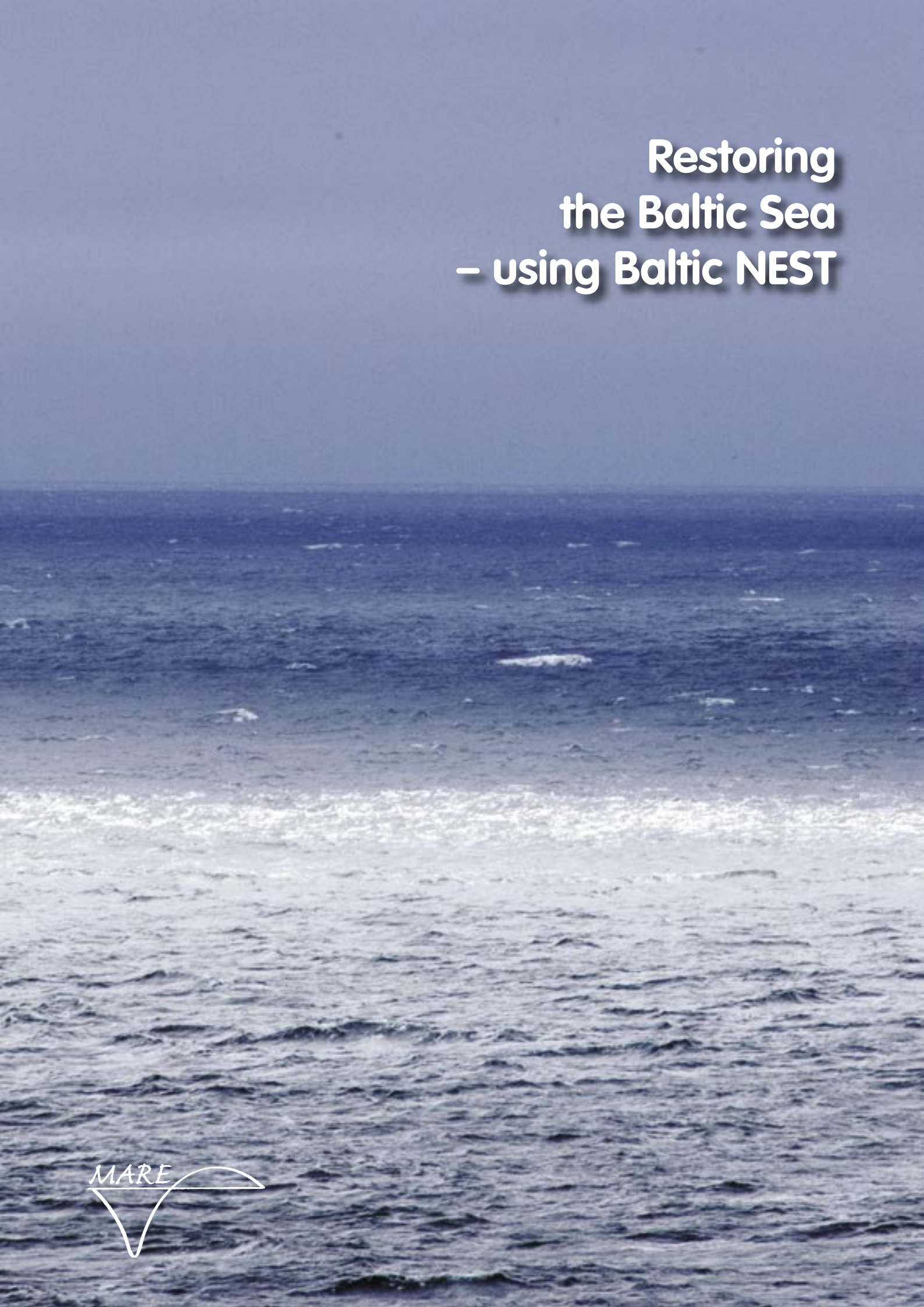
Restoring the Baltic Sea – using Baltic NEST



MARE

BALTIC NEST

From emission targets to environmental targets

Eutrophication is a serious environmental problem in the Baltic Sea. Despite various measures to limit the input of fertilising nitrogen and phosphorus, there has been no marked improvement of the marine environment. Every summer, blooms of blue-green algae drift towards the coasts, and the oxygen-depleted bottoms continue to expand. Within the Helsinki Commission, HELCOM, countries are developing tangible environmental targets and measures under the Baltic Sea Action Plan. In line with the EU Water Framework Directive and the proposed Marine Strategy, environmental work in the Baltic Sea is also increasingly focused on achieving a desired environmental quality rather than specific emission levels.

Another crucial issue for the Baltic Sea is the development of fish stocks. Commercially important species such as cod and herring are already overfished. Furthermore, joint efforts to reduce nutrient supply and achieve environmental targets could lead to a further decrease in fish production.

The Baltic Sea

Around the Baltic Sea live more than 85 million people whose waste water reaches the sea via water courses and land runoff. Due to the restricted water exchange, residence times for nutrients and pollutants are long. This means that measures taken in one country alone are usually inadequate for improving the environment, even along the coasts of that country. Cooperation is therefore needed, and Baltic Nest has been developed mainly to provide one basis for decision-making at international negotiations.

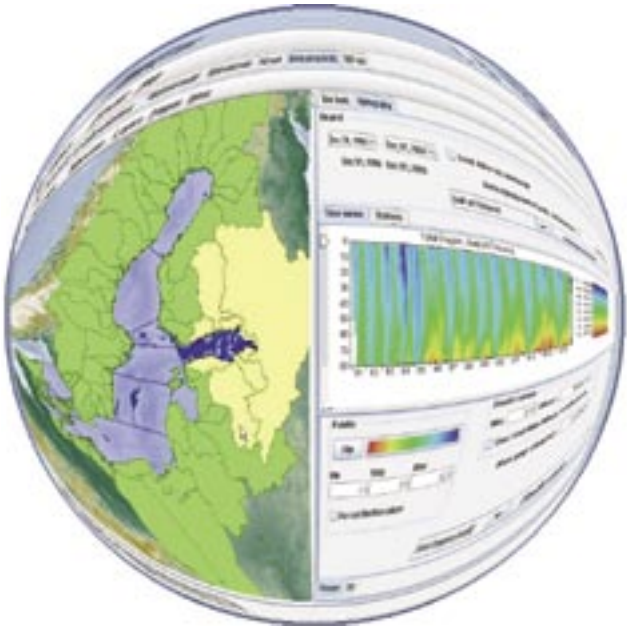
Baltic Nest shows the way!

The research community cannot set environmental targets for the Baltic Sea, or decide how quickly they must be achieved and how much money to spend. Research, however, can determine the reduction of nutrient input required to achieve certain targets, describe the effects on the environment of different measures and calculate costs. Baltic Nest has been developed precisely for this purpose.

Baltic Nest is a tool for visualising how various measures can improve the marine environment of the Baltic Sea, a so called decision support system. The programme thereby facilitates strong joint efforts to counteract environmental problems such as eutrophication and declining fish stocks. The aim is to use the system in international negotiations within for example HELCOM and the EU.

Describes the Baltic Sea ecosystem

Baltic Nest provides data and information from the entire Baltic drainage basin and the entire sea, and links measures on land with effects to the sea. The system has been developed within the research programme Marine Research on Eutrophication, MARE. Scientists from all the Baltic Sea countries and working groups in HELCOM are involved in the work. Baltic Nest links a number of models that together describe the ecology, oceanography, biogeochemical cycles, commercially important fish stocks, etc. in the Baltic Sea. Data used in the models are obtained from different official sources.



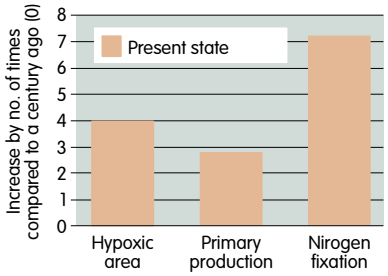
Baltic Nest is:

- a decision support system
- available for free on the Internet
- an aid to adaptive co-management

With Baltic Nest it is possible to:

- gather and synthesize information about the Baltic Sea environment
- calculate how nutrient loads and marine environments are affected by different measures
- provide basic documentation showing effects and costs of various management alternatives

The Baltic Sea a century ago



What is the aim of environmental work in the Baltic Sea? What is the desired marine environment? With the aid of the Baltic Nest models, scientists are able to describe environmental conditions such as water clarity, algal blooms, oxygen concentrations, fish production, etc. in the Baltic Sea a century ago, before the influences of man. Based on these reference values, environmental targets can be set for the Baltic Sea. For example, by how much do we want to reduce blue-green algal blooms in the Gulf of Finland, or how much cod do we want to be able to fish in the future?

Baltic Nest ca be used to calculate environmental conditions in the past. The graph shows present state of some ecosystem properties in the Baltic Proper, compared tp 100 years ago.

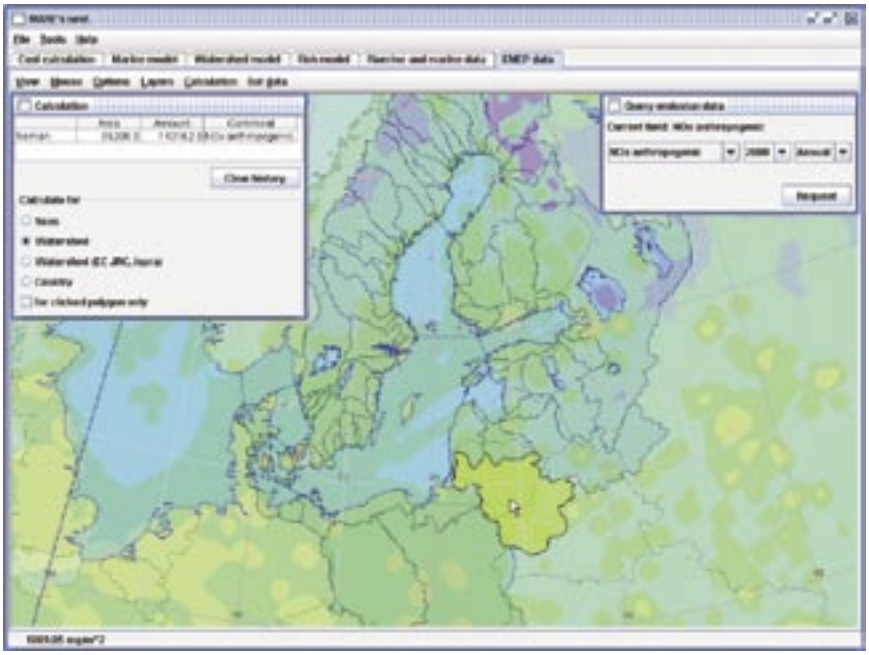
Baltic Nest provides information…

What are the total nutrient loads from each Baltic Sea country? What are the annual variations in nutrient concentrations in the Gulf of Riga? How extensive is agriculture in the Oder drainage basin?

The different modules in Baltic Nest contain data and statistics on emissions and deposition, state of the environment, and various human activities in the sub-watersheds around the Baltic Sea. The user can choose whether to have the information presented as maps, graphs or tables.

…about airborne emissions and deposition

Baltic Nest's *EMEP data* module shows atmospheric deposition and emissions of e.g. nitrogen and phosphorous. Information can be obtained for a certain year or a certain period, for the entire Baltic Sea or for a specific area. Data is presented as tables and graphs. This module is linked via Internet to EMEP (European Monitoring and Evaluation Programme) in Oslo, and the data is extracted directly from EMEP when requested by a user.



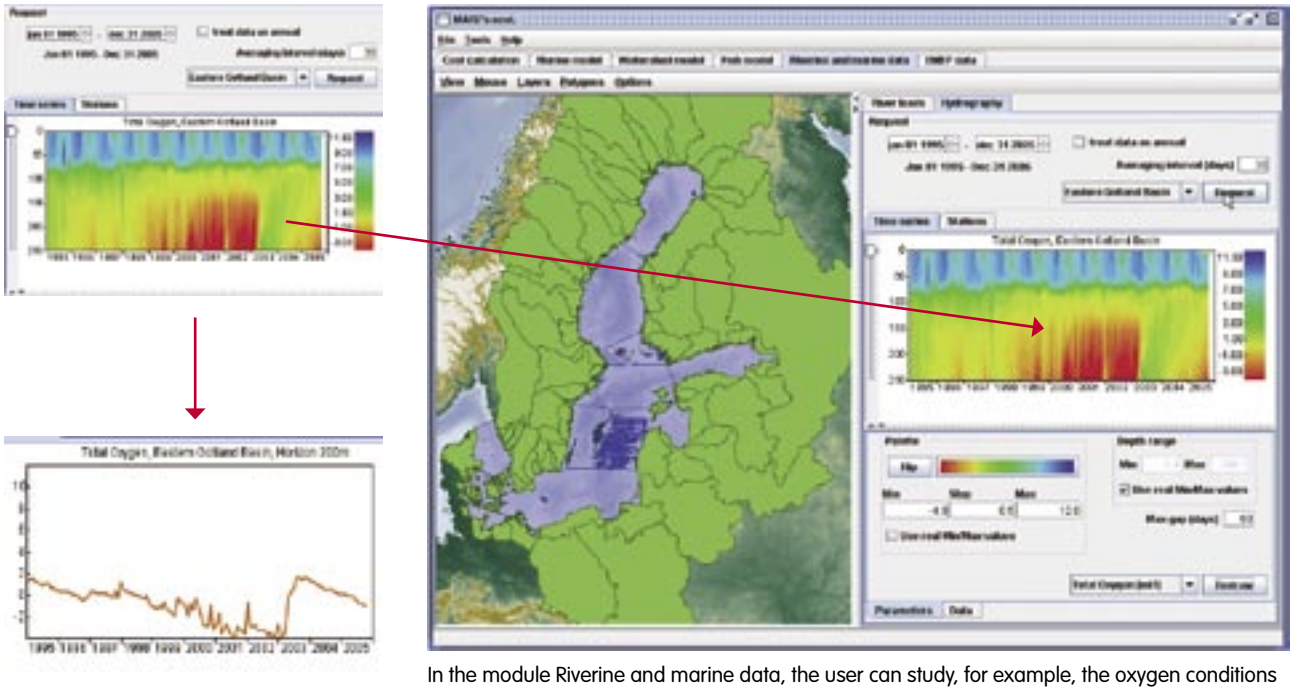
In the EMEP data module, the user selects information about a sea basin, watershed or country. By clicking on the map, information is obtained about the selected area. The example above shows the emission of anthropogenic NOx in the Neman watershed area in year 2000.

…about emission sources

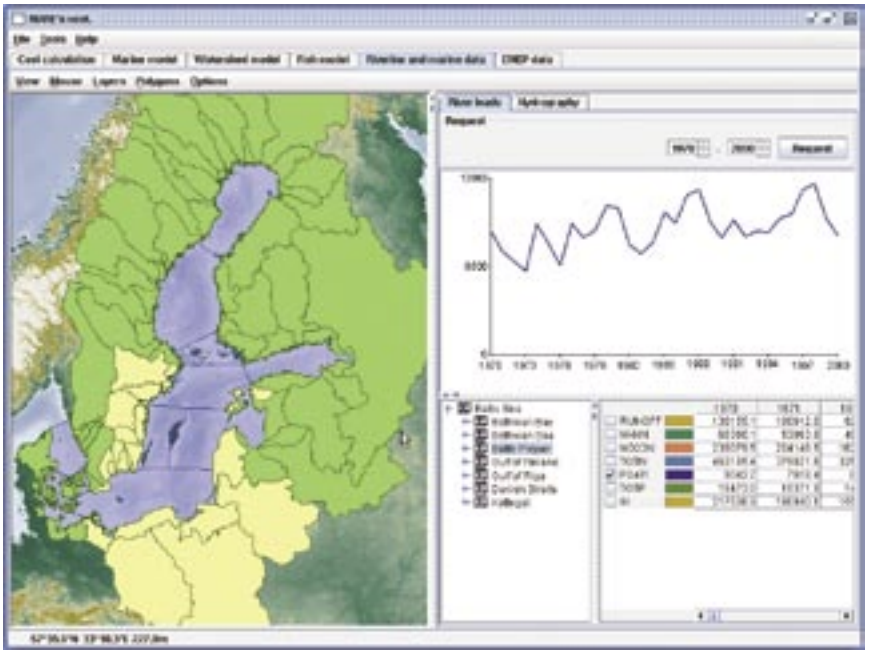
The *Watershed model* describis the more than one hundred sub-drainage basins in the Baltic Sea. For each watershed there are data on population, land use, level of connection and treatment capacity for sewage treatment plants, size of animal herds, and other factors that influence the load of fertilising substances.

…about runoff from land and status of the sea

The module *Riverine and marine data* provides hydrographic observations such as salinity, oxygen concentration and nutrients at different depths in different areas of the Baltic Sea. The information is extracted on line from BED, the Baltic Sea Environmental Database, which contains data from environmental monitoring and research in all of the Baltic Sea countries. It is possible to request information for a specific year or time period. The data is presented as graphs or tables.



In the module Riverine and marine data, the user can study, for example, the oxygen conditions in the Gotland Basin. The red area in the graph (right) shows the long period of oxygen deficiency from the mid-1990's until the new salt water inflow in 2003. The blue dots on the map show observation stations. By clicking on a station, detailed information will be shown for this specific station.



By clicking on the map, you can see the input of nitrogen and phosphorous to the Baltic Sea from one or several drainage basins during a selected time period. Shown above, is the annual phosphate load to the Baltic Sea Proper from the entire surrounding drainage area during the period 1970-2000.

Baltic Nest looks into the future

Joint efforts are needed to come to grips with environmental problems in the Baltic Sea. How can we use our resources in the most efficient ways? Baltic Nest enables decision makers and scientists to simulate various measures and find out how they would affect the marine environment.

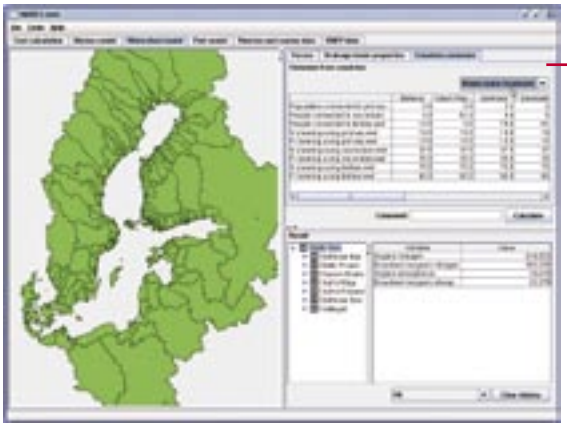
What will happen to the environment in the Baltic Sea…

Commissioned by HELCOM, scientists within the MARE programme have used Baltic Nest to develop a number of scenarios. One example is shown below.

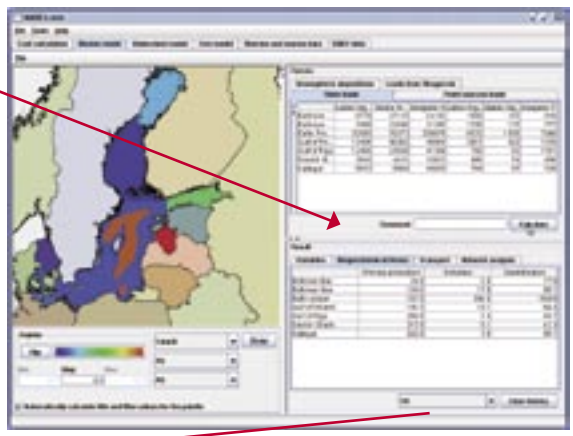
…if all people in densely built-up areas become connected to efficient sewage treatment plants?

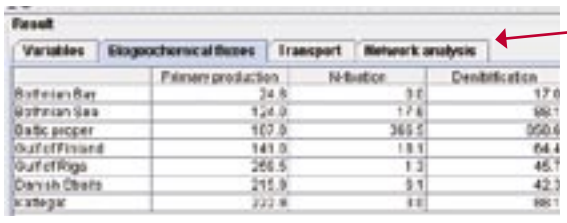
To find out the answer, start in the Watershed model. The user simulates that waste water from the entire urban population in the Baltic coastal countries is treated at the same level as in Sweden.

The model calculates by how much the nitrogen and phosphorous load reaching the coasts of the Baltic Sea would be reduced by this measure. The calculations take into account different factors that influence the amount of nutrients that actually reach the sea, e.g. how much is retained in soils, how much is transformed into nitrogen gas, etc.



The results from the Watershed model are inserted into the Marine model...



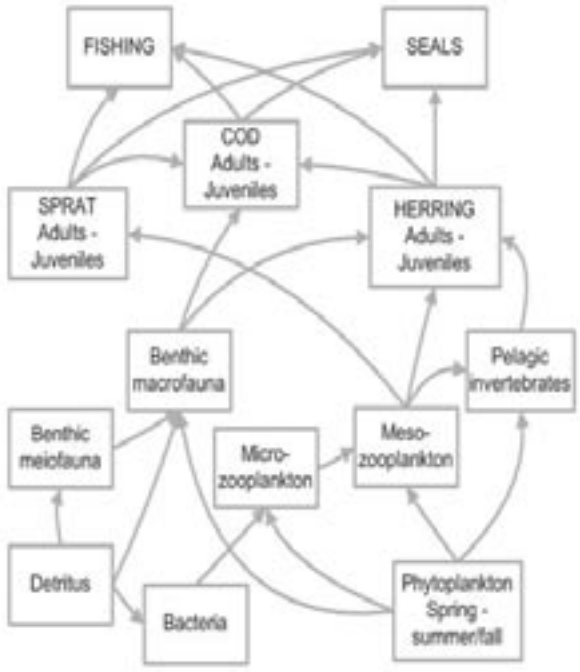


... which calculates the environmental benefits from this measure, e.g. improved water clarity, reduced primary production, fewer blue-green algal blooms, reduced expansion of oxygen-deficient bottoms.

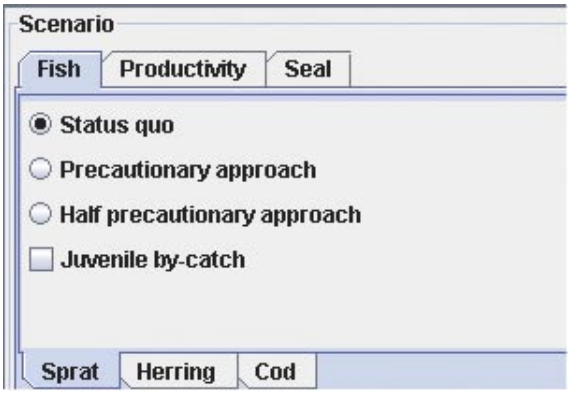
…if we follow scientific advice for sustainable fisheries?

How would catches of cod develop in the future if we follow ICES' recommendations? What would happen to the Baltic herring if seal stocks are restored to pristine, high levels?

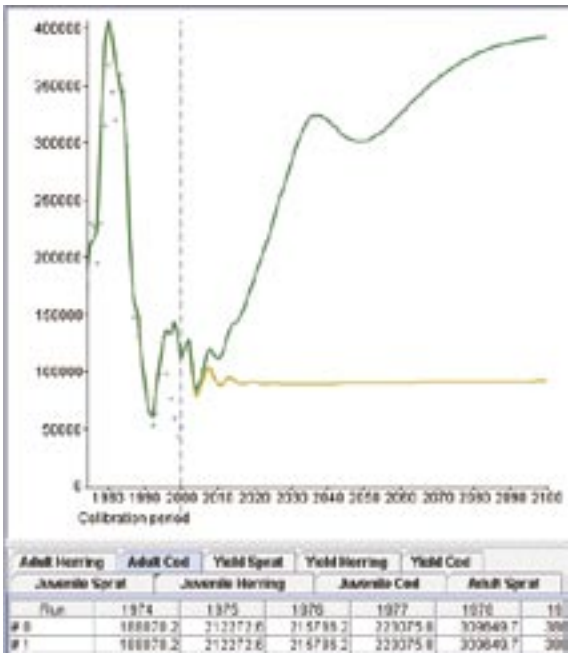
Baltic Nest's *Fish model* contains a model over the Baltic Sea food web, where fish is treated as part of an ecosystem including man (fishery), food availability (production) and the number of seals (predation). The model can thus be used for fisheries management, taking into consideration both fishing pressure and various environmental conditions.



The fish model is based on a detailed food web of the Baltic Proper



The user can explore the effects of various fishery management restrictions, seal predation and changes in eutrophication.

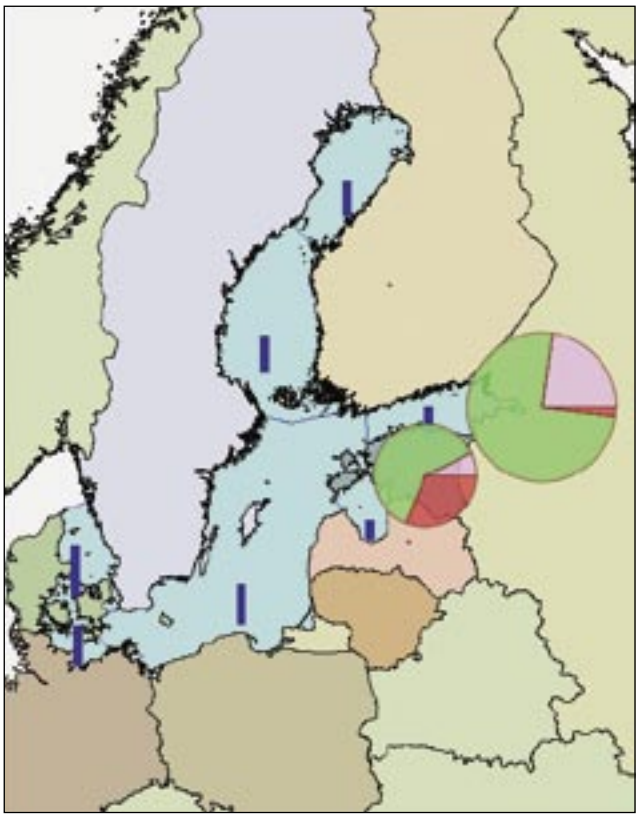


Results are shown as projections of the future development of populations; in this example the cod population with current levels of exploitation (brown) compared with a situation when ICES' recommendations are followed for cod as well as for herring and sprat (green).

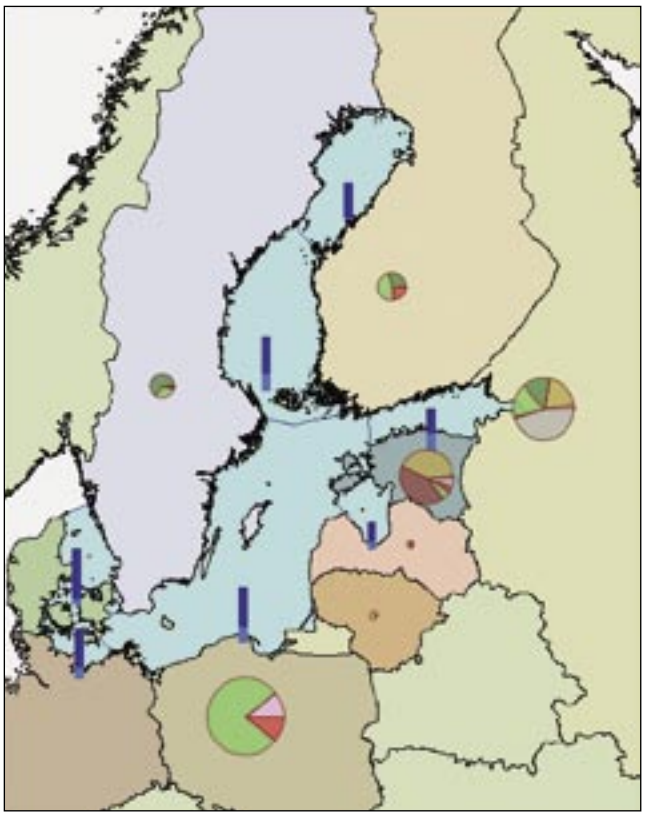
How much does it cost to improve the marine environment of the Baltic Sea? Which measures are the most cost-effective?

Baltic Nest's *Cost model* calculates the cost of achieving a certain environmental target, e.g. improved water clarity in the Gulf of Finland. Taking into account that the cost of different measures will vary from country to country, the model will propose the most cost-effective action programme. The user can also choose to exclude certain measures or certain countries.

As shown in the pictures below a substantial improvement in one of the sub-basins requires that all countries participate and share the costs; since everyone will benefit from the investments!



To achieve a modest environmental improvement in the Gulf of Finland; water clarity improved by 0.5 m, investments are needed in Russia and Estonia. The sections in the pie charts show the investments for measures in different economic sectors, e.g. green means investments in sewage treatments. The size of the pie charts shows the relative costs.



To achieve a substantial environmental improvement; water clarity improved by 3 m, large investments are also needed in other countries outside the Gulf of Finland, mainly Poland. This is due to the large loads reaching the Gulf from the Baltic Proper and that also need to be reduced.

The Cost model works on a number of pre-selected measures including:

- Increased treatment capacity in water treatment plants in the Baltic countries
- Land use change, e.g. grassland constructed on arable land
- Reduced livestocks of cattle and pigs

The measures used have been selected on the grounds that they can significantly impact the amount of nutrients reaching the sea. Thereafter, costs have been calculated by environmental economists.

Digital network for the Baltic Sea

Mathematical models are powerful tools for linking the complex information needed to understand the processes that cause eutrophication and other environmental problems. Models also offer opportunities to test the effects of different measures for improving the environment.

Baltic Nest links models that describe current knowledge about the marine environment, drainage basins, fishery and the costs for different measures in the Baltic Sea, as well as the effects of different measures for improving the marine environment. The models have been developed or modified within the research programme MARE - Marine Research on Eutrophication. More than 30 scientists from Sweden, Finland, Denmark, Poland, Russia and the Baltic States participate in the programme, which started in autumn 1999.

Baltic Nest now includes six different modules:

1. *EMEP data* shows emissions and deposition of atmospheric nitrogen and phosphorous
2. *Riverine and marine data* presents nutrient load data for watercourses and point sources, and hydrographic data from the different sub-basins of the Baltic Sea
3. *Watershed model* shows data from the more than 100 sub-drainage basins in the Baltic Sea, and calculates how the nutrient supply from these changes depending on various measures
4. *Marine model* describes the transport and cycling of nutrients in the Baltic Sea, and calculates how nutrient concentrations, chlorophyll concentrations, the expansion of oxygen-depleted bottoms, etc. change with altered nutrient loads
5. *Cost model* calculates costs for different emission-limiting measures, and distributes the costs in the most cost-effective way between measures and countries
6. *Fish model* calculates how varying fishing pressure, seal populations and eutrophication affect the development of cod, herring and sprat populations

Official data

Data used in Baltic Nest is extracted from various databases based on official statistics supplied by each country to the EU, HELCOM, ICES, etc. Baltic Nest is directly linked to some databases (currently EMEP, BED), which means that data used in the calculations are extracted in real time from respective database. In this way, the programme is always using the latest and currently most reliable information. The aim is to set up direct links to more databases.

Some data sources:

Hydrographic data on nutrient concentrations, water clarity, oxygen concentrations, etc. are extracted from BED - Baltic Environmental Database hosted by the Department of Systems Ecology at Stockholm University.

Atmospheric data are extracted from EMEP - European Monitoring and Evaluation Programme hosted by the Norwegian Institute for Air Research in Oslo.

Data on nutrient loads are extracted from the HELCOM database at the Finnish Environmental Institute, SYKE, in Helsinki to which all countries around the Baltic Sea report.

Fish data are collected from ICES, International Council for the Exploration of the Sea, based in Copenhagen.

Costs for emission-limiting measures in the Cost model have been calculated by environmental economists. At the moment, there is no international database for such information. Therefore the model must be updated through special project initiatives.

Standard or expert mode

Baltic Nest users can see the results in either 'standard' or 'expert' mode. Expert mode gives more detailed information. In future versions of Baltic Nest the difference will be better defined, as various users have different requirements.

Delimitations for Baltic Nest

The programme is developed for the open sea and covers the entire Baltic Sea watershed, except specific coastal areas such as archipelagos and bays. In future, it will be possible to link Baltic Nest to national coastal models for more detailed information on these areas.

The drainage basin model in Baltic Nest, like most drainage basin models, shows the effects of measures to improve the marine environment one year after they are taken. This means that improvements from measures that take longer to take effect, e.g. reverting arable land or improving the handling of manure, will be misleading. Being able to handle longer time-series is therefore a future challenge for Baltic Nest.

Quality assurance

To assess the reliability of the models, calculations made in Baltic Nest are carefully checked, for example by comparing estimated nitrogen and phosphorous concentrations with observed data. In a similar way, water clarity, primary production, the expansion of oxygen-depleted bottoms, etc. can be simulated for an earlier time period and compared and validated with monitored data.

Baltic NEST in the future

The development of Baltic Nest is financed through the research programme MARE, Marine Research on Eutrophication – A Scientific Base for Cost-Effective Measures for the Baltic Sea. Stockholm University hosts the MARE programme which comes to an end in 2006. A *Baltic Nest Institute* is planned in cooperation with HELCOM and several of the countries around the Baltic Sea, to ensure maintenance and further development of Baltic Nest.

Everyone is welcome to use Baltic Nest

Baltic Nest has primarily been developed for people working internationally with environmental issues relating to the Baltic Sea, e.g. within HELCOM and the EU. Officials and politicians in the Baltic Sea countries form another important target group. The programme does not require extensive computer skills, but due to the complexity and number of options some running-in is required.

Baltic Nest is free to use via Internet, see www.mare.su.se/nest. Here, you will also find a user's manual in pdf-format which can be downloaded to your computer.

The programme is Java-based and independent of the user's operating system or computer. If you do not have Java installed, it is easily to downloaded via the Baltic Nest website.

Baltic Nest is developed within the research programme MARE – Marine Research on Eutrophication. The programme is funded by the Swedish Foundation for Strategic Environmental Research, Mistra www.mistra.org.

For further information, please contact:

Sif Johansson, Programme Director
Swedish Environmental Protection Agency
106 48 Stockholm

Tel +46 (0)8 – 698 15 36
Sif.Johansson@naturvardsverket.se

Fredrik Wulff, Scientific Coordinator
Department of Systems Ecology
Stockholm University
106 91 Stockholm

Tel +46 (0)8 – 16 42 50
Fred@ecology.su.se

Website: www.mare.su.se/nest

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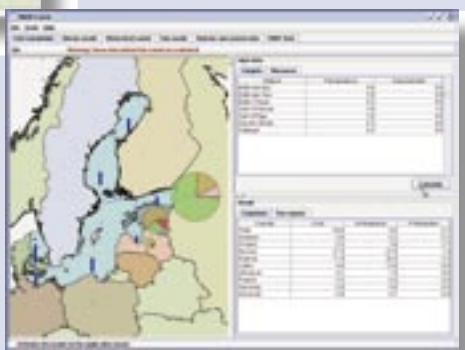
EMEP data

Marine model

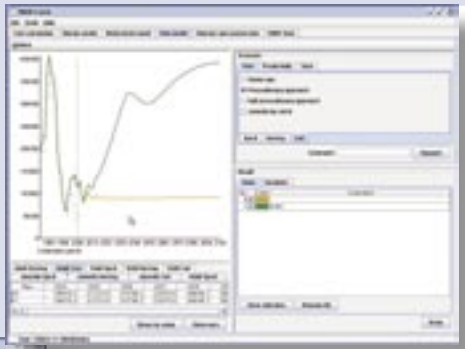
Cost calculation



NEST can be downloaded free of charge and installed via Internet from www.mare.su.se

Watershed model

Fish model



Riverine and marine data

MARE