# Calculation of maximum allowable inputs and country-wise nutrient load reduction targets for the HELCOM Baltic Sea Action Plan revision 2013

Bo Gustafsson

bo.gustafsson@su.se
www.balticnest.org

Stockholm University

Baltic Nest Institute

## The bloom 2005 put the environment of the Baltic Sea on the political agenda

Stockholm University

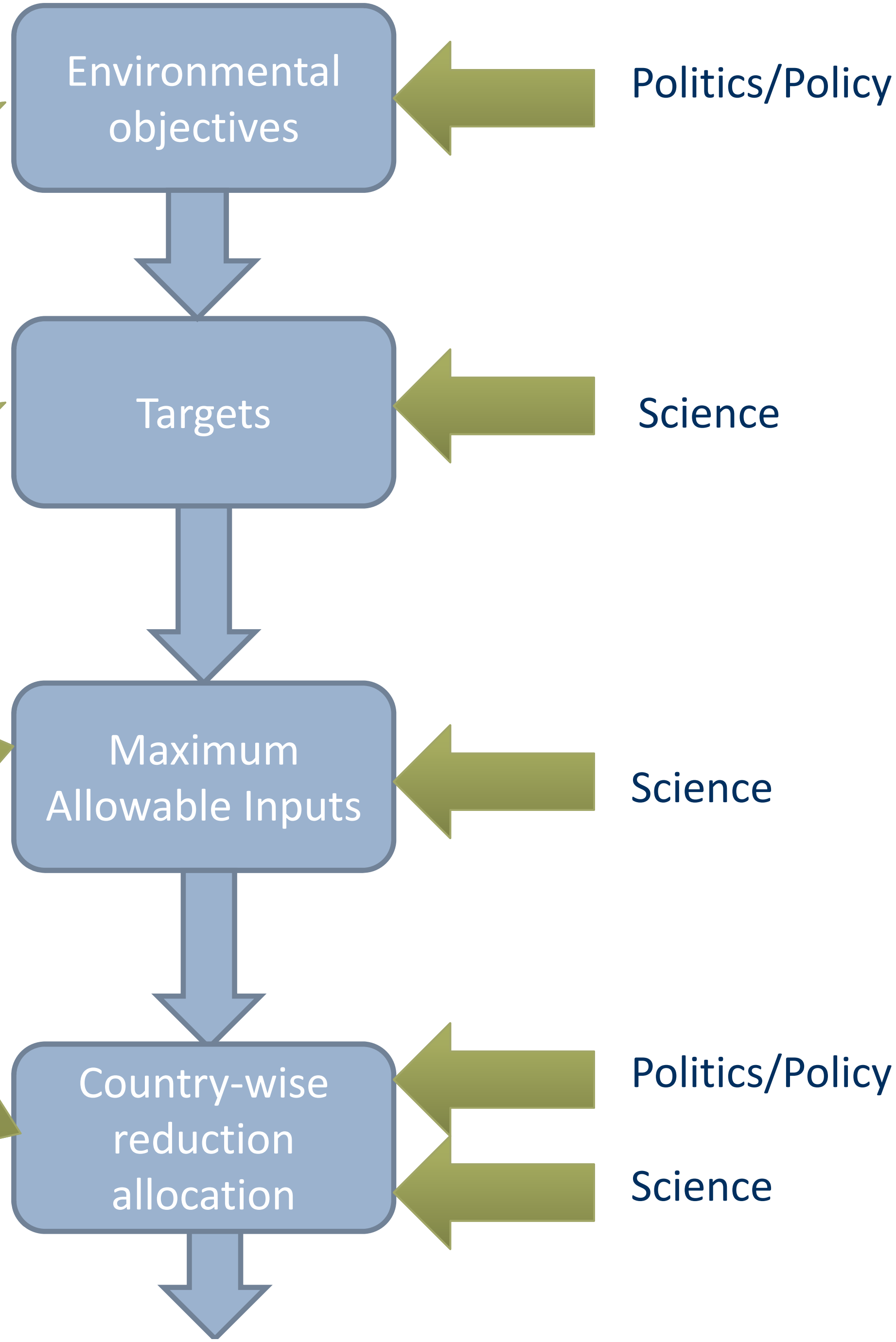
- HELCOM is the regional convention for the Baltic Sea environment
- In 2007, the environmental ministers of the Baltic countries signed the ambitions Baltic Sea Action Plan
- Among other things it contained:
  - *Maximum Allowable Loads* per basin
  - *Country-wise reduction targets*
- However, these were considered provisional and should be updated
- In practice, we redid the whole thing!

Baltic Nest Institute

# HELCOM EAM

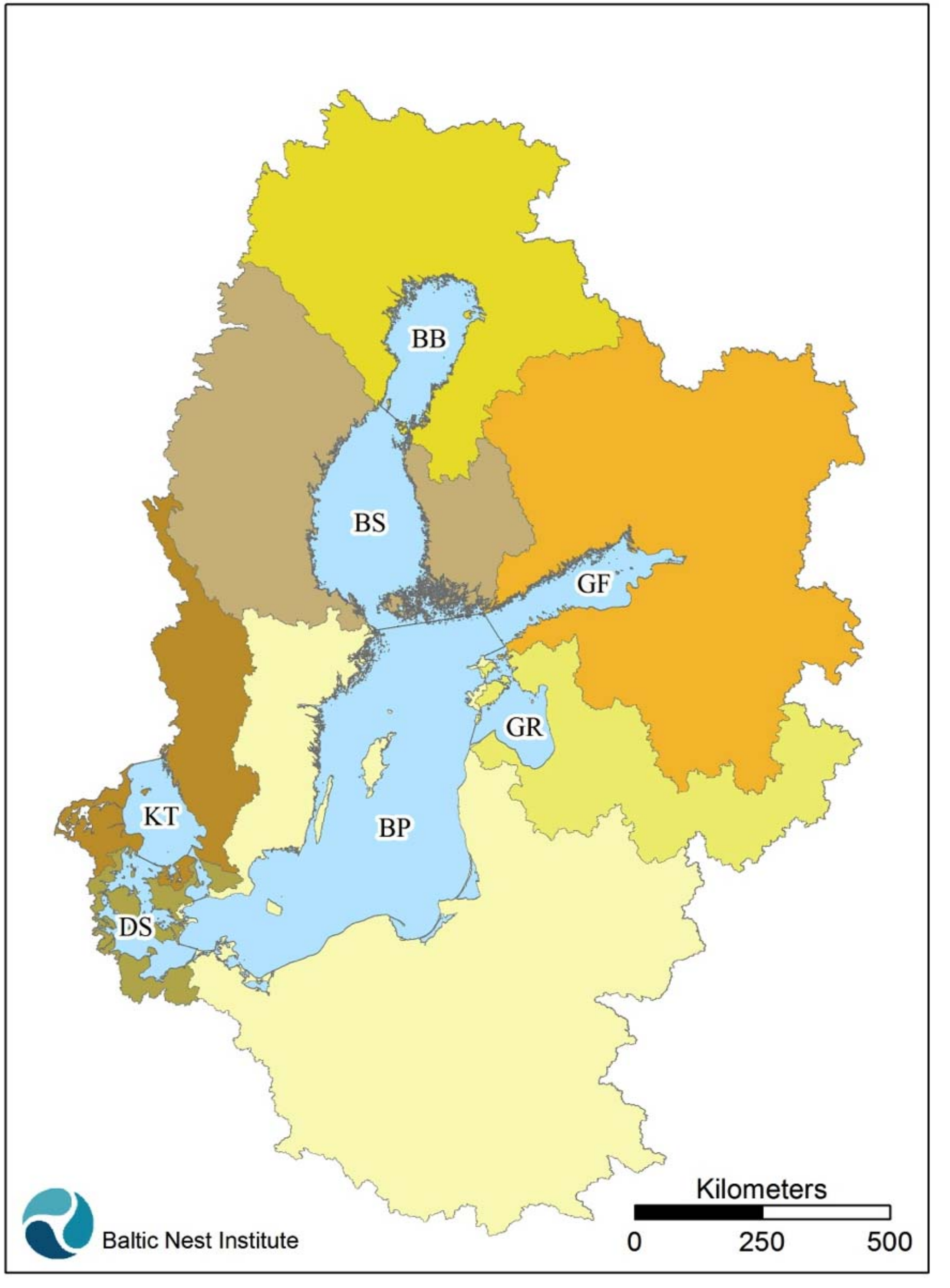
- ✓ Clear water
- ✓ Nutrient concentrations close to natural levels
- ✓ Natural occurrences of

| Country | Phosphorus |
|---|---|
| DK | 38 |
| EE | 320 |
| FI | 360 (330+30) |
| DE | 170 (110+60) |
| LV | 220 |
| LT | 1470 |
| PL | 7480 |
| RU | 3790 |
| SE | 530 |



# Resolution

Targets and MAI calculated on 7 basins




Baltic Nest Institute

# Environmental targets

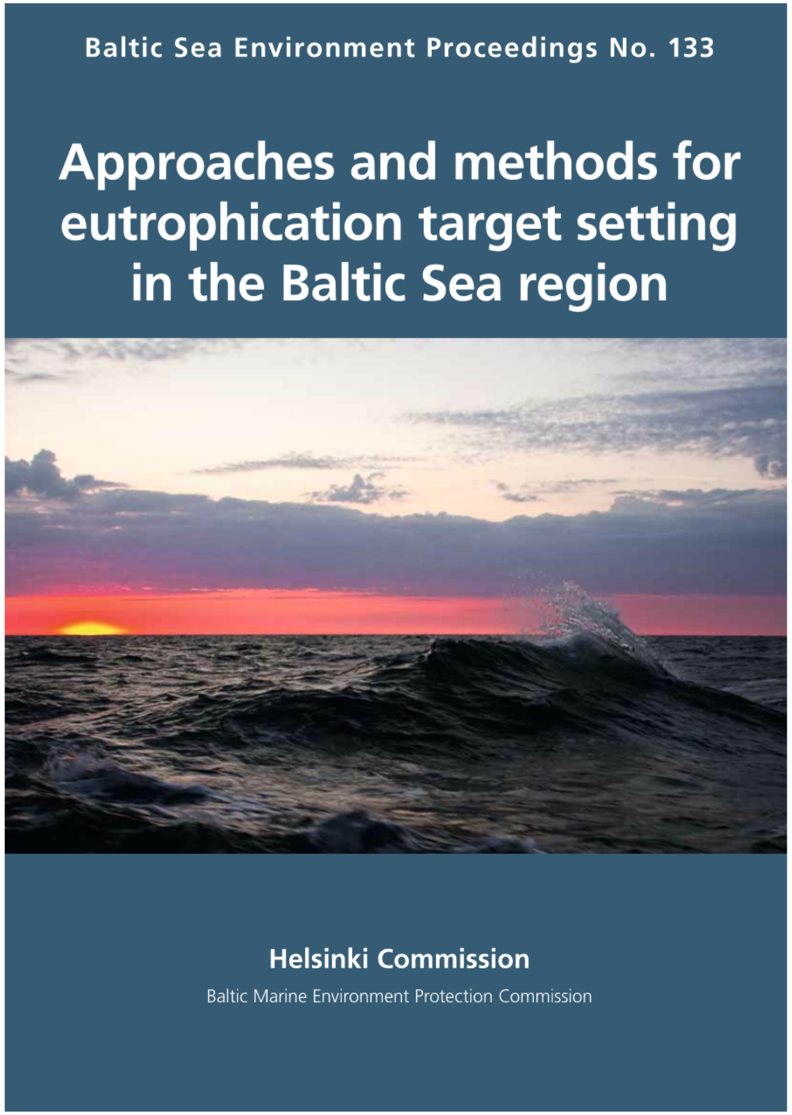
Stockholm University

An ambitious scientific foundation from the HELCOM TARGREV project

New targets on winter nutrient concentrations, summer Secchi depth and Chl-a concentration; plus targets on oxygen levels

| Basin | Winter | | Summer | |
|---|---|---|---|---|
| | DIN | DIP | Chl *a* | Secchi |
| KT | 5.0 | 0.49 | 1.5 | 7.6 |
| DS | 5.0 | 0.56 | 1.9 | 7.8 |
| BP | 2.6 | 0.30 | 1.7 | 7.4 |
| BS | 2.8 | 0.19 | 1.5 | 6.8 |
| BB | 5.2 | 0.07 | 2.0 | 5.8 |
| GR | 5.2 | 0.41 | 2.7 | 5.0 |
| GF | 3.8 | 0.59 | 2.0 | 5.5 |

+ targets on oxygen




Baltic Nest Institute

# Method to determine Maximum Allowable Inputs

Stockholm University

Question to be answered is:

*What combination of loads to the basins satisfies both targets and provides the maximal loads? -> optimization problem*

1. Determine relationships between loads and indicator response from a large amount (1000nds) of cleverly chosen model simulations
2. Find the solution to the optimization problem from the data base of relationships

Additional constrains that need to be considered are: model limitations and ecological relevance

Baltic Nest Institute

# BAltic sea Long-Term large-Scale Eutrophication Model

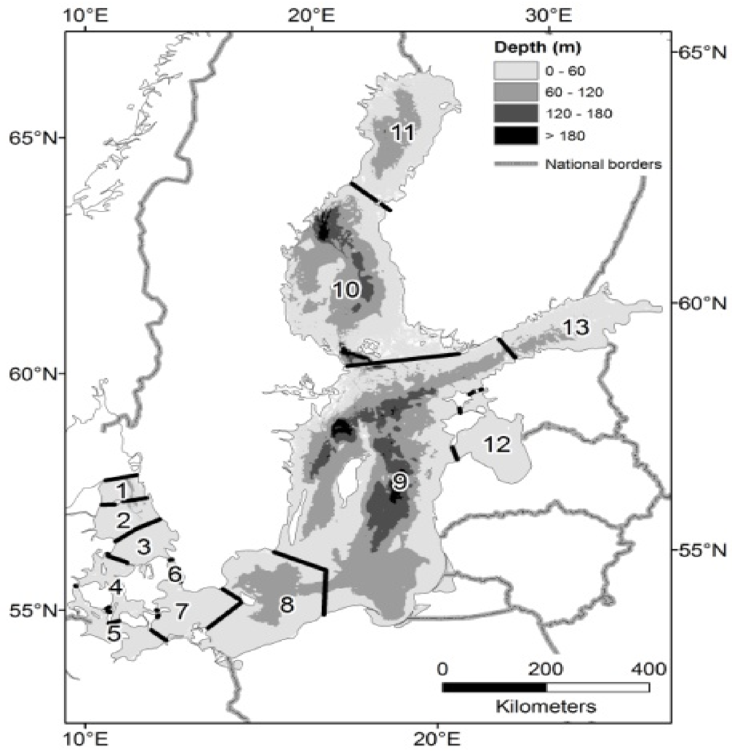
Main characteristics:

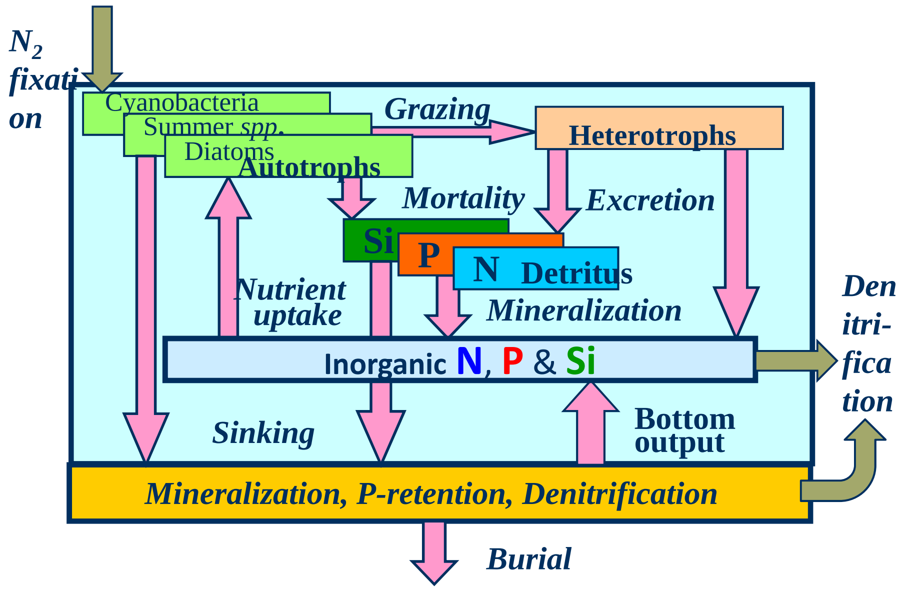
- 13 sub-basins
- High vertical resolution
- Full circulation dynamics
- Mechanistic biogeochemical cycles including sediments
- Forced by meteorology, river runoff and boundary conditions to the Skagerrak
- And nutrient loads from Land and Air
- Typical simulation times on a high-end workstation 200 simulation years in 30 - 60 minutes

Publically available to run on-line in Nest:

http://www.balticnest.org/nest

Baltic Nest Institute

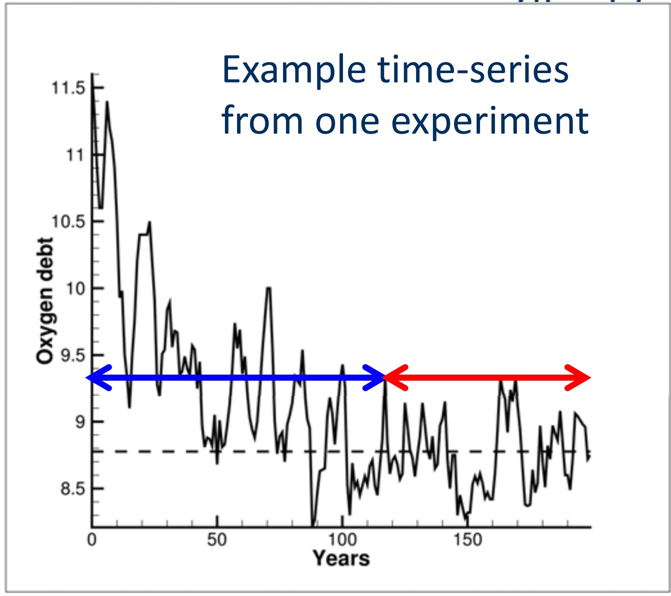


# Spin-up and evaluation period

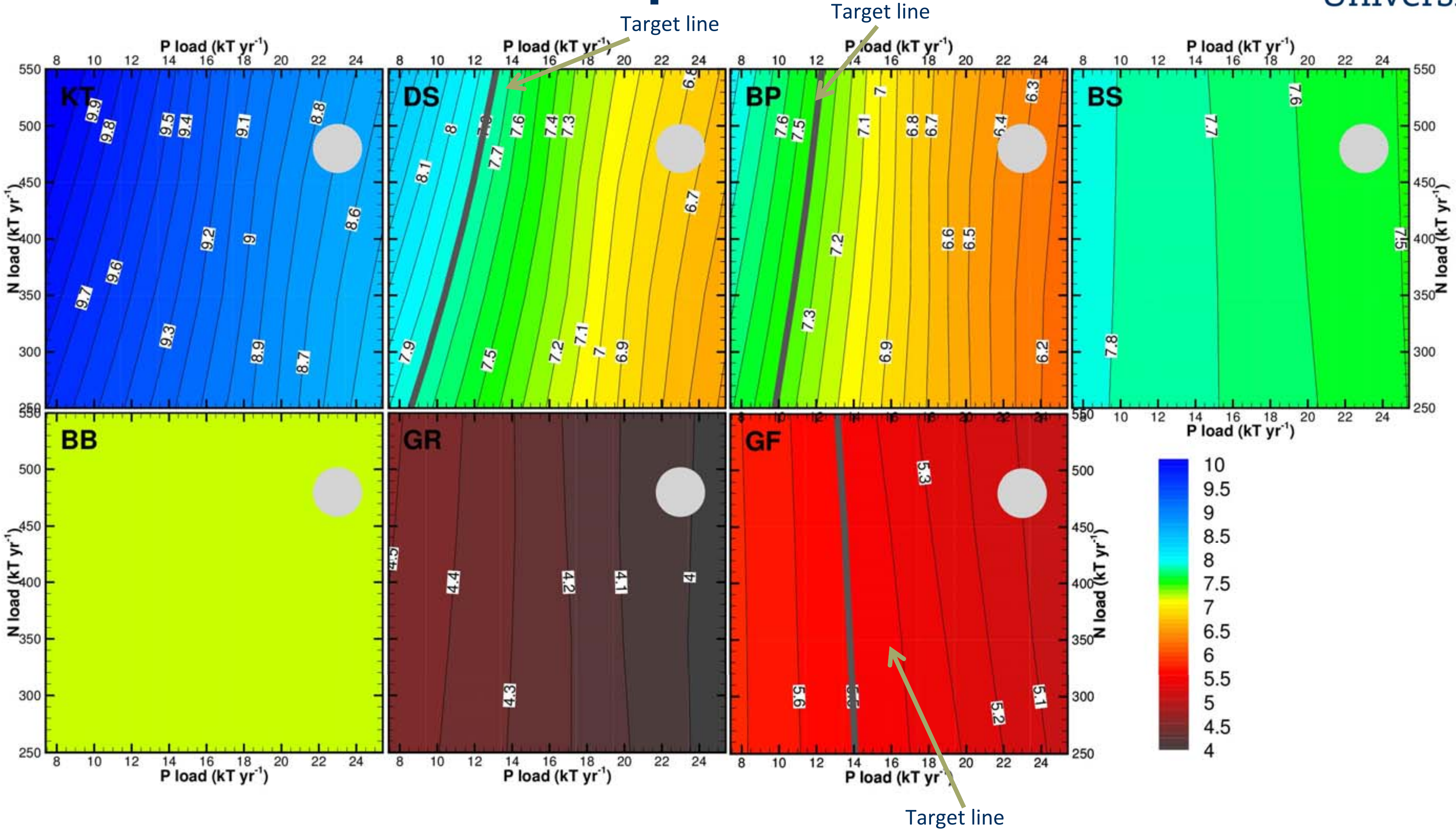
- Run the model with synthetic forcing:
  - constant climate – varying weather
  - Runs are 200 yrs long
  - Based on weather variations 1850-2009
  - First 125 yrs is spin-up and final 75 yrs is evaluation period

- Run systematically the model with various combinations of loads to the different basins and the results are combined into pressure-response relationships for the indicators




Baltic Nest Institute

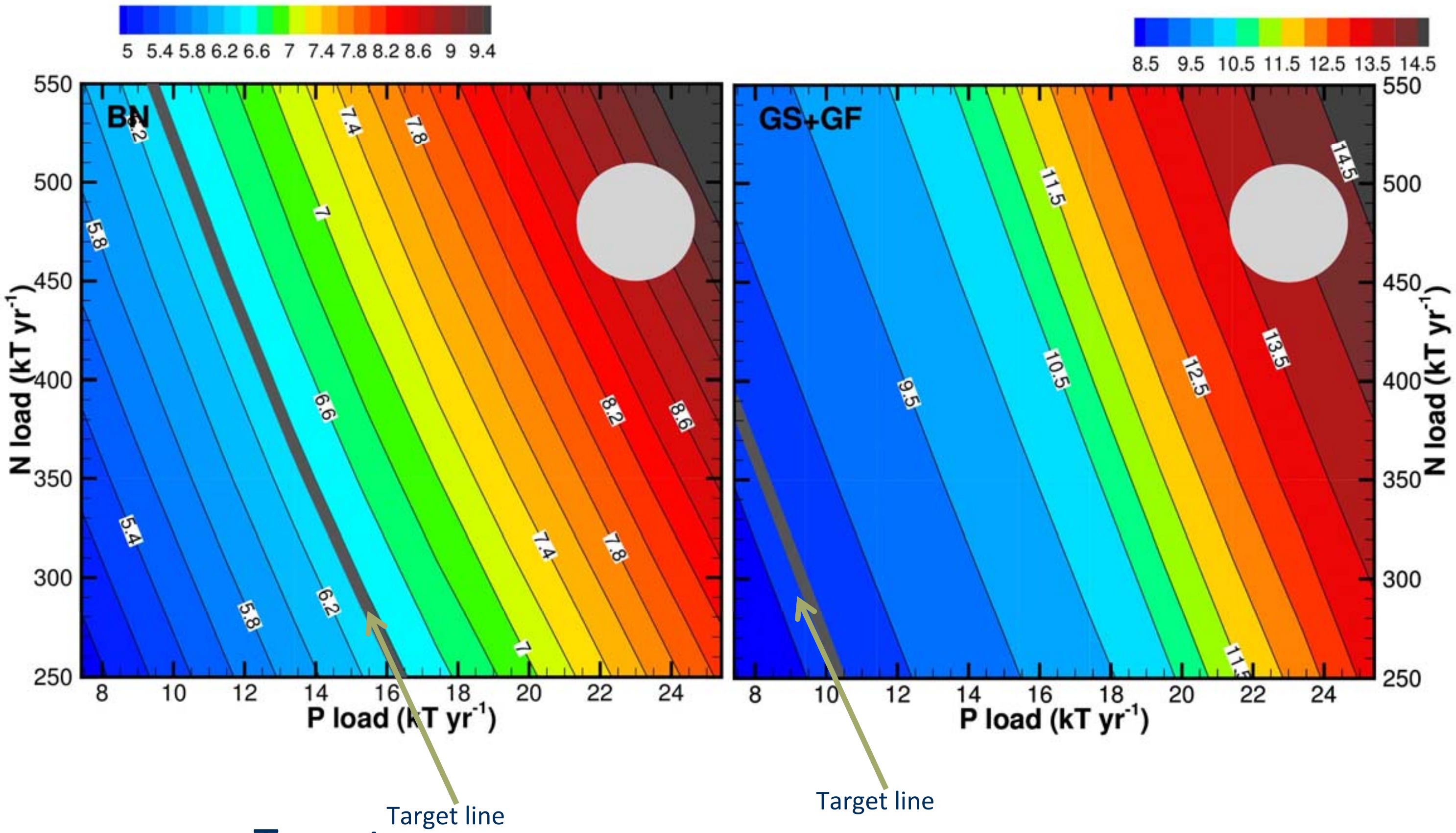
# Principle from simple example: Varying loads to Baltic proper only Summer Secchi depth




Stockholm University

Baltic Nest Institute

# Varying loads to Baltic proper only
# Oxygen debt




Targets:

GS+GF = 8.66 mg $l^{-1}$

BN = 6.37 mg $l^{-1}$

## The sensitivity experiment shows that:

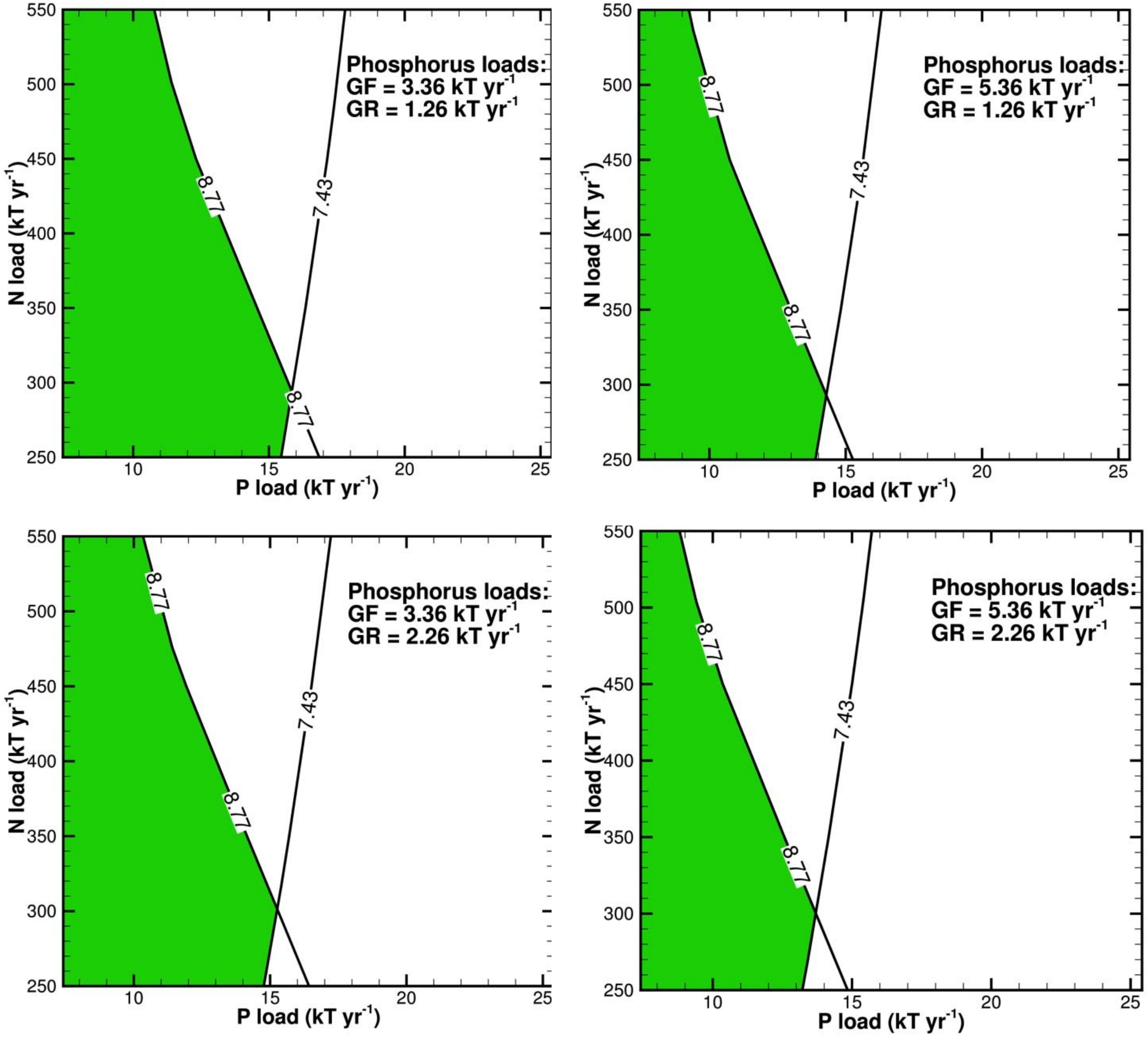
- Phosphorus is transported between the basins, while nitrogen loads affect conditions more locally
- Effects of load changes in the Gulf of Bothnia and Kattegat/Danish Straits have little effect on other basins
- Primary targets (summer Secchi and O2 debt) can be met by load reductions to Baltic proper alone or in different combinations of loads to BP, GF and GR
- However, even though primary targets are reached secondary targets are violated

# Finding optimal solution:

1. Make systematic test of simultaneous load changes to Baltic proper (both N and P), and P to Gulf of Finland and Gulf of Riga
2. Considering the target variables
   1. Summer Secchi
   2. O2 debt
   3. Winter DIN (in BP) and DIP (in BP, GR and GF)
3. Check under what conditions targets are satisfied
4. Find the maximal sum of the phosphorus loads to the three basins that still satisfies targets
5. Investigate individually MAI for N in GR and GF; and for N and P in remaining basins

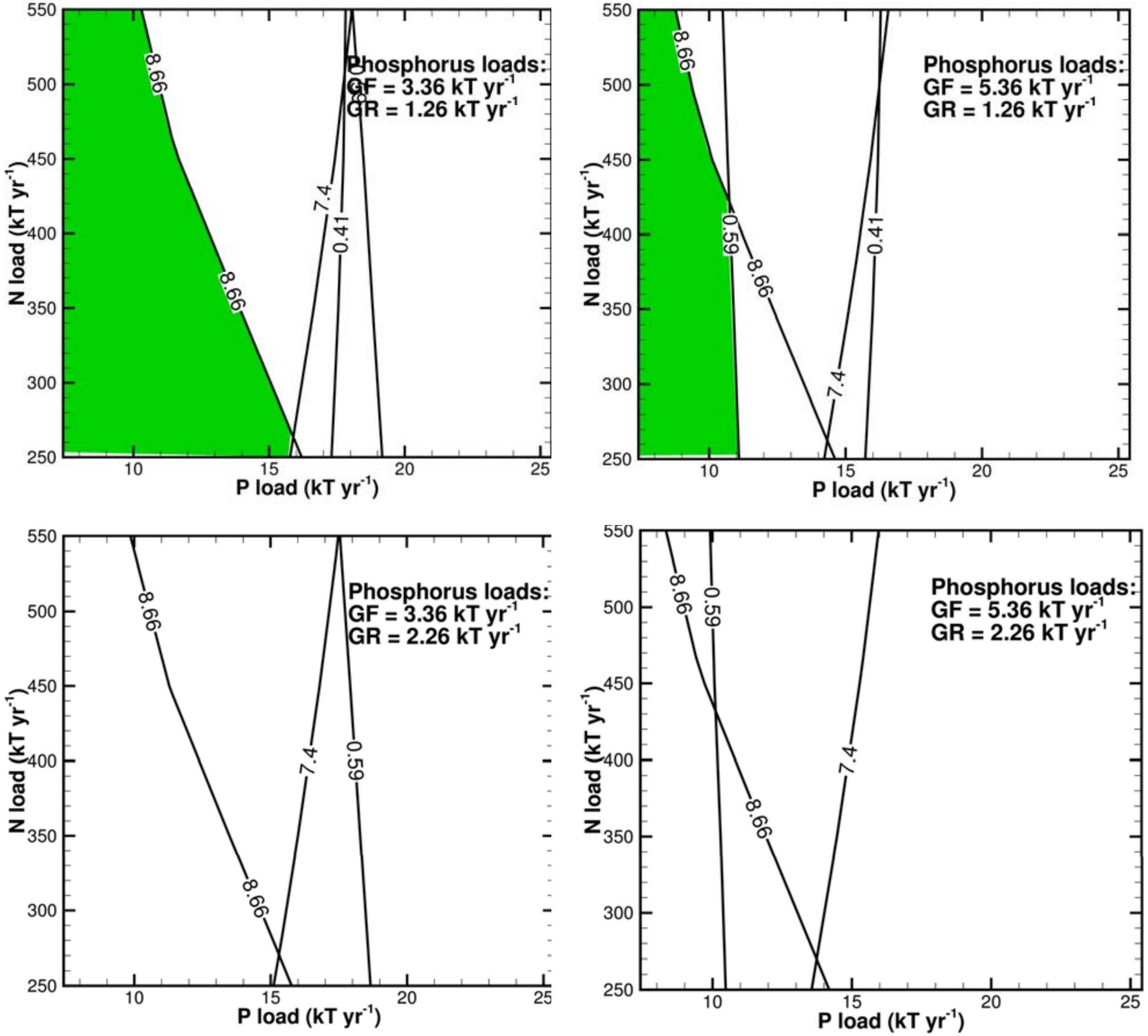
# Example: Loads that satisfies primary targets in green

Stockholm University




Baltic Institute

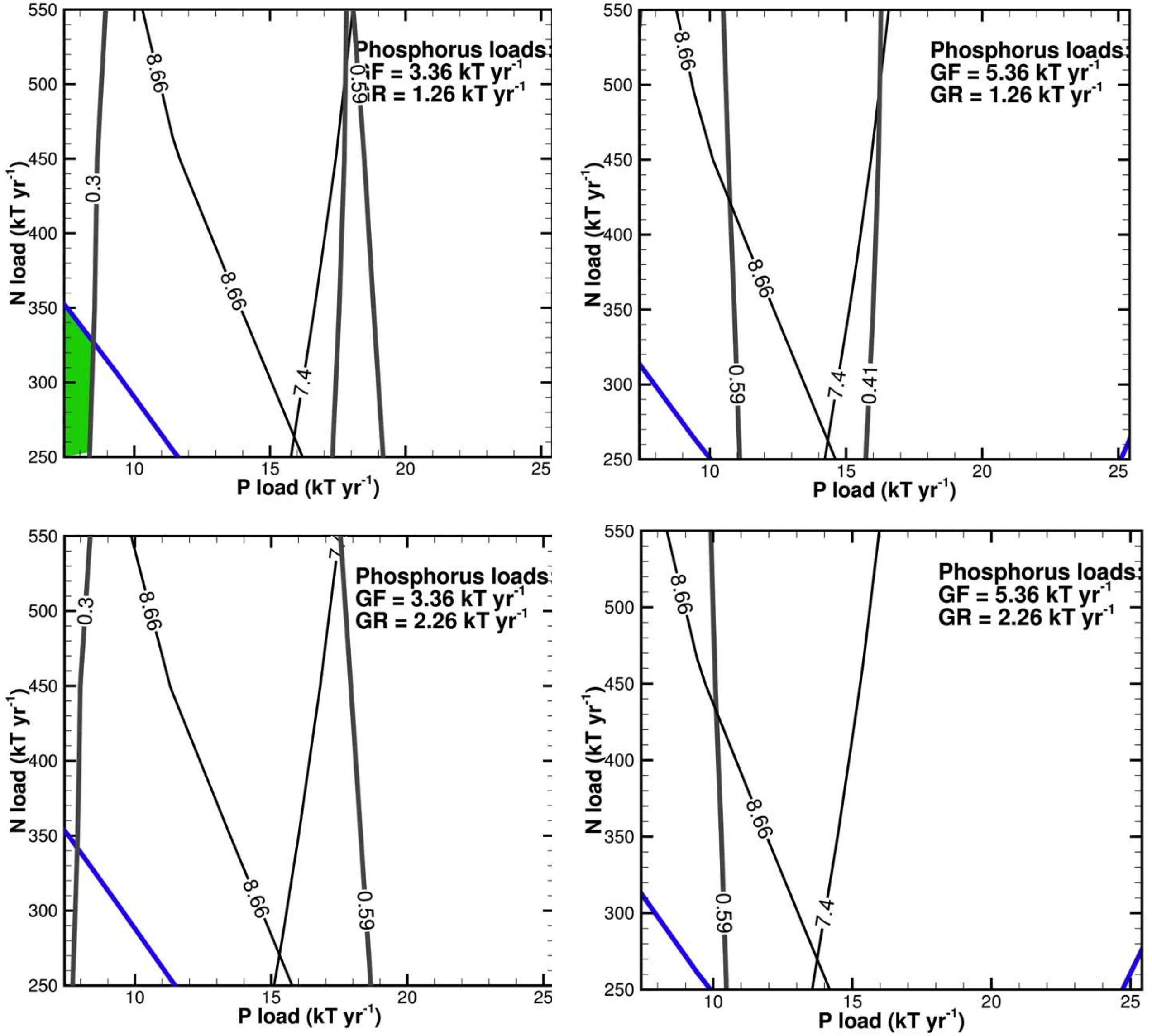
# Adding constrain of winter DIP targets in GR (0.41 μM) and GF (0.59 μM)



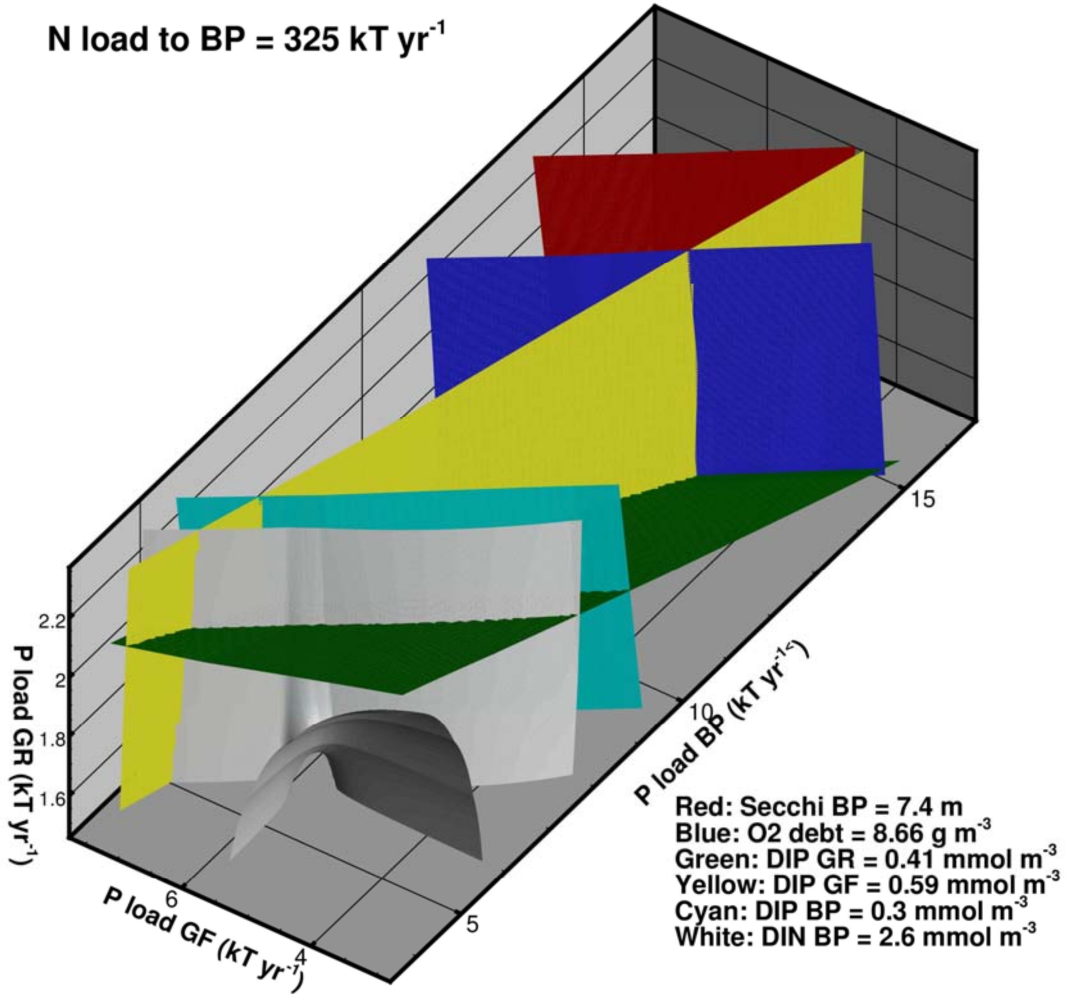

Stockholm University

Baltic Institute

# Adding constrain of winter DIP and DIN targets in BP



# Example of isosurfaces of targets




Stockholm University

Baltic Nest Institute

# Maximum allowable inputs and needed reductions

**WE RECOGNIZE** that the revised Maximum Allowable Inputs represent best available scientific knowledge base and data, and characterize the HELCOM long-term vision of the Baltic Sea unaffected by eutrophication that we aspire;

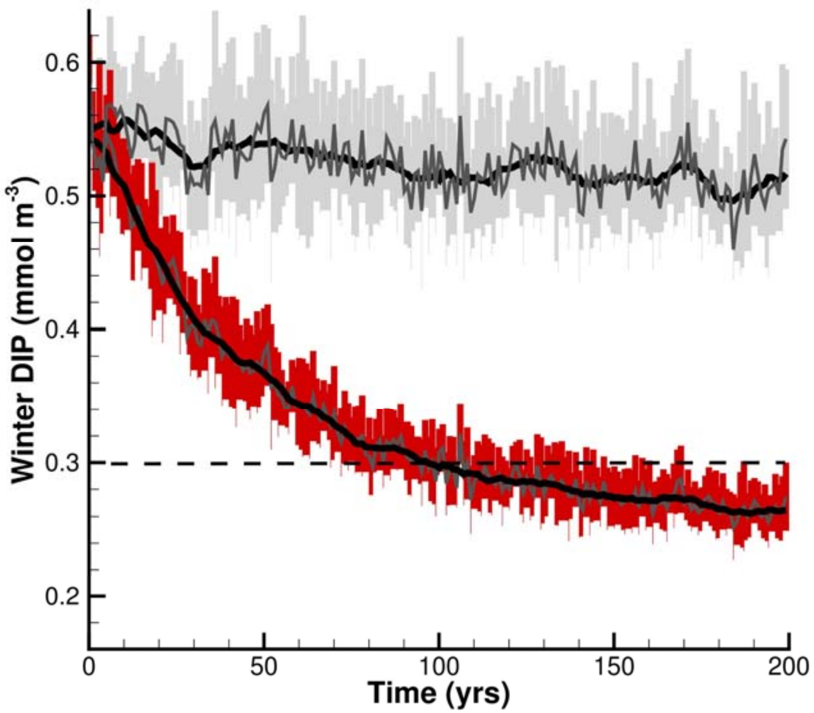
| Baltic Sea Sub-basin | Maximum Allowable Inputs | | Reference inputs | | Needed reductions | |
|---|---|---|---|---|---|---|
| | TN tons | TP tons | TN tons | TP tons | TN tons | TP tons |
| Kattegat | 74,000 | 1,687 | 78,761 | 1,687 | 4,761 | 0 |
| Danish Straits | 65,998 | 1,601 | 65,998 | 1,601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

# When will Baltic Sea be healthy?

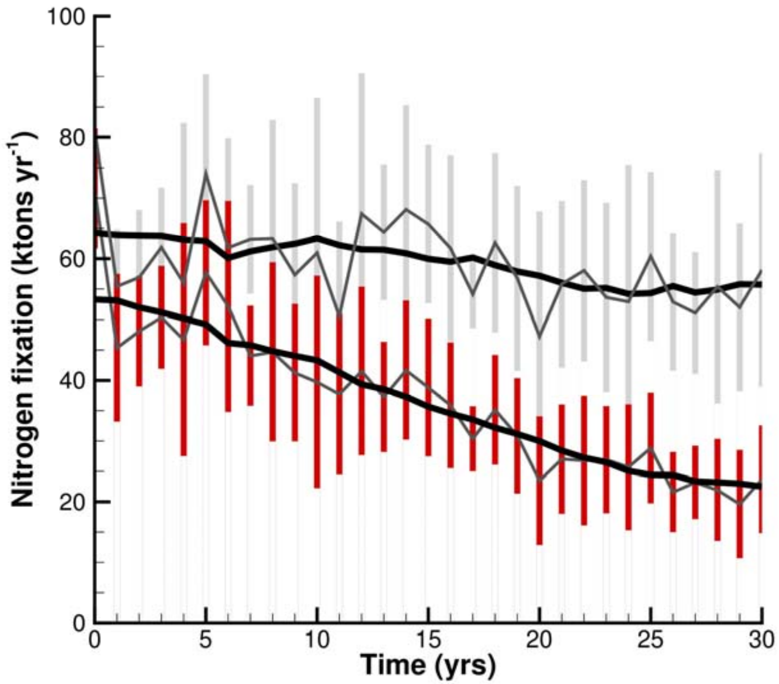
Long time before targets are reached (up to 100 years)
Significant improvement within decades, perhaps even shorter

Stockholm University

Winter DIP in Baltic Proper




Nitrogen fixation in Gulf of Finland




MAI is implemented year 0

An ensemble of 10 runs with different weather indicates variability

Red: MAI, Grey: Reference inputs

Baltic Nest Institute

# Country allocated reduction targets - CART

Stockholm University

**WE STRESS** that the achievement of good environmental status in relation to eutrophication in the Baltic Sea also relies on additional reduction efforts by non-Contracting Parties as follows:

- 18720 tons of airborne nitrogen from non-Contracting Parties assuming full implementation of the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone of the UNECE Convention on Long-range Transboundary Air Pollution until 2020;
- 3230 tons of waterborne nitrogen and 800 tons of waterborne phosphorus from non-Contracting Parties assuming that they take the same responsibility to reduce as the Contracting Parties,

**RECALLING** the decision of the Moscow Ministerial Meeting on reduction of air-borne nitrogen pollution from shipping which will lead to the reduction of 6930 tons on nitrogen over thirty years **WE ALSO STRESS** that the achievement of good environmental status in relation to eutrophication in the Baltic Sea also relies on additional reduction efforts by shipping;

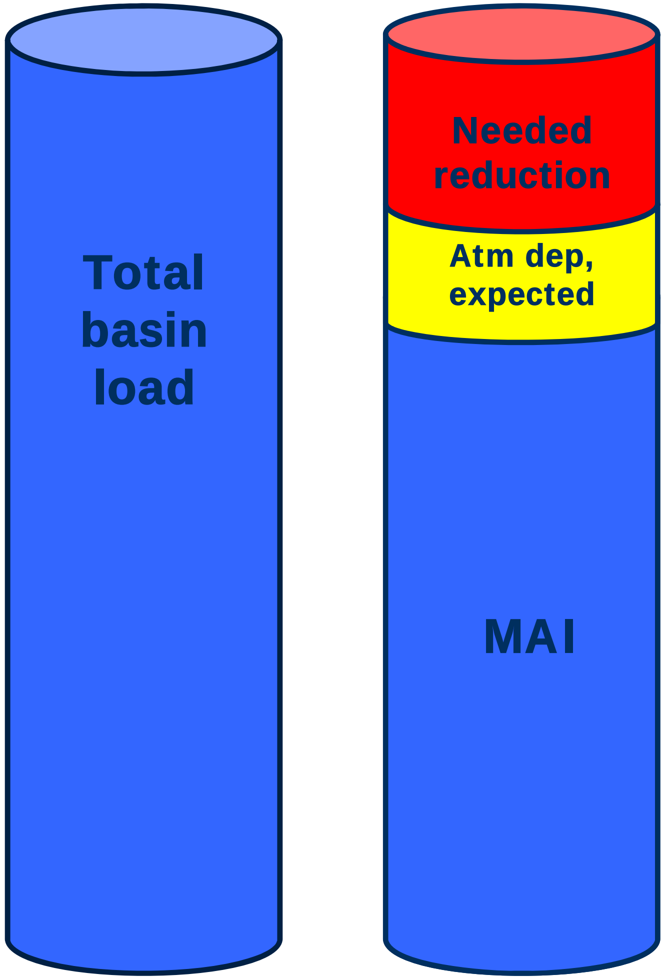
## Expected reductions from Gothenburg protocol as calculated by EMEP

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

Baltic Nest Institute

**Needed reduction** given by the difference between the **total loads** to the basin and the **MAI** plus **expected reductions** from non-HELCOM

With expected reductions




**Example BAP Nitrogen**

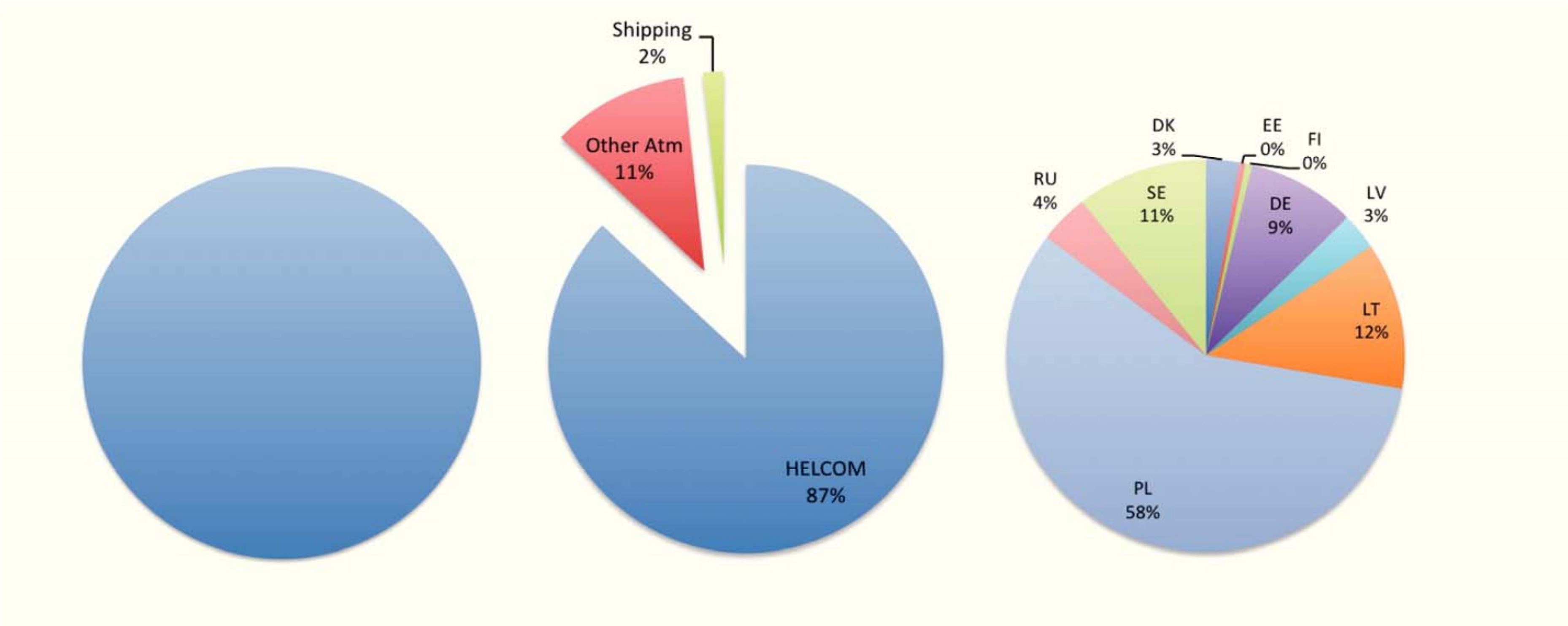
Total input = 423,921
MAI = 325,000
Total needed reduction= 98,921
Expected reduction from implementation of Gothenburg protocol = 14725
Expected reduction on shipping = 5735
Remaining needed reduction = 78461

Stockholm University

Baltic Nest Institute

# Allocation principles
## How the shares on inputs from different Contracting Parties to a Baltic Sea sub-basin are determined

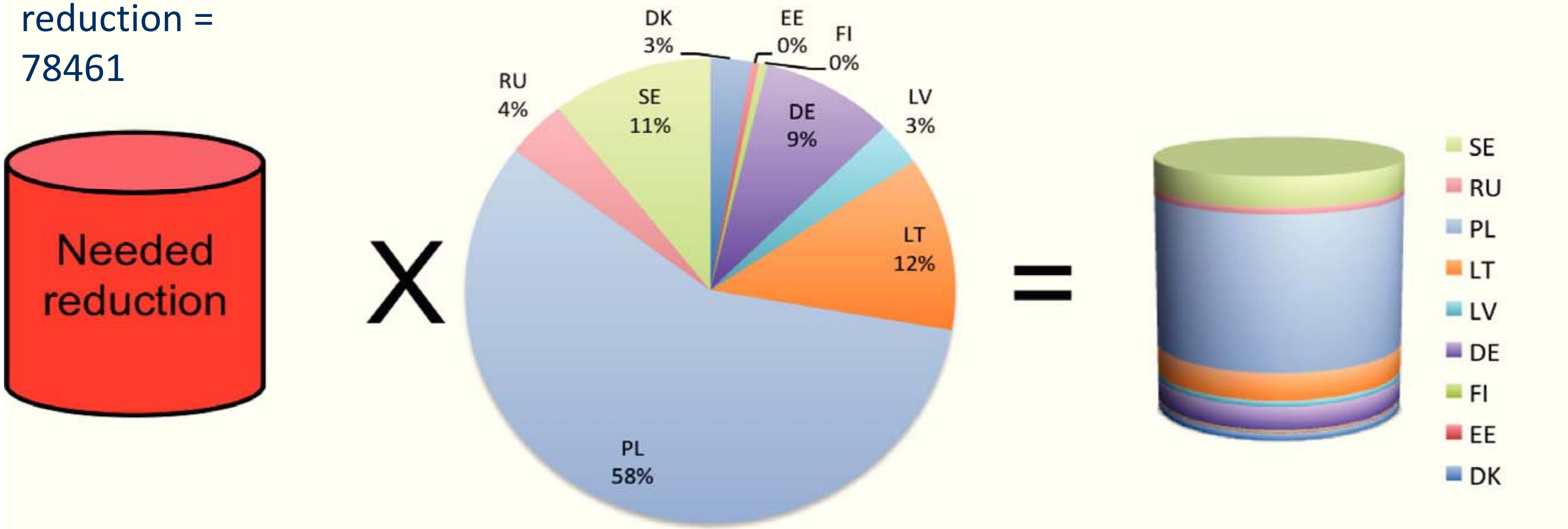
### Example Nitrogen Baltic proper




Baltic Nest Institute

# The country-wise reduction is determined by the share of the inputs (polluter pays principle) for each basin and nutrient

Remaining needed reduction = 78461




Example: Poland

*78461x58% = 45178 ton/yr*

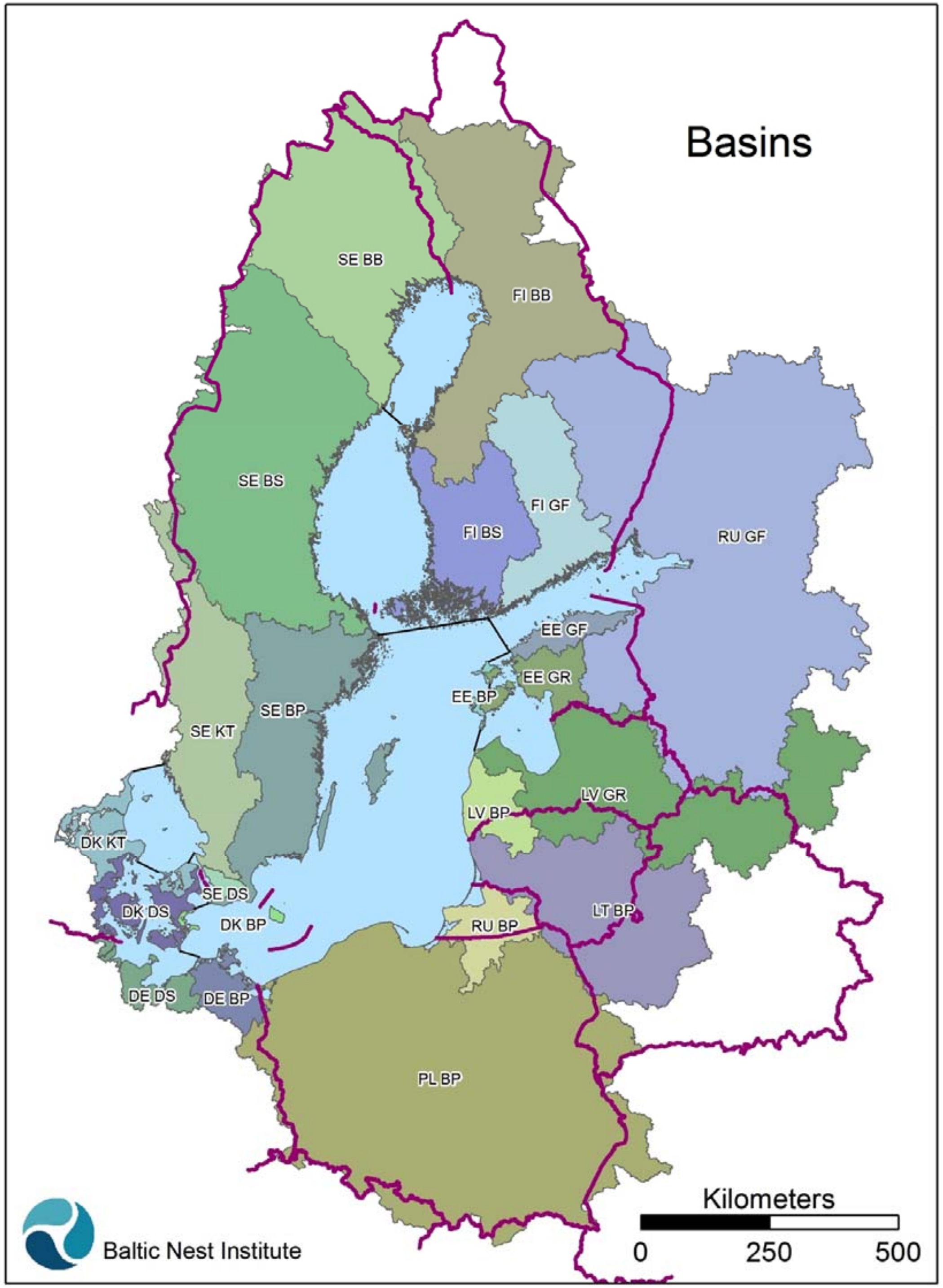
Stockholm University

Baltic Nest Institute

# The "Country-basin" catchments

- Inputs are primarily assigned to the country doing the monitoring (owning the river mouth)
- Major rivers carry nutrients from upstream countries (transboundary inputs)

The fulfillment of reduction requirements may therefore be shared with the countries upstream




Baltic Nest Institute

# Transboundary waterborne reference data

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

# End result are tables with detailed Country by basin reduction requirements

## Example: Nitrogen Baltic proper

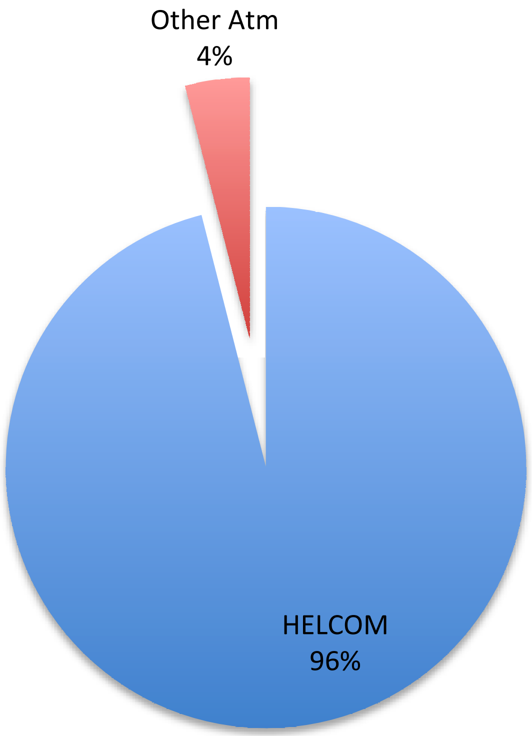
| **Nitrogen Baltic proper** | **Country by basin reduction before deduction transboundary shares** | **Transboundary shares** | | **CART** |
|---|---|---|---|---|
| | | **HELCOM countries** | **Non-HELCOM countries** | |
| DK | 2136 | | | 2136 |
| EE | 382 | | | 382 |
| FI | 424 | | | 424 |
| DE | 6922 | 497 | | 7419 |
| LV | 2360 | -715 | | 1645 |
| LT | 9550 | 715 | -1330 | 8935 |
| PL | 45178 | 158 | -1900 | 43436 |
| RU | 3153 | -655 | | 2498 |
| SE | 8356 | | | 8356 |
| *Gothenburg Protocol expected reduction in non Contracting parties* | *14725* | | | *14725* |
| *Expected reduction from shipping* | *5735* | | | *5735* |
| *BY* | | | *1977* | *1977* |
| *CZ* | | | *727* | *727* |
| *UA* | | | *526* | *526* |
| **Sum** | **98921** | **0** | **0** | **98921** |

Stockholm University

Baltic Nest Institute

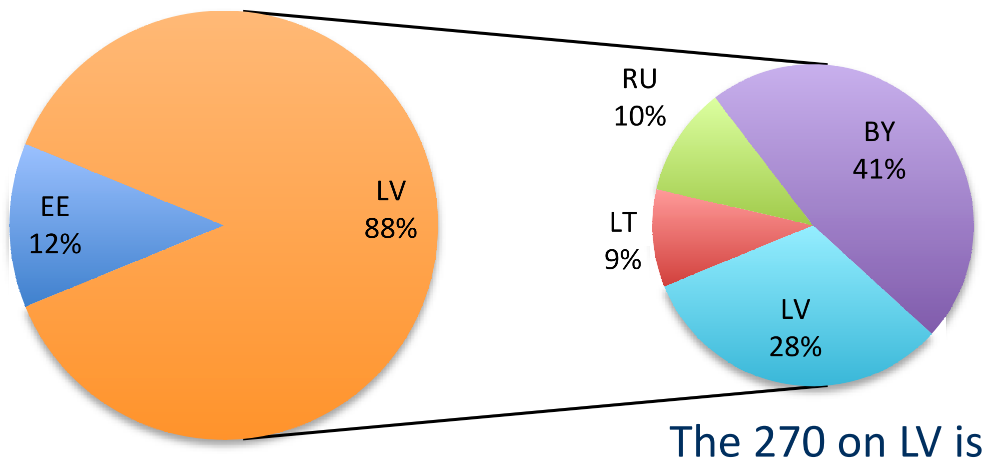
# Allocation also on non-HELCOM countries Example GOR Phosphorus

Before allocation only atmospheric P load is subtracted.




CART: The reduction is shared between the coastal states, EE and LV

Transboundary sharing among both CPs and BY of LV's reduction requirement




Needed reduction 308 ton
LV = 270
EE =38

The 270 on LV is shared
LV = 86
LT = 26
RU = 30
BY = 128

Baltic Nest Institute

Stockholm University

# Phosphorus

| Phosphorus | CART | Sharing CP | Sharing Non-CP | Obligation |
|---|---|---|---|---|
| DK | 38 | | | 38 |
| EE | 321 | | | 321 |
| FI | 338 | 26 | | 364 |
| DE | 111 | 64 | | 175 |
| LV | 441 | -98 | -128 | 215 |
| LT | 1672 | 68 | -272 | 1468 |
| PL | 7810 | 64 | -397 | 7477 |
| RU | 3911 | -124 | | 3787 |
| SE | 535 | | | 535 |
| *Other water* | | | *797* | *797* |
| **Sum** | **15177** | **0** | **0** | **15177** |

Numbers for Min. Declaration

# Nitrogen

| Nitrogen | CART | Sharing CP | Sharing Non-CP | Obligation |
|---|---|---|---|---|
| DK | 2886 | | | 2886 |
| EE | 1801 | | | 1801 |
| FI | 2430 | 599 | | 3029 |
| DE | 7166 | 497 | | 7663 |
| LV | 2384 | -715 | | 1669 |
| LT | 9584 | 715 | -1330 | 8969 |
| PL | 45352 | 158 | -1900 | 43610 |
| RU | 11635 | -1254 | | 10381 |
| SE | 9245 | | | 9245 |
| *Exp. Got. Prot* | *18722* | | | *18722* |
| *Exp. BAS* | *6929* | | | *6929* |
| *Other water* | | | *3230* | *3230* |
| **Sum** | **118134** | **0** | **0** | **118134** |

Baltic Nest Institute

# New aspect

Stockholm University

**RECOGNIZING** that reductions in nutrient inputs in sub-basins may have wide-spread effects, **WE AGREE** that extra reductions can be accounted for, in proportion to the effect on a neighboring basin with reduction targets, by the countries in reaching their Country Allocated Reduction Targets;

## Indications from BALTSEM results on P

| | | Gives the effect of 1 ton/yr direct reduction in these basins | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | KT | DS | BP | BS | BB | GR | GF |
| Reduction of X tons/yr in these basins | KT | 1.0 | 4.0 | 11.2 | 51.9 | - | 214.2 | 42.5 |
| | DS | 0.8 | 1.0 | 3.2 | 11.9 | 26.7 | 49.2 | 11.7 |
| | BP | 2.4 | 2.8 | 1.0 | 3.3 | 7.7 | 13.6 | 3.8 |
| | BS | 3.8 | 4.6 | 1.5 | 1.0 | 2.6 | 18.3 | 5.8 |
| | BB | 24.6 | 26.2 | 9.0 | 8.3 | 1.0 | 103.4 | 35.2 |
| | GR | 3.6 | 4.3 | 1.6 | 4.8 | 13.8 | 1.0 | 6.5 |
| | GF | 3.6 | 4.2 | 1.3 | 4.1 | 10.0 | 17.0 | 1.0 |

Baltic Nest Institute

# Future outlook

- Complementary objectives and targets on specific time-scales would be beneficial and also a prerequisite for handling climate change
- Insufficient data and models are available for a true “fair” or optimal sharing of the reduction requirements
- Only offshore is considered: Lacks coupling to regional/coastal perspective

# Lessons learnt!

Stockholm University

Prerequisites for success are (especially when many states are involved):

1. A solid general acceptance for methods and models in the scientific community in the involved countries (e.g., model intercomparison projects etc.)
2. Acceptance has to be acquired on the expert/civil servant level in the countries (they will take advice from the national scientists)
3. Humbleness towards the political process towards the end. There will be political compromise that may not be 100% in accordance with the scientific advice.

Naturally, there has to exist some forum or framework for the interaction necessary.

Baltic Nest Institute

# Some background documents are available on the HELCOM web-site (www.helcom.fi)

HELCOM MINISTERIAL MEETING COPENHAGEN 3 OCTOBER 2013

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

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

HELCOM

**Baltic Marine Environment Protection Commission**

Baltic Sea Environment Proceedings No. 141

## Review of the Fifth Baltic Sea Pollution Load Compilation for the 2013 HELCOM Ministerial Meeting

**Helsinki Commission**

Baltic Marine Environment Protection Commission

Stockholms Universitet

Stockholm University

Baltic Nest Institute

**The final technical report will be available in the BNI technical report series (www.balticnest.org)**