Abschlussbericht

ERANET BONUS: Verbundprojekt BONUS-125: ECOSUPPORT – Leistungsfähiges Modellsystem der Ostsee für Szenariensimulationen zur Unterstützung von Entscheidungsfindungen

Das diesem Bericht zugrundeliegende Vorhaben wurde teilweise mit Mitteln des Bundesministeriums für Bildung und Forschung unter den Förderkennzeichen 03F0492 A gefördert. Die Verantwortung für den Inhalt dieser Veröffentlichung liegt bei den Autoren.

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BONUS SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

ECO SUPPORT

ECOSUPPORT

(Advanced modeling tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making, http://www.baltex-research.eu/ecosupport)

Final report 2009-2011 (including annual report Y3: 2011-01-01 – 2011-12-31)

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1. Summary of Deliverables

1.1 Deliverables for the Y1 reporting period

WP no	No	Title	Due	Status
1	1	Reconstructed atmospheric forcing fields 1850-2007, riverborne nutrient loads including diffusive and point sources , airborne nutrient loads	Month 12	Delivered
1	2	Model data of the first transient simulation to force hydrological models of the catchment area and BS models 1960-2100	Month 6	Delivered
1	3	Model data sets of the whole ensemble 1960-2100	Month 12	Delivered
1	4	River flow data, river- and airborne nutrient loads and CO2 emissions 1960-2100	Month 12	Delivered
2	1	Unified high quality initial, forcing and validation data sets, model data sets 1961-2004	Month 6	Delivered
2	2	Detailed assessment of model skills	Month 9	Delivered
3	1	Unified validation data sets	Month 9	Delivered
5	1	Organisation and meeting minutes kick-off, annual GA, final conference	Month 2	Delivered
5	2	ECOSUPPORT webpage for internal and external information and data exchange, afterwards continuously updated	Month 3	Delivered

1.2 Deliverables for the Y2 reporting period

WP no	No	Title	Due	Status
1	5	Quantification of forcing biases, analysis of causes of biases in reconstructed and simulated forcing fields	Month 24	Delivered
2	3	Model data sets 1850-2007, understanding and quantification of the models capability to simulate perturbations in climate and nutrient loads	Month 24	Delivered
2	4	Model data of first transient simulation with BALTSEM and RCO-SCOBI 1960-2100	Month 18	Delivered
2	5	Model data of all transient simulations	Month 24	Delivered
2	8	Calculation of nutrient load reductions necessary to meet the BSAP targets	Month 24	Postponed to Y3 Completed in Y3
3	2	Food web model and BEM simulation results 1961-2004	Month 24	Completed
5	1	Organisation and meeting minutes kick-off, annual GA, final conference	Month 13	Delivered
5	4	ECOSUPPORT mid-term report	Month 19	Delivered

1.3 Deliverables for the Y3 reporting period

WP no	No	Title	Due	Status
2	6	Analysis of simulated changes (maps, transports, integrated budgets) of biogeochemical variables and ecological quality indicators in future climate and with altered nutrient loads	Month 30	Delivered
2	7	Uncertainty assessment of future projections, results of the analysis of various time horizons, e.g. 2010-2030, 2050-2070, output of the cause-and-effect studies	Month 36	Delivered
3	3	Output of the assessment of model skills, and analysis of regime-shifts in the food web	Month 30	Delivered
3	4	Food web and fish population model simulations for 1960-2100, assessment of impacts of ocean acidification effects on the key functional groups of organisms in the Baltic Sea ecosystem , cause-and-effect studies of simulated changes and analysis of scenarios	Month 33	Delivered
3	5	Probabilistic uncertainty assessments of biological responses (e. g., populations, food web structure) to model structure and forcing scenarios	Month 33	Delivered
4	1	Model simulations of present and future climates in the Gulf of Finland	Month 30	Delivered
4	2	Uncertainty estimates of the Gulf of Finland model output fields	Month 33	Delivered
4	3	Distribution maps of water quality indicators in the coastal zone and open Gulf of Finland	Month 33	Delivered
4	4	Recommendations for future country-wise actions on achieving and preserving good water quality of the Gulf of Finland and management its marine resources	Month 33	Delivered
4	5	Model data sets of hydrography and water quality indicators in Vistula Lagoon	Month 30	Delivered
4	6	Uncertainty estimates, and assessment of socioeconomic impact on Vistula Lagoon	Month 33	Delivered
4	7	Economic assessment of ecosystem goods and services of key ecosystem/habitats on the Polish Economical Zone based upon biological valuation maps in present and future climates	Month 33	Delivered
4	8	A cross-country analysis of stakeholder perceptions of climate change in the BS region	Month 36	Delivered
5	1	Organisation and meeting minutes, final conference	Month 25-36	Delivered
5	3	Publicly available web based DSS	Month 36	Delivered
5	5	ECOSUPPORT final report	Month 37	Delivered

Overall ECOSUPPORT conclusions:

1. **Climate change may have considerable impact on the marine environment with socioeconomic implications**
2. **Nutrient load reductions and sustainable fishery may even be more important in future climate than in present climate**

2. Executive summary

Today the Baltic Sea suffers from severe environmental problems due to eutrophication, e.g. large cyanobacteria blooms and dead sea beds. To overcome these problems it is of vital importance to reduce nutrient loads from the atmosphere, point sources and rivers with the help of international policies, e.g. HELCOM's Baltic Sea Action Plan (BSAP). The BSAP includes the load reductions necessary to obtain good water quality as well as nutrient load abatement strategies based upon a country-wise allocation scheme. The BSAP is currently under revision, i.e. new environmental targets were recently proposed by the TARGREV project and based on these targets revised maximum allowable loads and country allocations are under development.

ECOSUPPORT was designed to play a role by supplying decision makers with sound, scientific knowledge of results of actions on water and land. During 2009-2011 research at 11 institutes from seven Baltic Sea countries contributed to the understanding what effects different mitigation measures will have on the marine ecosystem. For this purpose, a multi-model system tool was developed to support decision makers to assess the anthropogenic impact on the Baltic Sea environment. The advanced modelling tool produces scenario simulations of the whole marine ecosystem that underpin and inform design strategies to ensure water quality standards, biodiversity and fish stocks.

As the response of the Baltic Sea system to changing nutrient loads from land is slow (we found that it will take at least 30 years approximately to see significant improvements of the environmental status in case of nutrient abatements), long scenario simulations are needed that take also the effects of changing climate into account. Hence, within ECOSUPPORT a new modelling approach was developed to calculate the combined effects of changing climate and changing nutrient loads on the Baltic Sea ecosystem. As models have biases due to our limited knowledge of climate and ecosystem processes, uncertainties were quantified using a multi-model ensemble approach for all components of the Earth system, i.e. models for the atmosphere, ocean and land surface including biogeochemical cycles and marine food webs. For coupled climate-environmental modeling the ensemble approach is novel and such a comprehensive downscaling approach has never been applied before.

To evaluate the models' sensitivity to changing drivers on long time scales we reconstructed atmospheric surface fields, runoff, nutrient loads from land and atmospheric deposition for the period 1850-2006. From the reconstruction of the past 150 years we learned about eutrophication, warming trends due to anthropogenic influences, and decadal variations (such as stagnation periods) helping to understand expected future changes. We found that all three Baltic Sea models applied in ECOSUPPORT are capable of simulating past climate variations and eutrophication since 1850 building confidence that the models are able to simulate future changes. Further, we found that nutrient loads increased with a noteworthy acceleration from the 1950s until peak values around 1980 followed by a decrease continuing up to present. However, modeled eutrophication is delayed and shows its largest expression during the 2000s at the end of the simulation period. The simulation results indicate that despite decreased nutrient loads in recent decades no improvement in water quality compared to the present state can be expected for the coming years.

For projections of future environmental status we applied a hierarchy of existing state-of-the-art sub-models of the Earth system. The "work horse" is a regional coupled atmosphere-ocean model which is used to generate the atmospheric and hydrological forcing for three oceanographic-biogeochemical models to calculate the impact of changing climate. It was found that a coupled atmosphere-ocean model is indeed necessary for the ECOSUPPORT applications because biases of simulated present climate in uncoupled regional atmosphere models significantly affect the simulated changes of future projections. All investigated climate projections were based upon the emission scenarios A1B and A2 suggesting warmer air temperatures in the Baltic Sea region, with an annual mean increase in the range of 2.7 - 3.8 °C at the end of the century compared to present climate.

Depending on the scenario simulation river runoff to the Baltic basin will increase in the range between 4 and 22%, with largest increase in the northern parts of the region. The latter results were derived from two completely different hydrological models. Thus, despite large discrepancies the projections agree with respect to a total runoff increase which causes a salinity decrease in the Baltic. One of the hydrological models was also used for experimenting with combined land-based remedial measures and future climate projections to quantify the impact on water and nutrient load to the sea. The experiments suggest that there is a possibility to reach the BSAP targets in future climate. In fact, climate change may help to reach the nitrogen goals, but overall, tough remedial measures are necessary both for waste water treatment and the agricultural sector to reach the phosphorous goals.

The scenario simulations performed with the three Baltic Sea models were forced with combined climate change and nutrient load scenarios. To identify and quantify the impact of nutrient load reductions on the eutrophication status in future climate we used ecological quality indicators suggested by HELCOM. Our results suggest that warmer water will decrease the oxygen saturation concentrations, increase the turnover rates of biogeochemical processes, and enhance the eutrophication. In addition, due to increased river flows eventually larger amounts of nutrients might be flushed out from land. These climate related changes will cause increased oxygen depletion, increased phytoplankton biomass, reduced water transparency and reduced biodiversity (due to decreased salinity). In particular, we showed that under the impact of warming climate, hypoxic and anoxic areas will very likely increase or at best only slightly decrease (in case of the BSAP scenario) compared to present conditions, regardless of the used global model and climate scenario. This result was highlighted in the scientific journal Nature Climate Change. Hence, in a warmer climate nutrient load reductions to the Baltic Sea are of even higher importance than in present climate. Our results will now directly feed into the BSAP revision process since ensemble modeling is a crucial aspect which was previously missing, but is now one of the key items in the HELCOM road map of the revision.

To analyze climate induced changes in the marine food web a new model for the central Baltic proper was developed containing 22 functional groups from primary producers to seals and fishery. In addition, statistical single- and multi-species models were used to link climatic forcing and lower trophic level processes to fish dynamics. We found that in future climate cod biomass will decrease and sprat biomass will increase assuming present day estimates of sustainable fishing. These results are relatively similar in both simple models of fish population dynamics and models of high food web complexity. The uncertainty due to incompletely understood ecological processes within the fish population models is in general larger than the uncertainty due to differences among the three oceanographic-biogeochemical models that force the fish models. The various, largely differing nutrient load scenarios have relatively little effect on the projected cod abundance simulated with the food web model assuming business-as-usual fishery. This finding suggests that the temporal evolution of salinity in changing climate which affects cod reproductive habitat will be the main driver of future cod biomass. Modifications due to nutrient loading are getting more important when the fishing pressure would decrease, e.g. under the so-called “cod recovery plan”. Thus, all food web and fish population models indicated that the level of cod fishery is important in determining the cod stock size also in the future, independent of the climate scenario used.

Our scenario simulations showed a continuous acidification of the Baltic Sea which is mainly controlled by the increasing atmospheric pCO_2 whereas other factors like increasing temperature and primary production are less important. Future acidification may impact Baltic biota. However, an overall conclusion on acidification impacts cannot yet be drawn because measurements are mostly from single-species and single-factor studies available and food web modeling including pH species sensitivities has just started.

Within ECOSUPPORT we also performed local assessments of the impact of changing climate on the marine environment. The “hot spots” Gulf of Finland, Vistula Lagoon and the Polish coastal waters were selected. In addition, a cross-country analysis of stakeholder perceptions of climate change in eight Baltic Sea countries was performed. Overall coastal stakeholders pay only little attention to adaptation and mitigation strategies. Hence, there is still a need for dissemination of information and knowledge that would enable a shift in thinking.

In order to inform stakeholders and the public about ECOSUPPORT efforts, a new form of scientific communication was developed. Research results were projected onto a cupola-shaped screen inside an inflatable, enclosed dome. Presentations for a wide range of audiences got an overwhelmingly positive response because the used visualization technique enhanced understanding and receptiveness. Presentations have been made at prominent stakeholder conferences as well as at public events and to target groups of stakeholders and policy makers. The work with the GeoDome was awarded the BONUS+ award 2011 for the best outreach activity.

Figure 1. Lena Ek (third from left), Environmental Minister of Sweden holding the ’fresh’ BONUS+ public engagement award together with Ms Gabriella Lindholm (left), chairlady of HELCOM and Dr Helén Andersson and Dr Patrick Wallman from the GeoDome team in front of the GeoDome at the Networking Village of the EUSBSR and BDF Forum 2011 in Gdansk, Poland. (Copyright Tina Neset, CSPR)

3. *Gained scientific results.*

3.1. WP1: Drivers related to changing climate and changing river- and airborne nutrient loadings due to anthropogenic activities

Highlight: *Large datasets of drivers 1850-2100 became publicly available*

The WP was devoted to the production of the external-drivers data used to force the ecosystem models of WP2, from 1850 onwards until present and in the future scenarios of greenhouse gas emissions and anthropogenic nutrient loads. The work package has had two methodologically different parts: providing forcing data in the past period, which has been mainly accomplished by analysis of existing observations, but also with some input from appropriate models to fill observational gaps. The second part is a product of climate simulations for future periods.

Concerning the **past period**, the **meteorological forcing** on a daily grid over the Baltic Sea region comprising air temperature, wind, sea level pressure, precipitation, cloudiness and humidity were reconstructed based on long observations of daily sea level pressure and temperature at a set of stations in and around the Baltic Sea area (HiResAFF, deliverable D1.1, see Section 1). These data were fed into a statistical model that also incorporated information from high resolution model simulations over recent three decades to reconstruct all other variables in a physically consistent way throughout 1850 to present (Schenk and Zorita, 2011). The quality of these reconstructions was also verified with standard statistical methods (D1.5). Past concentrations of **airborne nutrients** from 1870 onwards were derived from a revision of 45 historical articles containing relevant information (Ruoho-Airoloa et al., 2010, 2012). The final product represents monthly means over 5-year periods of concentration and deposition of ammonia and nitric acid (D1.4). The reconstruction of **river-borne nutrients**, phosphorous and nitrogen, was carried out based upon historical information (Gustafsson et al., 2012).

Regarding **future periods**, the simulations with the regional coupled atmosphere-ocean model RCAO for future scenarios of greenhouse gas emissions constitutes the bulk of the output of this work package (Meier et al., 2011d). The simulations are started in 1960 and cover the period until 2100. The regional model, representing the Baltic Sea area, was driven at its boundaries by data from two different simulations with global climate models (GCMs): ECHAM5/OPYC3, a climate model developed in Hamburg at the Max-Planck-Institute, and HadCM3, from the Hadley Centre in Exeter (UK). The global models were themselves driven by scenarios of concentrations of greenhouse gases in the atmosphere, the A1B and A2 scenarios. The spatial resolution of the regional model amounts to 25 km. An illustration of the output of this very large simulated data set (D1.2, 1.3) is displayed in Figure 2 showing the simulated changes in sea-surface temperature in different seasons. The use of two global models is a rough measure of the **uncertainty** attached to the use of a certain climate model. In general, **temperature changes** tend to be larger at higher latitudes and in the spring and summer seasons which could affect the intensity or frequency of algae blooms.

To provide a tool for analysis of water and nutrient fluxes in the Baltic Sea basin, the HYPE model was applied to the region (called Balt-HYPE -The BALTic Sea basin HYdrological Predictions for the Environment). It was used for experimenting with land-based remedial measures and future climate projections to quantify the impact on water and nutrient load to the sea (Arheimer et al., 2012). Model results show a large spread in results depending on climate model projection. Nevertheless, the experiment suggests that there is a possibility to reach the BSAP targets in a future climate. In fact, climate change will help to reach the nitrogen goal, but overall, tough remedial measures are necessary both for waste water treatment and the agricultural sector.

WP1 was completed in December 2010 and consequently there was no activity to report during 2011.

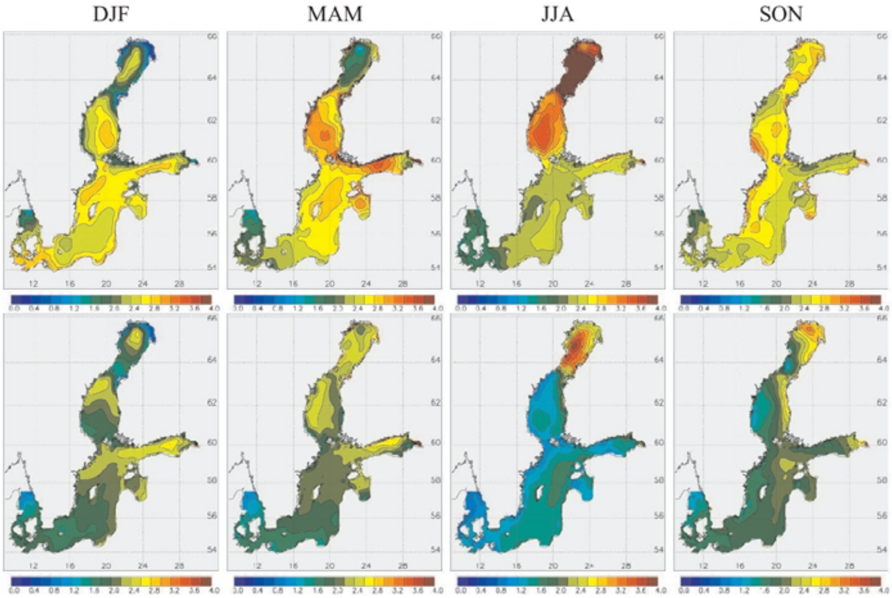


Figure 2. Seasonal mean sea surface temperature changes (in ◦C) for 2061–2090 and 1970–1999 in RCAO-HadCM3 A1B (upper panels) and RCAO-ECHAM5 A1B (lower panels). From left to right, changes for winter, spring, summer and autumn. Changes larger than 4ºC are shown in brown.

3.2. WP2: Impact on BS nutrient cycles, autotrophs and zooplankton

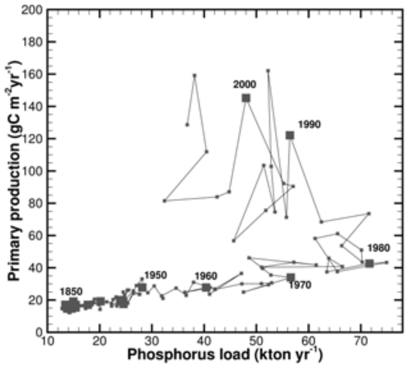
Highlight: *Ensemble modeling resulted in a low oxygen outlook and enabled the quantification of uncertainties of projected biogeochemical cycles 1850-2100*

Using an ensemble of three coupled physical-biogeochemical models for the Baltic Sea (BALTSEM, ERGOM, RCO-SCOBI) driven with four differing regionalized data sets from global climate simulations (WP1) we were able to quantify the influence of changing climate upon ecological quality indicators describing the status of the marine ecosystem. In particular oxygen conditions at the sea bottom, e.g. anoxic and hypoxic area, were studied (Meier et al., 2011b). This result was highlighted by Nature Climate Change (see A. Brown, 2012: Low oxygen outlook. Nature Climate Change, 2, 75 doi:10.1038/nclimate1406, http://www.nature.com/nclimate/journal/v2/n2/full/nclimate1406.html). The three models were driven with unified high quality initial and forcing data sets and evaluated with quality ensured observational data sets (D2.1).

A detailed assessment of model skills and comprehensive model inter-comparison has been performed using regionalized re-analysis data for the period 1961-2007 (D2.2). It was found that the results of the three models are close to observations from standard monitoring stations, although some fluxes and variables that cannot be observed, like integrated sediment pools, differ considerably between the models (Eilola et al., 2011a). Another important result was that ensemble average results are better than or as good as the results of any of the individual models supporting the idea of ensemble modeling to reduce uncertainties in scenario simulations caused by model biases (Eilola et al., 2011a).

To understand and quantify the models capability to simulate perturbations in climate and nutrient loads on long timescales a comprehensive reconstruction of the Baltic Sea state from 1850-2007 was performed using all three Baltic Sea models (D2.3). As shown by Gustafsson et al. (2012) the BALTSEM model, driven by the high resolution atmospheric forcing fields (HiResAFF), reproduces well salinities, temperatures and maximum ice extent. Nutrient loads increased with a noteworthy acceleration from the 1950s until peak values around 1980 followed by a decrease continuing up to present. BALTSEM shows a delayed response to the massive load increase with most eutrophic conditions occurring only at the end of the simulation, accompanied by an intensification of the pelagic cycling driven by a shift from spring to summer primary production. The simulation results indicated that no improvement in water quality of the Baltic Sea compared to its present state can be expected from the decrease in nutrient loads since about 1980 (Fig. 3).

Figure 3. Primary production in Baltic proper versus total phosphorus loads to the Baltic Sea from the



long-term simulation with Baltsem showing the hysteresis-like response of the Baltic Sea to nutrient loads. Although phosphorus loads decreased to levels of the late 1950s, primary production is at a higher level than ever before.

The analysis of future projections was based upon an ensemble of 54 transient model simulations for the period 1961-2099 (D2.4, 2.5). Applying various plausible nutrient load scenarios, that were developed by HELCOM and further detailed within ECOSUPPORT (Gustafsson et al., 2011b), we showed that under the impact of warming climate hypoxic and anoxic areas will very likely increase or at best only slightly decrease (in case of optimistic nutrient load reductions) compared to present conditions, regardless of the used global model and climate scenario (Meier et al., 2011b). The projected decreased oxygen concentrations are caused by (1) enlarged nutrient loads due to increased runoff, (2) reduced oxygen flux from the atmosphere to the ocean due to increased temperature, and (3) intensified internal nutrient cycling. In future climate a similar expansion of hypoxia as projected for the Baltic Sea can be expected also for other coastal oceans worldwide (Meier et al., 2011b).

Maps of simulated changes of biogeochemical variables and ecological quality indicators in future climate and with altered nutrient loads (D2.6) are displayed within the ECOSUPPORT Decision Support System at http://www.baltex-research.eu/ecosupport using Google Earth (see also Meier et al., 2011a; 2012b). Model results suggest that in future climate water quality, characterized by ecological quality indicators like winter nutrient, summer bottom oxygen and annual mean phytoplankton concentrations and annual mean Secchi depth, will be deteriorated compared to present conditions (Meier et al., 2012a; 2012c; Eilola et al., 2012). The number of days favoring cyanobacteria blooms will increase and anoxic events become more frequent and last longer (Neumann et al., 2012). Based on the analysis of biogeochemical fluxes we found that in warmer and more anoxic waters internal feedbacks will be reinforced. Increased phosphorus fluxes out of the sediments, reduced denitrification efficiency and increased nitrogen fixation may partly counteract nutrient load abatement strategies (Meier et al., 2012c).

The deteriorating effect from climate change on water quality implies that even larger nutrient load reductions must be undertaken in order to obtain the objective of good ecological status in the BSAP. It was calculated that due to climate change the maximum allowable nitrogen and phosphorus loads in the BSAP need to be additionally reduced with 118 000 and 5 600 ton yr^{-1}, respectively (D2.8).

Key results of 2011:

During 2011 the research focused on the analysis of the past reconstruction and on scenario simulations (D2.7). To study the impacts of the two dominating drivers, human activities on land (e.g., fertilizer use, burning of fossil fuels) and climate change with increasing water temperature and changing stratification, a series of cause-and-effect studies have been performed (Meier et al., 2012a; c). Further, an uncertainty assessment of future projections has been performed. It was found that uncertainties of the projections are dominated by unknown nutrient loads, biases of the GCMs and biases of the biogeochemical models (Meier et al., 2012c). Uncertainties caused by the GCMs and by the biogeochemical models are of comparable magnitude and depend on the region and variable of interest. We found largely differing sensitivities of the models to changing nutrient loads. A quantification of the climate change impact on water quality in terms of additional nutrient load reductions necessary to meet the BSAP in future climate was made (D2.8).

3.3. WP3: Impact on the food web

Highlight: *despite large uncertainties the ECOSUPPORT downscaling approach suggested that warming climate will cause reduced cod and increased sprat biomass*

There are several major drivers of population and food web variability in the Baltic Sea (e. g., climate variability/change, exploitation, eutrophication, marine mammal predation). Quantitatively investigating impacts of these drivers requires models that accommodate these forcings and unified data sets that can be used for model validation (D3.1). Moreover within ECOSUPPORT, there are several different models representing the consequences of these drivers at different levels within the food web (e. g., models that simulate fish populations and food-web dynamics). As it is unclear which of the models and model combinations give the most realistic results, the project has dedicated effort to assessment and methodological development of how to integrate and link the various models and their outputs (e. g, whether and how to construct ensemble averages). The linkage among models through the food web permits an evaluation of some of the uncertainties associated with the different model categories (e. g., biogeochemical-oceanographic models, fish population models).

The overall modeling framework for conducting scenario simulations and assessing model uncertainties is represented schematically in Figure 4. In terms of methodology and uncertainty, outputs from simple models of fish population dynamics or models of high food web complexity (Ecopath with Ecosim: EwE; Tomczak et al., 2012) are relatively similar when forced with oceanographic data provided by all three oceanographic models available within ECOSUPPORT (BALTSEM, ERGOM, RCO-SCOBI; see grey areas in Figure 5; MacKenzie et al., 2012; Niiranen et al., 2012b). The new Central Baltic Proper EwE model developed within ECOSUPPORT (D3.2) contains 22 functional groups from primary producers to seals and fishery (Niiranen et al., 2012a). The model was calibrated using data from all trophic levels, excluding primary producers.

The uncertainty of a fish population model itself can be greater than that estimated using any of the three oceanographic models. Further, it has been analyzed how the uncertainty of biological and environmental data affect the sensitivity of model parameterization (Niiranen et al., 2012a). The uncertainty associated with four *different* fish population models coupled to only one of the oceanographic-biogeochemical models (RCO-SCOBI) is modest-large (Fig. 5 left panel). However, although the fish population/food web models have very different parameterizations, assumptions and sensitivities to environmental forcing, all models indicate an initial decline in sprat biomass followed by a rise. Based on these calculations, it is likely that the sprat spawner biomass will increase in the Baltic Sea during the 21st century.

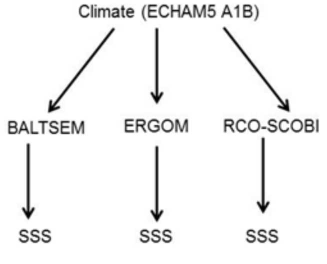
The EwE model has been run for the most extensive combination of climate, nutrient loading and fishery scenarios using output from all three WP2 biogeochemical models (Fig. 4). These simulations demonstrate the dominant impact of fishing on cod (Fig. 5 lower panels). However, worsening of reproduction conditions, due to climate change in combination with high nutrient loading, seems to limit the cod stock even at low fishing levels (Niiranen et al., 2012b). Nutrient loading had a higher effect on lower trophic level groups. Other project simulations showed that a recovery of the population of grey seals (which prey on cod) is also likely to have a smaller impact than exploitation and climate change on the development of cod biomass in the Baltic Sea during the 21st century (MacKenzie et al., 2011).

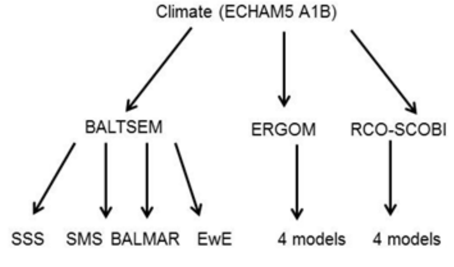
Climate scenario simulations showed a continuous acidification of the Baltic Sea which is mainly controlled by the increasing atmospheric pCO_2 (Kuznetsov and Neumann, 2012). Changes in pH due to other factors like increasing temperature and primary production are less important and differ between the regions. Future acidification may also impact Baltic biota (Havenhand, 2012). Although available data suggest that most species and ecologically important groups in the Baltic food web (zooplankton, macrozoobenthos, cod and sprat) will be robust to the expected changes in pH, from the review by Havenhand (2012) a general conclusion cannot be drawn because mostly single-species and single-factor studies are available. A preliminary sensitivity analysis of the consequences of ocean acidification on the Baltic ecosystem assuming some kind of ``worst case´´ suggests that ocean acidification may cause substantial (> 50%) declines in some key fish populations of the Baltic Sea (herring, cod) and in biomass of other taxa (zooplankton, benthic filter-feeders).

The main achievement of WP3 is that a diverse set of climate-oceanographic-biogeochemical, population and food web models has been linked to simulate various combinations of ecosystem drivers (fishing, climate change, nutrient loading, marine mammal predation) on ecosystem dynamics. This framework will facilitate future studies of the consequences of potential ecosystem and fishery management decisions and should be a valuable tool for both marine scientists and policymakers.

Key results of 2011:

During 2011 evaluations of both fish population and food web models were performed (D3.3). Good results of simulated sprat biomass were obtained from an ensemble of population models that need water temperature from a certain depth and a certain season of the year as input (MacKenzie et al., 2012). Although water temperature is satisfactorily simulated in all three Baltic Sea models, the quality is not sufficient as forcing for the population models. Hence, a bias correction has been performed. Also for the EwE food web model a sensitivity and uncertainty analysis was performed showing that the model results are sensitive to cod biomass input data and choice of environmental forcing (Niiranen et al., 2012a). Cause-and-effect studies with the food web model showed that hydrographic variability, exploitation and eutrophication have all contributed to the regime-shift of cod biomass in the late 20th century (Tomczak et al., 2012). Further, scenario simulations for 1960-2100 with both types of models were performed and the role of various combinations of drivers (fishing, climate change, nutrient loading, marine mammal predation) was investigated (D3.4). Uncertainties caused by (1) biases of the oceanographic-biogeochemical models, (2) biases of the GCMs and (3) biases of the fish population models were assessed (D3.5) (MacKenzie et al., 2012; Niiranen et al., 2012b).





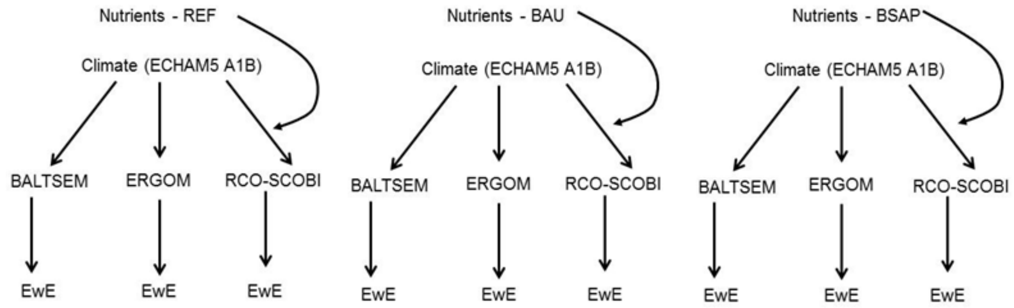


Figure 4. Schematic of hierarchical linkage of models and forcings within WP3 of ECOSUPPORT to investigate roles and uncertainties among processes and model configurations. Climate models (top row of panels) provide inputs to oceanographic-biogeochemical models (middle row of panels) which provide forcing to different fish population and food web models (lower row of panels). Additional simulations were conducted using a full food web model (EwE) to investigate combined effects of nutrient loading (BAU, REF and BSAP), climate variability (A1B and A2) and exploitation on fish populations (Fbau and F03) and food web structure (represented by lower panels).

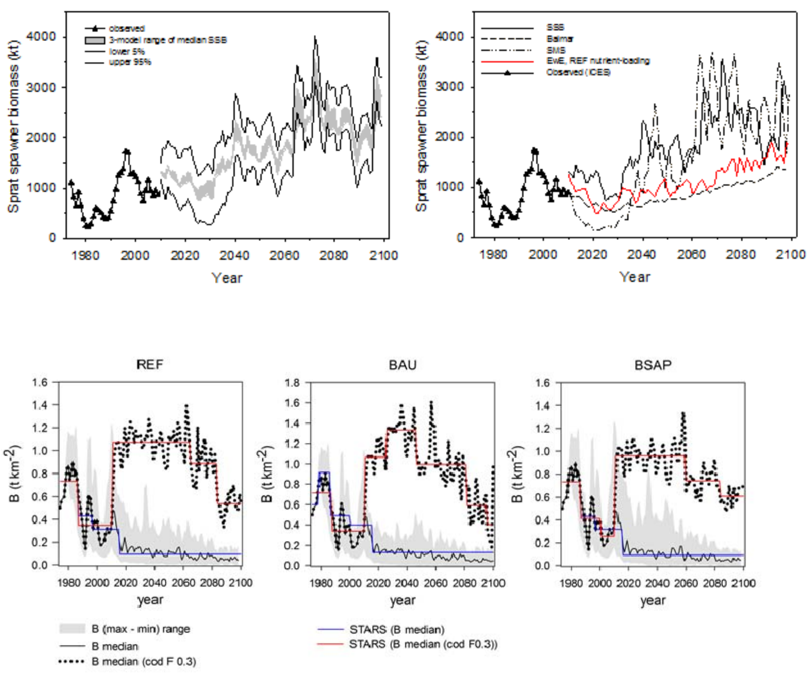


Figure 5. **Top left**: Projected spawner biomass of sprat in the Baltic Sea (ICES Subdivisions 22-32) assuming a temperature – driven spawner-recruit relationship with temperatures estimated from three different climate-oceanographic models forced with ECHAM5 modelled climate data according to the A1B emission scenario. The shaded area represents the range (minimum to maximum) among the three models, and the black lines represent the 95% confidence limits of spawner biomass or yield as estimated by the climate-oceanographic model (RCO-SCOBI) with least uncertainty in representing observed temperatures in a control period (1970-2005). Fishing mortality of sprat was at a currently defined sustainability level (F = 0.32: ICES 2011) and natural mortality (e. g., due to predation by cod and seals) was assumed equal to the mean level during 2008-2010. Also shown (triangles) are historical estimates of spawner biomass and yield during 1974-2010 (ICES 2011). Additional details of calculations are in MacKenzie et al. (2012). **Top right**: Similar to left panel, but sprat biomass estimated using different population and food web models. All projections use the A1B emission scenario, ECHAM5 climate forcing and the RCO-SCOBI oceanographic-biogeochemical model. Fishing mortality, F, of sprat, cod and herring were assumed equal to currently defined sustainability

level (i. e., F_{msy}: ICES 2011). Model abbreviations are following: SSS: stochastic single-species age-structured model; BALMAR: time-structured food web model involving sprat, herring, cod and zooplankton; SMS: stochastic multi-species age-structured model of predation interactions among cod, herring and sprat; EwE: Ecopath with Ecosim food web model of all trophic levels from primary producers to top predators assuming a reference nutrient loading scenario. Additional details of model assumptions and parameterisations in text and references (WGIAB 2009; Lindegren et al. 2010; Tomczak et al., 2012; MacKenzie et al., 2012). **Lower panels**: Projected spawner biomass of cod in the Baltic Sea (ICES Subdivisions 25-32) as simulated using EwE coupled to three oceanographic-biogeochemical models (BALTSEM, ERGOM, RCO-SCOBI) assuming three nutrient loading scenarios corresponding to current levels (REF), Business-as-Usual (assumes exponential growth in agriculture in all Baltic countries and atmospheric deposition), and Baltic Sea Action Plan reduction as well as two cod fishery scenarios ("Business-as-Usual" and "cod recovery plan" (F03)). The grey shaded area represents the range (minimum to maximum) among the three biogeochemical models. Additional details of model assumptions and parameterisations in Tomczak et al. (2012) and Niiranen et al. (2012b).

3.4. WP4: Impact on socio-economic and regional development, case study

Highlight: *Investigating regional to local impacts of climate change, both on ecosystem and socio-economic levels*

WP4 tasks comprised three regional case studies – the Gulf of Finland, Vistula Lagoon, the Polish Economic Zone – and socioeconomic impact in the Baltic Sea scale.

The response of thermohaline and bio-geochemical fields as well as physical processes to climate change was evaluated for the Gulf of Finland comparing a hindcast simulation (1997-2006) and one future projection (scenario A1B, 2070–2099) (D4.1, D4.2) (Raudsepp et al., 2012; Lessin et al., 2012). The results show that there is no statistically significant difference between the analysed fields and the processes between the last three decades of 2070-2099. Therefore, the last decade was selected and compared to the hindcast period. The results are briefly summarized below.

The water column is projected to become warmer by about 2 °C. The salinity stratification increases due to freshening of the upper layer and salinity increase in the near-bottom layer. The number of upwelling events in the Gulf is almost the same as in the hindcast period. The frequency and spatial scale of estuarine circulation reversals decreases due to the projected decrease of eastward and the increase of westward wind stress which support the estuarine circulation. This and the projected decrease of surface layer salinity reduce the homogenization of the water column in winter. The future projection showed a decrease of near-bottom oxygen concentrations and a frequent occurrence of anoxic conditions below 60 m depth in the Gulf. This will coincide with the increase of phosphate content in the deeper areas due to the release of phosphorus from the sediments. The near-bottom nitrate concentration will decrease due to the anaerobic denitrification. The changes in the nutrient ratio projected for the future scenario will lead to an increase in the nitrogen fixation, except in the easternmost part of the Gulf. The chlorophyll content will increase due to intensive cyanobacteria blooms in the offshore areas and due to enhanced flagellate growth in the Neva estuary (D4.3).

Available hydrological data of the Vistula Lagoon (1994-2008) were collected into a database (D4.5). The vulnerability analysis of development strategies of 17 municipalities of Russia and Poland against the changes in environmental conditions showed that municipalities of the Kaliningrad region are relatively ignorant to the effects of climate change. The high costs of protection measures against anticipated sea level rise play a key role for Polish municipalities. Assuming that in future climate storm activity and surges on the background of growing global mean sea level rise is increasing significantly, the rate of abrasion in the Gulf of Gdansk will increase. However, the latter scenario is not supported by our climate modelling.

The effects of climate change on marine ecosystem goods and services (MES) have been assessed (D4.7). We provided qualitative projections of socio-economic consequences of climate change based on current knowledge, literature review, and available models. We described key processes that need to be taken into account to achieve sustainable management in the Polish Marine Areas and tested how MES are perceived in the practice of urban planning and long term management. Our analysis reveals that soft sediment shores in the southern Baltic are expected to be exposed in case of higher storminess, lowering salinity and increased sea water temperature in the coming decades. As these phenomena are expected to cause increased erosion, oxygen deficiency and elevated effects of eutrophication, goods and services provided by the region will be strongly affected. Fishery is likely to evolve towards pelagic catch (industrial vessels) while recreational fishery will move for salmonids and pike, with loss of demersal fish, especially cod. Coastal recreation may benefit from elevated air and sea temperatures, although on the other hand (eventually) storminess and consequent turbidity may be inhibiting for the tourism increase. Along with the natural phenomena the implementation of EU environmental directives changes the area towards cleaner, less eutrophic and more intensively managed region. Although MES are commonly recognized at international (e.g., MFSD) and regional level (e.g., BSAP), their recognition in local planning and strategic documents (at the municipality level) is partial and limited to the services which are already captured by market mechanisms. Some municipalities are aware of their environmentally related advantages but these advantages rarely influence practical actions. Limited identification of MES leads to insufficient discussion of current and future trade-offs, even though the 'environment or development' dilemma is commonly emphasized.

The awareness among institutional stakeholders has been examined through questionnaires in eight Baltic countries. Our results indicate that problems related to global warming are secondary to short-term social and economic issues. The consensus is that problems caused by global warming will be increasingly important, but little attention is paid to adaptation and mitigation strategies. Current environmental problems are expected to continue to be urging in the future. We conclude that the apparent gap between decisions making, public concerns, and the scientific consensus may stem from the information bias: the latest data rarely influence commonly held opinions (D4.6, D4.8).

Key results of 2011:

All the WP4 deliverables were due during 2011. The above summary therefore well reflects the activities during the final year. The regional socio-economic impact of climate change (D4.8, D4.6) is summarized in the manuscript by Piwowarczyk et al., 2012; Climate Change in the Baltic Sea Region - A cross-country analysis of stakeholder perceptions and Economic assessment of ecosystem goods and the study on services of key ecosystem/habitats on the Polish Economical Zone (D4.7) by the manuscript by Weslawski et al., 2012 (both submitted to the Ambio special issue).

3.5. WP5: Co-ordination, data management, DSS, dissemination and outreach activities (all partners)

Highlight: *Usage of new, innovative and high-tech scientific communication tools to enable effective dissemination to stakeholders as well as extensive dissemination of scientific results through arrangement of conferences, participation in conferences and scientific publications.*

During the third and final year of the ECOSUPPORT project the consortium has gathered a number of times for workshops and scientific meetings. The management group has had regular three-monthly meetings where status reports for the different WPs has been shared among the group and then to the consortium and public through the webpage. The webpage has regularly been updated with both internal information and external dissemination. Work within WP5 has during the final year also focused on dissemination to the general public, policy makers and other stakeholders, through visualisation techniques, seminars and a web based decision support system. Overall the WP5 activities have been conducted according to the work plan and are summarized below.

Scientific communication in a GeoDome

The ECOSUPPORT project aimed to help policy makers by supplying state-of-the-art research on the state of the Baltic Sea under different scenarios. In order to make the research results accessible, a new form of scientific communication was developed, tested and evaluated during the project. Research data were projected onto a cupola-shaped screen inside an inflatable, enclosed dome (Fig. 6). Presentations have been made to a wide range of audiences, and overall the response has been overwhelmingly positive with the expressions that the used visualization technique enhanced understanding and receptiveness. Presentations have been made at prominent stakeholder conferences as well as at public events and to target groups of stakeholders, policy makers and politicians. The work with the GeoDome was awarded the BONUS+ award 2011 for best public activity or product.

ECOSUPPORT Web page

The project activities have been published on internal and external pages of the ECOSUPPORT homepage http://www.baltex-research.eu/ecosupport/ maintained by the BALTEX secretariat at the Helmholtz-Zentrum Geesthacht in Germany. This includes information about the project and its partners, project meetings, seminars and conferences as well as material for download: metadata, data, scientific papers and posters, stakeholder material, technical reports etc. The web page is also the home of the ECOSUPPORT decision support system.

Figure 6. ECOSUPPORT researchers, Director General SMHI and the GeoDome™ at the Government Offices of Sweden, November 2010. (Source: Patrik Källström**,** Norrköping Visualization Centre C)

Decision Support System (DSS)

This database gives information on the state of the Baltic Sea regarding oxygen content, cod-reproductive volume, nutrient content, chlorophyll concentrations, etc. under different scenarios of nutrient loads and climate change. Information is also included on uncertainties of the different scenario projections. The DSS is based on “Google Earth Maps” of the Baltic Sea to enable an easy-to-use and visually informative overview of the huge project data set (Fig. 7).

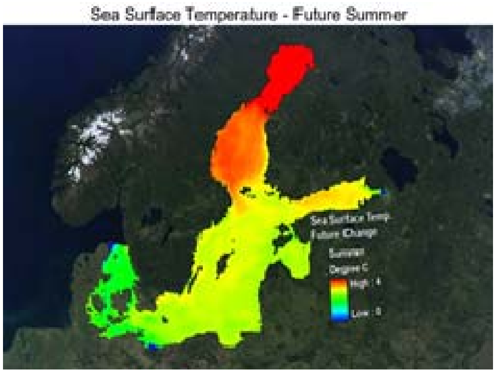


Figure 7. Example of the information that can be found in the DSS.

Other Stakeholder dissemination activities

The project arranged a well-visited (about 70 people) stakeholder conference together with the RECOCA project to present and discuss both projects' outcome on the environmental past, present and future status of the Baltic Sea, effects and costs of the implementation of the Baltic Sea Action Plan under scenarios of climate change, etc.

Figure 8. The ”researchers corner” at the exhibition “Ocean Environment” at the Norrköping Vizualisation Centre C. (Source: SMHI)

Researchers from the project have participated in an information movie “Notes on Climate Change” made by the Council of the Baltic Sea States. Project results have been used to make a “researchers corner” at the Norrköping Visualisation Center C exhibition on Ocean Environment (Fig. 8). We participated at stakeholder meetings arranged by BONUS+; the BONUS+ forum in Gdansk and for EU representatives in Brussels. For these events we produced a stakeholder folder and poster. We have also presented the project results in several media interviews (radio, TV, newspapers and web published articles).

Project-arranged international workshops and other scientific communication

The project has arranged two international workshops aimed at a wider scientific audience: **“**Uncertainties of scenario simulations” (BONUS cluster workshop) and “The Marine Ecosystem in a changing climate – on the added value of coupled climate-environmental modelling for the Baltic

Sea". We also supported the BONUS/AMBER PhD Climate Modelling School with organization and presentations.

We collaborated with many other international scientific programs and projects (including several BONUS+ projects, e.g. INFLOW, AMBER, HYPER, RECOCA, BalticWay, IBAM). For instance, we participated in a workshop organized by the BalticSTERN project (http://www.stockholmresilience.org/balticstern) and contributed to an assessment of scenarios for the Baltic Sea region performed by BalticSTERN. We participated also in several scientific panel discussions, e.g. organized by the Royal Swedish Academy of Agriculture and Forestry's water committee in May 2011. As ECOSUPPORT is a project under the umbrella of the BALTEX network, many ECOSUPPORT scientists collaborated naturally with BALTEX scientists. ECOSUPPORT scientists were active in participating in and chairing BALTEX working groups and contributed considerably to the scientific study conferences of BALTEX.

The project has been represented with talks and posters at a number of scientific meetings and conferences, e.g. BONUS annual conference in Lithuania, the BALTEX conference in Poland, the EUTRO 2010 conference in Denmark, the 8th BSSC in St Petersburg and ICES annual conference in Gdansk. 3 scientific posters summarising ECOSUPPORT efforts have been produced during the year as well as more than 71 publications of which half are published or under revision in refereed international journals (see Appendix). One licentiate and one doctoral thesis have been produced with aid of project material and funding. The project has secured a special issue with AMBIO, which will be published in autumn 2012.

Consortium Management

During the project period the consortium has met for scientific discussions/workshops and for consortium planning and steering at a number of occasions. The project started with a kick-off meeting. The two following years had annual meetings with General Assembly. In the 3rd year there was an annual consortium meeting coinciding with a final joint scientific conference with BONUS+ project RECOCA. Aside the annual meetings there have been two project workshops including all WPs: "Data Integration and Modelling" in 2009 and "Scenarios and long-term hindcasts" in 2011. There have also been two workshops within WP2, one within WP4 and one for WPs 1-3. The consortium has also gathered for meetings at the venues of scientific conferences such as the BSSC in 2009 and 2011. Meeting agendas, minutes and many of the presentations have been published on the project web page. The steering group had about four meetings per year, most of them by telephone conferences. After these meetings minutes and WP status reports have been published on the webpage. The overall status of the project has been disseminated in annual and final reports.

4. Practical implementation of project outputs

ECOSUPPORT results have been presented at a number of occasions for stakeholders and workgroups concerned with the issues of the Baltic Sea environmental health. Members have also served in different kinds of working groups and committees, such as ICES/HELCOM working group on Integrated Assessment of the Baltic Sea and TARGREV/HELCOM, addressing the Baltic Sea Action plan. The usefulness of ECOSUPPORT results in the revision of the ecological targets of eutrophication of the Baltic Sea Action Plan was for instance reported by the new Executive Secretary of HELCOM, Monika Stankiewicz (http://www.bonusportal.org/news_room/minister_ek_visits_the_bonus_offices_br_bonus_a_good_example_of_successful_cooperation.html).

During 2011 some of these occasions (BONUS performance statistic question 1-2) were:

1) June 21. Presentation for the European Parliament (Bo Gustafsson) (Q1)
2) November 7-9th. Ecosupport PI – Jan Marcin Weslawski – conference 'Planning for biodiversity', Warsaw (Q1)

3) Jan 25. Meeting with the Helcom Secretariat (Bo Gustafsson) (Q2))
4) May 15. Royal Swedish Agricultural Academy public seminar (Bo Gustafsson) (Q2))
5) August 24. Panel discussion and press conference at the EU-info center in StPetersburg) (Bo Gustafsson) (Q2)
6) September 6. Presentation for the Black Sea Commission experts (Bo Gustafsson) (Q2)
7) September 9. Presentation for the Baltic Stern steering committee (Bo Gustafsson) (Q2)
8) October 13. Meeting with the Swedish Farmers Association about BSAP (Bo Gustafsson) (Q2)
9) 24 October. BONUS Forum in Gdansk, coinciding with the 2nd Annual Forum for the EU Strategy for the Baltic Sea Region Development (Q2)
10) December 7. ECOSUPPORT and RECOCA Stakeholder conference (Q2)
11) Environmental Impact Assessment Committee for the Pomeranian Voidevoship (3 meetings; Jan Marcin Weslawski) (Q2)
12) First stakeholders meeting in the preparation process of the 'National strategy for the conservation of grey seals and harbour porpoises' (Jan Marcin Weslawski & Joanna Piwowarczyk (Q2)
13) HELCOM LOAD meetings (Tuija Ruoho-Airola, 2 meetings)
14) Meetings concerning marine acidification in the Baltic Sea (Incl. Kattegat and Skagerrak). Scientist and stakeholders from Swedish EPA, SMHI and Gothenburg University. (Jonathan Havenhand, 4 meetings) (Q2).
15) Participations as expert on marine acidification with Interreg project "Hav Möter Land" (Jon Havenhand, 2 meetings) (Q2).
16) Swedish representative in the Arctic Monitoring & Assessment Program: Arctic Ocean Acidification Program (Arctic Council) (Jonathan Havenhand, 2 meetings) (Q2).
17) Aug 2011: Member of the scientific committee of the 8th Baltic Sea Science Congress (BSSC) 2011``Joint research efforts for sustainable ecosystem management" St.Petersburg, Russia, 22-26 August, 2011 (Markus Meier) (Q2)
18) Aug 2011: Convener of the theme session ``Impact of changing climate and human-induced pressures on the Baltic Sea Ecosystem" proposed by the BONUS+ program by Markus Meier (Sweden), Joachim Dippner (Germany), Aarno Kotilainen (Finland) at the Baltic Sea Science Congress (BSSC), St.Petersburg, Russia, 22-26 August 2011 (Markus Meier) (Q2)
19) Sep 2011: Co-Convener of the theme session ``Integration of multidisciplinary knowledge in the Baltic Sea to support science-based management" proposed by the BONUS+ program by Sakari Kuikka (Finland), Michael Gilek (Sweden), Markus Meier (Sweden), Kari Lehtonen (Finland) at the 2011 Annual Science Conference of International Council for the Exploration of the Sea (ICES), Gdansk, Poland, 19-23 September 2011 (Q2)
20) Dec 2011: Organizer of the international ECOSUPPORT and RECOCA stakeholder conference on ``An outlook to the future Baltic Sea: how can we reach the targets of the Baltic Sea Action Plan?", Stockholm University, Stockholm, Sweden, 7 December 2011. (ECOSUPPORT project) (Q2)
21) Topic Editor of the EGU journal Ocean Science (http://www.ocean-science.net/index.html) (Markus Meier) (Q2)
22) since 2011: Contributing author for the BALTEX Assessment of Climate Change II (BACC II), chapter 4.3.4. Marine physical changes (incl. sea ice, storm surges and waves) (Q2)
23) since 2011: Member of the Working Group on Drafting a Science Plan for a scientific research network following BALTEX Phase II. (Q2)
24) Member of the Steering Group Committee of the 'ECOCHANGE' programme, the joint Strategic Marine Environmental Research Programme on the Baltic Sea of Umeå and Linnaeus universities. (Markus Meier) (Q2)
25) Member of Lithuanian-Russian WG on oil combating, he participated as an expert in the annual meeting, Klaipeda, 27 of September, 2010. (Boris Chubarenko) (Q2)

26) Member of Scientific Council of the P.P.Shirshov Institute of Oceanology of Russian Academy of Sciences. He regularly informed about BONUS news. Three thematic presentations were made: 27.03.2011 - Strategic priorities of research within BONUS

Program; 12.12.2011 - Final Conference of ECOSUPPORT and RECOCA Projects; 31.10.2011 - Information on BONUS Forum 2011 (Gdansk, 24 October, 2011). (Boris Chubarenko) (Q2)

27) ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB), 4–8 April 2011, Mallorca, Spain (Brian MacKenzie) (Q2)
28) ICES Science Committee, May 3-5, 2011, Copenhagen, Denmark (Brian MacKenzie) (Q2).
29) ICES Science Committee, Sept. 21-25, 2011, Gdansk, Poland (Brian MacKenzie) (Q2)
30) ICES SG History of Fish and Fisheries (SGHIST), 24-27 Oct, 2011, in CEFAS, Lowestoft, UK (Brian MacKenzie) (Q2).

Project efforts have been used to modify relevant policy documents (BSAP) (Q3):

1) September 1. HELCOM LOAD meeting
2) September 23. HELCOM LOAD core group meeting

Projects efforts have been used for suggestions for pertinent public policies (Q4)

1) September 29. Meeting with the Swedish Agency for Marine and Water Management
2) October 6. HELCOM MONAS meeting
3) March 31. HELCOM CORE/EUTRO meeting
4) April 13. HELCOM MONAS meeting
5) ECOSUPPORT outcome on the efficiency of the Baltic Sea Action Plan in future climate. Stakeholder material, project reports and scientific publications e.g.in AMBIO ECOSUPPORT special issue.
6) September, 2011. Agreement with Kaliningrad Centre for Hydrometeorology and Environmental Monitoring to develop mutually the letter to Government of Kaliningrad Oblast about needs to develop local agenda of climate change and adaptation to them.

5. *Comparison with the original research and financial plan*

The project has been successfully conducted without major deviations from the original research plan.

WP1 was mainly set-up as a data provider for the subsequent work packages, and its main motivation has been fulfilled within ECOSUPPORT.

WP2 has conducted physical-biogeochemical model simulations, making use of three different models for the Baltic Sea to conduct ensemble means and spread. There were no deviations to the original work plan and all deliverables, including the postponed D2.8 (due month 24), were conducted within the project finishing time.

WP3 has achieved its overall objectives of integrating outputs from multiple climate, oceanographic, biogeochemical and fishery/food web models and has developed hindcasts and forecasts of how populations and food webs of the Baltic Sea might react to some major forcings expected during the 21st century (i. e., climate change, exploitation, nutrient loading). The project has also identified and quantified some of the uncertainties that arise when using and combining different model outputs in an end-to-end ecosystem framework. There still remain some gaps in knowledge and analyses in relation to acidification effects on biota. Some adaptation of work plan was necessary due to changes in staff and new scientific findings during the project. The application of CART models to assess possible impacts of pH on species turned out to have limited applicability in ocean acidification studies and attempt to use such models would be extrapolatory and involve many uncertainties. Envelop model studies were instead planned and started but could not be completed due to staff departure. Instead a comprehensive literature review was conducted which will be included in the ECOSUPPORT special issue in AMBIO (Havenhand, 2012).

WP4 has achived the set goals of regional case studies and socio-economic studies. The deliverable of a stakeholder report (D4.8) was divided into two parts, where the part regarding the socio-economic situation is presented in a paper that will be included in the AMBIO special issue. The cost estimate for increased costs of the implementation of BSAP in future climate is, however, utterly uncertain. The analysis was based on results from the BALTCOST model obtained within the RECOCA project, and the analysis of the costs for BSAP in present climate shows that the marginal costs for the larger reductions is increasing drastically with load reduction. Thus, a proper analysis of the possibility of obtaining and the cost of additional load reductions would need a complete application of the BALTCOST or a similar model. This is beyond the capability of the ECOSUPPORT team. Due to this huge uncertainty we restricted the distribution of these order of magnitude estimates of the costs to project participants only.

WP5 has managed the projects and disseminated its results without deviation to the work plan.

6. Further research and exploitation of the results

One of the main aims of the ECOSUPPORT project was to construct a huge database that would be made available to the scientific community as well as to policy makers and other stakeholders. One of the highlights of the project was also the success in compiling this database that assesses many of the key parameters addressing the environmental status and the forcing parameters of the Baltic Sea. The material provides ample opportunity for further scientific analysis of forcing parameters, ecosystem functioning and uncertainties of scenario simulations. The project-gained understanding of the combined effect of nutrient loads and climate effects will also further be disseminated to stakeholders concerned with the eutrophication problems of the Baltic Sea (working groups within HELCOM, etc.), general Baltic Sea strategy and adaptation to climate change (information used within Interreg and Baltic Sea Strategy flagship projects, e.g. BALTADAPT). The climate change scenario simulations will be included in the upcoming BALTEX Assessment of Climate Change in the Baltic Sea Basin BACC (http://www.baltex-research.eu/BACC).

ECOSUPPORT research will partly be continued in some scientific follow-up projects, e.g. BEAM (Baltic Ecosystem Adaptive Management, 2010-2014, see http://www.smf.su.se/beam) funded by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) and Stockholm University's Strategic Marine Environmental Research Funds, and NorMER (The Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change", Nordic Centre of Excellence on Climate Change Effects on Marine Ecosystems and Resource Economics, 2011-2015, http://www.cees.uio.no/normer) funded by the Top-level Research Initiative (TRI), Nordforsk.

ECOSUPPORT has produced a huge amount of data that will very likely be used in other projects. The climate and nutrient transport reconstruction in the period 1850-present can certainly find application in further analysis of the environmental variability in the Baltic Sea area. Similarly, the climate simulations with the regional model RCAO, which has been used in ECOSUPPORT to drive the ecological models of the Baltic Sea, provide an interesting data set for other climate impact studies that are not necessarily directly linked to the ecology of the Baltic Sea. The life-time of model data, however, tends to be shorter than observational data sets, since model formulation and computer power are continuously improved. For scientific applications all data from ECOSUPPORT are publicly available. The reconstruction of climate and nutrient transport since 1850 will find their way to public data banks.

The thorough comparative analysis of three different Baltic Sea models, both in hindcast and in scenarios, have indicated some key uncertainties in biogeochemical process descriptions that calls for additional research efforts, for example, the phosphorus retention gradient from the Bothnian Bay to Baltic proper and differences in response to nutrient load reductions under climate change.

The revision of the maximum allowable loads in the HELCOM BSAP is ongoing in 2012-2013. ECOSUPPORT results feed directly into this work, not only the ensemble modeling results as such, but also the huge effort on developing and validating the response of the models to load reductions, and construction of high quality atmospheric and load forcing for the models increase both confidence and accuracy of the scientific recommendations that will be provided to the HELCOM decision process.

The calculations of additional nutrient load reductions necessary to achieve good environmental status under the pressure of climate change need to be further elaborated. What is performed so far is promising and gives realistic results, but the analysis will be expanded to include also other climate scenarios and a scientific publication will be written. The difficulty of estimating the costs of these reductions needs to be addressed with a joint project with environmental economists and catchment modelers since the results so far points to quite large additional reductions so the linear analysis done within the ECOSUPPORT probably underestimates true costs substantially.

Further, ECOSUPPORT has produced simulations which indicate some of the possible developments of major Baltic fish populations, expected fishery yields and food web dynamics (e. g., productivity, trophic flows, resilience) in response to some major forcings (e. g., CO2 emissions, nutrient loadings, exploitation). However new combinations of forcings with the existing ecological models need to be evaluated, and all models require continuous maintenance and development (e. g., re-parameterisation given new process knowledge). In addition, methodological issues related to bias correction of projections and construction of model ensembles from multiple model outputs require further investigation.

Moreover, there are still knowledge gaps and uncertainties in ecological processes – e. g., fish recruitment, acidification impacts on species within the food web, how population biomasses will respond as their prey or predator populations approach historical lows and highs, etc.. However the available results successfully illustrate how different climate and nutrient loading forcings can be integrated into models of fish populations and food web dynamics. These findings can contribute to the further development of ecosystem-based approaches for management of the Baltic Sea, which will be required as new combinations of climate forcing, nutrient loading, exploitation and food web structure emerge during the 21st century. It is anticipated that the projection forcing data and framework for analyses will be legacies which can be explored in further detail in the coming months and years.

The north-eastern Baltic Sea region is the focal area in the scientific research project "Estimation of environmental response to future climate projections in Estonia using air, sea and catchment area models (EstKliima)" (2012-2014) funded by Estonian Ministry of Education and Research and EU Structural Funds. The data and knowledge produced within ECOSUPPORT will be used as input in the EstKliima project.

The results obtained in the ECOSUPPORT will be used in formulation of the local scenarios of possible response of the Vistula Lagoon environment to global climate change, which is planned for submission to regional authority at the end of 2012 or beginning of 2013. It will also be used in the development of a draft of a local adaptation strategy for climate change for Kaliningrad Oblast (with planned submission at the end of 2014). The information will also be used by ABIORAS experts within the BALTADAPT project and in the collaborative project LAGOONS "Integrated Water Resources and Coastal Zone Management in European Lagoons in a Context of Climate Change" (2011-2014) within the framework of 7th Framework Programme.

The visualisation techniques (GeoDome and DSS) used within ECOSUPPORT also form the basis for further development since they contribute to the closing of the communication gap often occurring between state-of-the-art science and decision makers. Specific planned exploitation of the results also concerns both presentations at international conferences and further scientific publication (see list below).

Upcoming conference:

1. Invited presentation by H.E.M. Meier at the Second Joint International Symposium on ``Effects of Climate Change on the World's Oceans" of ICES, PICES and IOS (convened as one of the official events related to Expo-2012), Yeosu, Korea, May 15-19, 2012: Title: Hypoxia in future climates - a model ensemble study for the Baltic Sea.

Scientific papers in preparation

1. Andersson, H.C., Arheimer, B., Meier, H.E.M., Neset, T. and Wallman, P., 2012: Visualization of the impact of nutrient load and climate change scenarios of the Baltic Sea using a GeoDome. AMBIO, ECOSUPPORT special issue, manuscript in preparation.
2. MacKenzie, B. R., Neuenfeldt, S., Lindegren, M., Blenckner, T., Niiranen, S., Tomczak, M. A multi-model investigation of the development of the Baltic cod population during 21st century climate change. Manuscript in preparation.
3. Meier, H. E. M., 2012: ECOSUPPORT - a pilot study for decision support for Baltic Sea environmental management. AMBIO, ECOSUPPORT special issue, manuscript in preparation.
4. Meier, H.E.M., H. C. Andersson, B. Arheimer, T. Blenckner, B. Chubarenko, C. Donnelly, K. Eilola, B. G. Gustafsson, J. Havenhand, A. Höglund, I. Kuznetsov, B. MacKenzie, B. Müller-Karulis, T. Neumann, S. Niiranen, J. Piwowarczyk, U. Raudsepp, M. Reckermann, T. Ruoho-Airola, O. P. Savchuk, F. Schenk, J. M. Weslawski, and E. Zorita, 2012: Climate warming may unprecedently alter the Baltic ecosystem compared to the past 150 yrs. Environ. Res. Lett., manuscript in preparation.
5. Meier, H. E. M., H. C. Andersson, C. Dieterich, K. Eilola, B. G. Gustafsson, R. Friedland, I. Kuznetsov, B. Müller-Karulis, T. Neumann, and O. P. Savchuk, 2012: Uncertainties of biogeochemical cycles in transient scenario simulations for the Baltic Sea. Manuscript in preparation.
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8. Savchuk, O. P., B. G. Gustafsson and B. Müller-Karulis, 2012. BALTSEM - a marine model for decision support over the Baltic Sea Region. Manuscript in preparation.

Acknowledgement

The ECOSUPPORT project has received funding from the European Community’s Seventh Framework Progranne (FP/2007-20013) under grant agreement no. 217246 made with BONUS, the joint Baltic Sea research and development program and from national funding agencies.

We are grateful to the International BALTEX secretariat for hosting the ECOSUPPORT webpage. Special gratitude is due to Dr Marcus Reckermann, who set up the page and continuously uploaded all our updates.

We are also grateful to the BONUS secretariat for the funding the cluster activity “Workshop on Uncertainties of Scenario Simulations”, Norrköping, 2010 and of the GeoDome presentations at the

13th Baltic Development Forum Summit and the European Commission's 2nd Annual Forum on the EU strategy for the Baltic Sea region (EUSBSR) in Gdansk, 2011. Financial support for GeoDome visualizations has also been received from the Swedish Agency for Marine and Water Management and the Swedish International Development Cooperation Agency (SIDA) Baltic Sea Unit. They were made possible through support from the Swedish Meteorological and Hydrological Institute and cooperation with the BALTADAPT project and the Visualization Center C in Norrköping.

Appendix: Dissemination list

Publications

(peer-reviewed articles in international scientific journals are marked in yellow)

1) Alexandrov S.V., Gorbunova Ju.A. Biogenic load to the Vistula Lagoon with the run-off of the Pregolia River. Water: Chemistry and Ecology. 2010. № 1. Pp. 4-8. [In Russian] Александров С.В., Горбунова Ю.А. Биогенная нагрузка на Вислинский залив со стоком реки Преголя Вода: химия и экология. 2010. № 1. С. 4-8
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<u>Licentiate and Doctoral thesis</u>

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<u>Presentations and papers in conference material (excl. ECOSUPPORT meetings)</u>

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91) Navrotskaya S.E. The Features of level fluctuations in river mouth Pergola, Kaliningrad Region, according to the observations in 1996-2008. // Towards sustainable development of the Baltic Sea coast: proceedings of the 2nd Baltic Green Belt Forum. Palanga 13-16 April 2010.- Klaipeda: Dauginta Klaipedos universiteto leidykloje, 2010. ISBN 978-9955-18-503-1. P. 258-262.

92) Navrotskaya S.E., Chubarenko B.V. Dynamics of mean annual water level in the Pregolia River mouth near the Kaliningrad in 1901-2006. Proc. IX Int. Conf. “Innovation in Science and Education”, Kaliningrad, 18-20 October 2011. Kaliningrad: KGTU, 2011. Vol.1. Pp 157-159. *(Original Russian publication: Навроцкая С.Е., Чубаренко Б.В. Динамика среднего годового уровня в устье реки Преголи у Калининграда в 1901-2006 гг. / Труды VIII Междунар. науч. конференции «Инновации в науке и образовании – 2010», посвященной 80-летию образования университета. Калининград, КГТУ, 2010. С.157-159.)*

93) Navrotskaya S.E., Chubarenko B.V. Long-term dynamics of sea level in lagoons and coastal zone of South-East Baltic. Proc. of 2nd Int. Conf. “Creation and Use of Man-made Territories at the shore and in the water of seas, lakes and reservoirs”, Novosibirsk, 1-6 August 2011. Novosibirsk: SB RAS, 2011. ISBN 978-5-7692-1189-8. Pp. 265-269. *”(Original Russian publication: Навроцкая С. Е., Чубаренко Б. В. Многолетняя динамика уровня моря в лагунах и прибрежной зоне Юго-Восточной Балтики. / Создание искусственных пляжей, островов и других сооружений в береговой зоне морей, озер и водохранилищ: Труды 2-ой Междунар. конференции «Создание и использование искусственных земельных участков на берегах и акватории водоемов», Новосибирск, 1-6 августа 2011 г. (отв. ред. А.Ш. Хабидов) – Новосибирск: Изд-во СО РАН, 2011. ISBN 978-5-7692-1189-8.- с. 265-269.)*

94) Niiranen, S., Tomczak, M., Hjerne, O., and Blenckner, T. - "Baltic Proper food web dynamics in response to environmental drivers - linking time series analysis with modeling" (talk). CERF 2009, Portland, USA, November 2009

95) Niiranen, S., Tomczak, M., Blenckner, T. and Hjerne, O. “Dynamics and regimes of the Baltic Proper food web – Linking time series analysis with modelling”. ICES’09 ASC, Berlin, Germany (talk)

96) Niiranen, S., Tomczak, M. T. and Blenckner T (2010, talk). Ecosystem states of the Baltic Sea within the last 30 years – Implications for management. EUTRO 2010, 15-18 June 2010, Nyborg, Denmark.

97) Niiranen, S., Blenckner, T. and Biggs, R. (2010, talk). Are general mechanisms found behind regime shifts across marine ecosystems? Climate Change Effects on Fish and Fisheries, 24-29 April 2010, Sendai, Japan.

98) Niiranen, S., Tomczak, M. T., Hjerne, O. and Blenckner, T.. Baltic Sea Science Congress (St. Petersburg, Russia): “Challenges and unknowns in the future climate-response studies of the Baltic Sea ecosystem – a food-web model sensitivity analysis” (talk). 22-26/8/2011

99) Niiranen, S., Tomczak, M. T., Hjerne, O. and Blenckner, T. ASLO 2011 Aquatic Sciences Meeting (San Juan, Puerto Rico): "Lack of spatial connectivity as a contributor to the late 1980s central Baltic Sea regime shift?" (talk). 3-18/2/2011

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101) Passenko J., Lessin G., Maljutenko I. Analysis of temporal variability of measured and modeled vertical distributions of salinity and temperature in the Gulf of Finland during 10-year period. The 2nd International Conference (school) on DYNAMICS OF COASTAL ZONE OF NON-TIDAL SEAS, Baltiysk (Kaliningrad Oblast, Russia), 26–30.06. 2010.

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103) Piwowarczyk J., Weslawski J.M., Kotwicki L, Marine and coastal tourism confronting the nature protection measures, 3rd International Conference on Marine and coastal tourism, Sopot/Poland, 2010 (Name of the conference in Polish: III Międzynarodowa Konferencja Naukowa: 'Problemy turystyki morskiej i regionów nadmorskich')

104) Ruoho-Airola T, Parviainen M and Tarvainen V, 2010. Database of published nitrogen concentrations in air and precipitation around the Baltic Sea 1850-1960. In: Reckermann M and Isemer H-J. 6th Study Conference on BALTEX. 14-18 June 2010 Miedzyzdroje, Island of Wolin, Poland. Conference Proceedings. International BALTEX Secretariat, ISSN 1681-6471. Publication No. 46, June 2010, pp. 111-112.

105) Schenk, F. and E. Zorita. The Analog-Method: Reconstruction of Highly Resolved Atmospheric Forcing Fields, EGU General Assembley 2010 in Vienna, May 2010 http://meetings.copernicus.org/egu2010/http://meetings.copernicus.org/egu2010/

106) Schenk F. and E. Zorita. New dataset of highly resolved atmospheric forcing fields for 1850-2009.June 2010 6th BALTEX International Conference on Climate Change in Miedzyzdroje/Poland. June 2010http://www.baltex-research.eu/SZC2009/programme.html

107) Schenk F. and Zorita E.. Reconstruction of highly resolved atmospheric forcing fields for Northern Europe since 1850 AD.. EMS Annual Meeting & European Conference on Applied Climatology 2010, September 2010

108) Schenk F; Modelling the Baltic Sea with Flake. General Assembly of the CLM-community 2010, FU Berlin, Germany, September 20 http://www.emetsoc.org/annual_meetings/annual_meetings_2010.php

109) Schenk F.Reconstructing Storminess for Northern Europe since 1850. Seminar on Storm Studies, Deutscher Wetterdienst, Seewetteramt Hamburg, September 2010

110) Stont Zh., Chubarenko B. Analysis of changes in meteorological and hydrological characteristics for marine coasts and lagoons in the Kaliningrad Oblast (south-east Baltic) / Conference Proceedings. Climate Change. The environmental and socio-economic response in the southern Baltic region. University of Szczecin, Poland, 25-28 May 2009. P. 130.

111) Tomczak, M. Baltic food web model. ICES WGSAM, 2009

112) Tomczak, M. Ecological Network Analysis, indicators of food-web changes in the Baltic Sea. ICES WGHAME, 2009 '

113) M. T. Tomczak, J. J. Heymans, T. Blenckner, and S. Niiranen. Ecological network analysis, indicators of foodweb changes in the Baltic Sea. Presented at ICES ASC 2009, Berlin .ICES CM/2009/P:04

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115) Tomczak M, T. Eero, M., MacKenzie, B. R., Niiranen, S., Blenckner., T Changes in the Central Baltic Sea Ecosystem During the 20th Century – First attempt. Baltic Sea Science Congress 2011, St. Petersburg, Russia
116) Tomczak, M. T., Niiranen, S., Hjerne, O., Blenckner, T. Dynamics of the key food-web flows in the Central Baltic Sea. ICES Annual Science Conference 2011 Gdansk Poland. ICES CM 2011/R:14
117) Wallman, Patrik, Berit Arheimer, Kristina Isberg and Joel Dahné 2011: Balt-Hype and BaltHypeWeb – tools for assessment of the effects of the Baltic Sea Action Plan and climate change on hydrology and nutrient loads to the Baltic Sea, BSSC2011, St. Petersburg, Russia, 2011-08-26, Oral presentation
118) Wallman, Patrik, Berit Arheimer, Joel Dahné, Kristina Isberg and Johanna Nilsson 2011. Linking scales in assessments of mitigation options for riverine nutrient reduction. COST869 Final Conference, Keszthely, Hungary, 11-10-12, Oral and poster presentation
119) Wallman, Patrik, Berit Arheimer, Kristina Isberg, Chantal Donnelly and Joel Dahné 2011: E-HYPE and E-HypeWeb - Services for Water and Climate Information Istanbul, Turkey 2011-11-15-2011-1117, Oral and poster presentation.
120) Wallman, P. Dahné, J., Arheimer, B., Donnelly, C.: Balt-HYPE - a tool for water and nutrient management. Rusnip and Balthazar projects workshop on Russia, Helsinki, Oct. 25-26. 2010.
121) Weslavski, J. M., 2011: What science may and may not have to offer for the marine management. ECOSUPPORT and RECOCA stakeholder conference: An outlook to the future Baltic Sea: how can we reach the targets of the Baltic Sea Action Plan?, Stockholm 7 December, 2011.
122) Weslawski J.M., Piwowarczyk J., Beach and sandy shores in the marine ecosystem, Artificial reefs application for the sandy shores erosion control, rkshop in Jurata/Poland, 2010 (Zastosowanie modułów siedliskowych (Reef Ball) do stabilizacji brzegu morskiego oraz ochrony i odbudowy plaż)
123) J.M. Węsławski and Piwowarczyk, J.: Valuation of Polish coastal waters, “The marine ecosystem in changing climate - on the added value of coupled climate-environmental modeling for the Baltic Sea”, Norrköping, Sweden, 16 October, 2009.
124) BONUS annual conference 2010,Vilnius, Lithuania, 19-21 January, 2010, Author(s): H.E.M. Meier and ECOSUPPORT co-workers, Title: First results of recently performed scenario simulations for the Baltic Sea for 1961-2099.
125) BONUS annual conference 2010,Vilnius, Lithuania, 19-21 January, 2010, Author(s):Eilola, K., Almroth, E, Gustafsson, B.G. et al. Title: Uncertainty assessment of state-of-the-art coupled physical-biogeochemical models for the Baltic Sea.
126) BONUS annual conference 2010,Vilnius, Lithuania, 19-21 January, 2010, Author(s):Dahné, J., Donnelly, C., Strömqvist, J. et al. Title: Evaluating the combined effects of nutrient load reduction and climate scenarios for the Baltic Sea catchment.
127) International workshop on “Effects of climate change on the marine environment” organized by the Nordic Council of Ministers, Copenhagen, Denmark, 9-10 March, 2010. Author(s): H.E.M. Meier Title: Impact of changing hydrography on biogeochemical cycles in future climates of the Baltic Sea. (invited presentation)
128) Deutsche Meteorologische Gesellschaft, Deutscher Wetterdienst, Seewetteramt Hamburg, Hamburg, 16 March, 2010. Author(s): H.E.M. Meier, Title: Klimaszenarien für das 21. Jahrhundert - neue Ergebnisse basierend auf einem regionalen gekoppelten Atmosphäre-Eis-Ozeanmodell für die Ostsee.(invited presentation)
129) Presentation at Finland's environmental administration (SYKE), 24 May 2010, Helsinki, Finland, Author(s): H.E.M. Meier, Title: From daily algae forecasts toward scenario simulations of changing climate - an overview on environmental modelling activities at the Swedish Meteorological and Hydrological Institute. (invited presentation)
130) Sixth study conference on BALTEX, Miedzyzdroje, Island of Wolin, Poland, 14 - 18 June 2010, Author(s): H.E.M. Meier and ECOSUPPORT collaborators. Title: Transient scenario simulations for the Baltic Sea for 1961-2099. (solicited)

131) Sixth study conference on BALTEX, Miedzyzdroje, Island of Wolin, Poland, 14 - 18 June 2010, Author(s): K. Eilola, B.G. Gustafsson, R. Hordoir, A. H\"oglund, I. Kuznetsov, H.E.M. Meier, T. Neumann and O.P. Savchuk. Title: Quality assessment of state-of-the-art coupled physical-biogeochemical models for the Baltic Sea.
132) EUTRO 2010, Nyborg, Denmark, 14 - 18 June 2010, Author(s): H.E.M. Meier, H. Andersson, K. Eilola, R. Hordoir, and A. Höglund, presented by H. Andersson, Title: New scenario simulations of the Baltic Sea ecosystem to support decision making.
133) BalticStern workshop on scenarios, Stockholm Resilience Centre, Stockholm, Sweden, 6-7 October 2010, Author(s): H.E.M. Meier, Title: ``Coupled climate-environmental modelling for the Baltic Sea Region'' (invited presentation)
134) BONUS+ program cluster workshop on ``Uncertainties of scenario simulations'', Norrköping, Sweden, 14 October 2010. Author(s): H.E.M. Meier, A. Höglund, R. Döscher, H. Andersson, U. Löptien and E. Kjellström, Title: ``Quality assessment of atmospheric surface fields over the Baltic Sea of an ensemble of regional climate model simulations with respect to ocean dynamics''
135) SMHI & CSPR (ECOSUPPORT): Baltic Vision: Research results from the ECOSUPPORT project visualized by 30 mins presentations (ca 7/day) using a GeoDome™. Presenters P. Wallman and H. Andersson, Stockholm World Water Week, 7-9, September, 2010.
136) SMHI & CSPR (ECOSUPPORT): Baltic Vision: Research results from the ECOSUPPORT project visualized by 30 mins presentations using a GeoDome™. Presenters P. Wallman and H. Andersson, Stockholm University, November , 2010.
137) SMHI & CSPR (ECOSUPPORT): Baltic Vision: Research results from the ECOSUPPORT project visualized by 30 mins presentations using a GeoDome™. Presenters P. Wallman and H. Andersson, Government Offices of Sweden, November, 2010.
138) SMHI & CSPR (ECOSUPPORT): Baltic Vision: Research results from the ECOSUPPORT: Visualisation of the impact of climate change in the Batlic Sea region. Presenters P. Wallman and H. Andersson at the conference "One year with the European Union Baltic Sea Strategy. The East Sweden Region "Östsam", Norrköping, Sweden, October, 2010.
139) ECOSUPPORT: Project presentation by Helén Andersson at "Discussion- Baltic Sea" a one-day conference for scientists and stakeholders, Norrköping, Sweden, August, 2010.
140) ECOSUPPORT Decision Support System for the Baltic Sea in a future climate. Presented by Helén Andersson at the SMHI development day, May, 2010.

<u>Posters</u>

1) The ECOSUPPORT consortium (poster presented by H.C. Andersson), Selected Highlights from the ECOSUPPORT project. BONUS annual conference 2010 (Vilnius, Lithuania).
2) The ECOSUPPORT consortium (poster presented by M. Meier), ECOSUPPORT: Project approach and selected results. 6th Study Conference on BALTEX, Wolin, Poland, June 2010.
3) The ECOSUPPORT consortium (poster presented by H.C. Andersson), ECOSUPPORT: Project approach and selected results. EUTRO 2010, Nyborg, Denmark, June, 2010
4) Andersson, H.C, P. Wallaman, J. Dahné, C. Donnelly, K. Eilola and H.E.M Meier, Visualization of hydrological, physical and biogeochemical modelling of the Baltic Sea using a GoeDome (poster presented by H.C. Andersson), Baltic Sea Science Congress, St Petersburg, Russia, 22-26 August, 2011.
5) The ECOSUPPORT consortium (poster presented by H.C. Andersson): Selected highlights from the ECOSUPPORT project. ICES Annual Science Conference, Gdansk, Poland, 19-23 September, 2011.

6) The ECOSUPPORT consortium: Selected highlights from the ECOSUPPORT project (poster presented by H.C. Andersson), Baltic Sea Science Congress, St Petersburg, Russia, 22-26 August, 2011
7) Schimanke, S., G. Strandberg, E. Kjellström and H.E.M. Meier. Investigations of hypoxic areas in the Baltic Sea during the MCA and LIA using RCA3 forced with ECHO-G. (Poster presented by Semjon Schimanke), The Millennium Workshop , Hamburg, March 2011. http://www.emetsoc.org/annual_meetings/annual_meetings_2010.php

Web Tools

1) Baltic Sea HYdrological Predictions for the Environment <http://www.smhi.se/en/Research/Research-departments/Hydrology/baltic-sea-hydrological-predictions-for-the-environment-1.14179>

Media appearance/exhibitions

1) ECOSUPPORT material presented at the Norrköping Visualization Centre C exhibition "Water – a world of life", 21 January – 18 August 2012.
2) Interview (H.C. Andersson) for Swedish Radio P4: "SMHI awarded in Baltic Sea project" (SMHI prisas för Östersjöprojekt, in Swedish, October 2011. http://sverigesradio.se/sida/artikel.aspx?programid=160&artikel=4765571)
3) Participation by H.C. Andersson and p. Wallman in the film production made as Baltic 21 promotion material http://vimeo.com/23634803 (draft version) by Council of the Baltic Sea States (CBSS), 2011.
4) Interview (H.C. Andersson) for Russian television news on Baltic Sea marine environment research and presentations in a Geodome, St Petersburg, Russia, 22 March, 2011.

Lectures:

1) Meier, M: Invited guest lecture for undergraduate students at Södert örn University, Huddinge, Sweden, ``Impact of changing climate on the Baltic Sea'' (2 lecture hours), Oct 2010:
2) Oct 2010: Lectures for graduate students within the ``Climate Modelling School'' organized by the BONUS+ project AMBER, Norrköping, Sweden, ``Baltic Sea Climate Modelling'' (lecturers: Erik Kjellström, M. Meier, Eduardo Zorita)
3) Piwowarczyk J., Weslawski J.M: ‚Sandy beaches in need for sustainable development and public awareness, Institute of Oceanography, Nha Trang, Vietnam, 2010
4) Piwowarczyk J., Weslawski J.M: From conflicts to solutions: How science can help to solve the conflicts for marine resources, University of Science Ho Chi Minh City, Vietnam, 2010.
5) Wallman, P. Lecture for Kunskapsgymnasiet High School. Title: The Baltic Sea – a Threatened Inland Sea? Norrköping, December, 2010.
6) Andersson, H.C. Lecture on "The Baltic Sea – a sea under constant changes" (in Swedish) at the lecture series of the Norrköping Senior University, 2011.
7) Wallman, P. "Scientific communication in practice, with examples from Ecosupport", lecture at Södertörn University, Sweden, 2011.

Workshops and conferences arranged by ECOSUPPORT (excluding project own workshops)

1) ECOSUPPORT workshop on "The Marine Ecosystem in Changing Climate – on the added value of coupled climate-environmental modelling for the Baltic Sea", Norrköping, Sweden, 16 October, 2009.

2) BONUS cluster activity: workshop on “Uncertainties of Scenario Simulations”, SMHI, Norrköping, 14 October, 2010
3) ECOSUPPORT and RECOCA: Final scientific conference, Stockholm, 5-6 December, 2011.
4) ECOSUPPORT & RECOCA Stakeholder conference: An outlook to the future Baltic Sea: How can we reach the targets of the Baltic Sea Action Plan? Stockholm University, Stockholm 7 December.

Project Workshops and conferences

1. ECOSUPPORT Kick-off Meeting, Norrköping, Sweden, 26-27 January 2009.
2. Management Group Telephone Conference, 1 April, 2009
3. Management Group Telephone Conference, 18 June, 2009
4. ECOSUPPORT Scientific Meeting, Baltic Sea Science Congress, Tallinn, Estonia, 17 August 2009
5. ECOSUPPORT WP2 Meeting, Gothenburg, Sweden, 15 September, 2009
6. ECOSUPPORT Workshop on Data Integration and Modelling, Norrköping, Sweden, 14 October, 2009.
7. ECOSUPPORT General Assembly, Norrköping, Sweden, 15 October 2009.
8. ECOSUPPORT Management Group Telephone Conference, 9 Decemberl, 2009.
9. ECOSUPPORT Management Group Telephone Conference, 12 April, 2010.
10. ECOSUPPORT WP2 Meeting, Stockholm, Sweden, 5 May, 2010.
11. ECOSUPPORT Management Group Telephone Conference, 10 June, 2010.
12. ECOSUPPORT WP4 Meeting, Sopot, Poland, 6-7 September, 2010.
13. ECOSUPPORT WP1-3 Workshop on Data exchange and Integration, Charlottenlund, Denmark, 13 September, 2010.
14. ECOSUPPORT Management Group Meeting, Norrköping, Sweden, 15 October 2010.
15. ECOSUPPORT annual meeting/working groups, Norrköping, Sweden, 15 October, 2010
16. ECOSUPPORT General Assembly, Norrköping, Sweden, 15 October, 2010.
17. ECOSUPPORT Management Group telephone conference, 10 January, 2011
18. ECOSUPPORT Workshop on Scenarios and long-term hindcasts, Stockholm, Sweden, 8-10 March, 2011.
19. ECOSUPPORT management telephone conference, May 6, 2011.
20. ECOSUPPORT Management Group Telephone Conference, 22 June, 2011.
21. ECOSUPPORT project meeting, Baltic Sea Science Conference, St Petersburg, Russia, 22 August, 2011.
22. ECOSUPPORT management group telephone conference, 13 October, 2011.
23. ECOSUPPORT annual meeting, Stockholm, Sweden, 6 December, 2011.

Awards

1) ECOSUPPORT 2011. BONUS+ Award 2011 for the best public engagement activity or product: GEODOME – Stakeholder decision support by scientific communication.

Special Issue

1. AMBIO special issue 6, 2012, ECOSUPPORT – different ecosystem drivers under future climate scenarios in the Baltic Sea.