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BONUS briefing

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

RECOCA
Reduction of Baltic Sea nutrient inputs and cost allocation within the Baltic Sea catchment

The eutrophication section of the Baltic Sea Action Plan is a milestone for environmental governance, not only for the Baltic Sea region but also in setting environmental targets and nutrient reductions for marine environments in general. HELCOM is currently revising the necessary nutrient reduction and country allocation schemes of the Baltic Sea Action Plan. Here, RECOCA plays a key role.

OVERVIEW

RECOCA is an interdisciplinary research project, featuring scientists from nine groups in five countries and specializing in environmental economics, hydrology, agronomy and biogeochemistry.

RECOCA supports policymakers by providing interactive, user-friendly, online visualisations through the decision support system Nest. Major human induced drivers are related to diffusive and point emissions sources for the entire Baltic Sea catchment.

The project has created various model tools that allow users to calculate the effects of mitigation measures, view scenario analyses or produce maps showing hot spots of nutrient leakage. To estimate cost-effective ways to reach nutrient reduction goals, RECOCA has developed economic models, which account not only for the costs at the sources, but also the total costs of various abatement measures for the individual riparian countries. These models take into account natural conditions and reduction capacities in the different watersheds and the net effect of measures for the Baltic Sea.

The implementation of the eutrophication segment within the Baltic Sea Action Plan with the strategic goal of a "Baltic Sea unaffected by eutrophication", requires modelling tools in order to simulate the effects of various abatement strategies and to estimate the related costs.

The overall objectives of RECOCA are to
(i) simulate possible future riverine nutrient loads to the Baltic Sea
(ii) estimate cost effective reductions of these loads and corresponding improvements in ecological indicators
(iii) suggest cost allocation schemes for the riparian countries, based on cost-effectiveness

OUTLINE OF KEY RESEARCH

1. NEW CATCHMENT DATABASE AND NUTRIENT ACCOUNTING TOOL TO ESTIMATE NUTRIENT LOADING

RECOCA scientists have compiled data on land use patterns and levels of economic activities. These gridded data are now available via the Nest decision support system (Figure 1). Data originate from many sources, including the EU Joint Research Centre (fertilizer use, crop types), EUROSTAT (livestock data), HYDE database (population), CORINE (land cover) and SMHI (hydrological and climate forcing). All these data have been compiled for 117

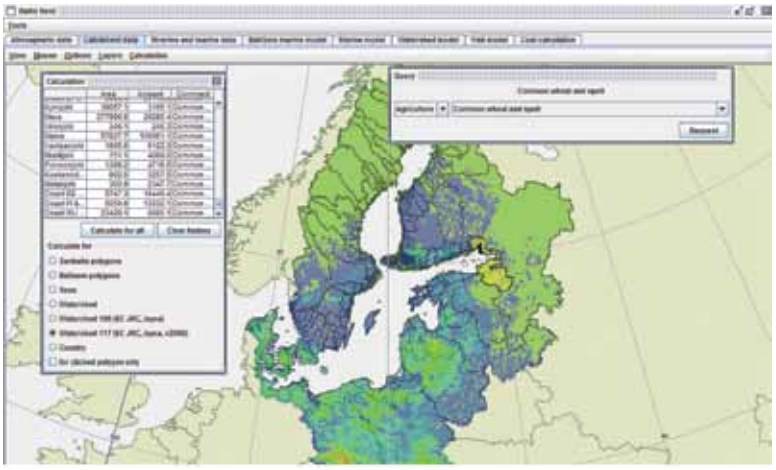

Figure 1. The new catchment database accessible via the Nest system (www.balticnest.org)

watersheds (82 major watersheds and 35 coastal areas) as well as for eight types of watersheds. The compiled data are organised into fertilizer use, atmospheric deposition, biological N-fixation, crops, animals and population distributions. RECOCA then calculates food and feed budgets for all watershed types using these data. The resulting nutrient budgets for all watershed types are then addressed in RECOCA. Moreover we have created a detailed list of point source data, i.e. statistics on municipal wastewater treatment including estimates on people connected and unconnected to sewage systems.

The data on land use patterns were organised to allow decision makers to be informed of all major drivers of nutrient emissions and estimate the total nutrient loading to the coast from a watershed. Anthropogenic nutrient loadings are determined by the use of fertilizers, atmospheric deposition, biological fixation and net feed and food import or export i.e. the difference between the nutrient requirements of humans and livestock and the crops and animal production in a watershed. A "nutrient accounting toolbox" quantifies the individual drivers of nutrient loads and this toolbox forms the basis for the dynamic catchment simulation model soon to be available via the Nest decision support system.

Nutrient fluxes to the Baltic Sea increase gradually as the man-made nutrient loading to the landscape increases. Synthetic fertilizers are the main sources of nutrient pollution. Other sources - such as nutrients in food and animal feed or atmospheric deposition - contribute and are sometimes dominant.

2. SIMULATIONS OF NUTRIENT PATHWAYS AND EFFECTS OF MITIGATION MEASURES FOR THE BALTIC SEA

RECOCA produced an array of dynamic simulation models to allow future users of the Nest decision support system to quantify the effects of mitigation measures or to undertake scenario analyses on likely trends in the agricultural sector. Mitigation measures simulated are e.g. changes in fertilizer use, livestock density and atmospheric deposition, the creation of wetlands or improved sewage treatment. However, to quantify the effects of these measures there is a need to describe the load reductions at the various sources, as well as the pathways and removal of nutrients in soils, groundwater, lakes and streams. Large amount of nutrients are retained in the drainage basins and do not reach the Baltic Sea.

The dynamic models produced in RECOCA simulate
i) nutrient leakage from agricultural soils and point sources,
ii) the natural removal of nutrients through pathways in the watersheds, and finally
iii) the net effects of mitigation measures observed as changes in nutrient loads at the river mouths and thus relevant for the Baltic Sea ecosystem.

Diffuse riverine leakage from agriculture is today the most important nutrient input to the Baltic Sea. The anticipated intensification of agricultural production in central and eastern European states (transitional countries) may lead to further increased nutrient leakages. The ability to quantify nutrient leakages from different production systems and to identify regional hot spots is crucial when selecting abating measures of these detrimental inputs to the Baltic Sea. The strong heterogeneity in farm size and production intensity within the watersheds has been described by three different management strategies, which were parameterised individually for each riparian country and calibrated to national statistics with regard to consumption of fertilizer and manure. Nutrient leakages from agricultural land were calculated using distributed management and land use data and a state of the art soil-vegetation-atmosphere model. Figure 2a shows calculated N leakage from agricultural soils at a level of detail, which has not been achieved previously for the Baltic Sea drainage basin.

The natural removal of nutrients along the flow path through groundwater and surface waters determines the cost efficiency of mitigation measures. Overall nutrient removal in ground and surface waters are calculated for the entire Baltic drainage basin subdivided into 103 catchments.

The net effects of mitigation measures on nutrient loads reaching the river mouths, and thus relevant for the Baltic Sea ecosystem,

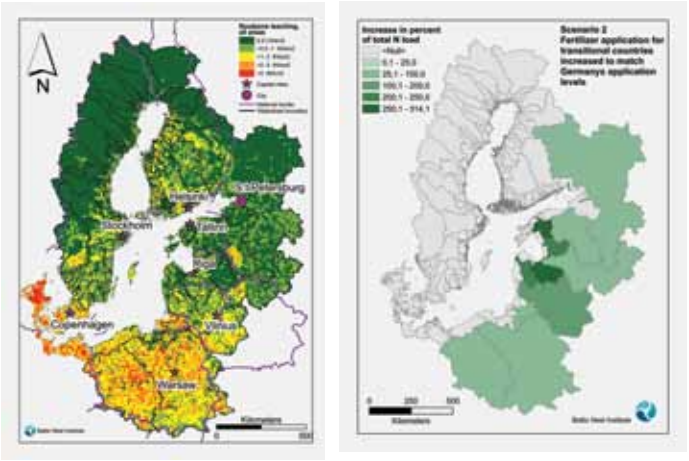

Figure 2. a) Hot spots of nutrient leakage from agriculture; b) simulations of increased fertilizer use in transitional countries.

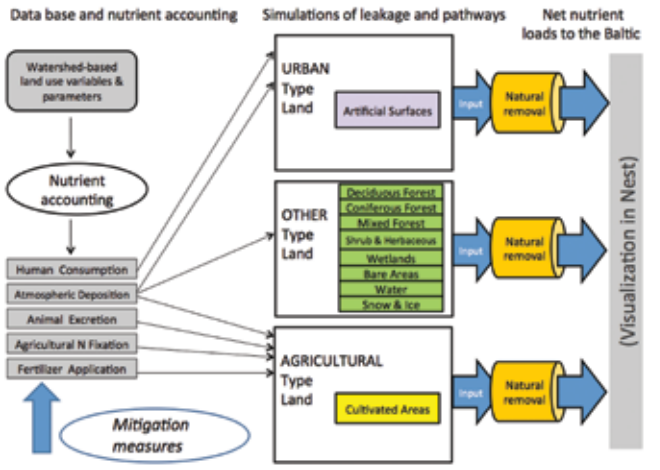

Figure 3. Integration scheme of data bases, accounting tools, dynamic models describing leakage and pathways to visualize net effects of mitigation measures in Nest.

is simulated using an updated catchment simulation model in Nest (CSIM). This dynamic model integrates the databases and accounting tools to predict leakage and nutrient removal along nutrient transport pathways through the watersheds (Figure 3) and can thus be used for management applications. This model system is currently being used to update the Baltic Sea Action Plan by estimating the effect of country-level compliance with the Waste Water Treatment Directive. This is as an essential step in the calculation of a country allocation scheme for nutrient abatement. The model shows that natural nutrient retention within the watersheds will substantially reduce the effects on Baltic Sea ecosystem from upstream measures. The model has already been used to simulate changes in fertilizer use. Figure 2b shows a scenario analysis of the effects of a likely increase in fertilizer use in transitional countries to levels comparable with Germany, Sweden or Denmark. Results suggest that in some watersheds the nutrient load to the Baltic Sea may increase significantly.

Dramatic increases in fertilizer use and manure are likely to occur in exactly those areas where nutrient leakage is already most intense, and there is a high risk that nutrient loads to the Baltic Sea from Poland, the Baltic states and Russia will increase.

3. NEW COST MINIMIZATION MODELS

Two cost-minimisation models will soon be available to assess the selection and distribution of cost-effective nutrient reductions to the Baltic Sea, e.g. by fulfilling the Baltic Sea Action Plan targets.

The BALTCOST model, developed jointly through RECOCA and the Baltic Nest Institute, is well suited for scenario modelling of cost-effective combinations of abatement measures to fulfil nutrient load reduction targets for the different Baltic Sea regions (7 regions in all). The model BALTCOST is also well suited to modelling cost-allocations between sea-regions, countries and main catchments.

The higher spatial resolution RECOCA model is well suited to address cost-effective spatial allocation of these abatement measures within countries and regions.

Both models provide results to help identify the most cost-effective measures for reducing nutrient loads. For a given set of sea-basin-specific N and P reduction targets both models can specify to what extent each measure should be applied and in which locations, but at different resolutions and scales, in order to reduce costs. Both models include abatement measures in the agricultural, energy and transport sectors, together with wetland restoration and improved wastewater treatment. Emissions to both air and water are thus included in the cost-minimisation calculations. Special attention is paid to the natural removal and transport of nutrients from agricultural and wastewater sources through rivers and lakes to the sea, and also air-borne transport of emissions from energy, transportation and agriculture.

The RECOCA model adds to the present cost-modelling tools for the Baltic, as it is the first bottom-up model, building on intensive, detailed interdisciplinary work and data exchange between the natural scientists and the economists in the RECOCA project. For each 10 km x 10 km grid cell, area-specific physiographic, cost and population data are used.

In particular, the RECOCA model accounts for
(i) surface water retention associated with each grid cell,
(ii) the area-specific potential of each abatement measure and its effectiveness, and area-specific cost coefficients.

All these components play important roles in determining regionally disaggregated cost-effective solutions for achieving a given nutrient reduction target. The Baltic Sea Action Plan sets nutrient load targets for the various Baltic Sea regions, and in the present plan the necessary emission reductions are allocated to each country and sea region, but this is not a cost-effective allocation. Furthermore, the Baltic Sea Action Plan itself does not describe which measures should be used to deliver these reductions.

The total costs of achieving Baltic Sea Action Plan targets would undoubtedly be lower if the cost-effectiveness of different measures were taken into account in the allocation of the country specific quotas.

NEXT STEP AND FUTURE PLANS

The RECOCA work is now in its synthesising phase. All databases are in place, component models are being finalised, and scenario analyses are being undertaken. The databases, the catchment model CSIM, which integrates major results from the dynamic models, and results from the cost-optimization model, will be made available via the Nest system (www.balticnest.org). Interactive online visualisation through the Nest system will allow policy makers to view the nutrient load reductions and cost allocations and compare result from different abatement strategies and target allocations schemes.

IN BRIEF

RECOCA
Reduction of Baltic Sea nutrient inputs and cost allocation within the Baltic Sea catchment

The Baltic Sea is under severe stress, experiencing eutrophication caused by excessive nutrient loads which lead to excessive phytoplankton production, reduced water transparency and ultimately hypoxia/anoxia. Combating eutrophication by nutrient reduction is vital in order to reach a healthier Baltic Sea. RECOCA has created an array of hierarchical connected data bases and models via the decision support system Nest, assuring for the first time realistic Baltic-wide estimates of anticipated nutrient reductions and their costs.

KEY RESULTS

- Dramatic increases in fertilizer use are likely to occur in transitional countries, and there is a high risk that nutrient loads to the Baltic Sea, particularly from Poland, the Baltic states and Russia will increase.
- Costs of achieving a cost-effective fulfilment of the targets set in the Baltic Sea Action Plan will undoubtedly be lower for the countries around the Baltic than the costs, which are incurred by these states under the present Baltic Sea Action Plan allocation of emissions reductions.
- RECOCA enables decision makers to produce well-grounded recommendations on how to achieve cost-effective nutrient reductions programmes at regional and Baltic-wide scale.

WHO NEEDS THE INFORMATION

The implementation of the eutrophication section within the Baltic Sea Action Plan requires modelling tools to simulate the effects of various abatement strategies and to estimate the related costs. RECOCA supports policy makers by providing interactive, user-friendly, online visualisations through the Nest system, relating major human induced and economic drivers to diffusive and point emissions sources for the entire Baltic Sea catchment.

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