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Science for a better future of the Baltic Sea region

Eutrophication:

the major environmental concern in the Baltic Sea

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ISECA Final Event, Boulgne-sur-Mer, 30 June 1 July 2014

Participation supported by iseca

Information System on the Eutrophication of our Coastal Areas


Picture credit: Jeff Schmaltz, NASA Aqua-MODIS
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This contribution is based on the outcomes of the BONUS+ projects ECOSUPPORT, HYPER and RECOCA as well as on the assesssments carried out by Baltic Marine Environment Protection Commission (HELCOM).
Other BONUS finished projects addressing eutrophication-related issues are AMBER, BALTIC-C, BALTIC GAS, IBAM, INFLOW, RISKGOV, PROBALT.
Synthesys of outcomes of these and other BONUS projects are published in AMBIO Vol.43, Issue 1, February 2014 and in BONUSPORTAL http://www.bonusportal.org/bonus_projects

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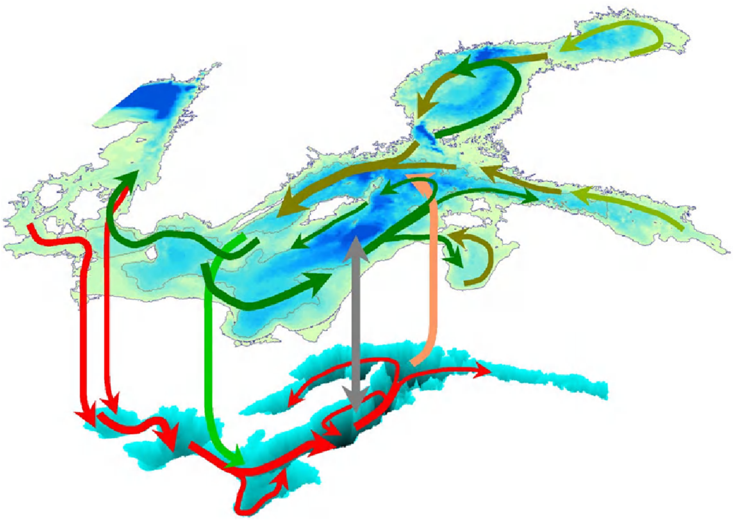
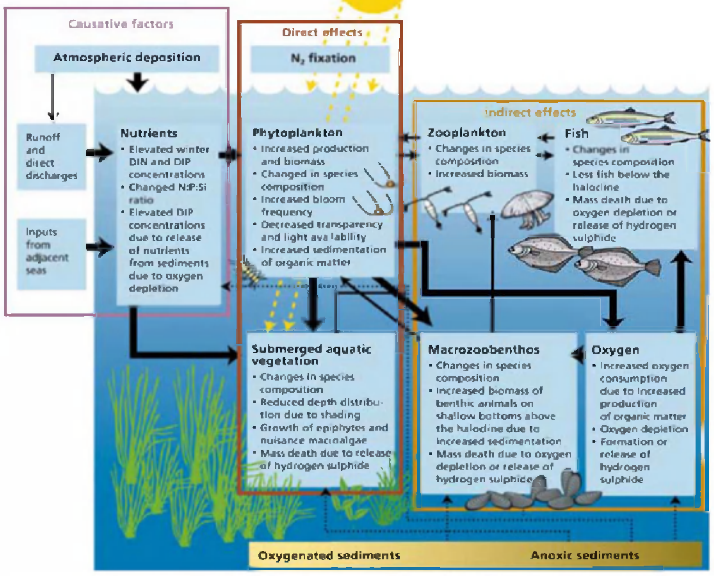
A bit of basics...



Baltic thermohaline circulation (Elken & Matthäus, 2008)

Juri Elken and Wolfgang Matthaus: The BACC book

A bit of basics...



Conceptual model of eutrophication (HELCOM, 2010).
The arrows indicate the interactions between different ecological compartments.

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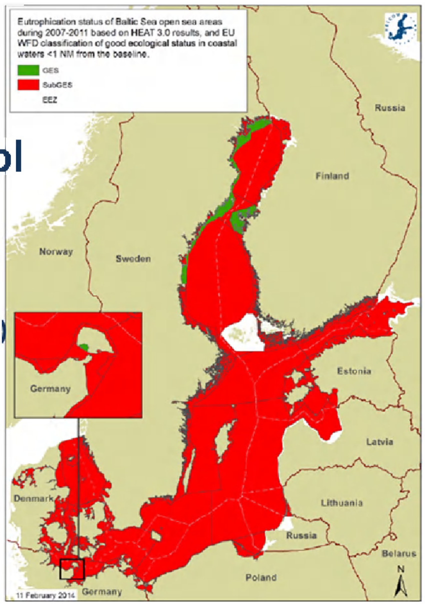
Is the Baltic Sea (really) so heavily eutrophied?

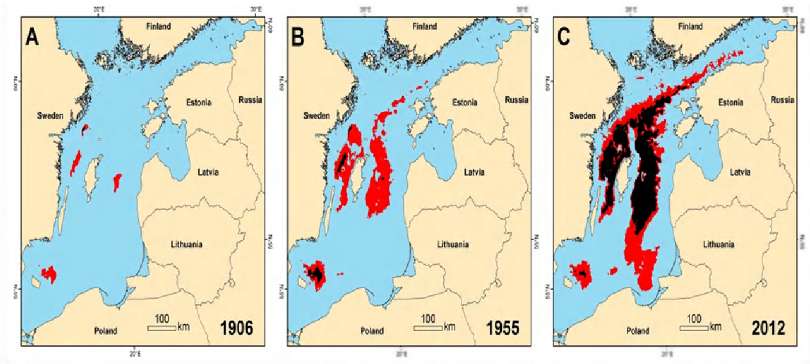
HEAT 3.0 assessment tool

Indicators
Winter DIN
Winter DIP
Chl α
Transparency (Secchi depth)
Oxygen debt



Eutrophication status in 2007-2011, all the open Baltic Sea sub-basins (HELCOM, 2014).

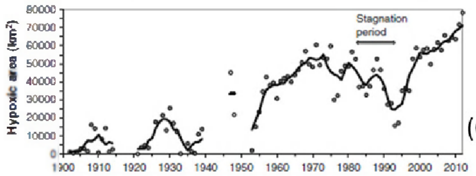
Is the Baltic Sea (really) so heavily eutrophied?



10x increase of low-oxygen areas!

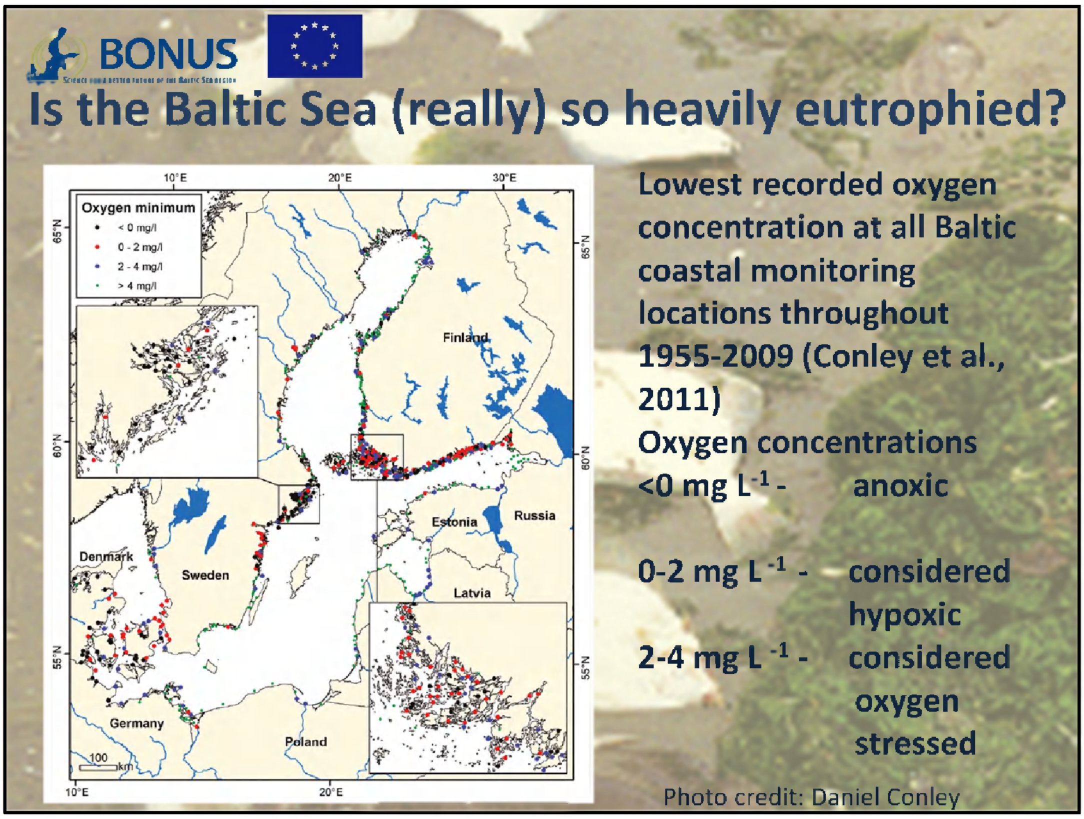
8(N)-25(P)% due to nutrient input!

Areas with low oxygen content (red) or no oxygen (black) in the Baltic Sea in 1906, 1955, 2012 (Carstensen et al. 2014). Estimated bottom oxygen concentrations <2 $mg \cdot L^{-1}$ are shown in red, and concentrations <0 $mg \cdot L^{-1}$ are shown in black.



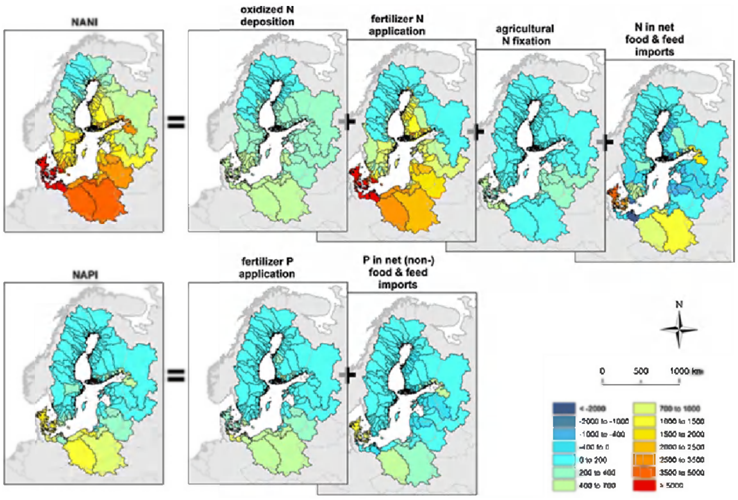
(Carstensen et al., 2014)

In the end of 2013 (on line version) J.Carstensen and D.Conley, B. Gustafsson (BONUS+ HYPER and ECOSSUPORT) togather with J.Andersen (HELCOM TARGREV) published a proof that the oxygen depletion zone in the deeper part of Baltic has increased more than 10 times since early 20th century (PNAS). It has grown from about 5,000 km^2 in 1900 to more than 60,000 km^2 in recent years.
The lower graph from AMBIO special BONUS synthesis issue illustrates that although oscilating due to periodic inflows and stagnation periods, it has been a steady dynamic sunce the early 1900ies.
Photo in the background is by Heye Ruhmor of Kiel Marine Research Institute / Geomar, apparently made in the 80ies-90ies of the previous century.



This is in part BONUS+ HYPER contribution.
Authors collected all available data from the coastal monitoring stations for 1955 - 2009.
115 sites with occurence of low O2 concentration were identified in the database.
This finding partly lead to the current BONUS COCOA project led by Jacob Carstensen (Aarhus Uni.) and Dan Conley (Lund Uni.)

Which are the critical sources of excess nutrients? Which societal drivers are responsible for nutrinet overlaod?



External N and P sources in the Baltic Sea catchments
(redrawn from Hong et al., 2012, Wulff et al., 2014, BONUS+ RECOCA)

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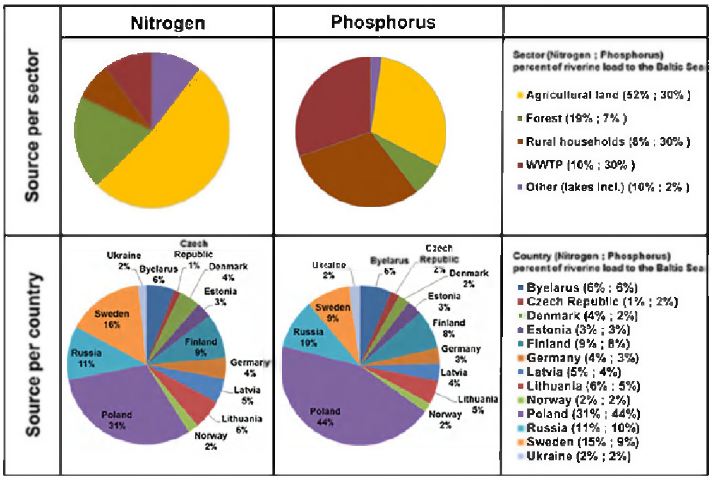
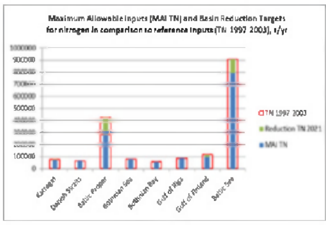
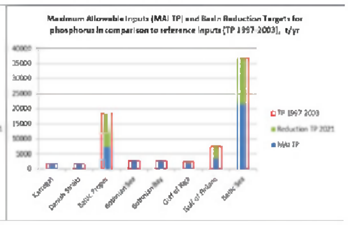


Source apportionment based on societal sector and country, using the Balt-HYPE model (Arheimer et al. , 2012, BONUS+ ECOSUPPORT).

What measures are (and should be) applied to control eutrophication of the Baltic Sea?

HELCOM BSAP nutrient reduction scheme updated in 2013 (1)





Total Baltic Sea		
	Total N (t /y)	**Total P (t/y)**
Reference input (1997-2003)(1)	**910 343**	**36 893**
Maximum allowable input (MAI) (1)	**792 209**	**21 716**
Needed reduction (1)	**118 134**	**15 177**
Feasible reduction of waterborn input (2)	**133 120**	**12 040**

Sources: (1) HELCOM 2013: Background doc for CPH Ministerial mtg)
(2) Wulff et al., 2014: BONUS+ RECOCA

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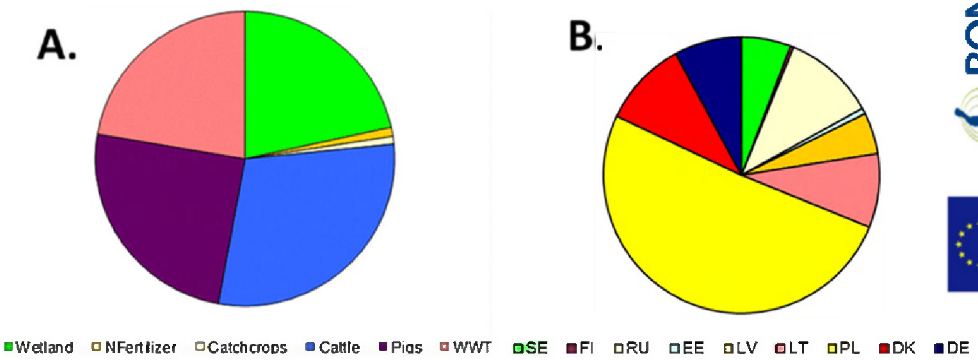
What measures are (and should be) applied to control eutrophication of the Baltic Sea?

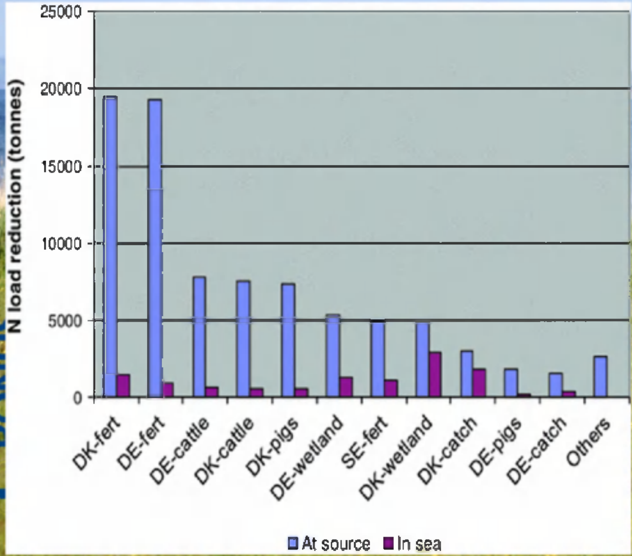


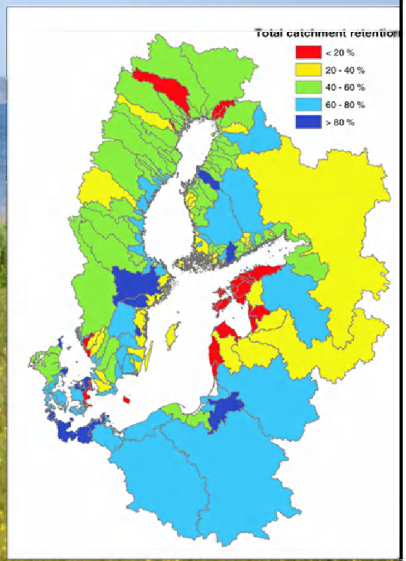
An optimisation experiment:

Distribution of the total annual costs of delivering the nutrient reduction targets among measures (A) and countries (B) using the lowest-cost combination of drainage basin specific abatement measures (Wulff et al., 2014, BONUS+ RECOCA)

The total estimated abatment costs are <u>EUR 4.65 billion/y</u>

What measures are (and should be) applied to control eutrophication of the Baltic Sea?





N abatement at source v. N load reduction (Wulff et al., 2014, BONUS+ RECOCA)

N retention in 117 Baltic catchments

What awaits us in the future?

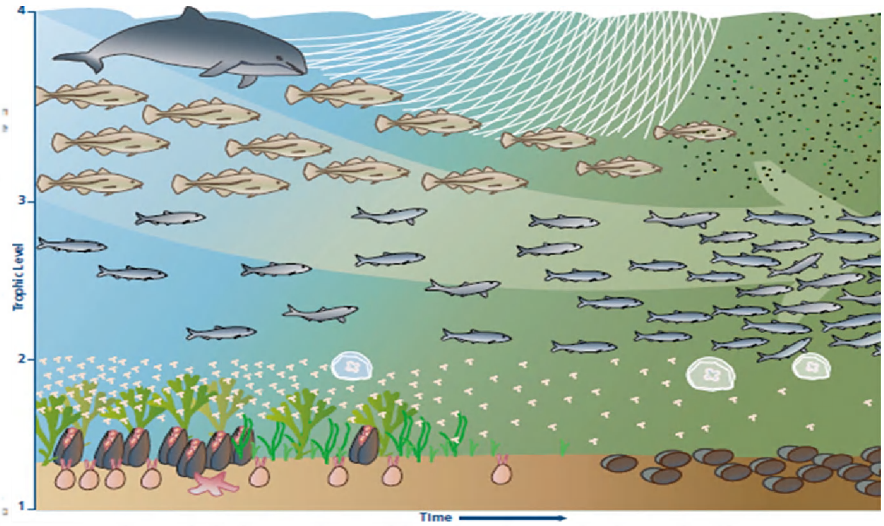
An optimistic scenario:

- Due to temperature increase and changing regime of the NS inflows, the low oxygen zones continue increasing;
- Internal loading of phosphorus accumulated in sediments increases;
- More frequent and massive blooms of N-fixing cyanobacteria;
- More N-input through N-fixing

Achieving the HELCOM Baltic Sea Action Plan targets will allow to maintain the system at current state of eutrophication

What awaits us in the future?

A pessimistic scenario:



Changes in food-web structure due to overfishing and eutrophication in the Baltic Sea (HELCOM, 2010, adapted from Watson & Pauly, 2001).

Future research needs

1. Extend existing models with carbon cycling including dissolved organic carbon, nitrogen, and phosphorus (DOC, DON, and DOP);

2. Improve understanding of nutrient retention in the coastal zone in catchment;

3. Couple in both ways the models for lower and higher trophic levels to study bottom-up and top-down controls of the marine ecosystem;

4. Further improve modeling of the land-sea continuum;

5. Extend multi-stressor approach taking inot account e.g. hazardous substances and invasive species.

Based on M.Meier et al., 2014, BONUS+ ECOSUPPORT


BONUS VISION
Economically and ecologically prosperous
Baltic Sea region where resources and goods
are used sustainably and where the long-term
management of the region is based on sound
knowledge derived from multidisciplinary research.
THANK YOU!

Quoted sources in order of appearance

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See HELCOM’s funny clip on Eutrophication & Agriculture issues on
http://www.youtube.com/watch?v=Vyv2EOdcS34