

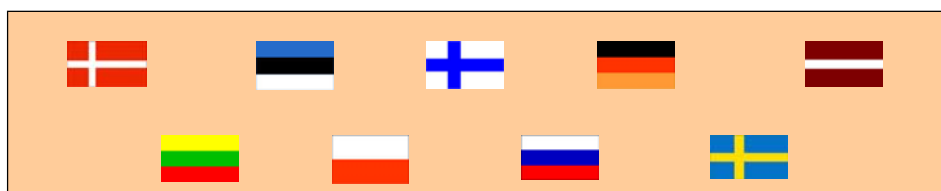


PAPA D5.4

Plan for introduction of operational ecological models in a pre-operational set-up

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EXECUTIVE SUMMARY

The PAPA-ECOMODEL group has identified the following recommendations to be used as the basis for a near-term operational ecosystem modeling framework in the Baltic Sea:

PARTNERSHIPS

will form the basis for a cost-efficient sharing of workload of ecosystem modeling in the Baltic Sea. Ways must be sought to efficiently link different services together without creating unnecessary overlap. Since operational ecosystem modeling is an emerging field, such arrangements can be found easier than in already established operational disciplines.

LEADERSHIP

is needed both on the national and Baltic levels in order to both maintain the momentum of ecosystem model development, and to overcome the organizational and infrastructural challenges that necessarily lie ahead of an emerging discipline. The vagueness of present stakeholder needs emphasizes the need for leadership and vision in the near term.

VALIDATION

is considered to be important for retaining stakeholder confidence in the model results. This is particularly important for ecosystem model results, where there still is a wide spread of model types and little experience of their reliability. Formal procedures and standard datasets should be developed for Baltic Sea ecosystem model validation.

FINANCING

Operational ecosystem services are expected to be established as a public service. Since pricing has been observed to reduce demand, free availability of the results is likely to be beneficial for the rapid adoption of operational ecological services. For specific purposes, fee-based services may emerge.

TIMETABLE

The different components of operational ecological forecast services will continue to be phased in with different time schedules. Many operational or semi-operational services already exist around the Baltic, including 3-dimensional ecological (FIMR, SMHI) and sediment transport models (BSH). Several institutes have made known their intention to contribute to the operational ecological application pool (e.g. Polish institutes, DMI). In addition, scenario experiments on the request of HELCOM and Nordic Council of Ministers are performed by eg. FIMR, SYKE, SMHI and Polish institutes.

<i>Service</i>	<i>Time-line</i>	<i>Contributors, present (future)</i>
Analysis and short-range forecast		
Sediment transport forecasts	Existing	BSH
3D nutrient field forecasts	Existing	FIMR (BSH, SMHI)
3D chlorophyll forecasts	Existing	FIMR (BSH, SMHI)
3D HAB forecast	Existing	FIMR
Fisheries	2008-12-31	ND
Seasonal forecasts		
HAB	Existing	FIMR, SYKE
Algal	Existing	FIMR
Zooplankton	2006-12-31	ND
Fisheries	2008-12-31	ND
Climate change	2008-12-31	ND
Anthropogenic scenarios	Existing	FIMR, SYKE, SMHI ()

1 ORGANIZATIONAL SITUATION

Any considerations of the arrangement of future activities in the area of operational oceanography must take the existing organisational structures, funding flows as well as the resulting interests into account. For example, the willingness of a data collecting organisation to share its observations with a modelling depends on the source of its funding (national/European) as well as the other functions that the organisation contains.

It is useful to categorise the organisations that would potentially provide operational services in on Baltic Sea ecosystem into the following types:

Vertically integrated marine research institutes which contain functions from basic research and routine laboratory analyzes to operational models and value-added information provision. Such institutes typically run most of HELCOM monitoring.

Operational agencies (typically meteorological offices) which have long experiences in running operational observing and modeling systems and may have research departments, but usually have a limited in-house oceanographic research department.

Horizontally integrated environment institutes which typically serve the large breadth of assessment and reporting needs of environment ministries.

Specialized research organizations (public or private) that provide value-added services for particular needs (e.g. EIAs).

In the initial stage of operational ecosystem model implementation, VIMRIs with an operational tilt have been most successful in implementing information services which are directly coupled to results from basic research. However, as the information needs increase, the VIMRIs will be stretched to match the increasing requirements with their emerging infrastructure in this area.

Several promising ecosystem modeling projects in the past have fallen victims of missing leadership and vision (e.g. through unfavorable organizational rearrangements or short-term funding), and their results have not carried over to sustained operational services. Such organizational problems have already put back operational Baltic ecosystem services by almost a decade, and must be overcome on both national as well as Baltic-wide levels if sustainable operational ecological services are to become a reality.

2 EXISTING CAPABILITIES

The present existing capabilities for operational ecosystem modeling in the Baltic were assessed for the 2004 BOOS workshop at SMHI, Norrköping. The following capabilities were identified:

DATA-DRIVEN INDICATORS

The simplest imaginable models are probably indicators for future development that are constructed from analysed observations. Such indicators can be calculated as soon as they are available, and do not include other assumptions than the expectation that the indicator would carry information about the future development of the system.

Such an indicator has been derived for several decades by Finnish scientists from springtime nutrient concentrations to predict the future biomass of cyanobacteria. The indicator is based on the surplus phosphate concentration. As mapping software has become readily available, geographic maps of this indicator have been drawn in recent years.

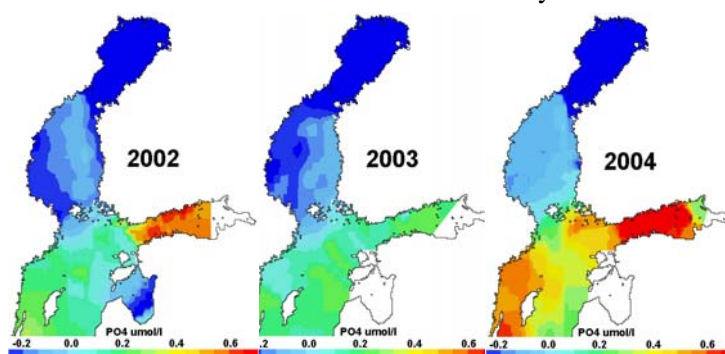


Figure 1 An indicator for the preconditions of cyanobacterial blooms during three consecutive years, ©FIMR 2004

Figure 1 shows the value of the indicator for three consecutive years, drawn from FIMR Baltic wide monitoring, and SYKE coastal stations to incorporate the coastal influence within 10 km or less from the coastline.

BASIN MODELS

Basin models refer to horizontally integrated models, that nevertheless contain the distribution of quantities in the vertical direction. Such models have been used for about two

decades by e.g. several Swedish research institutes for scenario studies.

3D SEDIMENT TRANSPORT MODELS

Suspended particulate matter (SPM) is an important parameter in ecological models as SPM concentration affects the penetration depth of light and has a major influence on primary production.

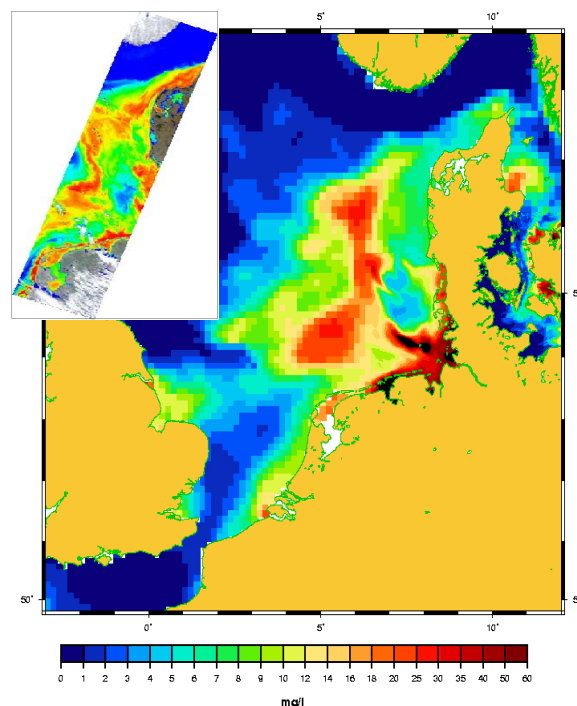
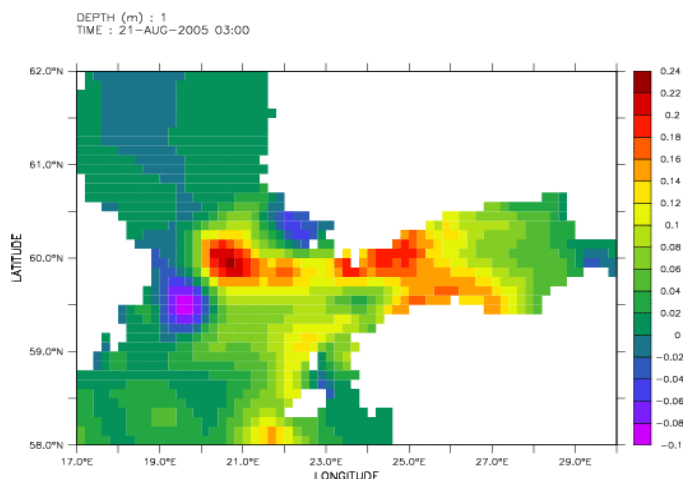


Figure 2: A comparison of the computed surface SPM distribution on 16.12.2003 and a NOAA figure (Channel NN-17 K1-K2) of the same day(BSH)

An operational three-dimensional SPM transport model for the North Sea and Baltic Sea has been developed at the Federal Maritime and Hydrographic Agency (BSH), in co-operation with the GKSS Research Center, Geesthacht. Besides transports and horizontal diffusion, the Eulerian SPM dispersion model simulates vertical mixing in the water column caused by current shear and wave orbital velocities, sinking of the SPM particles, sedimentation, resuspension, erosion, as well as diffusion and sediment bioturbation, cf. Figure 2.

3D ECOSYSTEM MODELS

REAL-TIME FORECAST



66h nodularia+aphanizomenon change

Figure 3: Operational cyanobacterial forecast at FIMR

A coupled physical-biological 3D model has been running operationally at FIMR since July 2003, and continuously since July 2004. Ecosystem model separates most common cyanobacteria in the Baltic (*Nodularia* and *Aphanizomenon*). The model makes operational 72 hour forecasts of nitrate, phosphate, silicate, diatoms, flagellates and two dedicated species of cyanobacteria⁸ The model results have been e.g. used to steer research vessel operations and to amend the algal situation bulletins at www.balticseaportal.fi.

NUTRIENT REDUCTION SCENARIOS

Ecosystem models with varying degrees of physical realism have been applied to analyze the effects of political decisions on the marine environment, and hence to assist in environmental decision making. The Nordic NO COMMENTS⁹ project analyzed the results of three different models on a North Sea-Baltic Sea continuum, and demonstrated for the first time the applicability of consistently coupled 3-dimensional physical-biological models for this purpose in the Baltic Sea.

⁸<http://www.fimr.fi/en/itamerikanta/bsds/2056.html>.

⁹ <http://www.imr.no/~morten/nocomments/>

SEASONAL SCENARIOS

Seasonal scenarios of phytoplankton conditions for the forthcoming summer have been calculated at FIMR for summer 2004. The initial conditions were obtained from FIMR monitoring results in January-February 2004, and the scenarios were based on the atmospheric development of years 2000 and 2002, cf. <http://www.fimr.fi/en/itamerikanta/bsds/2027.html>.

3 FUTURE DIRECTIONS

There is a wealth of possible future directions for ecological modeling. The group has identified the following directions as falling under the umbrella of the future development of operational ecological modeling

IMPROVED STATE ESTIMATES

There is a great need for improved state estimates that would help to interpret the known biases in the ecosystem models. Such estimates would build on the availability of observations from the HELCOM monitoring programs and PAPA/BOOS exchange arrangements, as well as novel assimilation schemes that would not only change the state of the modeled ecological fields, but also estimate the sources of error. There is a clear need for improved assimilation methods for satellite images.

The improved state estimates would result in a best estimate time series of the Baltic Sea state, that would then feed into the indicator reports needed by e.g. HELCOM and EEA.

BETTER BOUNDARY CONDITIONS FOR SHORT- AND MEDIUM TERM FORECASTS

The short- and medium term forecasts would be clearly improved by the availability of better chemical and biological boundary conditions in the meteorological weather forecast range. These would include at least river inflows and atmospheric deposition of nitrogen.

SEASONAL FORECASTS

More systematic methods, including a variety model perturbations, are needed to fully explore the potential of seasonal forecasts and the predictability of the ecosystem.

LONG-TERM FORECASTS

Climate change scenarios, when calculated from the present analyzed conditions, would offer an interesting future avenue for operational ecosystem modeling. In such scenarios, the initial condition would be fully determined, but the boundary conditions would obviously be least deterministic of all timescales here outlined.

The effects of anthropogenic actions other than climate related would fall well to this category as well. For example, the non-linear economic changes in the catchment area and their effects on the chemical and biological boundary conditions would deserve to be analyzed with the best available tools, such as those to be developed within the PAPA community.

VALIDATION

Validation is an important part of operational ecosystem modeling, and needs to be rapidly improved to retain end-user confidence in the result.

However, standard monitoring by HELCOM does not produce the best possible validation datasets, including resolution of ecosystem variability. Therefore, dedicated validation datasets for benchmark experiments including initial conditions should be developed.

The buildup and maintenance of end-user confidence necessitates also the development of formalized QA procedures, in line with international practices (e.g. ISO standards).

MODEL ISSUES

SPM MODELING

Suspended particulate matter modeling needs to be improved. In particular, resuspension, wave effects should be modeled according to wave processes (forced by wave models). The transport of SPM needs improvements. Bottom material distribution maps are needed and need to be updated. The relevant scales for the SPM modeling are very small, close to 100 m. Retrieval algorithms should be also developed for satellite images.

Operational model applications are likely to emerge locally, in particular for estimates of transparency.

ECOSYSTEM MODELS

In relation to the needs of environmental management, the ecosystem models are still in their infancy. Table 1 highlights with traffic light colors the parts of the ecosystem model require-

Physical	Chemical	Biological	Geophysical
Temperature	NO ₃ , PO ₄ , Si, NH ₄	Phytoplankton biomass (chlorophyll) and diversity	Seismicity
Conductivity	Trace metals, pH, radionucleides	Bacterial and phytoplankton cytometry	Bathymetry
Density, pressure	Dissolved gases (O ₂ , CO ₂ , DMS)	Viral particles	Gravimetry
Light, bioptics	Volatile organic pollutants	RNS, DNA, proteins, key enzymes	Magnetism
Turbidity, particle size distribution	Pesticides	Pelagic animals	Acoustic signals
Velocity, turbulence	PCB, PAH, CFC	Benthic communities	Seafloor characteristics

Table 1 Critical marine parameters (Integrating Marine Science in Europe, ESF, 2002) and traffic lights to illustrate the level to which they are currently described in operational ecological models

ments that are currently on the level to be validated (green), producing promising research results (yellow) or still need to be developed/implemented (red).

For the near term, the nutrient fluxes between the bottom sediments and the water column remain a critical issue in the Baltic. These are tightly coupled to the nutrient ratios in the water column, the oxygen conditions near the bottom and release of phosphate and silicate from the sediments – all of which need improvements in current models. Through nutrient ratios, these affect the balance between the functional groups of phytoplankton in the euphotic zone.

ALERT SYSTEM

Currently, the operational ecosystem results are not utilized efficiently. There is a clear need for a pan-Baltic ecosystem model watch, perhaps an alert network for exceptional ecosystem forecasts.

4STAKEHOLDER NEEDS

End user community of operational ecosystem results is currently not very well defined. We have attributed this to the emerging availability of ecosystem model results, as well as the need for establishing quality control procedures. Once these are in place, the end user community will probably evolve as a result of the establishment of services; demand is expected to surface afterwards.

Certain stakeholder needs are known from present contacts and are briefly described below:

HELCOM has expressed interest in model studies analyzing the Baltic Sea response to politically feasible scenarios, and has established a project to analyze such model results.

The **Nordic Council of Ministers (NMR)** is concerned with the requirements of the water framework directive (cross-boundary flows in particular), toxins in the marine ecosystem, and the marine resources.

ICES is beginning to embrace the ecosystem based management approach, and is interested in the effect of anthropogenic changes on the ecosystem on various levels, from climate to policymaking. Many branches of ICES feel, that more use could be made of the available operational oceanographic information in ICES assessments.

The **European Union** has several policies that need information from operational marine ecosystem models. In addition to the water framework directive, the forthcoming Marine Strategy, the common fisheries policy and the GMES process are in present or future need of operational marine ecosystem forecasts.

The **public** in many Baltic areas have a large concern for the Baltic environment: the recurrent harmful algal blooms, the reduction of secchi depth, the increase of filamentous algae (resulting in sliming of nets) and fish kills are common sources of concern and frequently covered in the media.

The **private sector**, e.g. tourist companies and hotels, are so far a potential user of operational ecosystem forecasts. These might include harmful algal blooms and upwelling (swimming temperature).

5MATCHING STAKEHOLDER NEEDS WITH ORGANISATIONAL STRUCTURES AND CAPABILITIES

The variety of existing organizational structures and capabilities around the Baltic Sea makes it difficult to identify a single, clearly structured route forward for ecosystem modeling.

Within the existing structures, the best way forward appears to be the establishment of an intertwined network of partnerships between the different actors, which would appropriately honor the interests of partners at different levels of the service chain. Such a partnership network can only be sustained, if all relevant partners share the benefits of the end result.

Informally, such partnerships exist e.g. within the NMR NO COMMENTS project and in the HELCOM COMBINE monitoring framework (albeit on a national level).

However, as the information needed by the stakeholders becomes ever more multidisciplinary, the partnerships will have to evolve to include the newly needed disciplines, which face the challenge of becoming operational themselves. With only weak demands from the stakeholders, it is unlikely that the evolution operational ecological services in the Baltic of through evolving partnerships would lead to a rapid fulfillment of emerging stakeholder needs.

The alternative of organizational rearrangements is worth considering in many countries, but is unlikely to proceed on the fora where present organizations are represented. In areas where rapid progress is needed, a sound scientific background, strong leadership, vision and political support are required.