulf of Riga	-1,131	-431	34.9	1.0	3.2	215	5	
Danish Straits	0	0	22.1	0.8	6.1	188	8	
Kattegat	0	0	18.7	0.7	7.8	210	5	

Table 12

Sweden	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 13

All countries	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	22.6	0.2	6.6	24	0	
Bothnian Sea	0	0	20.8	0.4	8.0	89	0	
Baltic Proper	-20,963	-8,009	21.7	0.6	7.0	147	194	*31,497*
Gulf of Finland	-10,557	-3,236	24.5	0.5	6.1	80	1	
Gulf of Riga	-2,770	-1,179	37.3	0.7	4.1	144	0	
Danish Straits	0	0	21.7	0.6	7.0	171	4	
Kattegat	0	0	18.6	0.6	7.9	202	3	

Table 14

Load reductions (N, P, expressed as tons per year) compared to 2004, if all counties ban P-containing detergent (as in Germany) and assuming that this will decrease load with 0.2 kg P per person and year, from conditions in 2004.

Belarus	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	132	12	
Baltic Proper	0	-294	22.3	0.8	6.0	188	406	*42,001*
Gulf of Finland	0	-1	25.6	0.8	4.6	140	26	
Gulf of Riga	0	-106	35.3	1.1	3.0	236	8	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 15

Czech republic	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	133	13	
Baltic Proper	0	-80	22.3	0.8	6.0	189	412	*42,313*
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 16

Denmark	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	13	
Baltic Proper	0	-1	22.3	0.8	6.0	189	412	42,345
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	-93	22.2	0.8	6.0	194	9	
Kattegat	0	-10	18.7	0.7	7.8	213	6	

Table 17

Estonia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	133	13	
Baltic Proper	0	-1	22.3	0.8	6.0	189	413	*42,363*
Gulf of Finland	0	-27	25.6	0.8	4.5	141	26	
Gulf of Riga	0	-5	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 18

Finland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	-29	21.5	0.2	6.3	27	0	
Bothnian Sea	0	-28	20.0	0.5	6.4	133	13	
Baltic Proper	0	0	22.3	0.8	6.0	189	411	42,391
Gulf of Finland	0	-103	25.6	0.8	4.6	140	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 19

Germany	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 20

Lithuania	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	133	13	
Baltic Proper	0	-182	22.3	0.8	6.0	188	409	*42,195*
Gulf of Finland	0	0	25.6	0.8	4.5	140	26	
Gulf of Riga	0	-19	35.4	1.1	3.0	239	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 21

Latvia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	133	13	
Baltic Proper	0	-7	22.3	0.8	6.0	189	412	*42,337*
Gulf of Finland	0	-2	25.6	0.8	4.5	141	26	
Gulf of Riga	0	-46	35.4	1.1	3.0	238	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 22

Norway	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,390
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	-2	18.7	0.7	7.8	213	6	

Table 23

Poland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	26	0	
Bothnian Sea	0	0	19.9	0.5	6.5	129	9	
Baltic Proper	0	-1,326	22.2	0.8	6.0	184	388	*36,907*
Gulf of Finland	0	0	25.6	0.8	4.6	137	25	
Gulf of Riga	0	0	35.3	1.1	3.0	236	8	
Danish Straits	0	0	22.2	0.8	6.1	192	8	
Kattegat	0	0	18.7	0.7	7.8	211	6	

Table 24

Russia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	19.9	0.5	6.0	131	12	
Baltic Proper	0	-59	22.3	0.8	6.0	187	401	*41,748*
Gulf of Finland	0	-623	25.5	0.8	4.7	135	23	
Gulf of Riga	0	-87	35.3	1.1	3.0	236	8	
Danish Straits	0	0	22.2	0.8	6.0	193	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 25

Sweden	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	-4	21.5	0.2	6.3	27	0	
Bothnian Sea	0	-14	20.0	0.5	6.0	133	13	
Baltic Proper	0	-51	22.3	0.8	6.0	189	412	42,326
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	-3	22.2	0.8	6.0	194	9	
Kattegat	0	-34	18.7	0.7	7.8	213	6	

Table 26

All countries	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^{2} yr^{-1}	tons N yr^{-1}	km^{2}
Bothnian Bay	0	-34	21.6	0.2	6.4	26	0	
Bothnian Sea	0	-43	19.8	0.5	6.7	123	4	
Baltic Proper	0	-2,000	22.1	0.8	6.0	178	357	*39,489*
Gulf of Finland	0	-757	25.4	0.8	4.8	127	19	
Gulf of Riga	0	-263	35.1	1.0	3.2	223	6	
Danish Straits	0	-96	22.1	0.8	6.1	188	8	
Kattegat	0	-47	18.7	0.7	6.6	210	5	

Table 27

Load reductions (N, P, expressed as tons per year) compared to 2004, if all counties ban P-containing detergent (as in Germany) and assuming that this will decrease load with 0.6 kg P per person and year, from conditions in 2004.

Belarus	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	19.9	0.5	7.0	130	10	
Baltic Proper	0	-823	22.3	0.8	6.0	185	392	*41,298*
Gulf of Finland	0	-4	25.6	0.8	4.6	138	25	
Gulf of Riga	0	-295	35.2	1.0	3.1	228	6	
Danish Straits	0	0	22.2	0.8	6.0	192	8	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 28

Czech republic	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	13	
Baltic Proper	0	-225	22.3	0.8	6.0	188	409	*42,172*
Gulf of Finland	0	0	25.6	0.8	4.5	140	26	
Gulf of Riga	0	0	35.4	1.1	3.0	239	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 29

Denmark	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	13	
Baltic Proper	0	-3	22.3	0.8	5.7	189	411	42,262
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	-260	22.2	0.8	6.0	194	9	
Kattegat	0	-29	18.7	0.7	7.8	212	6	

Table 30

Estonia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	133	13	
Baltic Proper	0	-2	22.3	0.8	6.0	189	412	*42,314*
Gulf of Finland	0	-76	25.6	0.8	4.6	140	26	
Gulf of Riga	0	-15	35.4	1.1	3.0	239	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 31

Finland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	-80	21.5	0.2	6.4	26	0	
Bothnian Sea	0	-79	20.0	0.5	6.4	132	12	
Baltic Proper	0	0	22.3	0.8	6.0	188	408	42,094
Gulf of Finland	0	-288	25.6	0.8	4.6	138	25	
Gulf of Riga	0	0	35.4	1.1	3.0	239	9	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 32

Germany	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,391
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 33

Lithuania	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	19.9	0.5	6.0	131	12	
Baltic Proper	0	-510	22.3	0.8	6.0	187	402	*42,195*
Gulf of Finland	0	0	25.6	0.8	4.6	139	26	
Gulf of Riga	0	-54	35.4	1.1	3.0	237	8	
Danish Straits	0	0	22.2	0.8	6.0	193	9	
Kattegat	0	0	18.7	0.7	7.8	212	6	

Table 34

Latvia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	133	13	
Baltic Proper	0	-19	22.3	0.8	6.0	188	410	*42,241*
Gulf of Finland	0	-6	25.6	0.8	4.5	140	26	
Gulf of Riga	0	-129	35.3	1.1	3.0	236	8	
Danish Straits	0	0	22.2	0.8	6.0	194	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 35

Norway	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	-1	20.0	0.5	6.0	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,389
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	-6	18.7	0.7	7.8	213	6	

Table 36

Poland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.4	26	0	
Bothnian Sea	0	0	19.7	0.5	7.0	121	2	
Baltic Proper	0	-3,712	22.1	0.8	6.1	175	341	*38,764*
Gulf of Finland	0	0	25.5	0.8	4.7	131	22	
Gulf of Riga	0	0	35.2	1.0	3.1	228	7	
Danish Straits	0	0	22.0	0.7	6.1	186	7	
Kattegat	0	0	18.7	0.7	7.8	211	6	

Table 37

Russia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.4	26	0	
Bothnian Sea	0	0	19.9	0.5	6.5	127	8	
Baltic Proper	0	-164	22.2	0.8	6.0	182	379	*40,598*
Gulf of Finland	0	-1,746	25.3	0.7	5.0	123	16	
Gulf of Riga	0	-243	35.2	1.0	3.1	227	6	
Danish Straits	0	0	22.1	0.8	6.1	191	8	
Kattegat	0	0	18.7	0.7	7.8	211	6	

Table 38

Sweden	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	-11	21.5	0.2	6.3	27	0	
Bothnian Sea	0	-40	20.0	0.5	6.4	133	13	
Baltic Proper	0	-142	22.3	0.8	6.0	188	410	42,209
Gulf of Finland	0	0	25.6	0.8	4.5	140	26	
Gulf of Riga	0	0	35.4	1.1	3.0	239	9	
Danish Straits	0	-9	22.2	0.8	6.0	194	9	
Kattegat	0	-95	18.7	0.7	7.8	212	6	

Table 39

All countries	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	-94	22.2	0.2	6.6	24	0	
Bothnian Sea	0	-120	20.4	0.4	7.2	102	0	
Baltic Proper	0	-5,600	21.9	0.7	6.7	160	254	*34,934*
Gulf of Finland	0	-2,120	25.1	0.6	5.5	102	5	
Gulf of Riga	0	-737	34.8	0.8	3.6	194	0	
Danish Straits	0	-269	21.9	0.7	6.6	178	5	
Kattegat	0	-131	18.6	0.6	6.9	205	4	

Table 40

Appendix 2. Load reductions (N, P, expressed as tons per year) compared to 2004, for a scenario where agriculture in all Baltic countries is intensified to the levels of Denmark. Calculations are made for each country separately and for all countries

Belarus	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.4	0.2	6.3	27	0	
Bothnian Sea	0	0	20.2	0.5	6.0	141	19	
Baltic Proper	36078	1476	22.6	0.9	6.0	202	444	*42,870*
Gulf of Finland	333	16	25.7	0.9	4.4	147	29	
Gulf of Riga	22273	957	38.2	1.3	2.7	331	10	
Danish Straits	0	0	22.4	0.8	6.0	202	10	
Kattegat	0	0	18.8	0.7	7.8	216	7	

Table 1

Czech republic	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.4	134	14	
Baltic Proper	2,840	117	22.3	0.8	6.0	190	415	*42,589*
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 2

Germany	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	135	15	
Baltic Proper	3,203	275	22.4	0.8	6.0	191	419	*42,589*
Gulf of Finland	0	0	25.6	0.8	4.5	142	27	
Gulf of Riga	0	0	35.5	1.1	3.0	241	9	
Danish Straits	1,996	190	22.3	0.8	6.0	198	9	
Kattegat	0	0	18.7	0.7	7.8	214	6	

Table 3

Estonia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.3	135	15	
Baltic Proper	567	37	22.4	0.8	6.0	192	423	*43,121*
Gulf of Finland	11,112	629	26.1	0.9	4.4	154	26	
Gulf of Riga	4,650	259	36.0	1.1	2.9	262	10	
Danish Straits	0	0	22.3	0.8	6.0	196	9	
Kattegat	0	0	18.7	0.7	7.8	213	6	

Table 4

Finland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^{2} yr^{-1}	tons N yr^{-1}	km^{2}
Bothnian Bay	1,004	103	21.6	0.2	6.3	27	0	
Bothnian Sea	1,190	58	20.0	0.5	6.0	135	13	
Baltic Proper	-2	0	22.3	0.8	6.0	190	415	42,358
Gulf of Finland	1,917	158	25.7	0.8	4.5	143	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	-2	0	22.2	0.8	6.0	195	9	
Kattegat	-1	0	18.7	0.7	7.8	213	6	

Table 5

Germany	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^{2} yr^{-1}	tons N yr^{-1}	km^{2}
Bothnian Bay	0	0	20.0	0.5	6.0	135	15	
Bothnian Sea	3,203	275	22.4	0.8	6.0	191	419	*42,589*
Baltic Proper	0	0	25.6	0.8	4.5	142	27	
Gulf of Finland	0	0	35.5	1.1	3.0	241	9	
Gulf of Riga	1,996	190	22.3	0.8	6.0	198	9	
Danish Straits	0	0	18.7	0.7	7.8	214	6	
Kattegat	5,199	465						

Table 6

Lithuania	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.4	0.2	6.2	27	0	
Bothnian Sea	0	0	20.2	0.5	6.2	142	20	
Baltic Proper	31,229	2,004	22.6	0.9	6.0	202	450	*45,738*
Gulf of Finland	0	0	25.7	0.9	4.4	147	29	
Gulf of Riga	7,600	499	36.6	1.2	2.8	280	11	
Danish Straits	-2	0	22.4	0.8	6.0	202	10	
Kattegat	-1	0	18.8	0.7	7.8	216	7	

Table 7

Latvia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.4	0.2	6.3	27	0	
Bothnian Sea	0	0	20.1	0.5	6.0	137	17	
Baltic Proper	4,053	240	22.4	0.9	6.0	195	433	*43,835*
Gulf of Finland	1,336	91	25.7	0.8	4.5	145	28	
Gulf of Riga	15,893	1,007	37.5	1.3	2.7	313	12	
Danish Straits	0	0	22.3	0.8	6.0	198	9	
Kattegat	0	0	18.7	0.7	7.8	214	6	

Table 8

Norway	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	52	2	20.0	0.5	6.4	133	14	
Baltic Proper	0	0	22.3	0.8	6.0	189	413	42,394
Gulf of Finland	0	0	25.6	0.8	4.5	141	26	
Gulf of Riga	0	0	35.4	1.1	3.0	240	9	
Danish Straits	0	0	22.2	0.8	6.0	195	9	
Kattegat	208	18	18.7	0.7	7.8	213	6	

Table 9

Poland	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.4	0.2	6.2	28	0	
Bothnian Sea	0	0	20.4	0.6	6.0	152	26	
Baltic Proper	149,761	5,736	23.1	0.9	6.0	226	476	*52,335*
Gulf of Finland	0	0	25.9	0.9	4.3	156	32	
Gulf of Riga	0	0	35.8	1.2	2.9	257	12	
Danish Straits	0	0	22.7	0.9	5.8	214	10	
Kattegat	0	0	18.9	0.7	7.7	221	7	

Table 10

Russia	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	0	0	21.5	0.2	6.3	27	0	
Bothnian Sea	0	0	20.0	0.5	6.0	136	15	
Baltic Proper	4,340	148	22.4	0.9	6.0	193	424	
Gulf of Finland	23,183	1,007	26.7	0.9	4.4	163	22	43,544
Gulf of Riga	4,887	211	36.1	1.1	2.9	261	9	
Danish Straits	0	0	22.3	0.8	6.0	197	9	
Kattegat	0	0	18.7	0.7	7.8	214	6	

Table 11

Sweden	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	106	14	21.5	0.2	6.3	27	0	
Bothnian Sea	1,135	78	20	0.5	6	136	15	
Baltic Proper	6,212	428	22.4	0.8	6	192	421	43,075
Gulf of Finland	0	0	25.6	0.8	4.5	142	27	
Gulf of Riga	0	0	35.5	1.1	3	241	9	
Danish Straits	397	23	22.3	0.8	6	197	9	
Kattegat	3,334	294	18.8	0.7	7.7	216	6	

Table 12

All countries	Load reductions, tons		Nutrient concentrations, µmol		Secchi depth	Primary production	Nitrogen fixation	Hypoxic area
Basin	N	P	N	P	meters	g C m^2 yr^{-1}	tons N yr^{-1}	km^2
Bothnian Bay	1,118	117	21.6	0.2	5.9	31	0	
Bothnian Sea	2,376	138	21.1	0.6	5.4	181	47	
Baltic Proper	238,314	10,460	24.1	1.1	5.0	270	601	63,916
Gulf of Finland	37,882	1,901	27.9	1.0	3.9	215	34	
Gulf of Riga	55,304	2,933	43.1	1.8	2.2	505	19	
Danish Straits	2,394	214	23.4	1.0	5.6	242	13	
Kattegat	3,543	312	19.1	0.8	7.5	235	9	

Table 13